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POTENTIAL IMPACTS OF THE PROPOSED DOW-SHELL PETROCHEMICAL COMPLEX ON FISH AND WILDLIFE RESOURCES IN ALASKA

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SECTION I

EXECUTIVE SUMMARY

A review of the Dow-Shell Group progress reports, similar existing petrochemical industries, literature dealing with the environmental effects of petrochemicals, and physical and biological data at each of the proposed sites, has revealed that insufficient information is available to predict the full magnitude of impacts which a petrochemical industry might have on Alaskan fish and wildlife resources. The Department's analysis of impacts has been inhibited by the lack of information in the Dow-Shell progress reports on the identity and quantity of all effluents, emissions, and wastes from the proposed facility, and lack of specific details on environmental engineering and pollution control practices which will be employed during facility construction and operation.

The major impacts to fish and wildlife resources are likely to occur from the operation of the main petrochemical complex and the construction of the gas liquids pipeline. Impacts associated with the main complex are likely to result from the accidental release of petrochemicals or discharge of thermal effluent into the marine and freshwater environments, the appropriation of groundwater or surface water to operate the plant, and the industrial and residential growth needed to support the facility.

A petrochemical industry at any of the proposed sites will have the greatest impact on marine fishery resources with the most vulnerable species being shellfish and salmon. Petrochemical manufacturing or transportation related impacts could result in direct mortality to existing fish populations, or could cause reduced production through loss of food

supplies or disruption of critical life stages. Sublethal impacts to shellfish such as razor clams, could include tainting of the meat and prevent consumption of these shellfish by humans. Marine mammals and waterfowl will also be adversely impacted if food supplies or critical habitat areas are altered by the proposed facility. The impact could result in a reduction of reproductive success, species avoidance of disturbed areas, or direct mortality to a local population. Increased human populations and their demand for fish and wildlife resources may result in the enactment of shorter hunting and fishing seasons. Permit hunting seasons will reduce the existing opportunities to participate in hunting and fishing activities.

The major long-term impacts of constructing the gas liquids pipeline from Prudhoe to the plant site will be on fish populations. The impact will occur if disturbance of critical fish habitat areas in watercourses used for spawning, rearing, and overwintering results in lower production or loss of habitat. The major terrestrial wildlife habitat loss will result from gravel removal, work pad construction, and spoil disposal. Adverse short-term impacts on wildlife populations along the pipeline corridor could result from the feeding of wildlife, hunting from construction camps, destruction of nuisance animals, road kills, noise and disturbance, and increased access to sensitive wildlife areas. Many impacts to birds and mammals can be minimized by routing the pipeline to avoid sensitive areas, and by strict management of construction practices. Significant operational impacts would result if the ambient temperature pipeline contributed to frost heave, thaw, or subsidence; if a pipeline rupture occurred under a stream crossing; or if disruption of surface water and/or sheet flow occurred along the pipeline.

The proposed tidewater petrochemical complex would have the lowest potential for adversely impacting fish and wildlife resources if it were located at the Fire Island or Pt. MacKenzie sites in Upper Cook Inlet. The highest potential for adverse impacts to marine and freshwater fish and wildlife resources would result if the site were located at the proposed Seward or Valdez sites. The proposed gas liquids pipeline would have the least impacts on fish and wildlife resources if it followed the Trans-Alaska Pipeline System (TAPS) to Valdez.

Final assessment of the short-term, long-term, and irreversible impacts of a petrochemical industry on fish and wildlife resources will require accurate and detailed accounts of chemical, physical, biological, and toxicological data. This level of information does not currently exist to evaluate the proposed Dow-Shell facility. To insure adequate protection for fish and wildlife resources, the following criteria should be met before a decision is made to support the project.

1. Each respective industrial process in the Dow-Shell complex is sufficiently understood by the State resource and regulatory agencies so that ecological impacts are known and can be mitigated.

2. The chemical products, by-products, feedstock, and wastes associated with the normal operation of each component industry will not enter

the environment in concentrations that are acutely or chronically toxic to any species which would be unintentionally exposed to them.

3. The Company will develop and maintain the resources and expertise to insure that any episodic, non-planned exposure of marine or terrestrial organisms to toxic concentrations resulting from spills or other accidents will be limited in geographical scope, temporary in nature, and not capable of creating a delayed or irreversible loss of resources or habitat.

4. The structure, scope of concern, and authority of industrial management for environmental protection is identified and specific commitments exist for fish and wildlife resource protection in both the construction and operational phase of all proposed facilities.

The certainty with which these conditions can be met will differ between the chemical industries and the individual chemicals produced, transported, and disposed of. For some chemicals no reasonable amount of environmental analysis or testing will provide full assurance of essentially zero or very low risk to fish and wildlife resources. In many cases the technology exists to limit the extent of risk by special precautions and restriction in the manufacture and handling of chemical products. Risk can also be limited in time by environmental monitoring to identify or quantify any adverse effects as early as possible.

Our review of the Dow-Shell proposal and the manufacture of petrochemicals, leads us to conclude that this industry has the capability to adversely impact several important fish and wildlife resources. The degree of risk or hazard that a petrochemical industry could have on fish and wildlife resources must be carefully balanced against the expected benefits.

INTRODUCTION

State of Alaska Agreement with Dow-Shell

In October 1980, the State of Alaska and nine chemical companies, known as the Dow-Shell Group, signed a Memorandum of Understanding and Intent for the purpose of studying the feasibility of a plan to establish a petrochemical industry in Alaska. As part of the State's agreement, a Citizens Advisory Committee composed of key State and local representatives was appointed by the Lt. Governor to represent all of the citizens of Alaska in reviewing the Dow-Shell Group's proposal and plan of study. This committee's function is to assure that all major concerns of the citizens of Alaska with respect to the establishment of a petrochemical industry are addressed.

In March 1981, representatives of seven State agencies met at the request of the Department of Environmental Conservation to form the Petrochemical Technical Group. The purpose of this group is to report on potential social and environmental problems associated with petrochemical development in Alaska. As a member of the Technical Group, the Department of Fish and Game has coordinated with the

Dow-Shell Group to review their progress reports and proposal for petrochemical development. This report was prepared in response to the Dow-Shell progress reports and identifies the Department's concerns in regarding the potential impacts of a petrochemical industry on the fish and wildlife resources of the State. Since design modifications are made by Dow-Shell each month as new information becomes available, recent design changes may not be covered in this report. The Department of Fish and Game will continue to review new information as it becomes available and is prepared to evaluate the completed Dow-Shell feasibility study when it is released.

Chemical Industries and Project Description

Under terms of an agreement with the State of Alaska, the companies involved in the feasibility study are described as the Dow-Shell Group. The members of the group include: Dow Chemical Company USA, Shell Chemical Company, Asahi-Dow Ltd., DuPont Company, Alaska Interstate Company, Alaska Interior Resources Company, Mitsubishi Chemical Industries Ltd., Mitsubishi Corporation, and Earth Resources Company of Alaska. The agreement designated Dow Chemical USA as the project leader, with Shell Chemical Company designated as the cosponsor of the study.

The Dow-Shell proposal is based on an assumed tidewater petrochemical industry site, with gas liquids recovery at Prudhoe Bay and pipeline transport of the gas liquids to a tidewater site in southcentral Alaska (Figure 1).

1. Gas liquids recovery

Lean oil extraction has been premised for the Prudhoe Bay NGL recovery upstream of a gas conditioning plant. This process will extract approximately 90,000 barrels per day (B/D) of ethane, 61,000 B/D of propane, 34,000 B/D of butane, and 21,000 B/D of pentanes and highers along with some carbon dioxide (approximately 4,000 B/D).

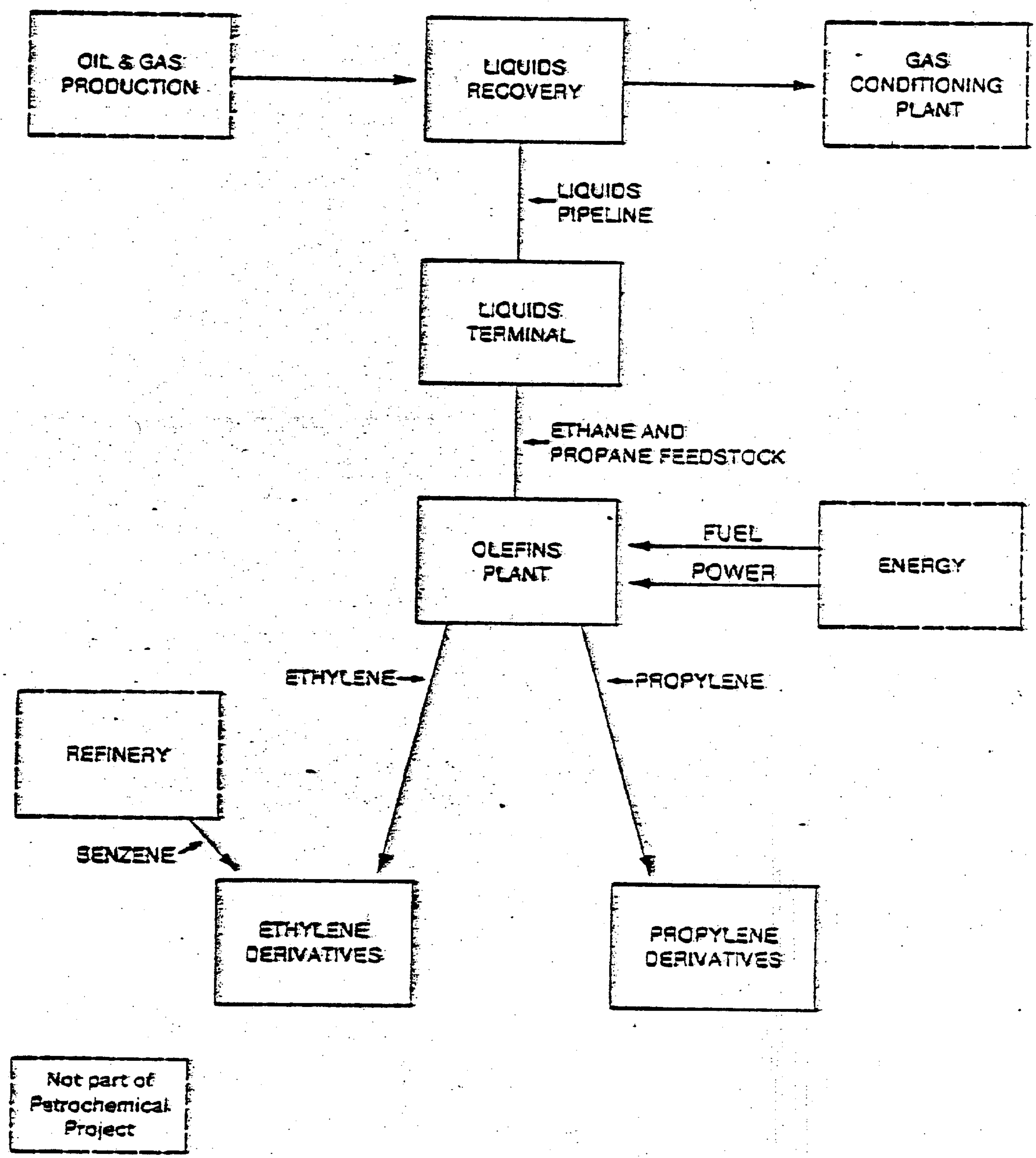
2. Gas liquids pipeline

The Dow-Shell gas liquids pipeline is proposed to carry and supply feedstock to the petrochemical complex. The products to be transported in this pipeline include ethane, propane, butane, and other low molecular weight hydrocarbons. The tidewater sites currently being considered by Dow-Shell for the petrochemical complex include: Pt. MacKenzie, Fire Island, Kenai, Seward, and Valdez (Figures 2, 3, 4, 5, and 6).

To serve each of these sites, several alternate pipeline corridors are being studied. From Prudhoe Bay the proposed pipeline will follow the Trans-Alaska Pipeline System (TAPS) and right-of-way to Fox Station north of Fairbanks; at that point it will branch contingent upon the selection of either the Valdez or

FIGURE 1

Basic Project Diagram



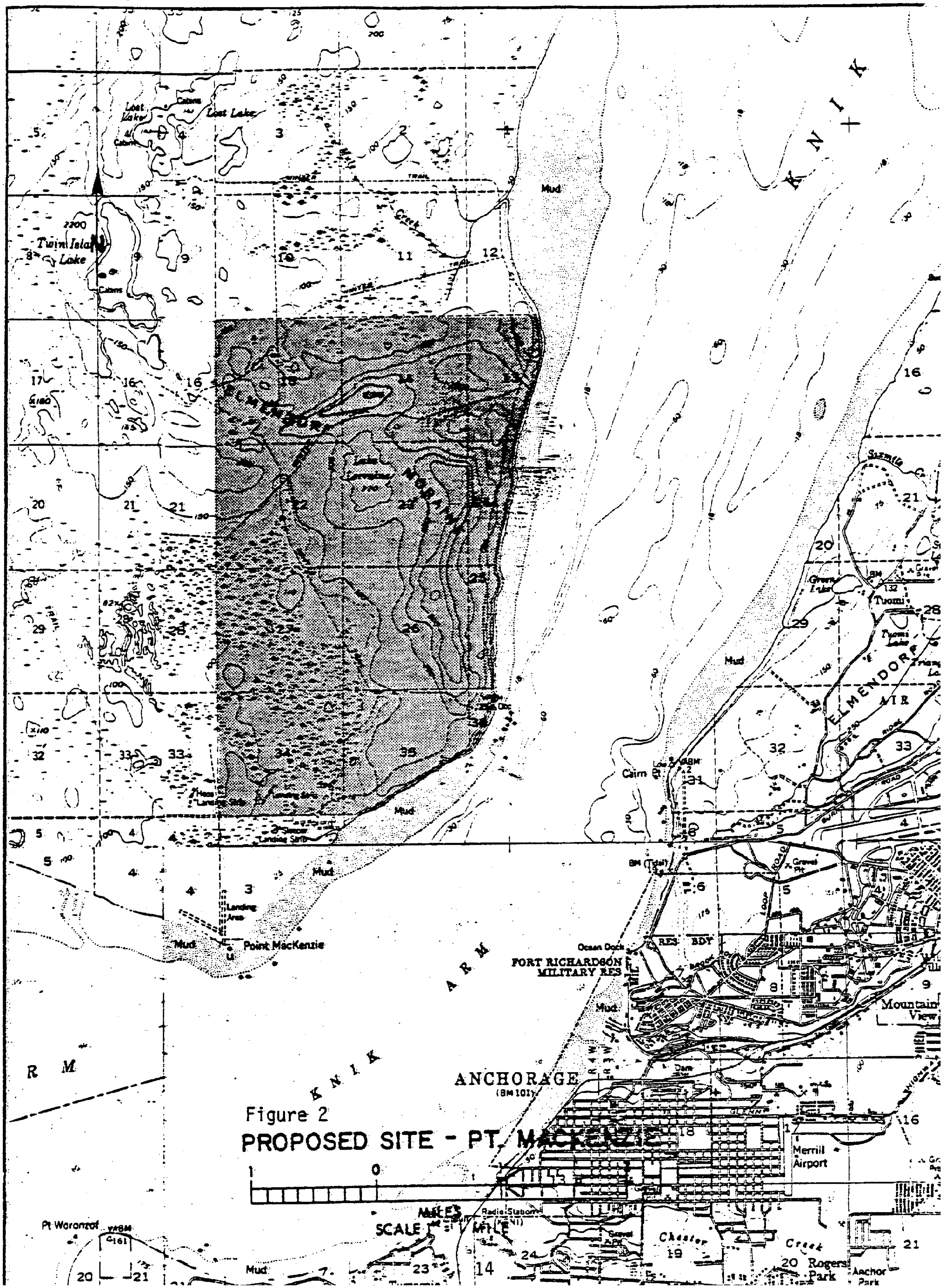


Figure 2
PROPOSED SITE - PT. MACKENZIE

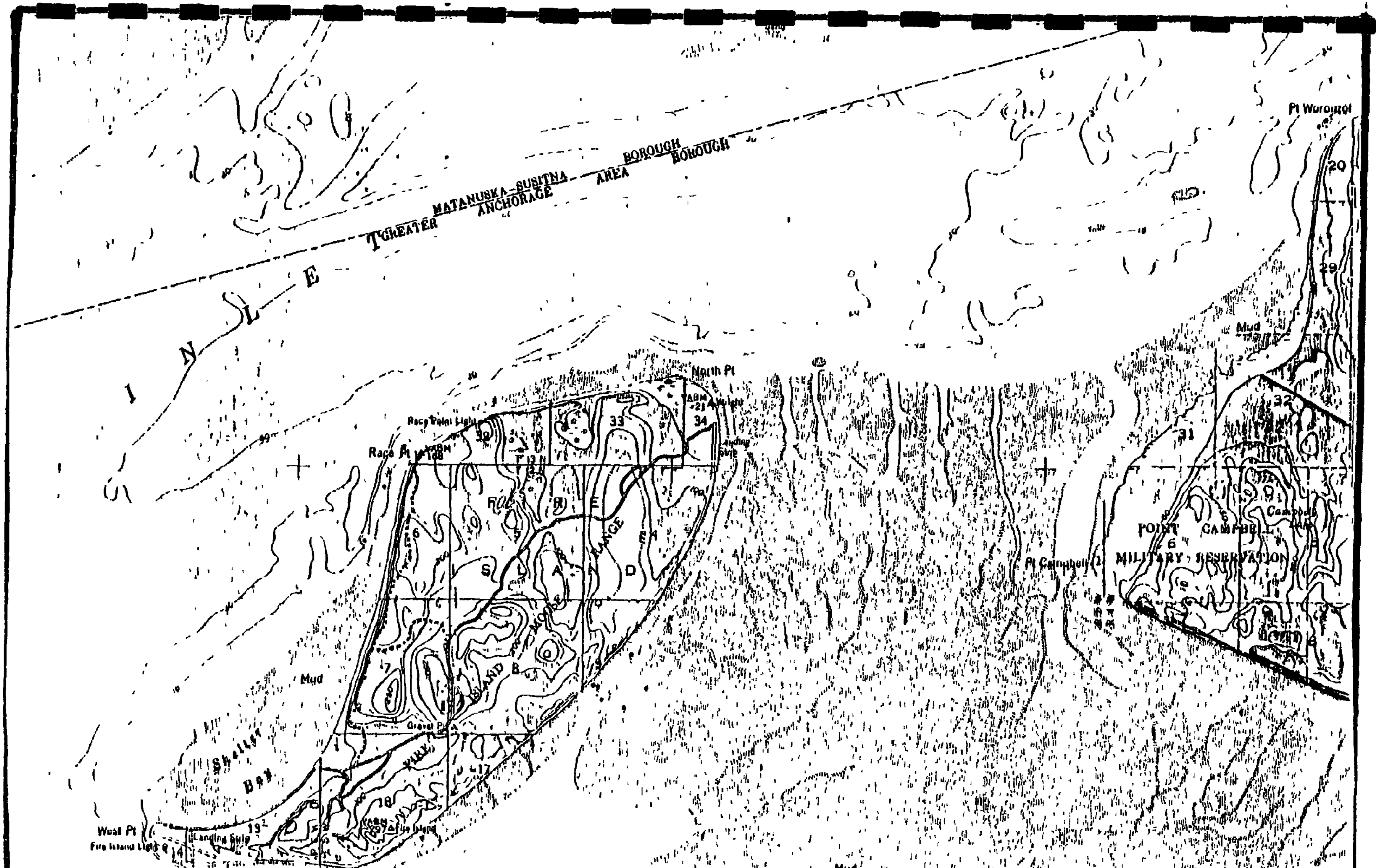


Figure 3
PROPOSED SITE - FIRE ISLAND

Figure 4
PROPOSED SITE - KENAI

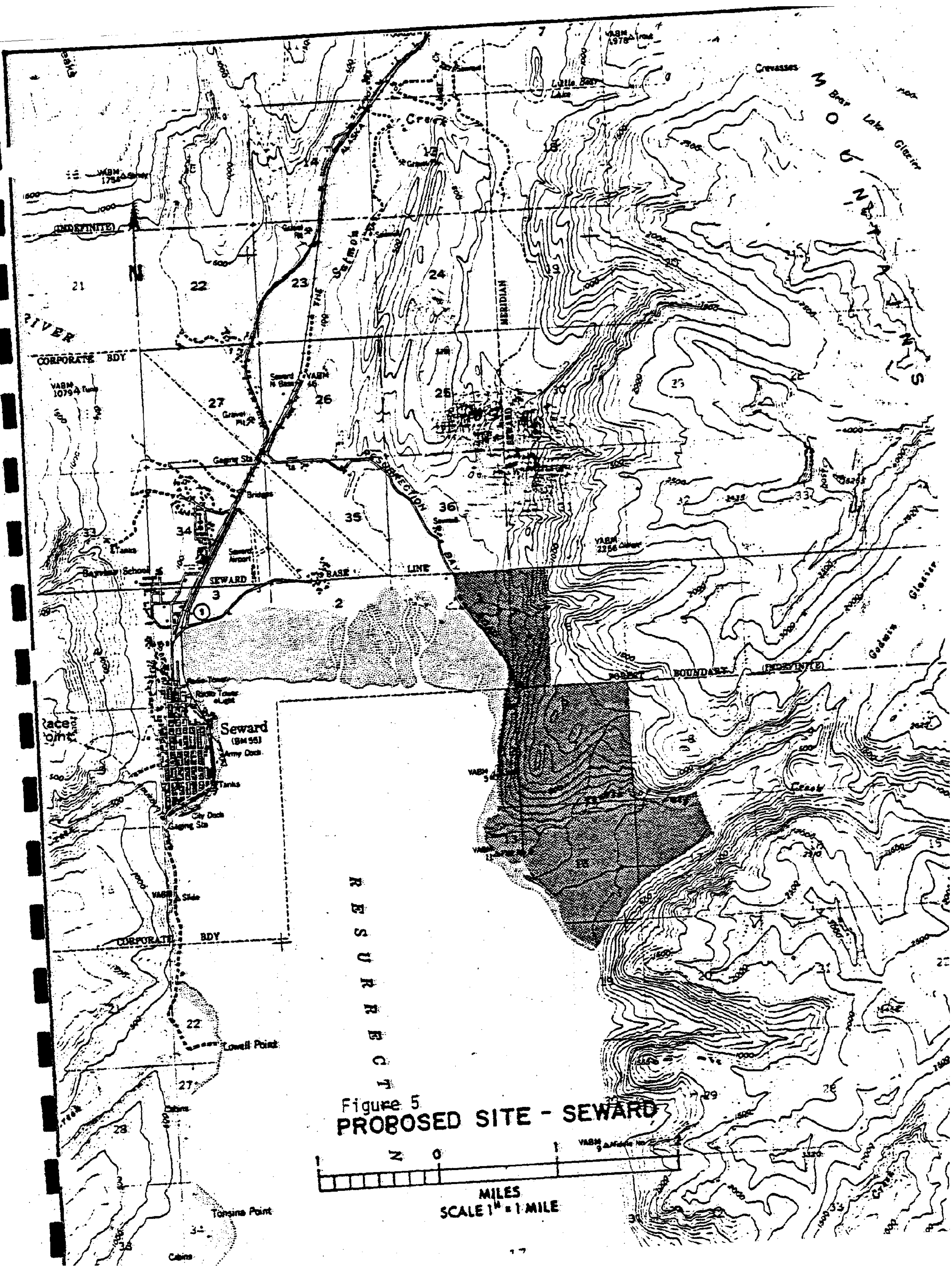


Figure 5
PROPOSED SITE - SEWARD

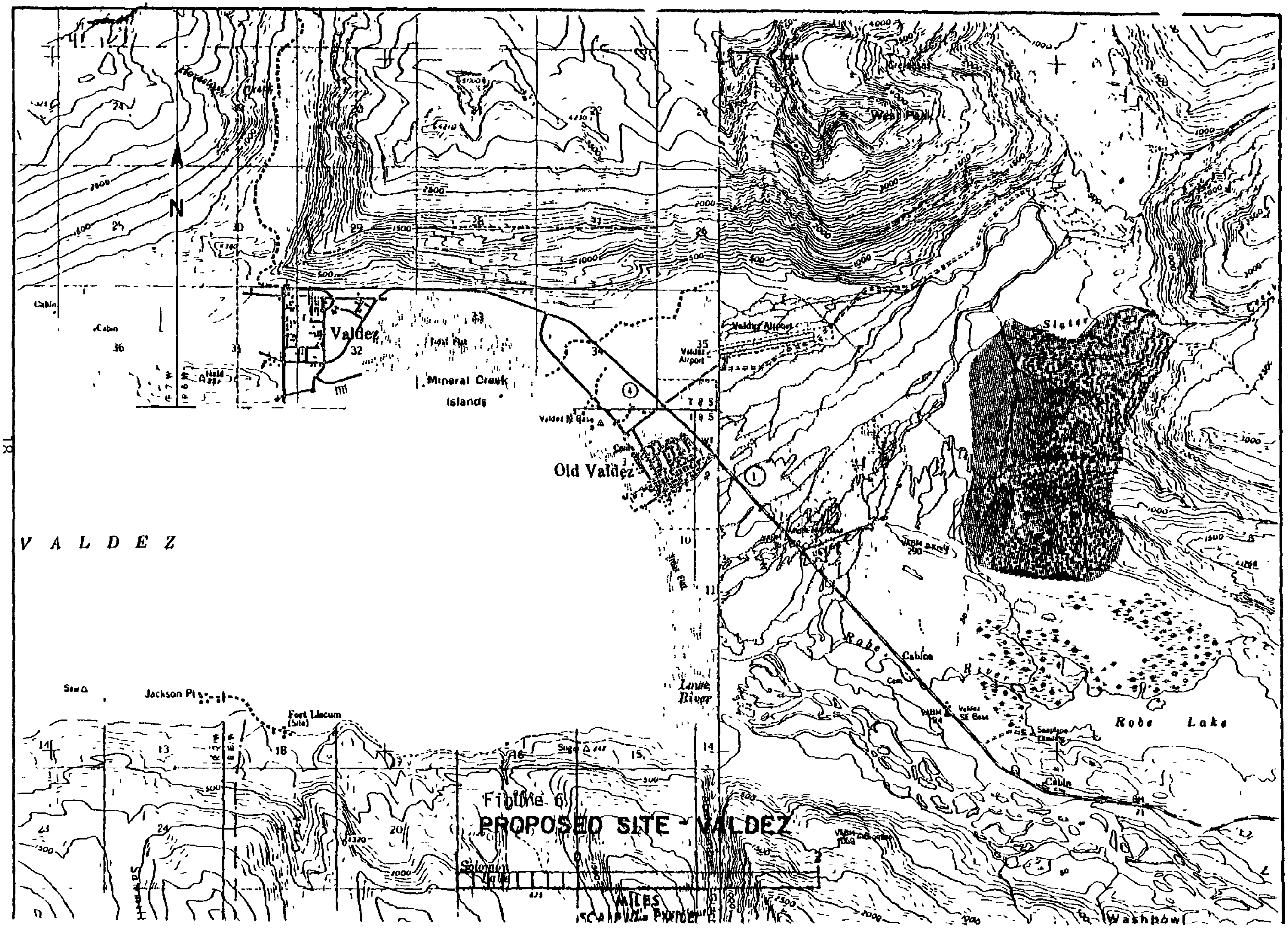


Figure 6
PROPOSED SITE - VALDEZ
V A L D E Z
Valdez
Old Valdez
Mineral Creek
Islands
Valdez Airport
Robe Lake
Robe River
Lowe River
Jackson Pt
Fort Liscum (Site)
Cabin
Washbowl
Slater
MILES

Cook Inlet region for the plant site location. The line either continues to Valdez along the TAPS route or will follow the Parks Highway and Alaska Railroad rights-of-way to Nancy Lake. From Nancy Lake, one branch will either lead to Pt. MacKenzie or Fire Island, or will cross Cook Inlet to Pt. Possession and into Kenai. An alternate pipeline route to Seward parallels the Sterling and Seward highways from Kenai.

The proposed gas liquids pipeline will be 20 inches in diameter, pressurized at 800-1,200 psi, and operated at ambient temperatures. The entire pipeline will be buried at a minimum depth of three feet with several aerial river crossings anticipated. Both summer and winter construction are proposed during the anticipated three-year construction period. Cook Inlet would be crossed by two, 20 inch pipelines separated by 1,000 feet (Dow-Shell Progress Report No.'s 2-4).

3. Petrochemical complex

Terminal facilities would be constructed at or near the petrochemical site. They would include hydrocarbon separation facilities; storage for ethane, propane, butane, pentane and highers; petrochemical plant product storage for both liquid and packaged products; and ship loading facilities.

At the pipeline terminal a fractionation plant will separate the NGLs into various components thus supplying ethane to an olefin plant with the remainder for use as petroleum gases. The basic production unit would be a world scale olefins plant with a capacity to produce one billion pounds of ethylene and 350 million pounds of propylene per year. Ethylene is the principle raw material for the manufacture of polyethylene, ethylbenzene, ethylene dichloride, and ethylene glycol. The type and quantity of products to be produced in derivative plants are listed in Table 1.

To manufacture many of the products, additional chemical reagents, such as benzene, will need to be refined elsewhere in Alaska or imported. In the manufacture of ethylbenzene, 7,800 barrels of benzene per day will be required. Quantities of other chemicals, such as chlorine to manufacture ethylene dichloride, are not currently identified.

The petrochemical complex will provide a foundation for numerous satellite industries. The Fairbanks area is the proposed site of a world scale methanol plant and a styrofoam industry. Other industries include the production of chlorine, benzene, caustic soda, and ammonia urea.

The energy system for the petrochemical complex may include a gas turbine power system fueled with medium BTU gas from coal, or direct burning of coal. Other utility requirements for the facility are given in Table 2.

Table 1. Products Being Studied
(Dow-Shell Progress Report No. 6)

Phase I

PRODUCT	MILLION LBS/YR
Ethylene	1,500
LPG (minimum)	4,800
Ethylbenzene	1,874
Ethylene Glycol	750
Ammonia	950
Polyethylene	400
Urea Prills	1,280
Benzene	1,400
Methanol	4,000
Styrofoam	under study

Phase II

PRODUCT	MILLION LBS/YR
Ethylene	1,500
LPG (balance)	1,500
Caustic Soda Solution	1,150
Ethylene Dichloride	700
Ethylene Glycol	600
Alpha Olefins Light	40
Alpha Olefins (2 grades)	360
Polyethylene	200

Table 2 Estimated Utility Requirements -
Dow-Shell Petrochemical Complex
(Dow-Shell Progress Report No. 4)

Utility	Phase I	Phase II	Total Phase I and II
Steam (lbs/hr)			(30, 50, 150, 179, 200, 350, 475, 900, 1,200 psi)
Low (30-50 psi)	150,000-200,000	250,000	450,000
Inter (150-200 psi)	5,000	240,000	250,000
High (350-900 psi)	230,000		230,000
Other	130,000 at 900 psi	40,000 at 1,200 psi	170,000
TOTAL	565,000	500,000	1,065,000
Power	70 MW	155 MW	225 MW
Condensate (gpm)	10 to 100 (required)	200 (required)	210
Demineralized Water (gpm)	15	300	315
Boiler Feed Water (gpm)	2,750	1,200-1,400	4,000
Cooling Water (gpm)	340,000 recirculation rate make up (estimated) 6,800 - 13,600	160,000 recirculation rate make up (estimated) 3,200 - 6,400	500,000 recirculation rate make up (estimated) 10,000 - 20,000
Potable Water (gpm)	200 60 process	100 250 process	300 300 process
Other Water	15,000 Fire Peak	15,000 Fire	15,000 Peak
Natural Gas (Billion BTU-hr)	3.7	2.1	5.8
Air (SCFM) by each participant	7,500 (plus Shell)	2,000 (plus Shell)	9,500 (plus Shell)
Nitrogen (SCFH)	75,000 100,000 Peak	25,000 60,000 Peak	100,000 160,000 Peak

The petrochemical complex and the gas liquids pipeline would require four years to construct. An average of 2,500 workers would be employed during the construction of the main plant and another 2,500-3,000 workers would be required for pipeline construction. A permanent work force of 700-900 workers would be required for the petrochemical complex and an additional 250 would be needed to operate the liquids pipeline.

SECTION II

FISH AND WILDLIFE RESOURCES AT PROPOSED TIDEWATER PETROCHEMICAL SITES

Resource Identification

Existing fish and wildlife resource data have been assembled for each of the five proposed tidewater sites. The sixth potential site at Fairbanks (Bonanza Creek) was omitted from this evaluation because specific information on the development of this site was not available at the time this report was prepared. It is the Department's understanding that only a portion of the complex could be located at Fairbanks and the remainder would need to be placed at tidewater. It has also been suggested that selection of the Fairbanks site would require that all products be shipped by railroad to a tidewater site (Dow-Shell Progress Reports 1-7).

The resources considered in this section are those which could be impacted by the proposed petrochemical industry, despite their relative distances from the actual project site. Since the marine ecosystem provides a more dynamic environment for the transport of petrochemical pollutants than terrestrial areas, marine resources are given a much broader coverage. In some situations, fish and wildlife survey or harvest data only exists for large units of land which include, but are not specific to a proposed site.

The information provided for each site summarizes the major resource values of the area, as existing information is very limited at several of the proposed sites. Major emphasis has been placed on fishery and marine resources for our review of this industry has indicated that these resources will receive the major impacts. The summarized data for each site has been compared and assigned a numerical value. A rating of the tidewater sites with respect to identified resource values appears at the end of this section in Table 6.

1. Commercial and subsistence fisheries

Upper Cook Inlet Sites (Kenai/Nikiski, Pt. MacKenzie, Fire Island) - Upper Cook Inlet is the dominant salmon production area of Cook Inlet accounting for 78 percent of the total area commercial salmon catch since 1960. Cook Inlet salmon catches average 7.5 percent of the annual Alaska production (1960-1980). Sockeye salmon dominate the commercial harvest with an average annual catch of 1.2 million fish (42%). The average contribution of other salmon species includes: pink 901,047 (52%), chum 607,814 (35%), coho 221,521 (12%), and king 10,754 (1%).

The average catch for all species during 1976-1980 is 4.4 million salmon having an average market value of 20.5 million dollars. Sockeye salmon have an average annual value of 4.4 million dollars, or 56% of the total catch value. The even year average for pink salmon is 1.5 million dollars, and the combined yearly average is 1.3 million dollars. The annual chum salmon value is 1.3 million dollars.

In the Central and North districts of Upper Cook Inlet commercial salmon fishing is presently restricted to drift and set gill net gear only and primarily harvests stocks of salmon bound for river systems north of Anchor Point. Both drift and set gill net gear is allowed at Nikiski, whereas only set net gear is allowed at Pt. MacKenzie and Fire Island.

Although all five species of salmon may be found in Cook Inlet simultaneously, each species has a normal period of occurrence. An early king salmon run can be expected during late May with the peak run occurring in mid-June. Sockeye salmon appear in early June and peak the third week of July. The early run of pink salmon peaks during July 12-17 and the later run peaks during July 26-August 6. Chum salmon run timing varies greatly from year to year; however runs usually peak from July 18-24, and correspond to the peak abundance of coho salmon. The timing of adult and juvenile salmon migrations for Upper Cook Inlet is summarized in Table 3.

A commercial herring set net fishery exists in Upper Cook Inlet and along beaches in the Nikiski area. Annual harvest over the last five years (1975-80) at Nikiski has averaged ten tons with a market value of $3,000.00. In 1979, 190 tons of herring were harvested in Central Cook Inlet by drift and set gillnet fishermen. No commercial shellfishery exists in Upper Cook Inlet waters. A commercial halibut fishery exists at Ninilchik approximately 35 miles south of the Kenai-Nikiski site. A

Table 3. Salmon Run-Timing, Upper Cook Inlet

King Salmon	
Adults	
Enter Freshwater	May 15 - Aug. 10
Actual Spawning	July 20 - Aug. 10
Juveniles	
Outmigration	Out by mid-August
Sockeye Salmon	
Adults	
Enter Freshwater	May 20 - Aug. 15
Actual Spawning	July 15 - Nov. 10
Juveniles	
Outmigration	Out by July 1
Coho Salmon	
Adults	
Enter Freshwater	July 25 - Nov. 10
Actual Spawning	Sept. 10 - Feb. 1
Juveniles	
Outmigration	Out by mid-July
Pink Salmon	
Adults	
Enter Freshwater	June 21-August 15
Actual Spawning	July 10-Sept. 1
Juveniles	
Outmigration	April 15-June 7
Chum Salmon	
Adults	
Enter Freshwater	July 1-Sept. 1
Actual Spawning	August 1-Oct. 1
Juveniles	
Outmigration	April 15-July 7

special subsistence fishing season for salmon occurs at Tyonek in Upper Cook Inlet.

Port Valdez - The Valdez region is an important commercial fishing area in Prince William Sound. The average annual catch for all salmon species in the Eastern District of Prince William Sound (which includes Valdez Arm and Port Valdez) is four million fish (1976-80). The 1980 value for three major species in the commercial catch was $4,860,000 for pink salmon, $678,000 for chum salmon, and $49,000 for red salmon. These figures represent approximately 45 percent of the total commercial harvest value in Prince William Sound. Small numbers of king and coho salmon are also harvested by commercial fishermen each year, but their combined value has not exceeded $10,000 (1976-80).

The herring sac roe fishery is the major herring fishery of Prince William Sound with a major effort of both gillnet and seine in the Northern District and Valdez Arm. An important herring fishery for bait and food exists along the outer shoreline of Valdez Arm. Permits for herring fishing in this area were last issued in 1977 when the annual catch was worth $1,375,000. Herring sac roe and spawn on kelp are also harvested near the mouth of Valdez Arm. A commercial kelp fishery exists on the east side of Valdez Arm and in Galena Bay. The average annual harvest of kelp is 200-250 tons (1976-79) with a commercial value of approximately $200,000.

Tanner crab are the only shellfish species commercially harvested in Valdez Arm. The fishing effort primarily occurs at the mouth of Valdez Arm. Subsistence fishing in Port Valdez is summarized in Table 5.

Seward/Resurrection Bay - The commercial salmon fishery in Resurrection Bay is limited to purse seining for pink and chum salmon. The 1980 pink salmon catch in Resurrection Bay was 156,763 fish valued at $159,657. The 27 year (1954-80) average annual catch for pink salmon is 19,743 fish, and for chum salmon, 1,395 fish. Principal salmon fishing areas in Resurrection Bay are Humpy Cove, Thumb Cove, and the mouth of Fourth of July Creek. Pink and chum salmon enter freshwater systems from Resurrection Bay during mid-July, and peak spawning occurs during the month of August.

A commercial fishery also exists for halibut, herring, and Tanner crab. Subsistence fishing in Resurrection Bay is summarized in Table 4.

2. Sport fishery

Kenai-Nikiski - Large runs of king, coho, and sockeye salmon enter the Kenai River each year. The Kenai River system supports one of the highest levels of sport fishing effort in Alaska. Anglers have expended an average of 159,148 man-days and harvested approximately 7,000 king salmon per year (1977-1980).

Table 4. Subsistence Fishing in Seward-Resurrection Bay (Stratton, 1981)

Resource	Percent Households HARVEST Subsistence Resource 25-49%	50-74%	75% or more	Percent Households USE Subsistence Resource 25-49%	50-74%	75% or more
FISH						
King Salmon				X		
Silver Salmon		X			X	
Red Salmon				X		
Pink Salmon	X					
Black Bass	X			X		
Dolly Varden	X			X		
Halibut				X		
Hooligan	X			X		
Fish Eggs				X		
CRAB						
King Crab				X		
Tanner Crab				X		
SHELLFISH						
Razor Clams	X			X		
Shrimp				X		

Table 5. Subsistence Fishing in Valdez (Stratton, 1981)

Resource	Percent Households HARVEST Subsistence Resource			Percent Households USE Subsistence Resource		
	25-49%	50-74%	75% or more	25-49%	50-74%	75% or more
FISH						
King Salmon					x	
Silver Salmon	x				x	
Red Salmon	x				x	
Chum Salmon	x			x		
Pink Salmon	x					x
Dolly Varden	x			x		
Fish Eggs	No information			x		
Halibut				x		
Lake Trout				x		
Red Snapper				x		
SHELLFISH						
Butter Clams				x		
Razor Clams				x		
Dungeness Clams				x		
King Crab					x	
Tanner Crab				x		
Shrimp					x	

The majority of the recreational king salmon harvest occurs in the mainstem Kenai River, and in saltwater along the lower Kenai Peninsula shoreline.

The Kenai River sockeye salmon runs also support an active sport fishery. The most heavily fished tributary is the Russian River, a clear water tributary of the Kenai River. An average of 50,000 sockeye from both early and late runs are taken from this river annually.

Razor clam beaches south of Kenai provide a heavily utilized sport fishery resource. The razor clam sport harvest from Kenai Peninsula beaches was 771,693 clams in 1980, and has averaged 846,469 annually (1979-1980). The man-day effort for razor clams has consistently increased each year since 1971. The east side Cook Inlet beaches are currently the most heavily used sport shell-fishery in the State.

Land locked salmon (cohos and sockeyes), lake trout, rainbow trout, grayling, and Dolly Varden are common in lakes throughout the area and subject to sportfishing effort. There are several stocked lakes in the Nikiski area including Cabin Lake, Bernice Lake, Island Lake, and Stormy Lake.

Pt. MacKenzie-Fire Island - The Pt. MacKenzie and Fire Island sites currently support the lowest level of sport fishing effort. However, salmon stocks which spawn in Upper Cook Inlet streams migrate along the beaches at these sites. Eulachon (hooligan) spawn in numerous Upper Cook Inlet streams during May and early June and are subject to locally intensive sport fishing effort. Upper Cook Inlet streams also support an active sport fishery for king, coho, and pink salmon. It is probable that salmon stocks bound for the Susitna River, Little Susitna River, Knik River, Fish Creek, Cottonwood Creek, Wasilla Creek, and other important sport fishing drainages in Turnagain and Knik Arm, occur in the Pt. MacKenzie-Fire Island area. Juvenile salmonids from Upper Cook Inlet streams may also occur in the area. Land locked coho salmon, rainbow trout, grayling, burbot, and Dolly Varden are fished in freshwater lakes throughout the Matanuska- Susitna Valley.

Port Valdez - A valuable sport fishery exists in the Valdez area. A creel census taken in 1980 indicated that sport fishermen fished 18,707 days in Port Valdez and caught 11,606 pink salmon, 5,545 coho salmon, 923 chum salmon, 568 sockeye salmon, and 121 king salmon. A sport fishery also exists for marine fish including greenling, halibut, sole, rockfish, and sculpins. King, Tanner, and dungeness crab are harvested by sport fishermen throughout the area.

Seward - The saltwater sport salmon fishery at Seward is one of the largest and most intensively managed sport fishery in the North-Central Gulf of Alaska. In 1980, Bear Lake and the State fish hatchery at Seward contributed an average of 23% of the coho salmon caught by sport fishermen. This hatchery produces over 100,000 coho smolts annually. The Seward Lagoon is also a major production area for smolts. Coho salmon account for about 80% of the seasonal sport salmon catch which averages 16,300 fish per year (1977-80). During 1980, 20,981 coho, 13,292 pink, and 150 king salmon were harvested by sport fishermen in Seward. In addition to salmon, Dolly Varden, halibut, rockfish, ling cod, flounder, hooligan, shrimp, and crab are also harvested.

3. Anadromous streams

Kenai/Nikiski - The Kenai River is located about eight miles south of Nikiski and is the most important anadromous stream in the area. The Kenai River sockeye salmon escapement in 1980 was over 373,000 fish, making it the largest sockeye salmon system in Cook Inlet. No king salmon escapement figures are available for the Kenai River, but substantial numbers of king salmon spawn in the Kenai River drainage. The average size of the late run of king salmon caught in the Kenai River is among the largest in the State. The Kenai River also supports anadromous runs of coho and pink salmon and Dolly Varden.

Bishop Creek, located approximately ten miles to the north of Nikiski, supports a run of sockeye salmon. Swanson River, located 15 miles north of the site, supports runs of both pink and coho salmon. All of the rivers provide important juvenile salmon rearing habitat.

Pt. MacKenzie - No anadromous streams are located directly adjacent to the proposed site. The Susitna and Little Susitna rivers located several miles to the west of Pt. MacKenzie, support five species of salmon as well as Dolly Varden. Fish Creek, an important sockeye and coho salmon stream, is located 12 miles north of the site. Sockeye salmon escapement in Fish Creek during 1980 was 63,000 fish, and coho escapement was 9,000 fish. Adult salmon stocks bound for both of these important spawning systems pass through the Pt. MacKenzie-Fire Island areas. Other anadromous streams in the Knik Arm system include Eagle River, Peters Creek, Cottonwood Creek, Ship Creek, Wasilla Creek and its tributaries, Knik River, and the Matanuska River.

Port Valdez - In Prince William Sound, salmon spawning is extremely widespread and no single stream or system plays a dominant role in salmon production. At least 41 anadromous fish streams have been identified within Port Valdez.

Siwash Creek and Lowe River are the major salmon producing streams in Port Valdez with average odd year escapements of 22,000 and 15,000 pink salmon respectively. The Robe River drainage is also a major producer with annual runs of 5,000 sockeye and 2,500 coho salmon. Major areas of the Robe River system used for spawning include Lower Corbin Creek, Robe Lake, and Brownie Creek.

Other anadromous tributaries to eastern Port Valdez include Crooked Creek (pink and chum salmon spawning), Abercrombie Gulch Creek (chum and coho spawning), Solomon Gulch Creek (intertidal pink spawning), Allison Creek (intertidal pink spawning), and Airport Creek (pink salmon spawning). While no indigenous stocks of king salmon exist in the area, immature king salmon frequent shallow subtidal areas in Port Valdez throughout the summer.

Seward - At least 16 anadromous fish streams have been identified in the northern end of Resurrection Bay. The Resurrection River and its tributaries represent the major area utilized by coho salmon stocks in the Bay. Humpy Creek is an important pink salmon producer and supports 5,000 to 6,000 salmon during even years. Fourth of July Creek supports runs of pink, coho, and chum salmon and is one of the more important spawning streams in Upper Resurrection Bay. Spring Creek supports a small run of pink salmon (500 to 1,000 fish). Most streams in Resurrection Bay support runs of Dolly Varden and eulachon. With the exception of Resurrection River, freshwater habitat available to spawning salmon is limited by small, steep, and generally unproductive watersheds that are drained by very short streams.

Fire Island - No anadromous streams have currently been identified on Fire Island. However, fishery stocks enroute to streams at the head of Turnagain and Knik Arm pass along the shorelines of Fire Island.

4. Other fishes

Kenai/Nikiski - Other finfish occurring in marine waters adjacent to the Nikiski site include prickleback, eulachon, tom cod, bering cisco, greenling, lamprey, Pacific cod, snail fish, sculpin, capelin, and sandlance (Bucher, 1976). Small species of pelagic schooling fish (capelin and sandlance) feed on plankton resources and are known to be important food for marine mammals, fish species, and birds.

Pt. MacKenzie/Fire Island - Resident fish populations in the Pt. MacKenzie-Fire Island region are assumed to be low because of severe environmental conditions and low primary and secondary productivity. Juvenile herring and halibut have been reported in Knik Arm (Jackson, 1970). Demersal fish, including starry flounder, Pacific tom cod, and lemon sole are found in small numbers. Other fish that are present seasonally include Dolly Varden, eulachon, stickleback, and humpback whitefish (Tetra Tech, 1977).

Port Valdez - The outer shorelines of Valdez Arm are a major spawning area for Pacific herring. Demersal fish within Port Valdez include greenling, sole, rockfish, halibut and sculpins. Large numbers of several bottomfish species are present in Port Valdez.

Seward/Resurrection Bay - Marine bottomfish of greatest commercial and sport fishing value in Resurrection Bay include rockfish, sole, and halibut. Other demersal fish present include starry flounder, Pacific tom cod, lemon sole, greenling, and sculpin. Rainbow trout and Dolly Varden populations exist in most streams draining into upper Resurrection Bay and at Bear Lake and other small lakes north of Seward.

5. Marine invertebrates

Kenai/Nikiski - Compared to the Valdez and Seward sites, invertebrate biomass at Nikiski is low. Twenty-six species of marine invertebrates have been identified at Nikiski including gastropod snails, clams, amphipods, crabs, isopods, and starfish (Hood et al., 1969; Jackson, 1978). Mudflats characterize much of the beach habitat at the Nikiski site. The intertidal mud flats support assemblages of polychaetes, clams, and other infaunal invertebrates. Water-borne detritus represents a large percentage of the diet of filter feeding intertidal invertebrates on beaches south of Kenai.

The invertebrate populations serve as an important food source for other marine species. Sea ducks and starry flounder move over the flats during high tide to feed on clams and mussels. Migrating birds rest on the flats and feed on worms, clams, and small meiofaunal organisms. During spring, out-migrating salmon fry forage over the flats for insect larvae and meiofaunal crustaceans. Harbor seals frequent the mudflats at high tide to feed on starry flounder and salmon.

Pt. MacKenzie/Fire Island - The least productive invertebrate habitat occurs at the Pt. MacKenzie and Fire Island sites. Only 11 species of marine invertebrates have currently been identified. Invertebrate populations are limited in diversity and abundance due to the high sedimentation rates, high turbidity, rapid currents, ice scour, and fluctuating salinities.

Port Valdez - Over 70 species of marine invertebrates have been identified in Port Valdez. This site has a high diversity and abundance of invertebrates because of the increased salinities, increased primary productivity, and greater habitat diversity. The rocky, intertidal habitat is characterized by barnacles, mussels, limpets, sea stars, clams, and crabs. Intertidal mudflat habitat is characterized by high populations of polychaetes, clams, and infaunal invertebrates.

The abundant intertidal and subtidal invertebrate populations are of vital significance to other marine life in Port Valdez. They are heavily used by shorebirds and waterfowl. Intertidal shellfish resources are also harvested by local residents (primarily butter clams, littlenecks, and horse clams). Halibut, king and Tanner crab, sea otters, and harbor seals have a diet consisting of a large percentage of infaunal or epifaunal invertebrates.

Seward/Resurrection Bay - Resurrection Bay also has a high diversity of intertidal and subtidal habitats, and contains a wide diversity and abundance of marine invertebrates. Marine invertebrates present in the highest density include: nine families and over 50 species of Annelidae; two families and 20 species of Mollusca; five families and 15 species of Arthropoda; and six species of Echinodermata (Feder et al., 1979).

Sizable mussel beds are located at the head of Resurrection Bay. The flats also contain high densities of the small clam, Macoma balthica. Clams and mussels provide critical food for wintering seabird and waterfowl populations, fish species, and sea otters.

The rich supply of amphipods, euphausiids, larval crustaceans, and forage fish in Resurrection Bay provide a rich food supply for whales and other marine mammals, salmon, and birds. High concentrations of pelagic invertebrates often determine the distribution of feeding fish, birds, and mammals within Resurrection Bay.

6. Marine mammals

Kenai/Nikiski - Harbor seals, belukha whales, killer whales, harbor porpoise, sea lions, and rarely walrus, occur in the Kenai-Nikiski area. Harbor seals and belukha whales are the most abundant marine mammals in Upper Cook Inlet (Calkins, 1980).

From May through September, harbor seals occur in highest numbers in Upper Cook Inlet and frequently enter the Kenai and other river systems. Seal movements into Upper Cook Inlet coincide with movements of anadromous prey species of fish such as eulachon and salmon (Calkins, 1980). Timing of key life history events for harbor seals in Cook Inlet are as follows: pupping - May 25 to June 25; nursing - May 25 to July 15; breeding - June 15 to July 20; molting - late June to early October.

The Cook Inlet belukha whale population has been estimated at 300 to 400 (Calkins, 1980). Sighting data from 1976-1979 confirm that belukhas are present during all seasons (Calkins, 1980). There is little information currently available on the seasonal use of specific habitats in Cook Inlet. Large river estuaries in the northwest Inlet are the primary concentration areas. The preferred food of the belukha in Cook Inlet during the summer appears to be osmerids and salmonids (Calkins, 1980).

Pt. MacKenzie and Fire Island - Belukha whales, harbor seals, and rarely, northern sea lions are recorded in the region. Beluga whale concentrations are found near the mouth of the Susitna River and throughout Knik Arm during July and early August. Use of the Pt. MacKenzie and Fire Island areas by other marine mammals is very limited.

Port Valdez - Marine mammals known to occur in the area include harbor seals, sea otters, harbor porpoise, killer whales, humpback whales, and minke whales. Harbor seals are the most abundant marine mammal in Port Valdez, and haul out areas (offshore rocks, sandbars, and beaches) exist throughout the Port. Harbor seals are widely distributed in Port Valdez and no specific concentration sites have been identified (Pitcher and Calkins, 1979). Harbor seals normally occupy areas in close proximity to the coast where they feed on herring, cod, flounder, smelt, rockfish, sculpin, and salmon.

Sea otters occur throughout Port Valdez and occupy near shore areas with reefs and rocky shoals. Their diet consists of bottom dwelling invertebrates and fish. Peak breeding and pupping occurs during spring, but can occur throughout the year. Sea otters are not migratory and major activities such as feeding, resting, breeding, and pupping all occur within the same general area (Calkins, 1980).

Harbor porpoise, humpback whales, killer whales, and minke whales range throughout Prince William Sound and frequently enter Valdez Arm in search of food.

Harbor porpoise usually occupy shallow areas where they feed on small fish (Calkins, 1980) and are easily disturbed by boat traffic. Humpback, minke, and killer whales are migratory and are present in Prince William Sound from April to December.

Current and proposed petrochemical developments in Port Valdez will require an increased knowledge of the ecology, distribution, and abundance of marine mammals.

Seward - Marine mammals occurring in Resurrection Bay include harbor seals, sea lions, sea otters, Dall and harbor porpoise, and humpback, grey, minke, killer, and fin whales.

Haul out and intensively used habitats for harbor seals in Resurrection Bay occur at Bear Glacier (70 animals, August 1976), Cheval Island (200 animals, August 1976), and at Pony Cove (40 animals, August 1976) (Pitcher and Calkins, 1979). Major prey of harbor seals in Resurrection Bay are walleye pollock, octopus, capelin, herring, and Pacific cod (Pitcher and Calkins, 1979).

Sea lion haul out sites exist at Rugged Island where 215 animals were censused in March 1976, Seal Rocks haul out (630 animals in March 1976), and Chiswell Islands (over 4,000 animals in March 1976) (Calkins and Pitcher, 1981). These haul out sites receive maximum use during the winter. Sea lions feed primarily on pollock and cephalopods (Calkins and Pitcher, 1981).

Sea otters are very common in areas around the Seward boat harbor and at the mouth of Fourth of July Creek. Sea otters remain in these areas throughout the year and do not migrate unless food becomes scarce.

Baleen whale species which occur in Resurrection Bay are usually solitary, but congregations may occur in areas of abundant food. These whales feed primarily on small, schooling fish (cod, pollock, capelin) and crustaceans, and may approach close to shore while feeding.

7. Terrestrial mammals

Kenai/Nikiski - The primary big game animals in the Kenai area are caribou, moose, brown bear, and black bear. The Kenai lowlands caribou herd numbers between 65-80 animals and was established from transplanting conducted in 1965. The calving grounds of this herd border the east side of the Wildwood site. The caribou winter east of the Salamatof Lakes region. Because this herd is accessible from the road system it is a local tourist attraction and is used for viewing and photography. In 1981, the Board of Game authorized a limited permit hunt for up to five animals.

Moose populations are high in areas adjacent to the site and a small number reside in the North Kenai area throughout the year. Winter concentrations occur around Daniels Lake and Bishop Creek. The annual sport hunting harvest of moose in Unit 15A (Kenai area) averages 176 animals (1978-81). The moose population in Unit 15A is currently estimated at 3,000 animals. Nonconsumptive use is also high and many tourists actively seek moose during the summer months.

Black bears and brown bears are widely distributed throughout the Kenai area. Black bears are relatively common and hunting is very popular in the Kenai area. The annual hunter harvest averages 25 bears in Unit 15A (1978-1980). Black bears are also available for viewing and photography during spring and late fall. Increases in human population and accompanying urban sprawl have resulted in bear-human conflicts and an increase in the number of "defense of life and property" killings.

Other mammals present in the Kenai area include wolves, land otter, beaver, mink, coyotes, marten, wolverine, lynx, muskrat, hare, and pocupine.

Pt. MacKenzie/Fire Island - Mammals most abundant in the Pt. MacKenzie area include mink, weasel, muskrat, beaver, land otter, marten, moose, black bear, lynx, hare, red fox, coyote, porcupine, wolf, and wolverine.

Winter concentrations of moose exist throughout the Pt. MacKenzie area and important calving areas exist to the west along the Little Susitna River. The annual sport hunting kill of moose in Unit 14A (including Pt. MacKenzie) averages 334 animals (1978-1981).

There are abundant beaver and land otter populations in the area. These species are of substantial economic value to area fur trappers. Clear-cut logging and construction of transportation and utility corridors have had detrimental effects on furbearers north of the proposed site.

A total of 18 moose were censused on Fire Island in 1980 (FAA, pers. comm.). In 1909, an Executive Order by the U.S. Government, declared the Island a reserve and breeding ground for moose. The moose reserve status was withdrawn in 1921 when the Island became a military reservation.

Other mammals present on Fire Island include mink, weasel, muskrat, land otter, and beaver.

Port Valdez - The vicinity of Valdez Arm and Port Valdez provides some of the best black bear habitat in the State. Beach fringes and tidal meadows are heavily used by black bears during spring and summer. Freshwater streams which support large runs of salmon are also heavily used by black bears during the summer. The annual hunter harvest of black bears in Unit 6D (including Port Valdez) averages 73 animals (1978-1980). Brown bears also range throughout the Valdez area and utilize coastal habitats during salmon runs.

Sitka black-tailed deer and mountain goats often winter along the beach during periods of heavy snowfall. A small population of mountain goats occupy the lower 25 miles of the Lowe River Valley.

Other locally abundant mammals occurring in the Port Valdez area include coyotes, marten, mink, land otter, and weasel. Beaches and intertidal zones are key habitat areas for many of these species.

Seward - Moose are distributed throughout the Resurrection Bay area, but populations are low compared to other areas of the Kenai Peninsula. A winter concentration area for moose extends north from the City of Seward to Bear Lake and east across the Fourth of July Creek. The annual hunter harvest of moose in Unit 7 (including the Seward area) averages 45 animals (1978-1981).

Black bears are abundant throughout Resurrection Bay and most river drainages provide excellent black bear habitat. The 1978-1980 harvest of black bears in Unit 7 has averaged 78 animals. Brown bears also frequent coastal habitat near the mouth of Resurrection Bay during the summer salmon runs. Mountain goats are distributed along the east slopes of the Harding Ice Field and utilize coastal areas during winter and areas above Fourth of July Creek in summer. Other mammals in the Seward area include mink, weasel, beaver, land otter, lynx, coyote, and hare.

8. Birds

Kenai/Nikiski - Important bird habitat in the area includes tidal flats, and freshwater lakes, streams, and marshes. Bird populations are at their highest densities during spring migratory periods (mid-April through mid-May) when many species are in the Kenai area for resting and feeding. The most important areas include the tidal marshes at the mouth of the Kenai River. Migratory waterfowl present in highest numbers include mallards, pintails, widgeon, snow geese, and Canada geese. Sandhill cranes remain to nest on the Kenai marshes and the wetlands adjacent to the site. Lyngbyaei sedge and arrow grass are a primary food of waterfowl on the Kenai flats.

Other waterfowl habitats occur adjacent to the Kenai site and include lakes and ponds used by trumpeter swans, scaup, goldeneye, pintail, and mallards. Several raptorial species (hawks, owls, eagles, and falcons) are present in the area. Bald eagles inhabit areas adjacent to the Kenai and Swanson Rivers. One hundred forty-six species of birds have been recorded within the Kenai National Wildlife Refuge which adjoins the Kenai Site (USFWS, 1968).

Pt. MacKenzie/Fire Island - Important bird habitats in the Pt. MacKenzie area include tidal flats at the Goose Bay and Susitna River State game refuges, and freshwater lakes, ponds, and rivers. Coastal waterfowl nesting areas within the Goose Bay and Susitna Refuges average 75 breeding birds per square mile, and inland areas at Pt. MacKenzie average 15 birds per square mile. Waterfowl species nesting in highest numbers include Canada geese, pintails, mallards, and green-winged teal.

The Susitna Flats State Game Refuge to the west of the site is one of the most important waterfowl staging and breeding areas in the Cook Inlet Basin. Estimated spring and fall waterfowl use of the Susitna Refuge exceeds 150,000 ducks, 50,000 geese, and 10,000 swans annually. Numbers of waterfowl nesting on the flats exceed 6,000 annually, including ducks, geese, and trumpeter swans. An average of 14 percent of the annual waterfowl harvest in Alaska occurs on the Susitna Flats making it the number one harvest area in the State.

Shorebirds which are most common and nest in the Pt. MacKenzie area include least sandpipers, greater and lesser yellowlegs, and semi-palmated plovers.

Intertidal areas on the south end of Fire Island and upland ponds are used by shorebirds and waterfowl during the spring and fall migrations. Upland ponds are frequently used for nesting by trumpeter swans and other waterfowl (FAA, pers. comm.). No information exists on other bird populations resident during the summer.

Port Valdez - Port Valdez provides important habitat for large concentrations of non-breeding waterfowl and shorebirds which utilize intertidal habitats throughout the year and are dependent upon ice-free waters during winter months. Approximately 70 species overwinter in this region including mallard; greater scaup; common and Barrow's goldeneye; bufflehead; oldsquaw;

harlequin; white-wing, surf, and common scoter; common and red-breasted mergansers; and Canada geese. During winter, large numbers of shorebirds including rock sandpipers, dunlin, surfbird, black turnstone, and black oystercatchers are found along the rocky shores and intertidal zone. The most important bird habitat in Port Valdez includes the Island Flats area on the northeast end of the Port (Hogan and Colgate, 1980). This area is the largest salt marsh in Valdez Arm and one of the largest coastal marshes in Prince William Sound (Hogan and Colgate, 1980).

Shoup Bay on the northwest end of Port Valdez provides important habitat to resident birds and contains the fourth largest black-legged kittiwake colony in Prince William Sound (Hogan and Colgate, 1980). Thirteen bald eagle nests exist in Port Valdez and most salmon streams receive intensive use by bald eagles during the summer and fall. There are a total of four Arctic tern colonies and one glaucous-wing gull colony in Port Valdez.

Seward - Major seabird colonies in Resurrection Bay exist at Barwell Island, Cape Resurrection, and the Chiswell Islands. Nesting species include common and thick-billed murres; pigeon guillemots; horned and tufted puffins; double crested, pelagic, and red faced cormorants; fork-tailed storm petrels; ancient, marbled, and Kittlitz's murrelets; and parakeet auklets. The average number of seabirds on the Chiswell Islands is 63,000 birds, including over 30,000 breeding pairs, and on Resurrection

Bay Islands, 24,000 birds, including 10,000 breeding pairs (Bailey, 1976). A black-legged kittiwake colony along Cape Resurrection accomodates 25,000 birds annually.

In addition to its importance to seabirds, Resurrection Bay also winters a substantial number of waterfowl including, scoters, mergansers, harlequin, oldsquaw, common and Barrow's goldeneye, and bufflehead. No intensive winter population surveys have been made. Due to a lack of broad tidal flats and deltas, Resurrection Bay does not receive the heavy use by migrating waterfowl and shorebirds which is common to the Upper Cook Inlet sites.

9. Primary productivity

Kenai/Nikiski - Although no quantitative data exists on primary productivity at the Nikiski site, productivity is relatively low compared to the Seward or Valdez sites. A valuable salt marsh ecosystem exists along the Kenai River flats eight miles south of the site. The Institute of Marine Science, University of Alaska (Hood et al., 1968; Rosenburg et al., 1969) has documented 65 species of zooplankton and arthropods, and 34 species of diatoms at Nikiski. Important members of this group include jellyfishes, ctenophores, pelagic molluscs, polychaetes, copepods and other crustaceans, echinoderm larvae, and fish larvae.

Zooplankton graze on phytoplankton and enriched detritus. These animals provide the first link in the marine food web and are a source of food to higher trophic levels. Zooplankton also provide an important food source to fish, birds, and benthic animals.

Pt. MacKenzie/Fire Island - There have been no measurements of primary productivity in Knik Arm; however biological activity in this ecosystem is very low compared to the other proposed sites. The glacially-derived sediments introduced into Knik Arm and adjacent waters severely restrict light penetration and limit the photic zone and photosynthesis to a very narrow surface layer. Jackson (1970) identified only ten taxa of diatoms during a summer survey of Knik Arm which indicates a very low diversity. An annual growth of the green alga, Vaucheria on tidal flats contributes some primary productivity to the upper Inlet. Other macrophyte populations can be expected to be small or nonexistent due to the absence of suitable attachment substrate, low salinity, and winter ice stress on the shallow environment.

Documented zooplankton diversity and abundance are equally low. Jackson (1970) surveyed Knik Arm and found cladocerans, copepods, protozoa, and rotifers to be the dominate species of zooplankton.

Coastal marshes near the sites, including Susitna Flats, Goose Bay, Eagle River Flats, and the Pt. Campbell-Pt. Woronzof area, contribute substantially to the primary production. Mud-dwelling invertebrates on these tidal flats are an important food source for migrating waterfowl and shorebirds.

Port Valdez - The annual net spring primary productivity reported in Valdez Arm (200g C/m^2 year, which is the rate of carbon uptake in grams/$meter^2$) and Port Valdez (150g C/m^2 year) is slightly higher than other inshore waters of similar latitude (Hood et al., 1973). Dinoflagellates (_Ceratium_, _Peridinium_, and _Gonyaulax_ sp.) are the most abundant phytoplankton in Port Valdez. The introduction of silt-laden freshwater tends to suppress phytoplankton growth during mid-summer.

Over 30 genera of zooplankton have been identified in Valdez Arm with calanoid copepods the dominant species (Hood et al., 1973). All shellfish within Port Valdez are planktonic during their early life history stage. The king and dungeness crabs, butter and littleneck clams, shrimp, and scallops all release larvae in the shallow nearshore waters of Port Valdez. These larvae are concentrated near the surface for up to three months where they feed on phytoplankton.

Eelgrass and kelp are abundant and important marine macrophytes in Port Valdez, and form a distinct subtidal zone in bay and inlets along Valdez Arm. They provide a valuable nursery area for juvenile salmonids and many species of invertebrates, such as crabs and shrimp, afford egg depositing substrate for spawning herring, and supply food for grazing invertebrate species which are in turn eaten by waterfowl, fish, and marine mammals.

Seward - Annual spring net primary productivity at two sites in Resurrection Bay varied between 228 and 285g C/m^2 (Heggie et al., 1975). Phytoplankton and zooplankton levels are very high compared to other systems along the outer Kenai Peninsula Coast (Paul, pers. comm.), but survey data on individual species and their abundance is not currently available. The ambient phytoplankton blooms deplete dissolved nutrients within the euphotic zone during the summer.

The relatively clear waters of Resurrection Bay allow for a high level of photosynthetic growth which results in enhanced biological productivity at all trophic levels. Kelp and eel grass are abundant in Resurrection Bay and reach peak biomass during spring and early summer. The high level of productivity supports the abundant marine mammal and seabird populations which exist in Resurrection Bay.

10. Ocean mixing and circulation

Kenai/Nikiski - The oceanography of the Kenai/Nikiski area has been studied by various investigators, primarily in relation to the Collier Chemical plant effluent. Dames and Moore's (1976) Environmental Impact Statement for the Collier plant addition is the most recent summary of the available data. The EIS concludes that due to the relatively strong tidal currents and mixing in the Kenai/Nikiski area, the Collier effluent will be rapidly mixed and dispersed. Average maximum tidal currents are two to four knots, and the minimum estimated current speed for an average tidal cycle is 0.5 knots. Tidal mixing in this area is sufficient to prevent all but minor vertical stratification of the water column.

Very limited drougue studies by the University of Alaska (Rosenberg et al., 1967) provided inconclusive evidence on the net circulation. One set of drougues was carried in an onshore direction, whereas a drogue from another set was carried offshore. Local salmon drift-net fishermen have observed little or no net surface circulation (movement of surface waters out of the area) except during periods of relatively large tidal ranges (spring tides) (Burbank, 1977). This suggests that there is a potential for accumulation of pollutants in the area, particularly during periods of neap tides and low freshwater runoff.

Past research efforts in the Kenai/Nikiski area have largely addressed the subject of mixing and dispersion of effluents in the vicinity of the discharge, although long-term accumulation of various components of the Collier effluent such as ammonia, nitrite, and nitrate, have also been studied. No buildup or adverse effects from the Collier effluent have been observed; however the effluent components studied are relatively quickly assimilated or absorbed into the natural system. Potential long-term accumulation of refractory or conservative pollutants (pollutants such as phenols and heavy metals which persist in their toxic state for relatively long periods), is as yet, an unanswered question.

The potential for synergistic effects (a biophysical effect, resulting from the interaction of two or more pollutants, which is greater than the sum of effects of each pollutant working separately) will be greatly increased by the presence of petrochemical effluents in the area. Synergistic effects are highly complex and little understood, but are known to occur with combinations of various effluent properties and constituents such as temperature, salinity, pH, carbon dioxide, organics, hydrocarbons, heavy metals, etc.. Other major industries or municipal sources contributing to the potential cumulative pollution and which may be sources for synergistic pollutants are:

A. Standard Refinery and Chugach Power Plant;
B. Tesoro Refinery;
C. Phillips-Marathon Liquification Facility;
D. Collier Chemical Plant; and
E. Kenai and Soldotna sewage disposal.

What little is known of the circulation in the area also suggests that Kenai area pollutants may be carried south past the Clam

Gulch clam fishery (Burbank, 1977). In this case, relatively small concentrations of heavy metals, hydrocarbons, and other pollutants might present a significant problem due to the tendency of shellfish to bioaccumulate toxic pollutants from exceptionally low concentrations in their environment.

In summary, the strong tidal mixing and consequent rapid dilution and dispersion of effluents discharged into nearshore marine waters of the Kenai/Nikiski area will substantially reduce the potential for adverse effects on the local marine resources. However, due to the lack of information concerning the net circulation and flushing of the receiving waters, there is a significant, but unknown potential for adverse cumulative environmental effects in the Kenai/Nikiski and Clam Gulch area. Synergistic effects from diverse industrial and municipal effluents are also a possibility.

Pt. MacKenzie and Fire Island - The oceanography of the Knik Arm region has been studied by Murphy et al. (1972), Britch (1976), Tetra Tech (1977), and others. These studies were mostly directed towards the Pt. Woronzof sewage treatment plant effects, however much of this information is thought to be applicable to Pt. MacKenzie and Fire Island.

Tidal currents are very strong in the Pt. MacKenzie/Pt. Woronzof region, having normal maximums of three to four knots. Although mixing is intense, some stratification of freshwater from Knik

Arm over the more saline Cook Inlet water has been observed. Nearshore eddies have been observed on either side of Pt. Woronzof and ice movements indicate similar eddies develop on both sides of Pt. MacKenzie (Britch, 1976). These eddies would contribute to retention and possible onshore transport of pollutants. Studies in the area however, generally indicate that mixing and dispersion due to tidal currents are highly efficient, and high concentrations of pollutants should be rapidly diluted.

Net transport (flushing of pollutants out of the Knik Arm area) is highly dependent on seasonal river flow. Murphy et al. (1972) have calculated that the net transport velocity in the area varies from near zero in March to approximately one mile per day in July. As a result of the low winter river discharge, the reduction in flushing will encourage a buildup of pollutants in the region during winter.

There is a potential for significant synergistic effects between the Anchorage sewage effluent and petrochemical effluent. For example, phenols (characteristic of refinery wastes) in the presence of residual chlorine (from sewage effluents) may produce lethal or sublethal compounds (McKee and Wolf, 1963).

Suspended sediment concentrations in the area are quite high, ranging from a few hundred to over 2,000 mg/l.

In summary, initial mixing and dispersion of pollutants should be highly efficient due to the strong tidal currents. However, flushing of conservative pollutants from the area may be a problem during the winter period of low river runoff. Synergistic effects with the Pt. Woronzof sewage effluent could be a significant problem.

Port Valdez - Tidal currents in Port Valdez are quite weak. Even in Valdez Narrows, where currents can be expected to be significantly greater than within Port Valdez, the maximum tidal currents are only 0.4 knots (Muench and Nebert, 1973).

Muench and Nebert concluded that estuarine circulation in Port Valdez, even during periods of maximum runoff, was confined to the upper 20 meters or less of the water column. Water movements at deeper depths were apparently responding primarily to wind and tidal currents.

Current meter measurements in Valdez Narrows in December indicated near-surface and deep outflows with mid-depth inflow. Measurements in March showed a deep water inflow and surface outflow. Mean current speeds were about two to three centimeters per second (.04 to .06 knots). From this data the residence time for Port Valdez water was calculated to be 40 days (excluding tidal flushing action). Prevailing easterly winds probably enhanced the flushing rate during the measurement periods.

Subsurface drougue studies within Port Valdez (Nebert and Muench, 1973) suggested an irregular circulation in the absence of winds. During periods of winds, the surface currents move generally in the direction of the wind. Estuarine circulation generated by freshwater runoff was confined to the upper ten to 15 meters of the water column.

A subsurface circulation pattern was inferred by Sharma and Burbank (1973) based on suspended load distribution. Burbank (1974) suggested a surface circulation pattern for Port Valdez based on ERTS imagery and hydrographic data indicating eastward transport along the southern shore and westward transport (outflow) along the northern shore. An eddy was noted in the eastern part of the bay.

Dye dispersion studies (Nebert et al., 1973) indicated an average tenfold dilution distance of 0.46 nautical miles. There is also a strong possibility of synergistic effects between the petrochemical effluent and the existing ballast water treatment effluent and Valdez sewage effluent.

In general, the available data suggests a moderate flushing rate for Port Valdez. The weak tidal currents will greatly inhibit mixing and dilution of pollutants within the bay.

Seward - Resurrection Bay is a fjord estuary that is approximately 30 kilometers long, six to eight kilometers wide, and oriented in a north-south direction. An inner basin, 290 meters deep, is separated from the outer reaches of the fjord by a 185 meter sill. Outer Resurrection Bay opens directly onto the Gulf of Alaska. Longitudinal and cross-channel bathymetry profiles have been described by Heggie et al. (1975).

Tidal currents are weak within Resurrection Bay, and turnover exchange of water with the Gulf of Alaska occurs only once each year. Due to weak and variable west winds over the adjacent continental shelf, winds in Resurrection Bay are predominantly southerly.

The water column of Resurrection Bay is stratified during the summer months because of the addition of freshwater from adjacent watersheds and glaciers and moderate surface warming. Fresh water is added to the outer reaches of the fjord from Bear Glacier and at the head of the Bay from the Resurrection River and smaller creeks. With decreased freshwater runoff, the water column approaches homogeneous conditions during the winter months, but surface waters probably still flow seaward due to northerly winds during this period.

Dispersion coefficients are estimated to average eight to 13 square feet per second. Dye studies indicate that a shear line develops about 1,500 feet offshore during calm weather. At flood tide, tidal currents between the shoreline and the shear line are northward, and tidal currents west of the shearline are southward (Heggie et al., 1975).

The available information suggests a moderate rate of flushing for Resurrection Bay and weak rates of dispersal and dilution for any pollutants within the Bay.

11. Recreation/aesthetics

Kenai/Nikiski - The shoreline at Nikiski is already industrialized and additional construction within the industrial zone would have little direct impact on recreational activities or aesthetics. If the shore facility were located inland, impacts to recreation and aesthetics would be greater, especially if the facility bordered a recreational or sport fishing lake. Camping and sport fishing are popular on nearly all of the small lakes in the region. The Kenai River and its tributaries support the largest freshwater sport fishery in Alaska. Anglers spend over 200,000 man-days/year in pursuit of salmon, trout, and char.

Captain Cook State Park is located to the north of the area near Swanson River and there are camping facilities available at Bernice Lake. The Kenai National Wildlife Refuge adjoins the site to the east and is intensively used for canoeing, camping, fishing, and hunting.

Pt. MacKenzie/Fire Island - Moderate hunting and trapping effort occurs at Pt. MacKenzie. The Susitna River Flats, located eight miles to the west, is the most intensively used duck hunting area in the State. There is very little sport fishing activity near Pt. MacKenzie; however there is considerable effort along the Little Susitna River five miles west of the site.

Present land usage of the area includes set net cabins located along the Bluff, utility line crossings, a submarine cable landing site to the west, a barge landing site to the west, and extensive agricultural development to the north. None of these facilities are highly visible from the Anchorage side of Knik Arm.

In 1971, the Federal Aviation Adminstration took over operation of Fire Island from the U.S. Air Force. Until November of 1980, there were approximately 14 families permanently residing on the island. At the current time the island has no permanent residents and is occupied only during the commercial fishing season. Little recreational use is currently made of Fire Island; however the island is visible from many parts of Anchorage and is an aesthetic resource for an undeterminable numbers of residents and tourists.

Port Valdez - Several areas in Valdez Arm have already been identified by the Division of State Parks on the basis of their recreation, scenic, wilderness, and heritage values. Galena Bay offers goo recreational opportunities. The Forest Service recognizes three anchorages in the bay and has built two recreational cabins on the shore. One archeological site is known at the mouth of Indian Creek. Sawmill Bay also provides an important area for recreation including boating and sport fishing for salmon, crab, clams, and halibut. The Forest Service maintains a public use cabin in Sawmill Bay. Shoup Bay is located in close proximity to Valdez and offers excellent recreation opportunities for hiking, fishing, and wildlife viewing (Meiners, 1977).

Seward - Seward has a city campground and a small boat harbor which receive intensive recreational use. The State of Alaska operates the 5,961 acre Caines Head Recreation Area along outer Resurrection Bay. Sport fishing constitutes an important recreational activity and tourist attractions in the Seward area contribute substantially to the economy of the area.

Table 6. Comparative Rating of Sites with Respect to Resource Values

Resources	Kenai	Point MacKenzie	Fire Island	Valdez	Seward
Fisheries - commercial and subsistence	5	2	2	4	4
Sport fish and Other Fish	3	1	1	6	6
Marine invertebrates	2	1	1	4	5
Marine mammals	3	2	2	5	5
Terrestrial mammals	4	5	1	2	2
Birds	1	3	2	5	4
Anadromous streams	3	1	1	5	4
Primary Productivity	2	1	1	4	5
Circulation and Mixing 1/	3	2	2	4	4
Recreation/aesthetics	3	2	1	5	4
TOTALS	31	20	14	44	43

1 - area of least biological importance
6 - area of greatest biological importance

1/ 1 - well mixed
6 - poorly mixed waters with good circulation

SECTION III

POTENTIAL IMPACTS OF THE DOW-SHELL PROPOSAL ON FISH AND WILDLIFE RESOURCES

Sources of Information on Petrochemical Industries

To accurately predict the potential biological impacts of a petrochemical industry, specific information on the identity, quantity, and concentration of compounds likely to be discharged or emitted into the environment is required. In addition, specific information is needed on pollution control and environmental protection measures which are planned for the facility. For example, to assess the potential impact of handling or landfilling waste chemical compounds, it is essential to know the identity and quantity of the compounds as well as a description of what precautions will be taken to prevent their escape or leakage into nearby rivers and streams. The Dow-Shell Group progress reports have not provided sufficient quantitative data on predicted effluents and emissions from the proposed petrochemical complex for use in reviewing and assessing impacts on fish and wildlife populations.

Several of the chemicals which have been identified as products or feedstocks for the petrochemical industry are highly toxic and have variable physical and chemical properties. To fully assess the consequences of their release into the environment, data is needed on their toxicity, bioaccumulation, biodegradability, and behavior under differing physical conditions. Evaluation of potential impacts is further limited by the lack of existing information concerning the biological effects of petrochemical effluents. The occurrence of emissions and discharges of hazardous materials from petrochemical manufacture has been well documented (EPA, 1980 and 1981), but little information exists on specific biological effects resulting from chronic discharges or accidental release of toxic petrochemicals.

The information on petrochemical wastes and by-products included in this report has been obtained from a review of the literature on the operation of facilities similar to those proposed for Alaska. Additional information has been provided through correspondence with State and Federal environmental protection agencies which have previously monitored petrochemical plants, and chemical engineers specialized in petrochemical manufacturing. Although some of this information is incomplete, it does provide a background upon which major potential project impacts can be assessed.

Effluents, Emissions, and Wastes From a Petrochemical Plant

During the operation of a petrochemical plant, environmental contaminants can be introduced into the environment from the following major sources:

1. discharged cooling and waste water;
2. air emissions;
3. leaks from product holding tanks, pipelines, cooling towers;
4. spills associated with product transfer; and
5. landfill waste disposal.

The direct release of petrochemicals from production plants is difficult to evaluate because manufactured compounds are normally not monitored in plant effluents. Murray and Riley (1973) have estimated that an average of 1.5 percent of the products manufactured at petrochemical plants are lost to the environment. In addition to the products manufactured, chemical compounds used as feedstocks, reagents, catalysts, detergents, solvents, and manufacturing wastes and by-products, constitute a major source of effluents.

The chlorination of ethylene to produce ethylene dichloride (EDC) requires the use of metallic chlorides as catalysts. Contingent upon the quality of the ethylene feedstock, the production yields of EDC will generate four to six percent waste (Stanford Research Institute, 1979). The operation of a petrochemical plant also requires the use of large volumes of cleaning solvents such as phenol, glycols, amines, and sulfolane which must be disposed of (Tucker et al., 1975). Other solid wastes include large volumes of caustic material such as sodium and aluminum hydroxide, sodium sulfide, and calcium carbonate.

Within the cooling towers, chemicals are frequently transferred into the recirculating water and eventually discharged into the environment (Taback et al., 1978). This chemical transfer results from leaks in valves, flanges, pumps, and compressor seals which have a ten to 50 percent frequency of leakage (EPA, 1980c). A variety of chemicals are used in cooling towers for corrosion and algae control. The use of these chemicals often constitutes a source of highly toxic pollutants such as phenol, chromium, and copper. Water passing through pumps, demineralization units, and cooling towers, will undergo a temperature gain of up to 20°F (Tucker et al., 1975).

Large volumes of hydrocarbon gases are by-products in the manufacture of petrochemicals. The preferred method of disposing of non-recoverable waste gases is to burn them in a flare (Taback et al., 1978). Proposed plans for waste disposal at the Dow-Shell complex indicate that most or all waste gases and liquids will be incinerated (Bill Anderson, Dow-Shell Group, pers. comm.). Flaring directly releases quantities of carbon monoxide, sulfur dioxide, and nitrogen oxide into the atmosphere. Predicted emissions from the Dow-Shell central complex are given in Table 7. In addition to normal operating emissions, emergencies at petrochemical plants frequently require the sudden venting or release of excessive amounts of chemical products due to compressor failures, overpressure in process vessels, line breaks, leaks, and power failures (Jones, 1973).

The annual quantity of petrochemicals discharged from domestic transport is unknown. Losses occur almost inevitably from loading, transfer operations, and accidents. During 1970, 80 tons of ethylene dichloride and 241 tons of benzene were spilled from ocean tankers (Hann, 1975). Cleaning of chemical tanks after off-loading of bulk chemicals involves removal of cargo residues with caustic detergents. This creates large quantities of waste mixtures which must be disposed of.

Toxicity of Petrochemical Products and Wastes to Animals and Plants

Table 7. Predicted Air Emissions From the Dow-Shell Central Petrochemical Complex.[1/]

Compound	Phase I (tons/yr)	Phase II (tons/yr)	Total
NO_x	3000-3600	2700-3100	5700-6700
CO	370-430	490-570	860-1000
HC	1000-1200	370-430	1400-1600
TSP	370-430	160-190	430-520
SO_2	0-1	0-4	0-5

1/ Preliminary estimates from Bill Anderson, Dow-Shell Group, June 8, 1981

Hydrocarbons such as ethane, propane, and butane have low partial pressures, low boiling points, are insoluble in water, and evaporate quickly in natural air. Because of their physical properties, these compounds do not normally present a toxic hazard to fish and wildlife. Straight chain hydrocarbons, aromatics, and products such as polyethylene, ethylene dichloride, and ethylene glycol evaporate slowly and are water soluble. These compounds dissipate slowly, have accumulation tendencies, and are highly toxic at low concentrations to plants and animals (Dowden and Bennett, 1965).

Effluents from petrochemical plants are often complex chemical mixtures with continually changing chemical compositions. Hatch and Mata (1981) identified over 50 different chemical compounds associated with the manufacture of ethylene products. Assessment of the biological impacts of these various parameters is complicated by the lack of adequate historical information on acute and chronic impacts on local species, and the total lack of information on the combined effects (additive, synergistic, or antagonistic) of all of these factors combined.

Hydrocarbons such as benzene, ethylbenzene, and ethylene dichloride are highly toxic to aquatic life at very low concentrations (EPA, 1980a), and any direct exposure can be expected to have adverse effects. These chemicals are very persistent in the environment and have a high potential for sublethal effects at low concentrations. For example, the half life of ethylene dichloride in water is estimated to be on the order of several thousand years (EPA, 1980b).

Aromatic hydrocarbons have proven to bioaccumulate and concentrate in marine animals (Jungclaus, 1978). Marine mammals are high trophic level consumers and may be directly and severely affected by ingestion of toxic compounds passed along the food chain. Indirect effects include behavior alterations, decreased vitality, or mortality resulting from petrochemical related mortality of prey items or destruction of habitat.

Partitioning of aromatic hydrocarbons across the skin and gills of fish is responsible for the tainting of fish flesh in waters containing low aromatic concentrations. Investigations of unpalatable fish from the lower Mississippi River have been correlated with discharges of aromatic compounds in the area (EPA, 1972).

The breakdown of hydrocarbons through evaporation, chemical hydrolysis, and biological degradation occurs slowly in cold climates (Tucker et al., 1975). Aromatic and chlorinated hydrocarbons also have a tendency to absorb and concentrate in sediments. High levels of sedimentation, such as exist in Upper Cook Inlet, are believed to provide a highly favorable medium for the uptake of chemical wastes. However, it is not known to what extent sediments in shallow oceanic areas represent a sink for these substances or merely a temporary storage site from which they will be released slowly in the future (Tucker et al., 1975).

Sulfur and nitrogen oxides are highly toxic to vegetation. Aquatic plants are most susceptable to chronic and subacute levels of these oxides (EPA, 1976). Ethylene is known to have adverse effects on plants and contributes to abnormal leaf growth; abcession of leaves, chlorosis, and reduction of growth. Many types of plants are sensitive to photochemical air pollution at levels of one to two ppm. Sulfur and nitrogen oxides form sulfuric and nitric acid when mixed with rain water, and comprise the main constituents of acid rain. Aquatic communities may also be affected by lower pH conditions resulting from acid rain.

Spills of hazardous chemicals, while much less frequent, can be significant in terms of their immediate and long-term effects on fish and wildlife habitat. The extent of the spill's effect will depend on its location, size, material spilled, concentration, and season of the year.

The following processes are related to the transport and transformation of waste materials and hazardous chemicals in the environment. Because the Alaskan environment differs significantly from areas where previous petrochemical development as occurred, the implications toward impacting fish and wildlife resources and habitats are poorly understood.

<u>Chemical Transport Processes</u>

Marine and Freshwater Ecosystems

1. transport in ocean currents;

2. uptake and metabolism by plants and animals;
3. chemical transformations, including precipitation;
4. diffusion into sediments including transport and deabsorption;
5. concentration in surface films; and
6. evaporation from surfaces.

Terrestrial Ecosystem

1. diffusion into soil as vapor or in water solution;
2. volatilization from burning dumps, incinerators, or reprocessing plants;
3. leaching into ground water;
4. adsorption and deadsorption from soil particles;
5. uptake by plants and animals;
6. metabolism by soil organisms; and
7. wind or water erosion of soil particles.

Atmosphere

1. transport of vapor-phase material or particles by wind;
2. absorption of vapor-phase emissions into snow packs and release into aquatic systems;
3. rain-out of particles;
4. fall-out and dry-deposition of particles; and
5. chemical changes such as photochemical oxidation and hydrolysis.

Potential Impacts of the Proposed Petrochemical Complex

The major impacts of the proposed facility on fish and wildlife resources fall into several general categories:

1. The introduction of toxic substances into the marine environment. A petrochemical industry located near a tidewater site will potentially affect commercial, subsistence, and sport fishery stocks, marine invertebrates, marine mammals, and birds. Adverse impacts could result from the discharge of thermal or waste effluent, tanker shipment spills, or the accidental release of chemicals at the terminal site or storage tanks.

2. The introduction of toxic substances into the freshwater and terrestrial environment. Leaks or spills of gas liquids, toxic materials used in petrochemical manufacture, leacheates from solid waste fills, airborne emissions, and acid rain will affect aquatic and terrestrial habitat with a resultant impact on fish and wildlife resources and their human use.

3. The expansion and growth of human populations and associated increased level of demand on fish and game resources. Residential, urban, and industrial expansion associated with the construction and operation of the facility will contribute to an annual loss of wildlife habitat. Increased human populations will result in increased demand for fish and wildlife resource. Existing opportunities to participate in fishing and hunting will be reduced by the necessity of enacting more restrictive permit seasons, lower bag limits, and additional limited entry

fisheries. Competition for hunting and fishing opportunities will exclude many individuals, some of which are existing resident users of the resources.

4. Groundwater withdrawal. Many of the proposed sites are in areas where the water table will be lowered by industrial withdrawals. Groundwater withdrawal and depletion and its net effect upon the surface water resources of adjacent streams, lakes, and wetlands, could contribute to the direct loss of fish and wildlife habitat.

5. Surface Water Withdrawal. Surface water withdrawal from anadromous streams or other important aquatic systems could result in the dewatering of fish spawning and rearing areas, entrainment or impingement of juvenile fish on intake screens, blocking of migration, freeze out of redds, and loss of adjacent marsh and riparian habitat.

Impacts resulting from construction are likely to be concentrated at the facility site. Many of these impacts are anticipated to be short term and can be mitigated by adherence to prescribed constraints and regulations on the design and timing of construction. The impact of the construction work force may be a significant problem at most of the sites and result from bear-human conflicts, increased sport hunting, fishing, and illegal kills, and increased travel into surrounding areas.

The major long-term impacts of the proposed facility will result during the operational stage after successive derivitive plants are brought into production. These impacts will have the greatest affect on marine fishery and wildlife resources. The resources discussed in this section are those which appear to be significantly affected by the central tidewater complex.

1. FISH - The proposed petrochemical facility could affect shellfish, salmon, herring, and bottomfish populations. Localized species such as clams, crabs, shrimp, and other shellfish are most sensitive to the uptake of hydrocarbon pollutants. Filter feeding clams and mussels rapidly accumulate and concentrate water soluble hydrocarbons and toxic compounds. Research by the National Marine Fisheries Service has demonstrated that petroleum hydrocarbons cause direct mortality to razor clams and that sublethal effects result in tainting of the meat (Rice and Karinen, 1976; Konigsberg, 1977). There is evidence to indicate that continued exposure to hydrocarbon pollution will result in the tainting of clams and mussels and may result in declining populations of shellfish. These effects can be minimized or avoided through strict adherence to State water quality standards and rigorous measures to avoid spills.

   Crabs and shrimp are also highly vulnerable to petrochemicals while in the larval stage and during the molting process. Direct mortality to adults has occurred from exposure to levels of hydrocarbons in the one to four ppm range (Karinen and Rice, 1974). Sublethal effects frequently alter feeding, mating, migration, and habitat selection and indirectly cause mortality.

Many studies have demonstrated that sublethal exposure to petroleum hydrocarbons inhibits growth of phytoplankton and zooplankton (Dunstan et al., 1975). Plankton form the base in the food chain for all finfish and shellfish stocks. Thermal pollution resulting from the discharge of heated effluent water from cooling towers can adversely affect marine life. Species of fish and shellfish such as juvenile salmon and larval stages of crab, may be killed by temperature changes of 2-3°F above ambient levels. Sea water which is pumped into plant cooling systems contains plankton, zooplankton, and larval stages of marine life. Organisms drawn into cooling systems are killed by a rise in temperature which often exceeds ambient levels by 20°F, and by physical shock and abrasion. Cooling waters may be chlorinated or treated to retard fouling. Chlorine and other antifouling compounds are very toxic to marine life. When cooling waters are drawn into a plant, larger organisms and fish may become entrapped or impinged on the intake screens.

Juvenile salmon and fry are sensitive to hydrocarbon pollutants. Salmon fry rapidly accumulate aromatic fractions of hydrocarbons in gut muscle and gill tissues. The proposed petrochemical facility could have its greatest impact on intertidally spawning adult salmon, smolts outmigrating from nearby coastal streams, and juvenile salmonids rearing in nearshore waters. Eggs and alevins in intertidal spawning areas could be continually exposed to soluble fractions of hydrocarbons and waste effluents associated with plant operation and maintenance. The net result may be lower yields of salmon to commercial and sport fishing interests.

Dredging, filling, and construction of a marine dock facility may have adverse short-term effects on local benthic biological communities. Insufficient information exists on the size or design of the dock facility to assess long-term impacts.

2. MAMMALS - Direct impacts of the central petrochemical complex on terrestrial mammals does not appear to be significant. Direct habitat destruction will probably be limited to the immediate construction site. Construction and operational noise levels may pose a disturbance factor at some sites. It is assumed that the entire complex will be fenced to prevent entry by moose and other large animals. Increased road and rail traffic serving the facility will contribute to increased road-kill mortality. The greatest impact on mammals will result from the secondary impact of residential and human population growth. Additional waste disposal or other food sources also attract bears or other carnivores. Animals which become nuisances will have to be destroyed.

Increases in human populations will likely result in the enactment of more restrictive hunting regulations to sustain wildlife populations. Current participation in hunting and trapping activities in southcentral Alaska is given in Table 8. The operating work force at the central petrochemical complex is estimated to consist of 370 operators, 220 craft/maintenence, and 410 non-craft (clerical and administrative) (J. Kruse, pers. comm.). Secondary growth associated with a petrochemical industry will contribute an even larger work force. Employment increases in the Matanuska-Susitna area are estimated to be 2,000 if the Pt. MacKenzie site were chosen, and 1,500 at the Kenai, Seward, or Valdez sites (J. Kruse, pers. comm.). There is currently no way to estimate the impacts of this populations growth on the current level of fish and game harvest at each site. However, it is expected that a substantial percentage of the workforce would consist of new residents to the State, and that many of these residents will want to compete with existing residents for fish and wildlife resources.

Marine mammal populations will decline if prey species of fish or invertebrates are adversely affected by the facility. Localized species such as sea otter, may suffer the greatest impacts (Calkins, 1980). Any localized reduction in food would likely result in a localized reduction of sea otter numbers. Direct contact with toxic hydrocarbons at spill sites could result in injury or mortality to harbor seals, sea lions, and sea otters. Marine mammals populations near shipping terminal sites could become selective feeders on contaminated prey and be exposed to concentrated amounts of petrochemicals. Increased ship traffic

Table 8. Participation in Hunting and Trapping Activities With Respect to Occupation, Southcentral Alaska (Inst. Social and Economic Research, 1979)

Game Species Hunted or Trapped	Occupation Class		
	Craft/Maintenence	Operators	Clerical/Administrative
Moose	56%[1/]	42%	15%
Caribou	9%	4%	1%
Waterfowl	30%	16%	10%
Small Game	24%	23%	8%
Furbearers	16%	9%	3%

1/ % participating in the last 12 months.

to the site and associated noise and disturbance could result in avoidance of traditional use areas by whales and porpoise and increase the potential for ship collisions with marine mammals.

3. BIRDS - None of the designated land tracts at the proposed sites are considered critical habitat for bird species. The greatest impact on birds would result from the secondary development of adjacent land areas, such as development in wetlands, increased noise and disturbance, increased harvest, disruption of food chains, and direct contamination through spills or improper waste disposal.

   Groundwater withdrawal for facility use could potentially decrease waterfowl habitat and reduce the productivity of local breeding populations through the dewatering of marshlands, ponds, and sloughs. A reduction in marine invertebrates, fish populations, or nearshore plant communities would affect the habitat use by migrating shorebirds and waterfowl. Birds landing on sludge or evaporating ponds may be affected by exposure to toxic chemicals.

4. VEGETATION - Vegetative cover will be lost at the site of plant construction and related facilities. This impact will be least severe at sites such as Kenai and Valdez which have already been subject to surface disturbance and development.

A major impact to vegetation could result from oxide air emissions and acid rainfall. This impact has received international attention in recent years, but is poorly understood. A detailed knowledge of air emission data and atmospheric conditions at each site is required to predict the magnitude of this impact. Secondary impacts will result from facilities required to support the industry. Road construction requires an extensive amount of land and borrow material, and this impact will extend far beyond the actual project site. The primary impacts include removal of vegetation, alteration of soils and drainage, and increased access to fish and wildlife habitat.

The information currently available does not allow a ranking of all the proposed sites with respect to the potential for being adversely impacted by petrochemical development. The Fire Island site appears to have the lowest potential for adverse impacts to fish, wildlife, and marine resources. The biological diversity at this site is low due to the low productivity of coastal waters, absence of major freshwater environments, and limited terrestrial habitat. The physical characteristics of the marine environment at Fire Island provide the greatest potential for minimizing the effects of a spill or discharge of waste effluent.

The physical and biological marine environment at the Pt. MacKenzie site is very similar to that of Fire Island and the potential for major impacts is similar. The potential for impacts to terrestrial wildlife populations and habitat is greatest at the Pt. MacKenzie site. The Kenai-Nikiski site appears intermediate with respect to impacts resulting from surface or ground water appropriation, discharge of waste effluents into marine and freshwater environments, and increased human populations.

The manufacture of petrochemicals would have the greatest potential for adversely impacting the marine environment at the Seward or Valdez sites. The marine ecosystems at these sites are highly productive and the most sensitive to the introduction of additional pollutants. The cummulative impacts of existing petroleum related facilities at Valdez and a new petrochemical industry may result in a long-term decline of marine fish and wildlife resources and habitats. Impacts to terrestrial wildlife species would be of lesser significance at the Valdez or Seward sites.

Potential Impacts of the Gas Liquids Pipeline

Most long-term impacts associated with the proposed gas liquids pipeline can be precluded by proper design, scheduling, construction, installation, restoration, operation, and pipeline maintenance. The degree to which the chemical industries comply with the prescribed methods and regulations designed to safeguard fish and wildlife habitat will largely determine the severity of impacts from the project. The loss or degradation of some wildlife habitat and a reduction in the numbers of some species is inevitable. The resources discussed in this section are only those which appear to be significantly affected and do not represent the total environment along the pipeline routes.

Additional construction plans are released monthly by Dow-Shell. Several aspects of the pipeline route and design have changed since this report was prepared, and these alterations and future changes will have impacts which are not addressed in this section. For example, an alternate pipeline route crossing the Minto Lakes west of Fairbanks has been proposed (Dow-Shell Progress Report No. 7). This route would have severe and irreversable impacts on a valuable wetland area and very likely would receive strong opposition by resource agencies.

1. FISH - The proposed Dow-Shell gas liquids pipeline will cross 200-300 rivers and streams between Prudhoe Bay and the tidewater petrochemical sites. Each stream crossing presents a potential adverse impact on the fish and other aquatic organisms residing there. The major impacts which the pipeline could potentially have on fish populations would result from water withdrawal, destruction of overwintering areas, increased sedimentation and turbidity, blockage of fish passage, and depletion of dissolved oxygen in the event of a pipeline leak or rupture.

   Winter fish habitat is severely restricted along many portions of the pipeline route. Stream rechannelization and siltation resulting from stream crossings can have serious detrimental effects on overwintering fish. If not engineered properly, an ambient temperature pipeline will induce icing at stream crossings during the winter, and result in the obstruction of normal flows and freezing of fish eggs. A pipeline rupture would have the greatest impact during winter when streams are covered with a heavy layer of ice and pollutants would become trapped and may remain undetected for long periods of time. Siltation may cause local problems by lowering water quality and oxygen levels to the point where fish and aquatic invertebrates are threatened. Gravel extracted from streams for pad and road construction can affect spawning habitat and stream channels. The cummulative impact of construction, operation, and repair of the proposed Dow-Shell gas liquids pipeline on the fish population in major drainages crossed by the system will depend upon the measures used to minimize construction impacts from siltation and dewatering, gravel extraction, and the toxicity of any products which may be spilled.

2. MAMMALS - The construction and operation of the proposed pipeline will reduce some mammal populations through destruction of habitat, road kills and nuisance control, harassment by employees of construction and pipeline companies, and by providing increased access to remote areas via the pipeline corridor and roads. Disturbance from pipeline construction noise and the accidental introduction of pollutants into the ecosystem also have the potential for serious impact. Revegetation and

management of the pipeline corridor may offset some of these impacts by improving habitat conditions for species such as moose and caribou.

Principal large mammals impacted would be caribou, Dall sheep, moose, bison, and grizzly bear. Migration of moose, caribou, and bison could be restricted during construction by the physical presence of equipment, pipeline sections, and open stretches of ditch. Construction noise and low altitude aircraft operations could adversely affect calving and lambing activities of large mammals. Most disturbance-related impacts can be alleviated by routing the pipeline to avoid sensitive areas, timing construction to avoid critical use periods, and locating pipeline facilities in non-sensitive areas.

Habitat loss will result in a reduction in the population level of small mammals such as squirrels and lemmings. This population reduction will have different implications for each of the small mammal species and their predators, but is considered insignificant in relation to the total amount of habitat available for small mammals.

3. BIRDS - The proposed pipeline has the potential for some unavoidable impacts on bird populations through disturbance by aircraft, construction activities, and human presence; pollution; habitat destruction; and direct mortality. Many conflicts can be

reduced or eliminated by proper route and facility location and by management of construction practices and scheduling.

The major groups of birds which would be impacted include raptors and waterfowl. Spring and summer operation and emergency repair activities could adversely affect nesting falcons and eagles. The pipeline routes cross large areas of wetlands and coastal plains which receive heavy use by swans, geese, ducks, loons, and shorebirds for nesting, staging, and molting. The noise of pipeline pump stations and monitoring activities could disrupt nesting and migrating waterfowl. The loss of waterfowl habitat may result from drainage of wetlands or alteration of stream flow and aquatic habitat.

Land requirements for the pipeline corridor represent a small fraction of available bird habitat. However, the loss or alteration of a critical staging area for migratory birds could adversely affect populations over a large area of Alaska.

4. VEGETATION - During pipeline construction, natural vegetation will be destroyed along the pipeline ditch, at camp and equipment yarding sites, airstrips, pump stations, communication towers, permanent roads, and other permanent facilities. Areas adjacent to the pipeline corridor will be partially destroyed or changed by downslope dewatering, ponding behind workpads, icing, spoil disposal sites, and summer and off-road vehicle use. If the Dow-Shell pipeline is not engineered to adequately handle sheet

flow and insure cross drainage, major impacts on vegetation could result outside the pipeline corridor.

Potential operational impacts include SO_2 and NO_2 emissions from pump stations and the fire hazard associated with a pipeline leak or rupture. A rupture or leak in the pipeline would allow large quantities of volatile gases to vaporize into the atmosphere. Contingent upon wind and temperature, these gases will form a plume and settle into low areas and river valleys or spread with wind currents into adjacent areas. Since the pipeline corridors parallel highways and railroads, there is a high potential for ignition of these dispersion plumes. A fire could have negative or positive impact on fish and wildlife habitat along the pipeline depending upon the time of year, the species affected, and the type of habitat present. A fire in permafrost regions could produce a deep thaw and promote erosion and subsidence.

Insufficient information exists regarding the specific routing and engineering design of the Dow-Shell gas liquids pipeline for our Department to select the most environmentally favorable route at this time. The cummulative impact of the pipeline would be greatest if the Seward site were chosen, primarily because it is the longest route and crosses the greatest number of sensitive habitat areas. The Valdez alternative would appear to have the lowest potential for impact if the existing TAPS right-of-way were used. However, the gas liquids pipeline alignment maps given to our Department do not indicate that the Dow-Shell pipeline will be constructed completely within the TAPS corridor. In addition, it seems highly unlikely that Alyeska Pipeline Company will allow the use of the TAPS gravel pad for constructing a gas liquids pipeline. Since the TAPS line already occupies the least environmentally sensitive corridor along the Prudhoe Bay to Valdez route, and if the Dow-Shell pipeline had to be routed along a substantially different route, then it is possible that the proposed Dow-Shell pipeline might have less environmental impacts if it were routed to a site in Upper Cook Inlet.

SECTION IV

IDENTIFICATION OF MAJOR STUDY REQUIREMENTS

There is currently insufficient information to allow the Department of Fish and Game to quantitatively predict the impacts of a petrochemical industry on specific fish and wildlife resources at any of the proposed sites. A considerable number of baseline field studies are needed before the effects of such issues as wastewater discharge, groundwater withdrawal, or marine transport of chemicals can be assessed. A preliminary identification of the major issues which need to be addressed include:

1. Ocean circulation and transport studies to determine if the release of chemicals at the pipeline terminal, manufacturing site, barge dock, or shipping route will adversely threaten area fish and wildlife populations or critical habitat areas.

2. The capacity of marine waters to dissipate thermal effluent needs to be examined and a model constructed to predict the impact of cooling water discharge to area marine life.

3. Studies are needed to determine the probability of a marine tanker shipping spill and its impact on marine fish, invertebrates, mammals, and birds. The interference of barge traffic with commercial fishing operations and whale movements also needs investigation.

4. The likelihood of toxic substances associated with petrochemical manufacture to bioaccumulate in local finfish and shellfish populations needs to be evaluated.

5. Studies are needed to identify and determine the synergistic potential between Dow-Shell effluent and existing industrial and municipal effluent at sites where current petroleum processing or transport activities occur.

6. Major freshwater fishery and hydrological studies are required to determine if the proposed quantities of process and cooling water can be withdrawn from local ground or surface water supplies throughout the year without the loss of major fishery habitat or wetlands important to birds and mammals.

7. The construction of a trans-Alaska gas liquids pipeline involves many activities which could adversely impact fish and wildlife habitat. Specific aspects of construction, such as gravel extraction, work pad construction, alteration of surface water flows, or routing through sensitive fish and wildlife habitats, will require field evaluation throughout the length of the pipeline corridor.

8. The impacts of construction workers, phase I and II operational personnel, and the associated residential growth must be evaluated with respect to the increased fishing and hunting demand which is likely to be placed on existing fish and wildlife resources.

9. A greater understanding is needed of the potential impacts of nitrogen and sulfur oxides on fish and wildlife habitat. The uptake of oxide into snowpacks and eventual release into anadromous streams, and the

potential for acid rainfall affecting vegetation or lowering the pH of surface lakes should be investigated.

10. Additional baseline data on fish and wildlife populations is needed along the proposed pipeline corridors and tidewater sites to make a more complete evaluation of potential biological impacts.

ASSESSMENT OF ENVIRONMENTAL PROTECTION MEASURES IN THE DOW-SHELL PROPOSAL

Review of the Dow-Shell Group's petrochemical proposal and progress reports has led us to the opinion that specific environmental protection commitments are lacking. The progress reports have been written in such general terms that specific environmental and fish and wildlife protection procedures are not included. The Dow-Shell Group has not responded to requests from our Department to identify environmental protection measures which will be employed during the construction of the gas liquids pipeline and central tidewater complex. Many of these measures could be costly and should be included in the feasibility study. Although there is no reason to believe that the Dow-Shell Group will not provide a responsible environmental corporate structure to manage its own operations and those of its associates, no commitment has been indicated during the course of their feasibility study.

The Dow-Shell Group has been reluctant to exhibit a commitment to specific environmental protection measures that it knows will be difficult to fulfill. The Dow-Shell progress reports do not demonstrate a complete awareness of the costly and technical environmental protection problems which must be overcome to construct and operate a gas liquids pipeline from Prudhoe Bay to a tidewater site. In other cases they have openly stated that all environmental standards will be met or exceeded, yet give no facts or details on how they will accomplish these measures. As a result, many of their procedures for environmental protection are qualified and not explicit. We believe that adequate environmental protection requires the stipulation of explicit commitments by industry and government in the early stages of project planning.

Without the details of specific pollution hazards and proposed environmental protection measures, the State can only rely on the good intentions of the industry, as well as the experience and ability of governmental regulation agencies. In cases where an industry has well established "rules of practice" to go by, this is often adequate, but "rules of practice" for petrochemical industries have not yet been established in Alaska.

SECTION V

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