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VOLUME II

THE ONSHORE IMPACTS OF ALASKAN OIL AND GAS DEVELOPMENT IN THE STATE OF WASHINGTON

report to

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

June 1977

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Washington State Dept. of Ecology

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Arthur D Little, Inc.

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VII. PETROLEUM INDUSTRY ACTIVITY ZONES: ENVIRONMENTAL SETTING AND IMPACT

This study addresses the impact of petroleum activity at three locations within Puget Sound. The first is Port Angeles, located on the Strait of Juan de Fuca in Clallam County. Although there is presently no petroleum industry at Port Angeles, it has been identified as a possible site for a Puget Sound oil superport, and the Northern Tier Pipeline Company proposes to construct a marine terminal for crude oil transshipment at Port Angeles. The second zone addressed is March Point, near the City of Anacortes in Skagit County. March Point is presently the site of the Shell and Texaco oil refineries. Marine terminals there currently receive the majority of the refinery feed stock. The scenarios addressed in this study do not consider transshipment at March Point; the activity is limited to a variety of ways in which the local refinery supply can be obtained. The third zone is Cherry Point, located on the Strait of Georgia near the City of Ferndale in Whatcom County. Cherry Point is an area designated as an industrial zone. It is the site of the Atlantic Richfield and Mobil Oil refineries as well as the Intalco Aluminum Smelter. The scenarios considered in this study are concerned with the method of regional supply for local refining needs and also with the possibility of using Cherry Point as a marine terminal for transshipment of crude oil to the midwestern United States.

Chapter VII begins with a description of the environmental setting at each of the three activity zones. The five basic environmental factors described in Chapter V are each addressed according to the methodology set forth. The second part of Chapter VII presents the environmental impact assessment of the various scenarios as they may affect the three activity zones. The project components which serve to generate the environmental impact are described in detail in Chapter VI; that project description is not repeated here.

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A. ENVIRONMENTAL SETTING

1. Port Angeles - Clallam County

Situated on the Strait of Juan de Fuca on the north coast of the Olympic Peninsula, Port Angeles is roughly equidistant between Cape Flattery and the Pacific Ocean on the west, and the urban areas of Seattle, Tacoma, and Everett on the eastern shore on Puget Sound. Port Angeles has a well protected harbor formed by Ediz Hook, a narrow sand spit extending into the Strait enclosing the harbor on two sides and providing protection from the majority of Pacific storms. The anchorage within the hook is over three miles long, with deep water exceeding 60 feet throughout. The protected harbor has served the Olympic Peninsula as a focus for its commerce relating to forest products, fisheries, and recently tourism. With a population of 16,000, Port Angeles is the major city in Clallam County. (See Figure VII-1.)

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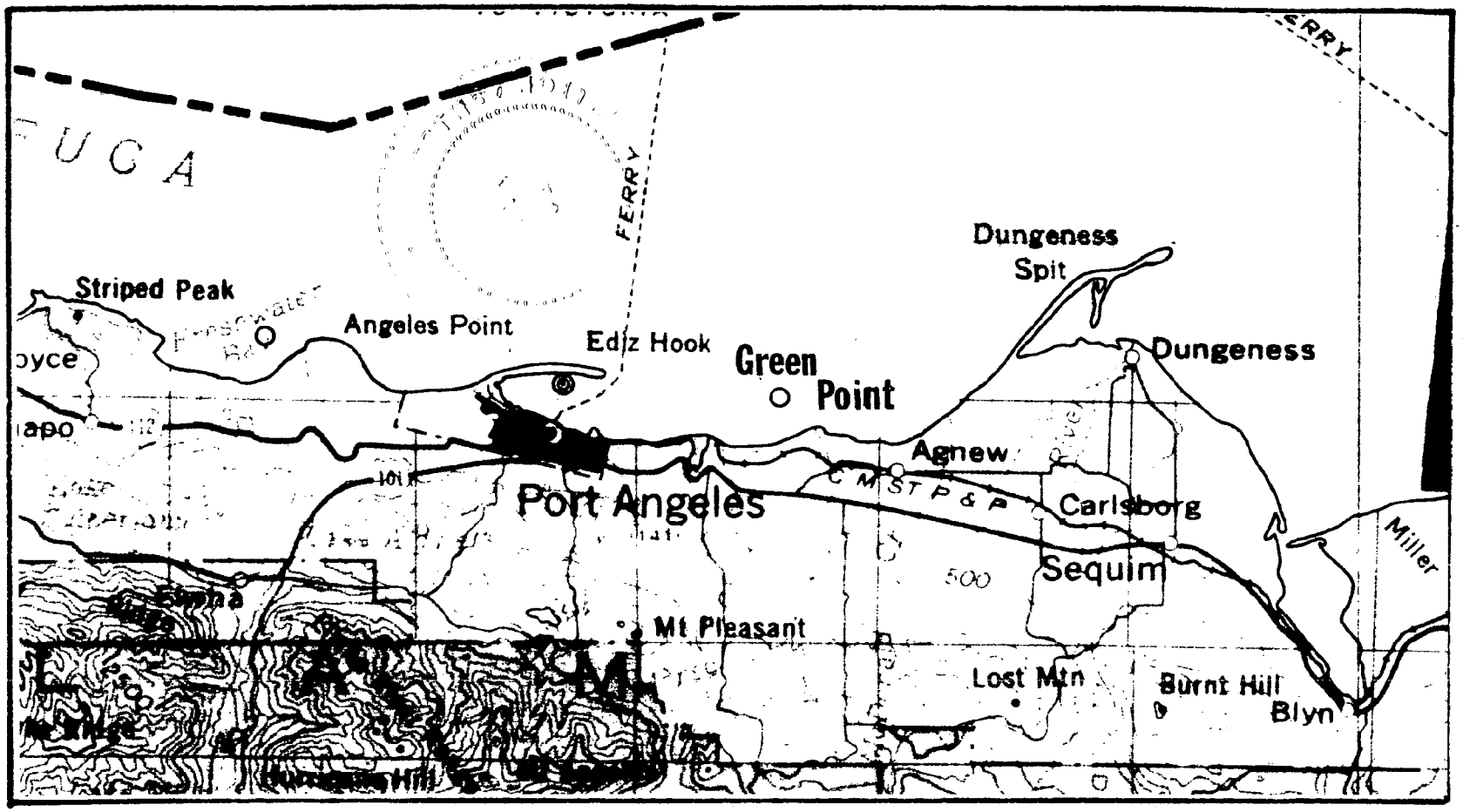


◎ Marine Terminal proposed by Northern Tier Pipeline Co.

○ Alternative Marine Terminal

0 2 4 6 mi
0 3 6 9 km
NORTH

FIGURE VII-1 LOCATION: PORT ANGELES

a. Land Use

(1) Regional. In the Clallam County/Port Angeles activity zone, the area most likely to be affected by induced population growth from oil terminal facilities and pipeline originating at Port Angeles is the corridor of flat land along the Strait of Juan de Fuca. This comprises the greater urban area of the City of Port Angeles, inclusive of the low-density spread of urbanization each of the city, mostly in the coastal belt between Port Angeles and Sequim. The City of Sequim and the Dungeness Valley area may also experience population growth as a result of oil projects.

As can be seen from Table VII-1, total acreages of land use categories were available only for the county as a whole and for the incorporated cities. Clallam County is extremely rural with the vast majority (89%) of the land in forest but a significant proportion (6%--64,000 acres) in some agricultural use. Present urban centers are restricted to the two incorporated cities previously mentioned and to the Town of Forks located to the west of the Olympic National Park. Land use in the corridor which will receive population impact is primarily low-density residential, with agriculture still practiced in the area of Sequim and on the Dungeness Cape. Residential dwelling unit densities in the affected zones, outside the incorporated areas, are on the order of two to four families per acre, except in the zone of intensive agriculture where the density drops to one to three families per acre. Much of the land is still undeveloped; the overall density is low enough that the area retains a rural, wooded character.

The City of Port Angeles is a definite urban center in the largely rural county. Consequently, no lands within the city boundary are expressly designated as open space or agriculture, but as of 1974, 41% of the total land area in the incorporated city was not developed. Of this, a high proportion is available for future residential growth. Likewise in the City of Sequim, approximately 1000 acres in extent, 48% of the total land area is still considered vacant.

- Land Values

Residential land values in Clallam County/Port Angeles are currently on the order of $24,000 per acre and the average parcel size is one-quarter acre ($6,000). (See Table VII-2.) However, much of the land changing ownership outside the distinctly urban area of the city is in larger parcels. Land value figures more current than 1974 were available anecdotally from the Clallam County Assessor's Office and are shown in Table VII-2. The inflationary trend has continued so that a five-acre parcel on the average sells for $5,000 per acre if it can be used for residence. The inflation rate has been about 30% per year over that period.

- Land Use Trends/Conflicts

According to information from the Clallam County Planning Department, the area undergoing the most rapid urban growth at present and expected to continue as the focus of development for some time in the future is the Sequim/Dungeness Valley, roughly 15-20 miles east of Port Angeles.

TABLE VII-1

LAND USE - ACREAGE - CLALLAM COUNTY

Activity Zone	Residential	Industrial	Agricultural	Timber	Commercial	Other
Clallam County (1971)	13,660 (1%)	650 (.06%)	64,092[a] (6%)	999,898[b] (89%)	157 (.01%)	N
Port Angeles (1974)	1,200 (22%)	300 (6%)	2,200 (41.5%)	undeveloped	100 (2.0%)	

[a] Includes "small private forest"
[b] Includes Federal, State, and private timberlands
N Data not available

Source: Clallam County Preliminary Comprehensive Plan (1976); Port Angeles Planning Director.

TABLE VII-2

LAND VALUES - CLALLAM COUNTY

	Residential			Agriculture		Timber
Activity Zone	Value/Acre	Parcel Size	Trend	Value/Acre	Acreage in ROW 84.34	Value/Acre
Clallam County	$ 5,000/ac 2,000/ac	5ac 20ac		$ 2,000/ac (cash crop) 1,500/ac (grazing)	30,300 ac (47.3%)	$1-100/ac depending on soil type and access. (Timber crop value determined separate from raw land value.)
Port Angeles	24,000/ac	¼ acre	Since 1973 annual inflation rate of 5-15% depending upon location.	Not Important	NONE	

Source: Clallam County Assessor; Port Angeles Planning Director.

(See Table VII-3.) This area has become attractive as a retirement community because of the combination of mild climate with relatively low precipitation and the availability of waterfront parcels. The actual growth which has occurred has been outstripped by speculation in land in this area. It was reported that only about one-third of the subdivided lots which have been sold in the last two to three years have been occupied.

Within the City of Port Angeles, the areas identified by the City Planning Director as the most prime development sites are in the south and west end of the city where the present "vacant" land use is now pasture and second-growth timber. In anticipation of development, the value of these lots has been rising at a moderate rate over the last three years or so.

Land speculation in the Sequim/Dungeness Valley is having an adverse effect upon agricultural land use according to the 1976 Clallam County Comprehensive Plan (unadopted). The acceleration in land speculation and subdivision is affecting the best agricultural land in the county. Less than half of all of the prime agricultural lands remaining in the county have been placed in open space taxation status under RCW 84.34. This reflects a general perception on the part of farmers that the sale of land for urbanization brings a far higher price per acre than the sale for continued agricultural use. The total acreage in farms has declined by about 11% between 1969 and 1974.

Since there is no current zoning effective in Clallam County, the land values are determined only by a perception of their salability for urban residential development rather than agricultural use. Yet the Clallam County Comprehensive Plan explicitly states that the perception of salability and speculation by farmers in conjunction with land developers is far in excess of the actual future need for land to support residential growth.

Trends in land use are also indicated by the rate of population growth and the likelihood that a recently observed pattern will continue into the future. Both Clallam County and the City of Port Angeles experienced very slow growth during the economic recession felt generally in Washington in the early 1970s. As shown from the population growth tables (Tables VII-4 through VII-6), the county began to recover and experience accelerated growth beginning in 1973-74 and in the last year growth rate in the county was 7.5%, the most rapid of any of the petroleum industry activity zones in this study. Population growth in the City of Port Angeles has only within the last year shown a marked turn-around from the depressed rate of the early 1970s. The official state government projections for the county (See Table VII-6) indicate a 1980 population of 36,550 and 38,300 in 1990, yielding an annual average growth rate of 0.3%. Local sources were less confident to speculate about the continuation of very recent growth trends.

The current preliminary Clallam County land use plan takes account of a number of problems which beset all areas in the process of undergoing rapid urban development. These problems include the need for urban services (see also the section on infrastructure), the failure of conventional

TABLE VII-3

GROWTH TRENDS AND PLANNING PERSPECTIVE - CLALLAM COUNTY

Activity Zone	Growth Trends/Planning Perspective
Clallam County	Sequim-Dungeness Valley is most active growth area. Suburban-type development/retirement community.
Port Angeles	South and west end of City undergoing speculative-type development. Multiple-family residential will be zoned along arterials. Strip commercial will give way to nodal commercial centers.

Source: Clallam County Planning Department; Port Angeles Planning Director.

TABLE VII-4

POPULATION GROWTH - CLALLAM COUNTY

Activity Zone	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1970/76 (6 year) Ann. Av.	1976 Population
Clallam County	+0.4%	+0.6%	+0.3%	+1.7%	+3.4%	+7.5%	2.3%	39,800
Port Angeles	+0.5%	+0.9%	+1.0%	-1.0%	-2.2%	C 1.6%	+0.14%	16,506

*Population Growth Rate 1970/76 Source: Washington State Office of Program Planning and Fiscal Management/Population Studies Division.

TABLE VII-5

components of population change 1970-76 - CLALLAM COUNTY

April 1, 1970 to April 1, 1976

POPULATION				COMPONENTS OF CHANGE			
1970	1976	Change Number	%	Births	Deaths	Natural Increase	Net Immigration
A	B	C (=B-A)		D	E	F (=D-E)	G (=C-F)
34,770	39,800	+5030	14.5	3,625	2,399	1,226	3,804

Source: Taken from Table 10, State of Washington Population Trends, 1976. Population Studies Division; Office of Program Planning and Fiscal Management.

TABLE VII-6

OFFICIAL POPULATION PROJECTIONS - CLALLAM COUNTY

	PROJECTED POPULATION						
ACTIVITY ZONE	1975	1975 Actual	1980	1985	1990	1995	2000
Clallam Co.	35,700	37,000	36,550	37,400	38,300	39,100	40,000

SOURCE: State of Washington, Office of Program Planning and Fiscal Management Official Estimates August, 1972

suburbs to provide a suitable residential environment, the inefficient utilization of land (urban sprawl), and the need for an expanded road and highway system. With an eye toward minimization of identified problems and in anticipation of continued growth and urban residential development, the plan attempts to concentrate development in the vicinity of existing centers of population. This mode of development stresses infilling of vacant parcels between existing subdivisions rather than the outward extension of the urban boundary. This form of growth should serve the multiple goals of minimizing urban sprawl, reducing the encroachment on agricultural land, and allowing for the most cost-effective extension of municipal services.

(2) Specific Project Site and Alternatives. There are three subalternatives for marine terminals and onshore facilities for a Port Angeles transshipment project. The prime Northern Tier proposal is for a fixed berth inside Ediz Hook. The engineering consultants to Northern Tier, however, examined two alternatives which would utilize single point moorings (SPMs) roughly one mile off coast at Freshwater Bay nine miles west of the Ediz Hook proposal, and at Green Point five miles east of Ediz Hook.

- Ediz Hook Subalternative

Land use along the sand spit forming Ediz Hook and its connection to the mainland is some industrial development interspersed with fallow land. The Crown Zellerbach paper facility occupies the triangle of land where the isthmus forming the Hook meets the mainland. A narrow two-lane road occupies the central portion of the spit itself with the breakwater reinforced by riprap immediately to the outside. On the harbor side, immediately at the waterfront in the central portion of the Hook, is the log booming area of ITT with the Puget Sound pilots' station just to the east. The wider zone of land at the east end of the Hook is occupied by the U.S. Coast Guard Station, including several buildings and a small air strip.

- Freshwater Bay Subalternative

The onshore backup area (surge/storage for an alternative offshore mooring site for Freshwater Bay) is an area of agricultural land above the flood plain of the Elwha River. The lands to the west and those fronting on Freshwater Bay are part of the Elwha Indian Reservation. Of some thousand acres of land between the Elwha River and the Port Angles city boundary which could potentially be affected by oil project development, roughly one-third is agricultural with some low-density residential development interspersed. The remaining two-thirds is relatively dense, second-growth woodland.

- Green Point Subalternative

A marine terminal at Green Point may use one of two possible onshore sites for surge/storage tankage. One of these is a largely fallow grassland near the mouth of Morse Creek. The site has some residences nearby

and is surrounded by a steep wooded bluff and by the railroad. Closer to Green Point itself, there are several hundred acres of wooded land with occasional clearings that could be used for a tank farm site. There is scattered residential development throughout this area.

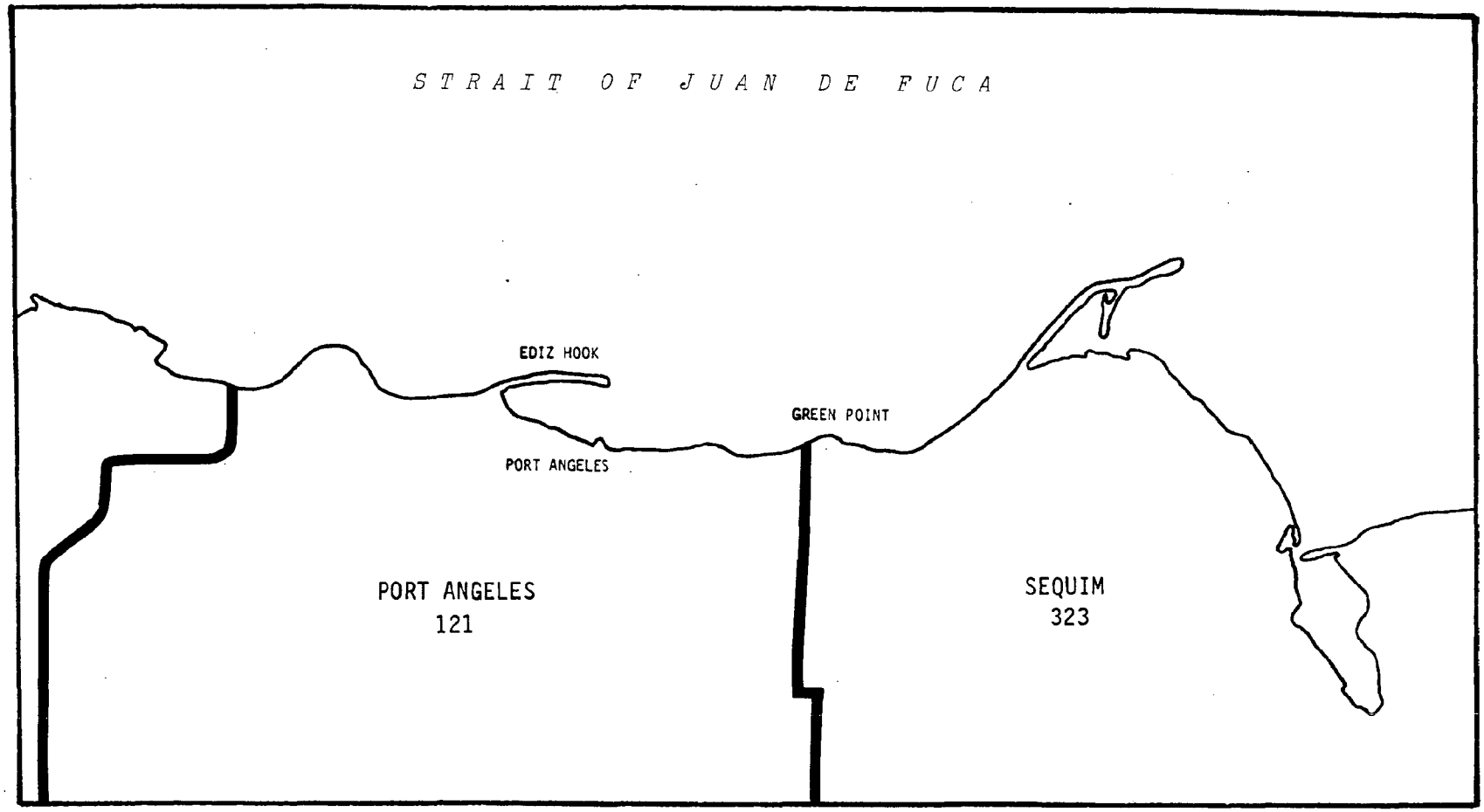
b. Infrastructure

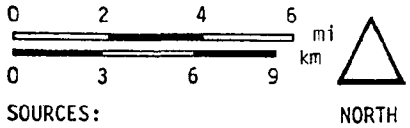
(1) Schools. Two school districts in Clallam County may be affected by population growth associated with petroleum industry activities at Port Angeles (see Figure VII-2). They are the Port Angeles and Sequim districts. The Port Angeles school district has experienced an overall decline in enrollment of 3.6% over the last five years, while the Sequim district has gained 17.7% in enrollment. Both districts are presently operating well over capacity in comparison to the current state standards for space in public schools. Overcrowding generally means more pupils per classroom than is desirable, as stipulated by state standards, and may also mean conversion to classroom use of space not intended for regular instruction (cafeteria during non-meal hours, etc.). Both districts are using a small number of portable classroom units, but they provide only 1% (Port Angeles), and 6% (Sequim) of the additional space for instruction needed in 1976-77. Port Angeles school district is actively engaged in school construction, and has expended $2.3 million since January 1971 for school capital development. The Sequim district has expended no money for this purpose in the same time period. (See Tables VII-7 through VII-10.)

The decline in Port Angeles district enrollment over the last five years is attributable both to a very slow rate of population growth in the City of Port Angeles and to the general decline in birth rate, a phenomenon which is quite apparent in Washington State and has resulted in declining school enrollments statewide. Growth in the Sequim district enrollment over the same interval reflects a high rate of in-migration, accommodated by a high rate of residential construction.

Data available over the past three years indicate that the total market value of real and personal property taxes levied on assessed valuation, calculated according to the "indicated ratio" formula which varies from place to place and from year to year. Increases in market value in a particular district are due both to new construction and to inflation. In 1976, total market value of the Port Angeles district was 80% greater than that of the Sequim district. Sources of revenues for the two districts are roughly the same proportion of local taxes, county administrative, and state and federal funds (see Table VII-11). In both districts, about half of the total revenue is provided by state funds with one-fourth to one-third from local taxes. Port Angeles has the higher proportion of local funds. Fiscal information is summarized in Tables VII-11 to VII-15.

At present both districts have a large excess bonding capacity which could be translated into new capital development through voter approval ($12.7 million in Port Angeles and $7.9 million in Sequim). (See Table VII-14.) Port Angeles passed the most recent bond issue in February of 1976, bringing the present bonded indebtedness to $3.4 million. Sequim has not passed a bond issue since 1955 and has only $1.03 million left to repay of the $6.8 million incurred at that time.





SOURCES:
State of Washington, Superintendent of Public Instruction, "Boundaries of the 303 School Districts in Existence on October 15, 1976".

FIGURE VII-2 SCHOOL DISTRICTS: PORT ANGELES

TABLE VII-7

SCHOOL DISTRICT HISTORICAL ENROLLMENT - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Historical Enrollment (October 1) 1971	1972	1973	1974	1975	Total (K-12) 1976	Percent Change 1971-76	Percent Annual Change (Exponential)
CLALLAM COUNTY								
Port Angeles 121	5007	4868	4813	4713	4960	4826	-3.6	-0.7
Sequim 323	1465	1558	1637	1762	1747	1724	+17.7%	+3.3

Source:State of Washington, Superintendent of Public Instruction

TABLE VII-8

CURRENT ENROLLMENT AND AVERAGE DAILY ATTENDANCE - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Current Enrollment (October, 1976)			1976 Total (K-12)	Average Daily Attendance 1975-76
CLALLAM COUNTY					
Port Angeles 121	2398 (K-6)	1166 (7-9)	1262 (10-12)	4826	4478
Sequim 323	562 (K-4)	520 (5-8)	642 (9-12)	1724	1616

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-9

SCHOOL DISTRICT EXISTING CAPACITY - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Satisfactory Existing School District Capacity 1976	Capacity Remaining Absolute Number of Pupils	Percentage	Temporary Facilities (1975-76 Inventory)
CLALLAM COUNTY/ PORT ANGELES				
Port Angeles 121	3310	-1516	-31.4	2 portable class room 2302 sf
Sequim 323	1282	-442	-25.6	3 Portable class room 2702 sf

Source: State of Washington, Superintendent of Public Instruction.

TABLE VII-10

SCHOOL DISTRICT CERTIFICATED STAFF RATIOS - CLALLAM COUNTY
(per 1000 FTE* pupils)

ACTIVITY ZONE/ SCHOOL DISTRICT	Teachers				Other**			
	High School	Jr. High School	Middle School	Elem. School	High School	Jr. High School	Middle School	Elem. School
Clallam County/ PORT ANGELES								
Port Angeles 121	41.63	41.03	-	42.69	7.84	6.93	-	5.34
Sequim 323	45.25	-	41.97	43.19	8.85	-	4.55	3.91

*FTE = Full Time Equivalent

**Other = School Administrators, Supervisors, and Support Services

SOURCE: State of Washington, Superintendent of Public Instruction

TABLE VII-11

SCHOOL DISTRICT REVENUE AND COST - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	SOURCES OF REVENUE - 1974-75 (% of total)					REVENUE VS COST ($) 1974-75			
	Local Taxes	County Admin. Funds	State Funds	Federal Funds	Other*	Market Value per Pupil	Revenue per Pupil	Expenditure per Pupil**	Net Cost per Pupil**
Clallam County/ PORT ANGELES									
Port Angeles 121	30.64	4.6	52.43	10.33	2.0	49,881	1120	1146	1055
Sequim 323	24.64	4.25	53.44	9.90	7.77	63,899	1009	1065	916

Source: State of Washington, Superintendent of Public Instruction

*Other=Local non-tax revenue, non-revenue receipts, and payment from districts.

**See text for explanation of difference between expenditure and net cost.

TABLE VII-12

TAXABLE PROPERTY - MARKET VALUE - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Taxable Property Total Market Value ($ Thousands)				
	1974	1975	Δ% 1974-75	1976	Δ% 1975-76
CLALLAM COUNTY					
Port Angeles 121	265,207.2	288,098.5	+8.6	322,564.1	+12.0
Sequim 323	128,101.5	137,978.4	+77	179,269.4	+29.6

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-13

ASSESSED VALUE - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Indicated Ratios* (Assessed Value/Market Value 1973	1974	1975	Taxable Property Assessed Valuation ($ Thousands) 1974	1975	1976
CLALLAM COUNTY/ PORT ANGELES	40.4	81.6	94.3			
Port Angeles 121				107,143.7	235,088.4	304,177.9
Sequim 323				51,753.0	112,592.4	169,051.0

*Weighted ratio including components for real and personal property

Source: State of Washington, Department of Revenue.

TABLE VII-14

SCHOOL DISTRICT BONDING STATUS - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Bonded Debt 7/1/76 ($ Millions)	Amount Last Bond Issue	Date Passed
CLALLAM COUNTY PORT ANGELES			
Port Angeles 121	3.425	2.700	2/1/76
Sequim 323	1.029	6.8	1955

SOURCE: State of Washington, Superintendent of Public Instruction

TABLE VII-15

SCHOOL DISTRICT TAX RATES - CLALLAM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	TAX RATES-1976 Collections ($/1000 of assessed Valuation) State Levy	Bond Retirement	Special Levy(Local)
CLALLAM COUNTY PORT ANGELES			
Port Angeles 121	3.83	0.51	5.23
Sequim 323	3.83	0.78	-

SOURCE: Tax Assessor's Office/Clallam, Skagit, Whatcom Counties

In Clallam County, assessed value/pupil is not well correlated with the solvency of the district. In 1974-75, Port Angeles had a $26 disparity between revenue and expenditure per pupil and Sequim had a $56 deficit. (See Table VII-11.) Apparently a high proportion of the lands assessed within the district are exempt from special school taxes.

The Sequim district, probably owing to its high proportion of older residents, has consistently been reluctant to incur fiscal obligation either for school operation and maintenance or for new school construction; a bond issue has not passed in 21 years. The 1975 special levy (about $4.6/1000 in calendar 1976 dollars of assessed valuation) would have provided the district with $557,000 in operation and maintenance funds, but it failed both special levy elections since it was not approved by the required 60% of the electorate. Consequently, in 1976 all of the Sequim district operation and maintenance revenues would have had to come from the state school tax (with an exception of the small proportion from federal sources, etc.) and from any funds which could have come from a district reserve fund based in part on local taxes from previous years. By contrast, Port Angeles passed their excess levy for 1976 in the first election which yielded the district $5.23/$1,000 of assessed valuation, and accounted for 58% of the property taxes collected for public school operation and maintenance expenditures.

(2) Water Supply. Water supply for Port Angeles is provided by the city as a municipal service. The sole source of water supply for the city is Morse Creek, a mountain stream three miles to the east. This creek is not large enough to ensure adequate supply to the city in future years; this source is just barely meeting the city's needs at present. Moreover, Port Angeles is involved in a law suit with the Department of Social and Health Services (DSHS) because the waters from this creek violate turbidity and coliform standards. In addition to water quantity and quality problems, the transmission line from the creek to the town is operating at its peak capacity -- 13 million gallons per day (MGD), usually reached in the summer months.

Rates of water usage in Port Angeles are about 900 gallons per residence per day. Much water wastage occurs because Port Angeles is not on a metered system but uses a flat rate of $4.50 a month per residential user. Thus, water consumption rates in Port Angeles are nearly three times the typical consumption rates for a metered system. If the system were metered, average use could be cut to 7 MGD. Peak use would also diminish and the 13 MGD capacity transmission line would then provide ample capacity for serving the town at its present size. Currently, the city has no immediate plans to convert to a metered system.

The Port Angeles water system serves the entire population (16,000) within the city limits. The system also serves a public utilities district (PUD) comprising about 2000 people. Water is sold wholesale by Port Angeles to the district, which then retails the water to its customers. In the rest of the unincorporated vicinity of Port Angeles, residences use individual wells for their water supply; farther away in the county there are small community systems.

As a result of the law suite now pending the judge's decision in the state court, Port Angeles will most likely be required to pursue one of two options: better treatment of their existing source, or an alternate source of drinking water. The first option does not appear viable since Morse Creek is not large enough to supply enough water to justify a large investment in a water treatment plant. Alternative sources of drinking water being investigated by Port Angeles are ground water, the desalination of saltwater, and an infiltration system under the Elwha River. Since ground water reserves in the area are not sufficient for a large municipal well and desalination is extremely expensive, the two most likely alternatives being considered by Port Angeles are the infiltration plant on Morse Creek concurrent with a metered water system which would cut water consumption. According to Mark Spahr of the DSHS, the economics of the latter two choices are about equivalent. However, he favors the Elwha River option because the transmission line could be sized for 30-50 years of capacity, whereas the filtration plant on Morse Creek system would only last about 20 years, even with metered water use without expansion of the 13 MGD delivery pipeline.

Port Angeles' new water source would be financed by a 40% construction grant from DSHS and the remainder by revenue bonds raised by water users in Port Angeles. Water rates would have to be raised to $8 or $9 per month. DSHS has calculated that either the Elwha infiltration or the Morse Creek filtration plant would have a capital cost of $3-3.5 million. Operation and maintenance plus bond redemption would cost the city $0.5 million per year for the life of the bond. Either plant would have 7 MGD capacity and will probably take two to three years to put in operation.

The source of drinking water for the Town of Sequim is the Dungeness River, two miles west of the city. The Town of Sequim now faces similar water supply problems to Port Angeles. The transmission line with a present capacity of 1.8 MGD is undersized. Although the city's water system is now metered, until a year ago water use was not metered and was even higher than that of Port Angeles because the Town of Sequim receives little rainfall and much water was used for sprinkling and irrigation. Although water consumption rates are declining, peak consumption is presently 1.6 MGD, and the system will probably reach capacity in one or two years' time. Sequim is a rapidly growing community due to an influx of retired people. Furthermore, the water supply receives no treatment and has experienced turbidity problems. An engineering study investigated expansion of the town's drinking water supply. The two options identified are infiltration wells (called Rannee wells) on the Dungeness River, or deep municipal wells. The latter appears possible since there are already many residences with individual wells in and around the Town of Sequim.

(3) Wastewater

- City of Port Angeles

The City of Port Angeles operates a primary sewage treatment plant which discharges into Port Angeles harbor. (See Tables VII-16 and VII-17 for statistics on this treatment plant.) The city has an NPDES permit,

TABLE VII-16

WASTEWATER DISPOSAL - SERVICE POPULATION: PORT ANGELES

Basin	Municipal Plant	Unsewered Population[a]	Existing Wastewater Generation Rates: Flow (mgd)[b]	Sewered Population[c]	Flow (gpcd)[d]	Design Population
North Olympic Coastal	City of Port Angeles	0		16,100	143.0	24,400
	Port Angeles Coast Guard Station	NA	ND	ND	ND	ND

a 1975 estimate, within incorporated limits
b Average daily flow for 1975 in million gallons per day
c 1975 estimate
d Gallons per capita per day

NA = not available; ND = no data

Source: North Olympic Coastal Basin Water Quality Management Plan

TABLE VII-17

WASTEWATER DISPOSAL - DISCHARGE LOCATION: PORT ANGELES

Basin	Municipal Plant	Existing Level of Treatment	Discharge Location	NPDES Permit Status: Have Permit	In Compliance	District Upgrading or Expansion Plans
North Olympic Coastal	City of Port Angeles	Primary	Port Angeles Harbor	Yes	No	Plant to be upgraded by July 1, 1977. Morse Creek area to be tied in to Port Angeles as urbanization warrants
	Port Angeles Coast Guard Station	ND	Port Angeles Harbor	Yes	ND	ND

ND = no data

Source: North Olympic Coastal Basin Water Quality Management Plan

but is not in compliance. The city is now conducting a problem survey, identifying infiltration and inflow sources as the preliminary steps in preparation of a facilities plan. Port Angeles' sewage treatment plant will be rehabilitated, upgraded to secondary treatment, and storm water overflow problems corrected if and when grants are made available. Plans will involve an increase in capacity based on population projections for the town. Although a secondary plant is required by July 1, 1977, the upgraded plant at Port Angeles will probably not be completed until 1980 at the earliest. According to Stan Springer, of the Southwest Regional Office of the Department of Ecology, Port Angeles is probably not high on the Department of Ecology's priority list for receiving state grants. The Port Angeles plant is relatively new, well maintained, run efficiently, and has the advantage of relatively deep and good quality receiving water at its outfall. At present the treatment plant at Port Angeles is serving approximately 16,000 people; its design population is approximately 24,000.

- Port Angeles Coast Guard Station

On Ediz Hook, the Coast Guard Station uses a septic tank drain field for sanitary sewage for about 100 people. Although the sewage is not discharged directly into Port Angeles harbor, it reaches the surrounding waters fairly quickly through the small drain field in the highly permeable sand substrate of Ediz Hook.

- City of Sequim

The incorporated City of Sequim operates a .5 MGD secondary sewage treatment plant which discharges into the mouth of Sequim Bay. Because it is now serving almost its design population and the service area population is projected to double between now and the year 2000, plans are being made to extend the sewage treatment and collection system. A development north of Sequim, called Sunland, also requires sewer service; its ultimate planned population is 3000. The City of Sequim has completed a draft facilities plan in which these capacity problems as well as storm water overflow problems are corrected. Two proposals exist to include the community of Sunland in the city's sewer system: one large regional plant of 1.5 MGD capacity, or two separate systems, a 1.0 MGD plant at Sequim with ground disposal at Sunland. Thus, the Town of Sequim sewage treatment capacity could be either doubled or tripled. The expanded system will most likely be completed around 1980 since the facilities plan draft must be approved and grant funds appropriated.

(4) Solid Waste. Three industrial and two general purpose solid waste disposal sites are located within 10 miles of Port Angeles. Peninsula Plywood operates a wood chip dump, ITT Rayonier uses a modified land fill for demolition waste at 13th and M streets, and M&R Timber Company uses a modified land fill for sawmill wastes at 16th and I streets. None of these are sanitary land fills. A general purpose open dump, Blue Mountain dump, is located 10 miles east of Port Angeles and is used by both self-haulers and a refuse contractor in Sequim and the eastern portion of Clallam County. Port Angeles operates a non-fee, self-haul sanitary land fill about four miles from the town. Serving the city and surrounding unincorporated land, the landfill uses small successive

sections of a 60-acre piece of land. No information was given in the Clallam County Solid Waste Management Plan or the Department of Ecology's 303(e) reports as to the expected life times or capacities of any of these disposal sites. Visual eyesore and smoldering problems were cited for the 16th and I streets and Blue Mountain dump, respectively. Although a dark leachate is running into a creek that passes through Peninsula Plywood's wood chip pile, no other problems were mentioned.

(5) Transportation. The two major interstate or state highways serving the Port Angeles area are U.S. Route 101 which passes through both Sequim and Port Angeles, and State Route 112 which follows the northern shoreline of western Clallam County, meeting Route 101 west of Port Angeles. Otherwise, northern Clallam County is served by local roads, such as old Olympic Highway near Sequim, east Mt. Pleasant Road near Morse Creek, and 18th Street near Port Angeles. Old Puget Sound Highway 9G approaches Port Angeles from the south. All of these local roads are "light duty" rural roads.

Both U.S. 101 and State Route 112 have segments that are nearing or exceeding capacity. As would be expected, these congested areas are located closest to the urbanized areas of Port Angeles and Sequim, while the rural portions of both roads (west of Port Angeles) are far below capacity. U.S. 101 in particular exhibits large variations in traffic loading -- the "bottleneck" behavior of rural roads. The section of 101 between Port Angeles and Sequim also contains some two-lane and some four-lane stretches. Overall, the peak loading (in excess of capacity) is found at each end of the segment, nearest the cities of Port Angeles and Sequim. (See Table VII-18 for volume/capacity values of both U.S. 101 and State Route 112.)

TABLE VII-18

HIGHWAY VOLUME/CAPACITY RATIOS - CLALLAM COUNTY

Road No.	Control Section	Volume/Capacity Ratio		
		Maximum	Mean	Standard Deviation
Clallam County				
U.S. 101	0503	2.85	.56	.52
	0504	1.58	.62	.33
	0505	1.40	.69	.26
112	0534	.89	.27	.25

c. Terrestrial Biology

(1) Ediz Hook. The upland vegetation of Ediz Hook is sparse and extremely disturbed. A possible surge/storage area adjacent to the Crown Zellerbach industrial site consists of about 100 acres of vacant, cleared land with a 20-acre lagoon. The vegetation of this parcel is entirely the weedy grassland species characteristic of sites subject to recent clearing or extreme disturbance. The marine shoreline aspect of Ediz Hook biology is discussed in the section on marine biology.

(2) Freshwater Bay - Angeles Point Subalternative. The area between the lower Elwha River and the Port Angeles city boundary comprises approximately 1050 acres; the central third is agricultural land under intensive cultivation, and the remainder is forest. The lands east of the river are in Indian ownership, forming part of the Elwha Reservation. A possible tank farm site is on agricultural land just inland of Angeles Point. The forest land surrounding is a relatively late successional complex of mixed deciduous and coniferous species (refer to the appendix Characteristic Species of Puget Sound Upland Habitat).

The age and relative richness of the forest in the vicinity of Port Angeles is variable from place to place, according to precipitation, soil type, and the recency of disturbance. The area is primarily used for timber production; large parts of the area are nearly pure dense stands of Douglas fir with sporadic clear-cutting scars. It appears that much of the area is subject to a clear-cutting and reforestation program that has been in existence for some time. The more recently disturbed areas appear to contain a higher proportion of shrub and deciduous species.

The Port Angeles plain is intercut by ravines containing several major rivers. The ravines support a lush riparian zone along the bluffs and occasionally on the river bottom depending upon the canyon width.

(3) Green Point Subalternative. There are two subalternatives for an onshore tank farm serving an offshore mooring at Green Point. The flood plain of Morse Creek is approximately 120 acres in extent. It lies on either side of the creek, surrounded by a steep (45 degree or 100% slope) bluff separating it from the railroad right-of-way and minor residential development. The vegetation of the flood plain is grassland with a small zone of riparian growth just at the river mouth before the creek enters the Strait of Juan de Fuca. The bluff consists of somewhat dense shrubby and riparian vegetation.

A tank farm site at Green Point itself is an area of woodland, approximately 175 acres in size, just east of Green Point and Siebert Creek. The area has about a 3% slope with northeast exposure and is bounded on the south by the railroad right-of-way. Siebert Creek to the east has carved a shallow, relatively broad stream channel with sides sloping at about 25%. To the east of the channel is a residential area between the railroad right-of-way and Gherke Road. There is a very small marsh at the mouth of Siebert Creek. The woodland on the tank farm site is a relatively well developed, late second-growth forest of mixed coniferous and deciduous tree species. Dominant trees include Douglas

fir, western red cedar, big leaf maple, and vine maple. The forest is relatively mature. It appears to have been undisturbed for close to 100 years, and it does not appear to have been greatly affected by the residential development occurring to the east of Siebert Creek.

d. Air Quality

Air quality at Port Angeles is generally good due to strong ventilating winds along the Strait. Although sulfur oxide and particulate emissions from forest product and paper industries have caused significant violations, current abatement programs seem to be reducing the potential for violation of air quality standards for those pollutants. (See Tables VII-19 and VII-20.) Detailed assessment of air quality impacts of industrial emissions in Port Angeles is hampered by lack of monitoring data.

The location of Port Angeles on the Strait of Juan de Fuca indicates that the area has significant capacity to dissipate pollutants. Other urban areas are more than 60 miles downwind, and the air flow channeled through the Strait of Olympic Range does not impact any enclosed plains or valleys. Thus, the typical effect of industrial emissions is moderate. It is likely that only with conditions of strong inversion, with light or variable winds, do the heavy concentration of sulfur oxides emitted by industry create excessive concentrations within the City of Port Angeles. In this regard, the close proximity of the residential portion of the city to major industry and the only deepwater anchorage at the port is a drawback. The probability of strong inversions with oxidant producing conditions is low at Port Angeles. No oxidant is available to indicate the magnitude of any current oxidant experience.

e. Water Quality/Marine Biology

Port Angeles is located in the north Olympic Coastal Basin (see Table VII-21). The dominant beneficial uses in these waters are log storage and navigation. There are fewer aquatic resources in and around Port Angeles harbor. Pacific oyster culture, clam beds, and crab are present (DNR Marine Atlas, 1974). However, an Army Corps of Engineers EIS for an erosion control project on Ediz Hook states that shellfish and waterfowl are neither abundant nor important in the Ediz Hook area itself. The Marine Atlas further indicates a major waterfowl area and sports and commercial bottom-fishing as well as sport and commercial salmon fisheries. No endangered species are known to occupy Ediz Hook.

Four industrial dischargers and one municipal discharger use Port Angeles waters. ITT Rayonier discharges 35.7 MGD of waste liquid and backwash waste into port waters. Peninsula Plywood discharges only 0.1 MGD of glue waste, while Crown Zellerbach discharges 9.7 MGD of cooling water and drainage and blowdown waste containing zinc and fiber into port waters. Atlantic Richfield discharges oil separator effluent when there has been an oil spill into Tumwater Creek which is a tributary to Port Angeles. The City of Port Angeles also discharges 2.3 MGD of primary effluent into port waters.

TABLE VII-19

ANNUAL EMISSION FROM ITT RAYONIER AND CROWN ZELLERBACH - PORT ANGELES

Data Source	Emissions (tons per year)				
	Particulate	SO_2	NO_x	HC	CO
EPA Region X	2200	5200	1600	200	4000
Washington State Dept. of Ecology Report 1974	2196	4077			
Teknekron*	1407	3891	1425		
ITT Rayonier	641	2490	695		
Crown Zellerbach	766	1401	730		

* Combination of boiler data from John Rosene (Olympic APCA) and process data from Gary Rothwell (Washington State Department of Ecology). Compiled by Erwin Kauper, Teknekron Associate.

Source: Teknekron, 1976.

TABLE VII-20

AIR MONITORING DATA - PORT ANGELES

PARTICULATES

	24-hour maximum (ug/m^3)	Occurrences 24-hr Avg. Exceeding 260 ug/m^3 (Federal)	150 ug/m^3 (State)	Annual Geometric Mean* (ug/m^3)
1974				
Police Station	187	0	2	70
Hospital	108	0	0	45
1975				
Police Station	212	0	2	66
Hospital	208	0	2	43
Pool Site (5 mo.)	105	0	0	42
1976				
Hospital	110	0	0	42
Pool Site	112	0	0	40
City Light	217	0	5	72

*Federal Standard is 75 ug/m^3

State Standard is 60 ug/m^3

SULFUR DIOXIDE

	Annual maximum hourly average	# hours > 40 pphm	Annual maximum 24 hour average	Annual Average
3rd at Chesnut (3 Mo.) 1976	98	5	21	2

Source: State of Washington, Department of Ecology.

TABLE VII-21

WATER QUALITY - PORT ANGELES

NORTH OLYMPIC COASTAL BASIN - WATER RESOURCE INVENTORY AREA 18 AND 19

Existing Water Quality (not ranked for severity of problems)

Segment 07 - Port Angeles Harbor: Class A, effluent limited. A "special coliform condition" is in effect, otherwise good water quality.

Segment 08 - Port Angeles Harbor Tributaries: Class A, water quality limited. No water quality data available. Water quality limitation due to non-point source runoff. ARCO and ITT also discharge into this segment (Ennis, Tumwater Creeks).

Segment 15 - Strait of Juan de Fuca: Class AA, effluent limited. No water quality data available however Class AA Standards are considered applicable.

Issues

Urban and forestry practice runoff make tributaries' water quality limited. In the Harbor, coliform violations appear to be main water quality issue.

Beneficial Uses

Log storage
Navigation
Recreation
Salmonid rearing

Aquatic Resources

Pacific Oyster Culture
Subtidal clam beds (4+ types)
Salmon fishery (5+ species)
Crabs
Bottom-fishing, sport and commercial
Major waterfowl area
(Shellfish and waterfowl minor in abundance and importance on Ediz Hook)
No known endangered species

Public Recreation/Protected Areas

State tidelands
Ediz Hook City Park of Port Angeles
Ediz Hook underwater recreation area

Discharges Within 10 Miles of Marine Terminal

Discharger	Quantity (mgd)	Effluent
ITT Rayonier	35.7	Waste liquor (sulfides), backwash waste
Peninsula Plywood	0.1	Glue waste (settled and screened)
Crown Zellerbach	9.7	Zinc, fiber; cooling water
ARCO	?	Oil separator effluent
City of Port Angeles	2.3	Primary effluent

Sources: Department of Ecology, State of Washington, 303(e) Water Quality Management Plan - North Olympic Coastal Basin, October 1975; Department of Natural Resources, State of Washington Marine Atlas, 1974; Department of Ecology, State of Washington, Fauna Survey, 1975.

The three segments comprising the receiving waters for the Port Angeles site are not ranked by the Department of Ecology for severity of water quality problems. The Port Angeles harbor segment has Class A waters and is effluent limited; it has good water quality although a "special coliform condition" is in effect. The Strait of Juan de Fuca just outside the port has Class AA waters, although no water quality data is available. The tributaries to Port Angeles, Ennis and Tumwater Creeks are classified as Class A waters but are water quality limited due to the nonpoint source runoff of forestry and urban development. No water quality data are available for the waters.

Sensitive areas to be protected from pollution in the Port Angeles area include the Ediz Hook underwater recreation area and city parks, as well as state-owned tidelands. However, Port Angeles harbor is zoned commercial by the Department of Natural Resources. The main water quality issues in Port Angeles area waters appear to be the violation of coliform standards in the harbor and the polluted runoff from the harbor's tributaries. The coastal environment of the Strait of Juan de Fuca is less sheltered than that of the inner Sound, and the degree and diversity of biological activity are less. Numerous small coves and river mouths dot both sides of the Strait, and on a small scale these provide an important habitat for anadromous fish (salmon and steelhead), herring, and shellfish. These include the Grey Wolf, Lyre and Dungeness Rivers, and Discovery and Sequim Bays. These habitats are limited in extent compared to those of the inner Sound, and their regional biological significance is proportionately less. The exposed beaches and intertidal zones are not noted for unusual or abundant marine life. The Dungeness National Wildlife Refuge, 12 miles east of Port Angeles, serves as a migratory bird refuge and as harbor seal habitat.

2. March Point/Anacortes - Skagit County

March Point is a small peninsula extending into Padilla Bay from the isthmus that connects Fidalgo Island with the mainland portion of Skagit County. The peninsula is presently the site of two major refineries -- Shell and Texaco -- as well as several smaller industries providing support for the petroleum refineries. The City of Anacortes (population of 8000) lies two miles to the west across Fidalgo Bay. The anchorage off March Point is sheltered Padilla Bay, approached via the Guemes Channel and Rosario Strait. The anchorage at Anacortes and March Point is moderately deep with protection from prevailing storm winds and waves. The economy depends on petroleum as well as on traditional Puget Sound resources -- timber and fisheries. The broad flood plain of the Skagit River to the east separates March Point from the urban centers of Mount Vernon and Burlington, 12 miles distant along Interstate 5. The nearest large city is Bellingham, 35 miles to the northeast. (See Figure VII-3.)

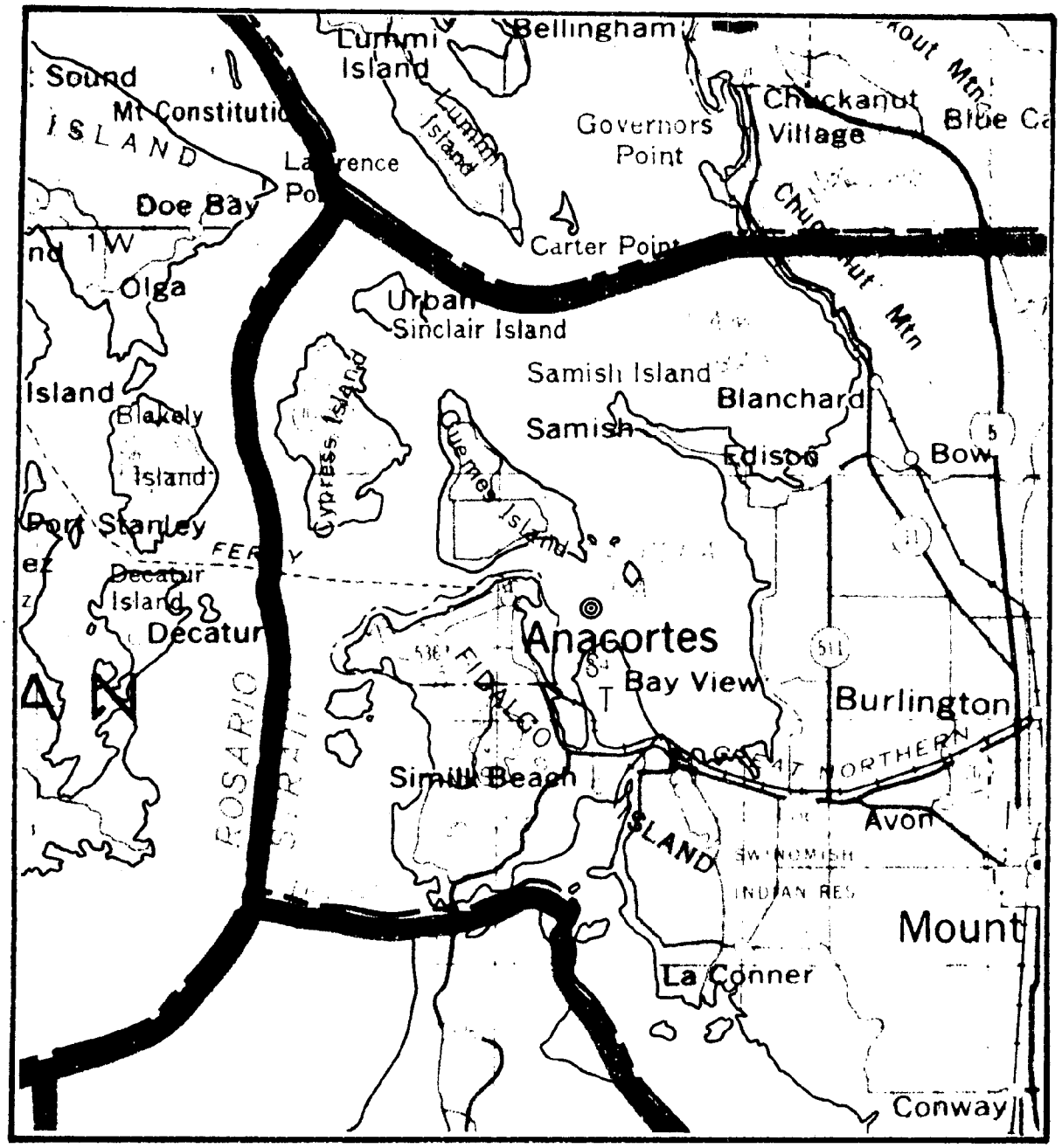


FIGURE VII-3 LOCATION: MARCH POINT

a. Land Use

(1) Regional. A portion of Skagit County lies within the sphere of influence of petroleum development projects or their associated population growth. The level of activity expected from the scenarios considered in this study is small, however. The area of possible impact includes the Island's district, parts of the Skagit flood plain, the Mount Vernon area, and possibly the Burlington/Bayview area (definition of these areas is given in the Skagit County Comprehensive Plan). Within the area potentially affected, Table VII-22 shows that the vast majority of acreage is either in agriculture (45%) or in timberland (46%). Only a small proportion (5%) of the total land area is currently residential development, about 6400 acres. The great majority of industrially developed land in Skagit County is the March Point refinery complex, which accounts for 84% of the present industrial land use in the affected portion of Skagit County. The other industrial development is oriented toward either agriculture (fertilizer manufacturing plant) or the forest products industry. Industrialization accounts for only 1.4% of all potentially affected lands in western Skagit County, and only 4.4% of all acreage in the Island's district.

In comparison to other parts of the county, agriculture is a highly conspicuous land use in the affected zone because of the abundance of fertile flat land lying in the flood plain of the Skagit River. Water is so plentiful in the soil that most crops are dry farmed and there is no need for irrigation water, even in summer. In terms of gross dollar value, agriculture is the most important economic activity in Skagit County.

Within the incorporated boundaries of the City of Anacortes, the major land use is residential; 67% is developed as residential dwelling units. There is no true agriculture practiced within the city boundaries. The closest zoning category is "rural suburban" or "vacant" which is wood lots or timberland lying in small parcels and accounts for 25% of the total city acreage. March Point lies outside of the city limits.

- Land Values

Within Skagit County, land available for residential use is concentrated around the urban centers -- Anacortes, Mount Vernon, Burlington -- and in smaller communities such as La Conner and Sedro-Woolley. In the urban centers, residential land is generally sold in parcels of one-quarter acre at a cost of $6,000 to $10,000 for the parcel ($24,000 to $40,000 per acre), depending on factors such as location with respect to commercial centers and view quality (Table VII-23). Within the last five years, residential land values have increased at the rate of about 11% per year due to the combined effects of inflation and strict zoning which tightly defines the residential development area. Agricultural land now commands a price of between $1,800 and $2,500 per acre. The lower figure is for boot bottom land in the best upland location where the potential uses are the least restricted. The price of agricultural land has tended to stabilize at the present value because of the extensive application of the open space taxation law in Skagit County. Ninety percent of all agricultural land (90,000 acres) are protected from "true and fair value" taxation and thereby from speculation detrimental to their productivity.

TABLE VII-22

LAND USE - ACREAGE - SKAGIT COUNTY

Activity Zone	Residential	Industrial	Agricultural	Timber	Commercial	Other
Skagit County (1973)	9,488 (1.7%)	954 (0.2%)	106,760 (19.3%)	426,088 (77.1%)	815 (0.1%)	6,483 (1.2%)
						Community and Public 2,007 (0.4%)
Portion of Skagit Co. Potentially Affected by Project Scenarios	6,380 (4.9%)	1,780 (1.4%)	56,650 (45.4%)	60,200 (45.8%)	810 (0.6%)	2,490 (1.9%)
						Community and Public 710 (0.5%)
Anacortes (1976)	3,200 (67%)	300 (6%)	0	0	100 (2%)	1,200ac (vacant) (25%)

Source: Skagit County Comprehensive Plans, Islands District, Skagit River Floodplain and Related Uplands; Anacortes Comprehensive Plan, 1977.

TABLE VII-23

LAND VALUES - SKAGIT COUNTY

	Residential			Agriculture		Timber
Activity Zone	Value/Acre	Parcel Size	Trend	Value/Acre	Acreage in RCW 84.34	Value/Acre
Skagit County	24,000/ac 40,000/ac	¼ acre	Rise in residential land values (11%/year) due to inflation and scarcity owing to strict zoning.	1,800 (bottom land) 2,500 (best upland)	90,000 (90%) ac	$60-132/ac depending on soil type and access
Anacortes	27,200/ac (central city) 163,350/ac (prime waterfront location)	1/5 acre	6.8% annual inflation rate in land values.	No real agriculture in City Zoning category "rural suburban" is timberland in small parcels.		

Source: Skagit County Assessor; Skagit County Planning Department; Anacortes City Manager.

Within the City of Anacortes, residential development is at a slightly higher density; parcel sizes are one-fifth acre with the cost per acre ranging between $27,200 in the central city to an extreme high of $163,300 for a prime waterfront location. Figures given by the city manager of Anacortes indicates that the last several years have seen a 7% annual inflation rate in residential land cost, similar to the rate of general inflation in the United States, but below the inflation of land prices in most urban areas.

The town of Mount Vernon, county seat of Skagit County, has been one of the fastest growing areas in the county and, hence, serves as a model for residential land costs within this region. Mount Vernon is also the preferred location for urban growth in Skagit County. This municipality sustained an average annual growth rate four times that of Anacortes in the interval from 1970 to 1976 and has a current population of 10,300 compared to 8000 in Anacortes (see Table VII-24).

- Land Use Trends - Planning Perspective

The State Office of Program Planning and Fiscal Management (OPP&FM) predicts only very moderate growth for Skagit County between now and the year 2000 (0.1% per year). The economic mainstays of the county are agriculture, forestry, and tourism, and these are expected to continue with the assistance of planning and zoning policies which encourage and perpetuate these activities. Growth in the last six years countywide was estimated by the OPP&FM to be occurring at an average on only 0.5% per year (see Tables VII-25 through VII-27).

Specific policies in the 1975 Comprehsnive Plan for the parts of Skagit County which are the most critical to the determination of future land use as relevant to induced development from oil projects are as follows:

1. The existing agricultural pasture and forestry land, especially those in flood plains are to be protected from other forms of development. The prime agricultural land should be protected by encroachment by more intensive uses.

2. Agriculture areas should receive protection from the 20-year flood.

3. The open space taxation laws of 1970 and 1973 should be retained as viable methods of land use control.

4. The urban areas should grow first by infilling development on vacant land at existing densities of development prior to the extension of the urban boundary.

5. Planned unit development should be utilized where possible to cluster neighborhoods and create open space within residential areas.

TABLE VII-24

POPULATION GROWTH - SKAGIT COUNTY

Activity Zone	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1970/76 (6 year) Ann. Av.	1976 Population
Skagit County	+0.6%	+0.4%	+0.2%	0	+0.8%	+1.3%	+0.54%	54,100
Anacortes	+0.8%	+0.4%	+0.1%	+0.1%	+1.7%	+0.9%	+0.7%	8,010

*Population Growth Rate 1970/76 Source: Washington State Office of Program Planning and Fiscal Management/Population Studies Division.

TABLE VII-25

GROWTH TRENDS AND PLANNING PERSPECTIVE - SKAGIT COUNTY

Activity Zone	Growth Trends/Planning Perspective
Skagit County	Most growth is in incorporated areas. "Hot spots" are east of Mt. Vernon and at Shelter Bay on the Swinomish Indian reservation.
Anacortes	Growth trend is toward retirement community. Future growth in workforce-population sector depends on oil and other industry future. Proposed pulpmill - 100 employees. Proposed fish processing plant - 200/300 employees.

Source: Skagit County Planning Department; City of Anacortes, City Manager.

TABLE VII-26

COMPONENTS OF POPULATION CHANGE 1970-76 - SKAGIT COUNTY

April 1, 1970 to April 1, 1976

POPULATION				COMPONENTS OF CHANGE			
1970	1976	Change Number	%	Births	Deaths	Natural Increase	Net Immigration
A	B	C (=B-A)		D	E	F (=D-E)	G (=C-F)
52,381	54,100	+1719	3.3	4,704	3,431	1,273	446

Source: Taken from Table 10, State of Washington Population Trends, 1976. Population Studies Division; Office of Program Planning and Fiscal Management.

TABLE VII-27

OFFICIAL POPULATION PROJECTIONS - SKAGIT COUNTY

	PROJECTED POPULATION						
ACTIVITY ZONE	1975	1975 Actual	1980	1985	1990	1995	2000
Skagit Co.	52,700	53,400	52,950	53,200	53,500	53,700	54,000

SOURCE: State of Washington, Office of Program Planning and Fiscal Management Official Estimates August, 1972

6. High density residential development in appropriately zoned areas should only occur when all urban services are available.

7. A significant degree of low-density urban development should only occur when such uses do not interfere with resource production or extraction activities on the land.

8. "Unilateral and independent actions of the Swinomish tribal community are inconsistent with this comprehensive plan for the island's area and Skagit County. Industrial, commercial, and residential development on the Seinomish Reservation should be coordinated with the plans and policies of Skagit County government...."

9. The zoning shall be revised to conform with the comprehensive plans.

10. The tourist industry and recreational activities should be enhanced, partly to add to the economic base of the island's area.

11. Plans for new population utilities (sewer services, water, solid waste) should be coordinated on a regional basis to attain a more efficient, equitable, and economic system of service for all the communities involved (Skagit County land use policies specific to the coastal zone environment will be discussed under impact for each industrial site).

A new comprehensive land use plan has been completed in draft for the City of Anacortes. The plan is geared toward development in the existing residential areas at a very slow to moderate rate between now and the year 2000 and some supporting industrial development in the waterfront zone, including the Port of Anacortes. The last six years has seen a growth rate in Anacortes roughly comparable to the countywide rate with a slowdown between 1971 and 1974 due to economic recession and with a modest recovery since that time. The city manager of Anacortes indicated that the development trend for the city is primarily as a retirement community. Retirement living and the recreational opportunities afforded by Fidalgo Island are the attraction for a relatively low level of population growth and the tourism industry. A more rapid rate of residential growth in this city could be keyed to oil industry and other industrial development in the nearby industrial zones (March Point) and in the waterfront area. Presently, roughly half of the industrial work force at March Point resides within the City of Anacortes. As of now several industrial projects are proposed for a fill site on Fidalgo Bay directly opposite the March Point Oil Refinery, assisted by federal urban redevelopment monies. These include a sawmill and fish processing plant; the latter would employ 200-300 persons. Other development proposals for the Anacortes City industrial zone include a pulp mill and a plywood mill, each of which would employ on the order of 100 persons.

The rate of population growth in residential development in Anacortes proper and in the surrounding areas depends upon the fruition of such potential sources of employment. This city which now contains 75% of the total population on Fidalgo Island will probably experience the greatest growth effects since the existing urban areas can more readily provide the framework of municipal services to serve the growth. In addition, the Skagit County's restrictive policies with respect to outlying low-density urban development would tend to discourage a high degree of scattered residential growth in the unincorporated portions of the island.

Also significant, the proportion of growth provided by industrial employment as opposed to retirement will affect the age structure of the community and its economic prosperity, both of which influence public policy. The economic future of Anacortes and particularly its recovery from a slow period in the early 1970s would seem to depend most heavily on the introduction of new industries such as those proposed which both add directly to the tax base and to the area's employment. Decisions regarding future land use at the city level would thus tend to be favorable to industrial development and associated residential growth, including the oil industry which now provides employment for about 13% of the families in Anacortes. The city would probably show a preference for industrial proposals actually within its municipal boundaries since only the latter contribute to the city's tax base. Expansion on March Point would not benefit municipal finance directly.

(2) Specific Petroleum Development Industrial Sites

- March Point

Land use in the industrially zoned area of March Point is dominated by the refinery sites for Shell Oil and Texaco Oil companies, which own virtually the entire area of the peninsula forming March Point. For both Shell and Texaco, approximately 250 acres is intensively developed as the refinery site -- paved areas, structures, and access roads. The remainder of the land is fallow grass land or pasture land with pockets of second-growth woody vegetation. Both refineries have their main plant on the coastal plain with access roads leading to their offloading facilities at Padilla Bay and their storage tankage at higher elevation to permit petroleum and product movement by gravity flow. The major effect of present and future oil industrial development at March Point concerns the the coastal zone and the near-shore marine environment, particularly in the light of the coastal zone management program now in effect in Washington.

The primary concern is the future productivity of Padilla Bay conflicting with its potential use as the terminal site for offloading petroleum and as a potential land area for possible industrial expansion by filling. The tideland in Padilla Bay, lying west of the center of the Swinomish Channel and north to March Point, is designated as "industrial reserve" in the Skagit County Comprehensive Plan for the Island's district. The current status of this land in the plan is to allow industrial development of that area of tideland when the need is adequately demonstrated, all other alternative sites are exhausted, and the development of the area is the total project leaving no room for subsequent further encroachment on

the tidelands on a piecemeal basis. The county policy further specifies that aquaculture should be encouraged in Padilla Bay and that future filling activities should be conducted so as to preserve the ecological balance in the area.

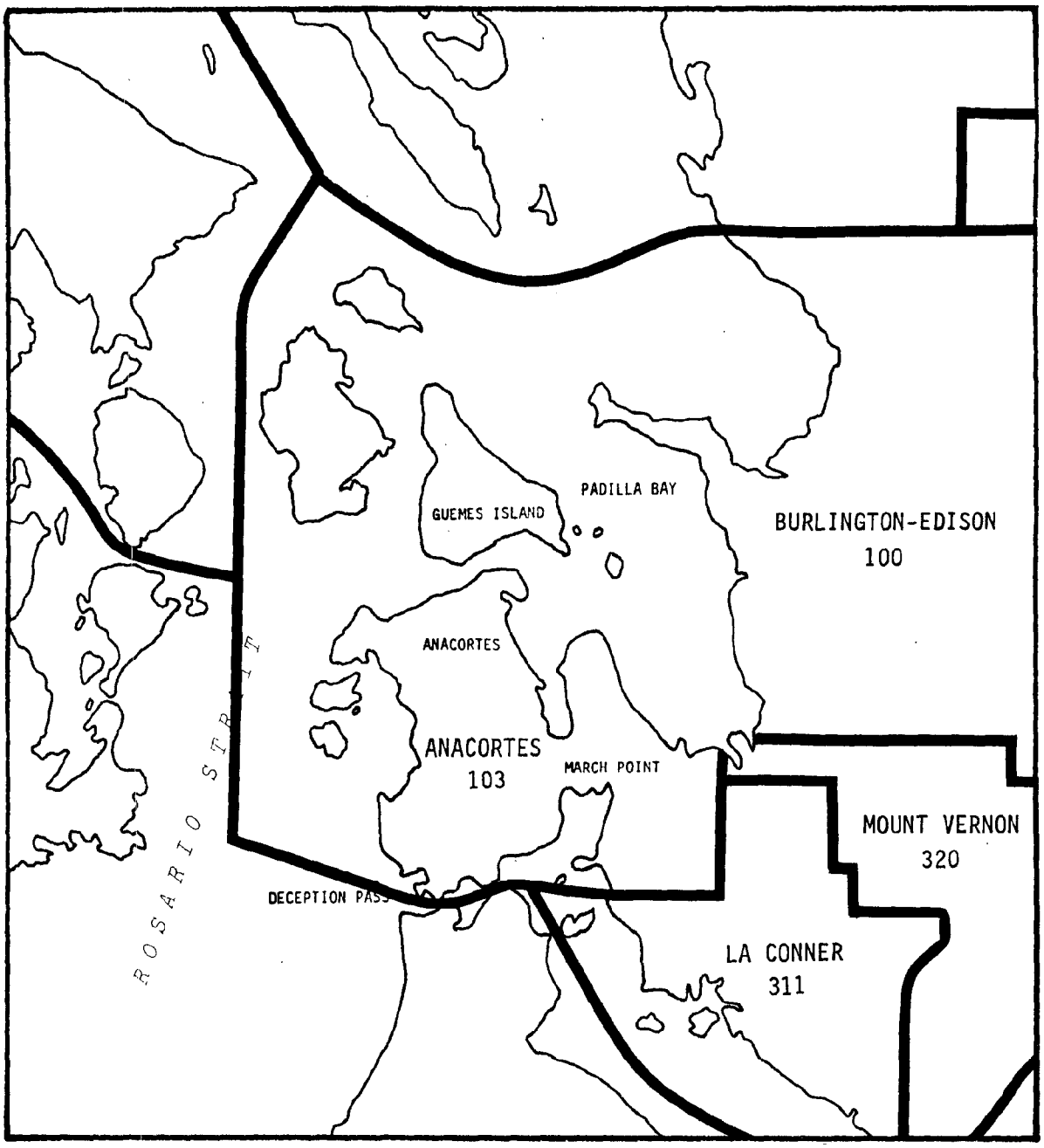
- Burrows Bay

Since Burrows Bay has been identified as a possible alternative terminal site for oil transshipment with a connecting pipeline leading across Fidalgo Island, land use in the zone potentially affected is briefly described. No scenario involving Burrows Bay is assessed in this study. Land use in this heavily wooded area is very low-density residential. There are a number of home sites at the top of the steep cliff adjoining Burrows Bay, obviously selected for both view quality and privacy. The rural homesites lying in the vicinity of the potential pipeline route are either small farms or family or retirement residences oriented toward the isolation and recreational opportunities afforded on Fidalgo Island. There are several lakes on the island, extensive forest lands, and Deception Pass State Park at the south end of the island which is one of the most heavily used recreational spots in the state.

b. Infrastructure

(1) Schools. Four school districts within Skagit County may be affected by population growth associated with petroleum industry employment at March Point: Anacortes, La Conner, Mount Vernon, and Burlington-Edison (see Figure VII-4). Anacortes and Burlington-Edison have experienced an overall decline in enrollment over the last two years (8.6% and 2.6%, respectively), while the other two have experienced very modest growth (La Conner with 6%, and Mount Vernon with 1%). In Skagit County, the decline or very slow growth in school enrollment is largely attributable to the declining birth rate, since school enrollment generally grew more slowly than the population of these areas, where growth was also due to net in-migration. For example, while the City of Mount Vernon had an 8.1% increase in population between 1974 and 1975 and an overall annual increase of 3.2% over the interval 1971-76, this was not reflected by a corresponding increase in public school enrollment, which increased by only 1% per year over the same period (see Table VII-28). The 1.8% annual decrease in Anacortes district enrollment over this interval in the face of its 0.7% rate of annual population growth is due to both the effects of declining birth rate and of advancing age structure of the community, as retired people become a higher proportion of the total residents (see Tables VII-29 through VII-31).

Of the four school districts, only Anacortes is still operating with excess capacity. Based on current space standards, the Anacortes district could still provide enrollment for an additional 400 students (19%) without experiencing overcrowding of facilities (Table VII-30). In contrast, the three other districts are presently 3-21% over capacity. Burlington-Edison is in the least favorable position with an existing 550 student excess. None of the four districts is augmenting space by using portable classrooms.



0 2 4 6 mi
0 3 6 9 km

NORTH

SOURCES:
State of Washington, Superintendent of Public Instruction, "Boundaries of the 303 School Districts in Existence on October 15, 1976".

FIGURE VII-4 SCHOOL DISTRICTS: MARCH POINT

TABLE VII-28

SCHOOL DISTRICT HISTORICAL ENROLLMENT - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Historical Enrollment (October 1) 1971	1972	1973	1974	1975	Total (K-12) 1976	Percent Change 1971-76	Percent Annual Change (Exponential)
SKAGIT COUNTY								
Anacortes 103	2357	2347	2312	2217	2207	2154	-8.6	-1.8
LaConner 311	480	468	462	496	529	509	+6.0	+1.2
Mt. Vernon 320	3187	3168	3133	3118	3241	3220	+1.0	+0.2
Burlington-Edison 100	2731	2738	2706	2668	2651	2661	-2.6	-0.5

Source:State of Washington, Superintendent of Public Instruction

TABLE VII-29

CURRENT ENROLLMENT AND AVERAGE DAILY ATTENDANCE - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Current Enrollment (October, 1976)			1976 Total (K-12)	Average Daily Attendance 1975-76
SKAGIT COUNTY					
Anacortes 103	1026 (K-6)	549 (7-9)	579 (10-12)	2154	2026
La Conner 311	321 (K-8)		188 (9-12)	509	463
Mt. Vernon 320	1570 (K-6)	487 (7-8)	1163 (9-12)	3220	2988
Burlington-Edison 100	1796 (K-8)		865 (9-12)	2661	2488

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-30

SCHOOL DISTRICT EXISTING CAPACITY - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Satisfactory Existing School District Capacity 1976	Capacity Remaining Absolute Number of Pupils	Percentage	Temporary Facilities (1975-76 Inventory)
SKAGIT COUNTY ANACORTES/MARCH POINT				
Anacortes 103	2554	+400	+18.6	-
LaConner 311	496	-13	-2.6	-
Mt. Vernon 320	2966	-254	-7.9	-
Burlington-Edison 100	2110	-551	-20.7	-

Source: State of Washington, Superintendent of Public Instruction.

TABLE VII-31

SCHOOL DISTRICT CERTIFICATED STAFF RATIOS - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Teachers				Other**			
	High School	Jr. High School	Middle School	Elem. School	High School	Jr. High School	Middle School	Elem. School
SKAGIT COUNTY/ ANACORTES/MARCH PT.								
Anacortes 103	44.99	45.49	-	44.91	8.83	7.71	-	5.15
La Conner 311	57.42	-	-	41.36	9.88	-	-	7.14
Mt. Vernon 320	Same as Port Angeles							
Burlington-Edison 100	Same as Anacortes							

*FTE = Full Time Equivalent

**Other = School Administrators, Supervisors, and Support Services

SOURCE: State of Washington, Superintendent of Public Instruction

The excess capacity in the Anacortes district is due to school construction over the last five years and was made possible by $3.5 million in capital expenditures. School construction in a district with declining enrollment implies that the new facilities are intended to deal with previously existing space shortages, and that modest increases in enrollment are expected over the next 5-10 years. The Burlington-Edison district has expended $1.04 million since January 1, 1971 on new facilities development, which should relieve the majority of the present overcrowding once the new facilities are completed. Neither Mount Vernon nor La Conner district has expended any funds for capital development since the end of 1970, but the latter passed a $225,000 bond issue in May 1974, which should soon be reflected in increased capacity. Mount Vernon has not passed a bond issue since 1964.

The total market value of real and personal property for all four districts has increased rapidly since 1974 owing to the revaluation and new construction. Of the four districts, Anacortes and La Conner showed the greatest increases (1974-76); Mount Vernon and Burlington-Edison both showed only a 3-4% increase the first year and then jumped by over 20% the second. (See Tables VII-32 through VII-36.)

Among these four districts the assessed valuation per pupil is correlated with the district's ability to pay its way. For school year 1974-75 (for which data were available), Anacortes and La Conner had revenues per pupil which exceeded their expenditures per pupil, and also had assessed valuation/pupil significantly higher than the other two districts. Both Mount Vernon and Burlington-Edison had a deficit that year between revenue and expenditure (Mount Vernon with $-18/pupil and Burlington-Edison with $-77/pupil).

As of July 1976, excess bonding capacity remained in all the districts. Mount Vernon district has excess bonding capacity of over $8 million since it has not passed a bond issue since 1964 and has only $0.13 million of bonded debt remaining. Anacortes has an additional $10.9 million of bonding capacity and has recently incurred $2.0 million of its $3.25 million in indebtedness through the passage of a bond issue in 1975. La Conner's $0.885 million in remaining capacity reflects the small population of the district as well as the loss of potential revenue producing lands to agricultural preserves.

The relative contribution of the different revenue sources varies markedly for these four Skagit County school districts. The wealthiest, Anacortes, received slightly over half its revenue (1974-75) from local taxes, about one-third from the state, and about 5% federal funding. La Conner, the smallest, received one-third of its revenues from local taxes, a third from the state, and one-quarter from federal sources. Burlington-Edison, the poorest and operating with the largest deficit, received one-fourth of its revenue from local taxes, 58% state assistance, and about 8% federal grant money. Mount Vernon district, with a relatively small deficit per student, received about a third of its operating revenue from local taxes, slightly over half from the state, and only 4% federal money.

TABLE VII-32

TAXABLE PROPERTY - MARKET VALUE - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Taxable Property Total Market Value ($ Thousands) 1974	1975	Δ% 1974-75	1976	Δ% 1975-76
SKAGIT COUNTY					
Anacortes 103	260,863.2	311,233.4	+19.3	368,984.1	+18.6
La Conner 311	33,054.9	37,314.6	+12.9	43,471.2	+16.5
Mt. Vernon 320	172,546.7	179,097.1	+3.8	215,065.8	+20.1
Burlington-Edison 100	129,381.7	133,663.4	+3.3	161,109.3	+20.5

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-33

ASSESSED VALUE - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Indicated Ratios* (Assessed Value/Market Value 1973	1974	1975	Taxable Property Assessed Valuation ($ Thousands) 1974	1975	1976
SKAGIT COUNTY ANACORTES/MARCH POINT	44.8	91.1	82.4			
Anacortes 103				116,866.7	283,533.6	304,042.9
LaConner 311				14,808.6	33,993.6	35,820.3
Mt. Vernon 320				77,300.9	163,157.5	177,214.2
Burlington-Edison 100				579,630.0	121,767.4	132,754.1

*Weighted ratio including components for real and personal property

Source: State of Washington, Department of Revenue.

TABLE VII-34

SCHOOL DISTRICT REVENUE AND COST - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	SOURCES OF REVENUE - 1974-75 (% of total)					REVENUE VS COST ($) 1974-75			
	Local Taxes	County Admin. Funds	State Funds	Federal Funds	Other*	Market Value per Pupil	Revenue per Pupil	Expenditure per Pupil**	Net Cost per Pupil**
SKAGIT COUNTY/ ANACORTES/MARCH PT.									
Anacortes 103	54.62	2.88	32.26	5.26	4.98	127,091	1585	1509	1326
La Conner 311	32.53	2.65	33.67	25.91	5.24	68,535	1665	1596	1259
Mt. Vernon 320	31.97	3.80	53.57	4.30	6.36	52,327	1231	1249	1127
Burlinton-Edison 100	25.21	3.61	57.82	8.12	5.24	45,640	1305	1382	1120

Source: State of Washington, Superintendent of Public Instruction

*Other=Local non-tax revenue, non-revenue receipts, and payment from districts.

**See text for explanation of difference between expenditure and net cost.

TABLE VII-35

SCHOOL DISTRICT BONDING STATUS - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Bonded Debt 7/1/76 ($ Millions)	Amount Last Bond Issue	Date Passed
SKAGIT COUNTY ANACORTES/MARCH POINT			
Anacortes 103	3.254	2.920	1975
LaConner 311	.815	.225	5/1/74
Mt. Vernon 320	.130	.280	1964
Burlington/Edison 100	1.580	.900	12/72

SOURCE: State of Washington, Superintendent of Public Instruction

TABLE VII-36

SCHOOL DISTRICT TAX RATES - SKAGIT COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	TAX RATES-1976 Collections ($/1000 of assessed Valuation)		
	State Levy	Bond Retirement	Special Levy(Local)
SKAGIT COUNTY			
ANACORTES/MARSH POINT			
Anacortes 103	4.402	.484	4.723
LaConner 311	4.402	3.867	6.856
Mt. Vernon 320	4.402	6.009	5.798
Burlington-Edison 100	4.402	1.883	6.032

SOURCE: Tax Assessor's Office/Clallam, Skagit, Whatcom Counties

All four districts passed their special levy appropriations in 1975 (for taxes collected in calendar 1976) in the first election. As a result each district collected between $4.7 and $6.8/$1,000 of assessed valuation via the local excess school levy which, matched by the $4.402/$1,000 collected by the state, accounted for between 52% and 61% of all property taxes collected for public school operations.

(2) Water Supply. The sole source of drinking water for the City of Anacortes is the Skagit River. Anacortes operates a water treatment filtration plant very near the City of Mount Vernon. The plant's design capacity is 33 MGD, but it actually produces only 18 MGD of treated water of which 90% is used by industry. The City of Anacortes uses about 1.8 MGD or about 10% of the plant's water production. This same filtration plant also supplies drinking water to several others in the vicinity of Anacortes, including the Town of La Conner, five to six miles south of the Mount Vernon-Anacortes Road. The Skagit County Public Utilities District buys water from Anacortes and retails it both on Fidalgo Island and to the scattered population between Mount Vernon and Anacortes. In addition, the communities of Oak Harbor and the Naval Air Station on Whidbey Island both buy water from the Anacortes plant. Because water supply distribution is so complex in the Anacortes area, the DSHS Seattle office has proposed that Anacortes directly supply all of Fidalgo Island. The county PUD would then restrict service to the mainland west of Mount Vernon.

While there are no problems with capacity of this plant to serve the population in the area, pipelines from this plant cannot always be sent out to outlying communities because the pipes in its present distribution system are too small. Anacortes has received a federal HUD Community Development Act grant to upgrade its pipe system. Other than this program, no expansion in the Anacortes plant is planned for the near future.

Inside the city limits of Anacortes no wells exist because none are allowed. Building permits are simply not granted to people inside city limits who do not currently receive city water; they will be forced to wait until the pipe system is upgraded. In outlying rural areas, individual wells exist and are sufficient for families with five-acre tracks. In addition, some small community water systems on Fidalgo Island obtain water from small community wells or buy their water from Anacortes via the county PUD for subsequent distribution to their own members.

The consumption rate of Anacortes' drinking water is a fairly typical 100 gallons per person per day (G/PD) and 150 G/PD with sprinklers. Water use is metered.

Mount Vernon's water supply is purchased from the Skagit County PUD; its source is a large reservoir, Judy Reservoir, fed by a spring with other water coming from Rannee wells near the Skagit River. The capacity of Judy Reservoir is 33 MGD, with its peak production now at 10 MGD. Of this amount, Mount Vernon uses about 1.1 MGD on an average day, twice that on a peak day. While the total service population of the reservoir is about 31,000, the service population in Mount Vernon is about 10,000, and

the remainder are in the Town of Burlington, Sedro Woolley, and vicinity. Water quality problems include occasional elevated turbidity and coliform; capacity problems do not exist now, but a filtration plant will probably be built in about 10 years. A use pattern, peculiar to the Mount Vernon area that tends to use large amounts of water, is irrigation in rural areas; this irrigation produces a peak water consumption rate of almost 400 G/PD, almost three times the average consumption rate of 130 G/PD.

(3) Wastewater. Anacortes operates a .8 MGD primary sewage treatment plant which discharges into Guemes Channel. Because its effluent is the result of only primary treatment and because its sewer population of 8000 is very close to the design population of about 9000, plans are being made for expansion and upgrading of the Anacortes treatment plant. A facilities plan is now being completed. In the engineering report, an environmental assessment has been made; a negative declaration or a requirement for an EIS may be issued by the EPA and the Department of Ecology. The new plant for Anacortes will involve secondary treatment and an expansion of hydraulic capacity to about 5 MGD. An additional element in Anacortes' future system is a connection from the City of Skyline on the west side of Fidalgo Island into the sewage collection system for the Anacortes treatment plant. This connection would involve only about 20,000 gallons per day addition to the system. (See Tables VII-37 and VII-38.)

Mount Vernon completed construction of a secondary treatment plant discharging into the Skagit River in 1974. Its capacity is less than 1 MGD, and seems adequate for its present service population. There is a proposal to include the Big Lake community which is outside Mount Vernon's city limits in Mount Vernon's sewage system. Big Lake has no adequate receiving water nearby and so would pump its waste to the Mount Vernon plant. Negotiations are under way at present. If the proposal is approved, Mount Vernon will have to expand its treatment plant slightly.

(4) Solid Waste. The closest solid waste disposal sites to Anacortes are about five miles to the southeast: Gibraltar Sanitary Landfill on Similk Bay and the Whitmarsh site on Padilla Bay. The Whitmarsh site has been closed since 1974, while the Gibraltar Landfill is still in use. Leachate is not sampled unless water quality problems develop in the waters receiving landfill runoff. Information is not given in the Department of Ecology's 303(e) documents as to the expected life times or service areas of solid waste disposal sites. No air or water quality problems were cited in connection with either disposal site.

(5) Transportation. Western Skagit County is served by Interstate 5 which passes from south to north just east of the Town of Mount Vernon and by a number of state highways. Route 20 extends from Oak Harbor on Whidbey Island through Anacortes, Mount Vernon, and east to Sedro Woolley. Other state highways in the Mount Vernon vicinity are Routes 11, 237, 534, and 9. The main county road is Lake Forest Road which enters Anacortes from the south.

TABLE VII-37

WASTEWATER DISPOSAL - SERVICE POPULATION: MARCH POINT/ANACORTES

Basin	Municipal Plant	Unsewered Population[a]	Existing Wastewater Generation Rates: Flow (mgd)[b]	Sewered Population[c]	Flow (gpcd)[d]	Design Population
Skagit	City of Anacortes	164	.82	8,000	102.5	9,417
	City of Skyline	67	.02	150	133.3	673

a 1975 estimate, within incorporated limits
b Average daily flow for 1975 in million gallons per day
c 1975 estimate
d Gallons per capita per day

Source: Skagit Basin Water Quality Management Plan.

TABLE VII-38

WASTEWATER DISPOSAL - DISCHARGE LOCATION: MARCH POINT/ANA

Basin	Municipal Plant	Existing Level of Treatment	Discharge Location	NPDES Permit Status: Have Permit	In Compliance	District Upgrading or Expansion Plans
Skagit	City of Anacortes	Primary	Guemes Channel	Yes	No	201 Plans being prepared to upgrade, expand STP, and correct infiltration and inflow problems
	City of Skyline	Primary	Burrows Bay	Yes	No	Planning being done on feasibility of constructing an interceptor line from Skyline to Anacortes STP

Source: Skagit Basin Water Quality Management Plan

The only state road on Fidalgo Island is Route 20. While the segment east of Anacortes is far below its capacity, the segments of Route 20 northwest and south of Anacortes have problems of bottlenecks typical on two-lane rural roads, which are called upon to serve peak loads due to tourism. Although average volume to capacity ratio (V/C) is under 1.0, the traffic load on these roads reaches and exceeds capacity at a few points. (See Table VII-39.)

Western Skagit County is served by several local roads in addition to Interstate 5 and the above mentioned state highways. Access to Bay View is via the La Conner and Samish Road and Johnson Road. Numerous local arterial roads in the Mount Vernon vicinity include McLean Road, River Bend Road, Blackburn Road, Digby Road and Division Street. Of the state roads serving the Mount Vernon area, only two have traffic loads approaching capacity: Route 20 between Interstate 5 and Sedro Woolley, and Route 538 between Mount Vernon and Route 9. Maximum V/C ratios are near and over 1.0, respectively, while average V/C values are high at around 0.70. All other segments of these routes and other state roads are far below capacity.

c. Terrestrial Biology

(1) March Point. The remaining open lands of the peninsula forming the portion of Fidalgo Island with March Point at the northern tip are in a state of early succession. Of the approximately 1700 acres forming this peninsula, roughly 500 have been effectively converted to urban industrial use by the two oil companies -- Shell and Texaco. Roughly 800 acres of open lands not in agriculture remain on the peninsula; 500 acres are in the ownership of the two oil companies. The vegetation of these open space areas is divided between early second-growth forest with many deciduous trees and shrubs and very early successional disturbed grasslands which are slowly being invaded by trees and shrubs. The recency of disturbance in portions adjacent to roads is evidenced by the abundance of weedy species such as introduced composites, including thistles and goldenrod. Common trees and shrubs include the highly characteristic big leaf maple, vine maple, red alder, ocean spray, snowberry, and willow. No upland areas of particular envirnmental sensitivity were identified in this portion of Fidalgo Island.

(2) Burrows Bay (hypothetical offshore terminal and pipeline). The cliff which would be traversed by pipeline leading from the offshore mooring point to the main pipeline corridor at Burrows Bay is extremely steep with dense stands of Douglas firs and other conifers extending from top to bottom. The area is in a relatively advanced seral stage with many mature conifers and pockets of deciduous species, particularly alders. The area has the appearance of being in a relatively undisturbed state and is also highly scenic.

The pipeline route alignment across Fidalgo Island would traverse an area of fairly well developed seral forest with a relatively high proportion of mature coniferous trees. Some portions of the route are in fallow fields where shrubs such as gorse, snowberry, and several members of the genus Rubus (bramble) have invaded. There are also some drier pockets within the forest on the road adjacent to Lake Campbell which harbor pockets of Pacific madrone.

TABLE VII-39

HIGHWAY VOLUME/CAPACITY RATIOS - SKAGIT COUNTY

Road No.	Control Section	Volume/Capacity Ratio Maximum	Mean	Standard Deviation
1-5	2901	0.55	.47	.095
	2902	0.66	.57	.096
	2903	0.59	.53	.061
	2904	0.36	.34	.011
20	2931	1.00	.25	.168
	2932	1.99	.70	.473
	2934	0.49	.38	.076
	2948	0.29	.26	.012
	2906)		n.a.	
	2907)			
	2937	0.95	.73	.161
237	2933	0.12	.10	.017
11	2905	0.24	.11	.055
538	2936	1.08	.70	.351
534	2935	0.57	.13	.128
9	2938	0.17	.12	.037
	2939	0.42	.31	.055
	2940	0.38	.18	.073

d. Air Quality

Air quality in western Skagit County is affected by the Shell and Texaco major refineries and by a sulfite pulp mill located at Anacortes. The refineries emit large quantities of sulfur oxide particulates and hydrocarbons. Sulfur oxides are the principal emissions from the sulfur pulp mill; annual emissions for the area are in excess of 14,000 tons (see Table VII-40). The prevailing winds in some seasons direct both hydrocarbon and sulfur oxides eastward toward the minor urban areas stretching north from Seattle along Puget Sound. Although oxidant is not monitored in the immediate vicinity of Anacortes, it is probable that oxidant levels approaching the federal standard are occasionally experienced in the inland plains to the east. Since meteorologic conditions are variable in the area, it is likely that conditions occasionally exist that would restrict the dissipation of such industrially generated pollutants as sulfur oxides and reactive organic gases. Sulfur oxide monitoring at March Point shows significant emissions but only occasional violation of air quality standards (see Table VII-41).

e. Water Quality/Marine Biology

March Point and Anacortes, on Fidalgo Island, are in the Skagit River basin (see Table VII-42). The most intense uses of these waters are navigation, recreational boating, wildlife habitat, and sport fishing. In addition to shellfish and shrimp culture, salmon fisheries (sports and commercial) and waterfowl areas are located in these waters. This basin receives the discharges of six major industries and two minor municipal treatment plants. Scott Paper is the largest of all dischargers; the 6.5 MGD effluent has high biochemical oxygen demand (BOD) and high temperatures. Publishers Forest Products discharges 5 MBD, but no data was available on the quality of this effluent. The Texaco and Shell refineries present in this basin also discharge effluents with high temperatures, high pH, and chemicals such as ammonia, sulfides, phenolic compounds, and chromium. The cities of Anacortes and Skyline discharge small amounts of primary effluent into the waters surrounding Fidalgo Island.

There are four segments in this basin; all have Class A waters except for Burrows Bay with Class AA waters. All segments are classed as effluent limited by the Department of Ecology. Historical and 1974 water quality data show no apparent significant violations of water quality standards. However, in two of the four segments a problem with septic tank drain field and solid waste land fill leachates was reported. In addition, Anacortes Sewage Treatment Plant effluent exceeds standards. Because of these problems and possibly because of larger populations, three or the four segments comprising the project site vicinity are ranked first, second, and third in problem severity out of 12 in the basin.

Besides the existing biological resources and beneficial uses, several state and city recreation areas exist in this site's vicinity which need to be protected from oil-related pollution. The water quality issues which were cited in the 303(e) report for this basin were limited to contamination of beaches and oyster beds from sanitary wastes. Padilla

TABLE VII-40

ANNUAL AIR EMISSIONS FROM EXISTING SOURCES AT MARCH POINT

Source	Emissions (tons per year) Particulate	SO_2	NO_x	HC	CO
Shell	1400	8230	1280	2520	580
Texaco	1020	5610	1770	2530	-
Scott Paper	10	390	60	2	5
Allied Chemical	1	190	-	-	-

TABLE VII-41

AIR MONITORING DATA - MARCH POINT

SULFUR DIOXIDE

	Annual maximum hourly average	# hours > 40 pphm	Annual maximum 24 hour average	Annual Average
1974	22	0	6	1
1975	20	0	7	1
1976	26	0	6	0

Source: State of Washington, Department of Ecology.

TABLE VII-42

WATER QUALITY/ANACORTES - MARCH POINT

SKAGIT RIVER BASIN - WATER RESOURCES INVENTORY AREA 3

Existing Water Quality

Segment 02 - Padilla Bay: Class A, effluent limited. Good water quality, no significant violations in 1974 data. Problems: landfill and septic tank leachate into oyster beds and beaches.
Ranked 3rd of 12 in problem severity.

Segment 03 - Fidalgo Bay: Class A, effluent limited. 1974 data show no apparent violations and "quite good" water quality.
Ranked 2nd of 12 in problem severity.

Segment 04 - Guemes Channel: Class A, effluent limited. Historical data indicate no violations and "quite good" water quality. Problems: failing septic tank drain fields; Anacortes' sewage treatment plant effluent exceeds standards.
Ranked 1st of 12 in problem severity.

Segment 08 - Burrows Bay: Class A, effluent limited. No data available.
Ranked 7th of 12 in problem severity.

Issues

Contamination from sanitary wastes (municipal and septic tank fields).
Segments 02, 03, and 04 ranked highest in Basin for urgency of water quality problems.

Beneficial Uses

Navigation
Boating
Wildlife habitat
Sport fishing
Scenic viewing
Industrial use
Log rafting
Shellfish rearing
Commercial fishing

Aquatic Resources

Pacific Oyster Culture
Intertidal hardshell clams
Dungeness Crabs
Shrimp
Salmon fishery - sport and commercial
Major waterfowl area and eelgrass beds

Public Recreation/Protected Areas

Anacortes City Park
Washington Department of Game
Waterfowl area and State tidelands
Saddlebag Island State Park
3 underwater recreation areas

Discharges Within 10 Miles of Marine Terminal

Dischargers	Quantity (mgd)	Effluent
Scott Paper	6.46	High Biochemical Oxygen Demand, high temperature
Farwest Fisheries	0.6	-no data-
Texaco	3.0	High Suspended Solids, high pH, high temperature
Shell	2.1	Ammonia, sulfides, chromium, phenolic compounds, high pH
Allied Chemical	0.03	-no data-
Publishers Forest Products	5.0	-no data-
City of Anacortes	1.3	Primary effluent
City of Skyline	0.5	Primary effluent

Sources: Department of Ecology, 303(e) Skagit River Basin; Department of Natural Resources, Marine Atlas, 1974; Department of Ecology, Fauna Survey, 1975.

Bay supports large populations of flatfish and serves as a nursery area for finfish such as salmon and steelhead, and for invertebrates such as crabs, clams, and oysters -- productivity of the latter two is enhanced by mariculture. Waterfowl such as gulls, brant, diving, and dabbling ducks utilize the juvenile fish resources on the extensive eelgrass beds as food. Padilla Bay is recognized to be such an important resource that this 15,000-acre area has been classified as an area of statewide significance under the State Shoreline Management Act. The Skagit River delta and estuary comprises a highly productive habitat in Puget Sound, and one of the most important waterfowl marshes in the state. Whistling swans and snow geese are among the many birds which occur here.

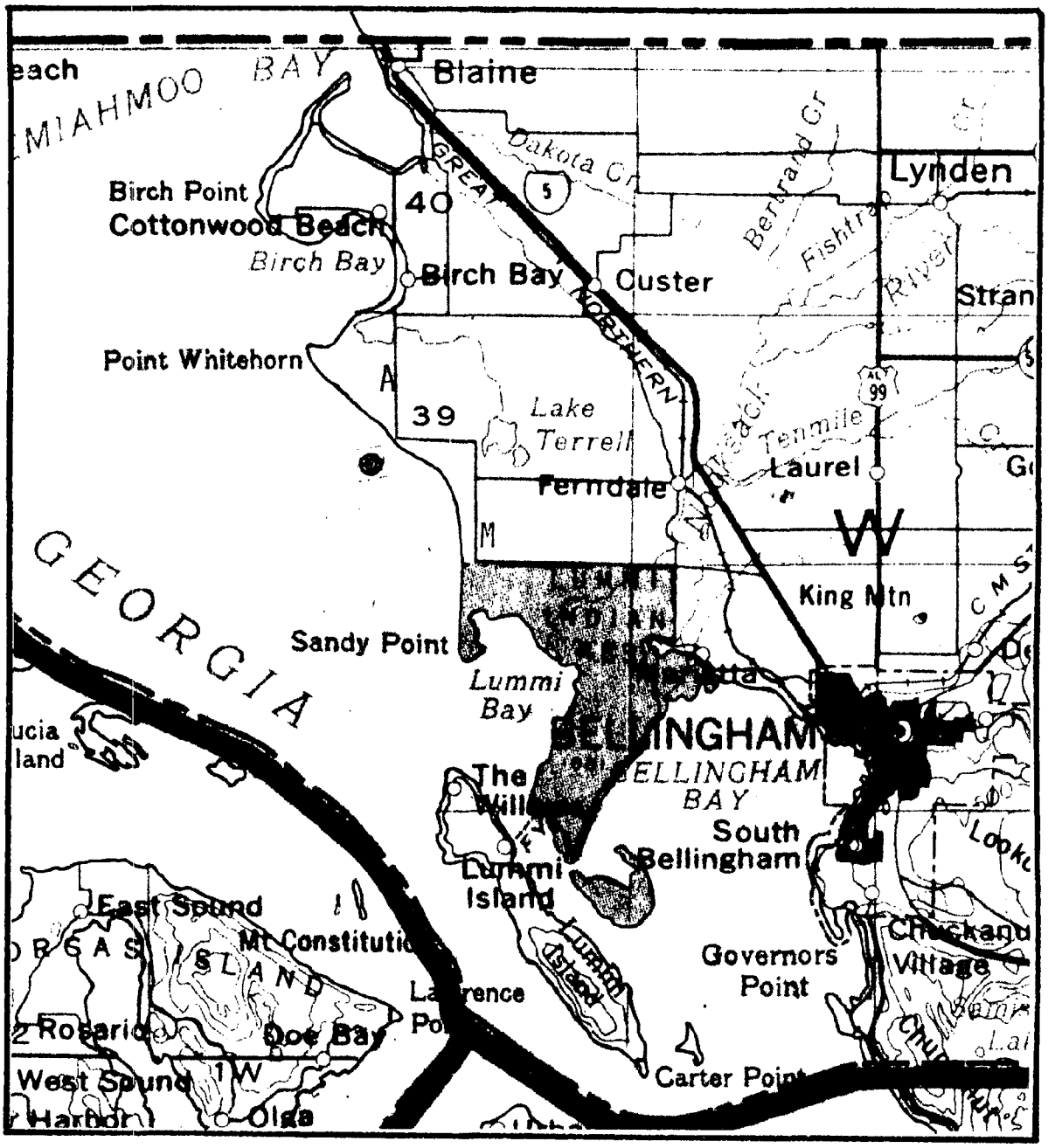
3. Cherry Point/Ferndale - Whatcom County

Cherry Point is a broad portion of the flat plateau of western Whatcom County, presently the site of three major industries (the Atlantic Richfield and Mobil Oil refineries and Intalco Aluminum). Major communities are the towns of Ferndale to the east, Blaine to the north, with the large City of Bellingham 12 miles to the southeast (Figure VII-5). The agricultural economy has been strong in western Whatcom County, but the newer elements of tourism and industrial development have risen in significance over the past decade. Industrial operations along Cherry Point are facilitated by the deep water of Georgia Strait that lies close to the shore. Cherry Point has no enclosed anchorage, but its location on the inner Puget Sound provides a relatively mild wave and wind environment. Marine terminals may be located anywhere along the shore immediately adjoining industrial development.

a. Land Use

(1) Regional. Land use in Whatcom County is similar to land use in Skagit County in that the predominant acreages are either in agriculture, both intensive and extensive, or in forest. At the present time, 4.5% of the land area of Whatcom County is in urban use (22,000 acres, not broken down by specific land use category). (See Table VII-43.) Nearly 30% is in agriculture, including grazing lands and, as in Skagit County, this occupies the lowlands in the western third of the county. Most of the forest lands, 63% of the county area, are in the mountainous, eastern two-thirds of the county. Those include a very high proportion of public lands -- Mt. Baker National Forest and the North Cascades National Park. The county contains a number of small incorporated communities which grew up as early logging or fishing centers, railroad stops, and gradually were converted into agricultural communities. These include the two small cities potentially affected by oil development projects at Cherry Point -- Ferndale and Blaine -- and several other communities to the east. The one large industrial city, Bellingham (population 42,000), assumed its preeminence owing to its location on Bellingham Bay which facilitated shipping and supply operations for the continuing activity of the county.

Population growth in Whatcom County is occurring in and around urban centers, mostly as low-density suburban development (see Table VII-44). Some growth, designated by the county as "rural non-farm" land use, is



A Arco Refinery
M Mobil Refinery
◎ Possible Marine Terminal

0 2 4 6 mi
0 3 6 9 km

NORTH

FIGURE VII-5 LOCATION: CHERRY POINT

TABLE VII-43

LAND USE - ACREAGE - WHATCOM COUNTY

Activity Zone	Residential	Industrial	Agricultural	Timber	Commercial	Other
Whatcom County (1970)	21,760 (4.5%)	See First Column[c]	140,000 (29.0%) (Includes pasture and fallow)	304,000 (63.0%)	See First Column	16,640 (Rural/nonfarm)
Ferndale	N	N	N	N	N	N
Blaine	N	N	N	N	N	N
Bellingham	11,250	950	150	150	750	1,750

[c] Whatcom County comprehensive plan lumps all three categories as "Urban and Intensive"

[N] Data not available

Source: Whatcom County Comprehensive Plan (1970); Bellingham Planning Department.

TABLE VII-44

GROWTH TRENDS AND PLANNING PERSPECTIVE - WHATCOM COUNTY

Activity Zone	Growth Trends/Planning Perspective
Whatcom County	More rapid growth than in neighboring Skagit County due to development interest and speculation by British Columbian business and private developers. Reflected in lack of interest in preservation of agricultural and open space lands (only 25% in RCW 84.34). Major development areas are incorporated cities.
Ferndale	Much subdivision activity in and around the city over the last 5 years - a continuing trend. Some land speculation by Canadian developers. Growth is due to employment in local industries (Intalco Aluminum, Mobil, Atlantic Richfield) and Bellingham industries (pulp mills, logging, dairy).
Blaine	Growth has occurred mostly outside the city limits.
Bellingham	Slow upward trend in population. Uneven growth rate due to market changes in various industries. Prime areas for residential growth are NE between I-5 and Lake Whatcom, South Central Valley area and SW, along the Bay.

Source: Whatcom County Planning Department; City Planning Departments.

taking place on marginal agricultural lands and other farm lands which have been left idle by land speculation and rising prices. Seasonal, recreational residential development, and general recreational land use is important in Whatcom County; one major market is Canadian tourists coming from the large Vancouver area. In addition to single family development primarily to serve year-round demand, there is a very high degree of subdivision activity to serve recreational demand -- recreational vehicle parking sites, mobile homes, cabins, and resort units.

- Land Values

Available parcel sizes for residential development are on the average one-third acre in the unincorporated lands of Whatcom County and one-fifth acre within the city limits of Ferndale (see Table VII-45). The cost per acre is approximately $13,600 to $20,400 for average lots in the flatlands and as high as $41,000 to $54,400 for view lots. Prices per acre are similar in both the incorporated and unincorporated areas. Within the county there has been a 10% annual rise in residential land values over the last five years, which is slightly above the general inflation rate in the county. The incorporated areas have experienced a higher rate of land appreciation (14.5% annually, reported for Blaine). Agricultural land sells for between $800 per acre for extensive (pasture) use, and $1500-2500 per acre for cash crops, depending upon location, soil type, and other factors. Whatcom County land use regulations comprise numerous zoning designations allowing for between five families per acre and one family per 40 acres. The price per acre generally drops with increasing parcel size and is also related to the likelihood of the continuation of agricultural practice.

- Land Use Trends/Planning Perspectives

Land use trends and planning issues in Whatcom County are in some ways more complex than in neighboring Skagit County because of the influence of nearby Canadian businesses and land developers and because of the migration and recreational pressure from the City of Vancouver, roughly 50 miles to the north. In the first place, speculation by Canadian land developers is causing a general inflation in land values and, in particular, an inflationary trend in farm land prices which is taking valuable farm land out of production owing to the subdivision and occasional sales of neighboring parcels which lead to their revaluation. Unsuccessful speculation is also a problem. The 1970 Whatcom County Comprehensive Plan reported that in 1969 alone there were enough proposals for lot subdivisions to account for all of the population growth projected for Whatcom County between 1970 and 1990.

A secondary effect of land speculation in the county, which is also detrimental to the health of the agricultural economy, is the perception by farmers of the imminent profit to be made by the sale of their lands for urban development. This is borne out by the fact that only 25% of all prime agricultural lands in Whatcom County (35,000 acres) have been put into open space preserve taxation status. (Recall that in Skagit

TABLE VII-45

LAND VALUES - WHATCOM COUNTY

	Residential				Agriculture		Timber
Activity Zone	Value/Acre	Parcel Size	Trend	Value/Acre	Acreage in RCW 84.34		Value/Acre
Whatcom County	13,600/ac- 20,400 (average lots) 40,800/ac- 54,450/ac (view lots)	1/3 acre	10% annual rise in land values (last 5 years).	800/ac (grazing) 1,500/ac- 2,500/ac (cash crops)	35,000 ac	(25%)	$30-138/ac depending on soil type and access.
Ferndale	Similar to Whatcom County	1/5 acre		None			-
Blaine			14.5% annual inflation in lot prices.	None			-
Bellingham	$15,000/acre	3/10 acre	12-15% annual inflation in housing and land cost	None			-

Source: Whatcom County Planning Department; City Planning Departments.

County, 90% of prime agricultural lands had been so classified.) Thus, the owners of over 100,000 acres of crop and pasture lands in Whatcom County are sufficiently motivated by the prospect of near-term sale of their land that they are not interested in the tax relief for farm production afforded by the open space taxation laws such as RCW 84.34.

The intensity of the demand for recreational property in Whatcom County is documented in a study of the Birch Bay community just south of Blaine as part of the revised preliminary comprehensive plan for Birch Bay. Development forms a roughly concentric ring around the semi-circular boundary of Birch Bay. The study indicated a 1975 permanent population of 3000 persons residing in 1000 dwelling units (950 permanent and 50 mobile homes), and a seasonal population of an additional 7000 persons, mostly Canadian visitors. By the year 1990 the permanent population is expected to double, and the summer seasonal component to increase to 20,000. Logically enough the means of livelihood for the permanent residents is largely the tourist industry with a smaller proportion employed in neighboring Blaine or at the Blaine Air Force Base. The anticipation of a rapidly growing seasonal recreation demand has already created a major flurry of subdivision activity in Birch Bay. The study noted that the aggregate of all residential cabins, mobile homes, and recreational vehicle lots currently available or proposed for the community will provide all of the dwelling unit space necessary to accommodate the projected 1990 population, both permanent and seasonal. This amounts to 5750 new units and lots of which 30% are already available within existing subdivisions.

Over the course of the last six years, the growth rate in Whatcom County as a whole has been modest, but has averaged three times the rate for Skagit County according to official state estimates (see Tables VII-46 through VII-48). A large proportion of the growth in the unincorporated areas has taken place just outside the city coundaries and has the form of relatively low-density suburban sprawl. Residential growth in the unincorporated county has taken place at approximately the same rate as in the cities as a result of both urban growth itself and as a result of the suburbanization of the unincorporated periphery.

Official state population estimates indicate that the rate of growth in both the county and the incorporated cities slowed as a result of the economic recession in the early 1970s. However, some of the urban communities, particularly Ferndale, continued to grow at a very rapid rate in comparison to the surrounding areas. Ferndale had the major growth spurt in 1970-72 when growth was taking place between 10% and 16% per year, and sustained an overall average annual growth rate for the period 1970-76 of 6.2%. The rate of growth in the City of Baline was much more modest by comparison but still averaged over 50% more than the countywide rate. The mayor of Ferndale indicated that the rapid growth rate in his municipality was due to growth in local industry employment, including the Atlantic Richfield Refinery (1971). He indicated that the majority of Ferndale residents were employed in the three nearby industries -- Intalco Aluminum, Mobil Oil, and Atlantic Richfield. Some seasonal

TABLE VII-46

POPULATION GROWTH - WHATCOM COUNTY

Activity Zone	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1970/76 (6 year) Ann. Av.	1976 Population
Whatcom County	+2,2%	+1.4%	0	+0.2%	+1.2%	+4.4%	+1.6%	90,000
Ferndale	+15.6%	+9.6%	+2.2%	+4.5%	+3.5%	+2.3%	+6.2%	3,100
Blaine	+2.3%	0	+2.5%	+3.4%	+5.7%	+1.1%	+2.5%	2,265
Bellingham	+0.8%	+2.0%	-0.74%	+7.5%	+1.2%	+2.7%	+1.1%	42,100

*Population Growth Rate 1970/76 Source: Washington State Office of Program Planning and Fiscal Management/Population Studies Division.

TABLE VII-47

COMPONENTS OF POPULATION CHANGE 1970-76 - WHATCOM COUNTY

POPULATION				COMPONENTS OF CHANGE			
1970	1976	Change Number	%	Births	Deaths	Natural Increase	Net Immigration
A	B	C (=B-A)		D	E	F (=D-E)	G (C-F)
81,983	90,000	+8017	9.8	7,556	4,816	2,740	5,277

Source: Taken from Table 10, State of Washington Population Trends, 1976. Population Studies Division; Office of Program Planning and Fiscal Management.

TABLE VII-48

OFFICIAL POPULATION PROJECTIONS - WHATCOM COUNTY

	PROJECTED POPULATION						
ACTIVITY ZONE	1975	1975 Actual	1980	1985	1990	1995	2000
Whatcom Co.	82,960	86,200	90,110	97,250	104,400	111,500	118,500

SOURCE: State of Washington, Office of Program Planning and Fiscal Management Official Estimates August, 1972

employment was also provided by a local food processing plant, and the remainder of Ferndale residents commuted to Bellingham to jobs in the pulp mill, other forest product industries, and dairy plants.

The relatively rapid growth of Ferndale in comparison to Blaine is an indication of the greater appeal of the latter as a place of residence. Within a 10-mile radius of the industrial complex located near Cherry Point, the Whatcom County Comprehensive Plan recognizes a number of land use planning categories which reflect both current land use and zoning regulations in force, and are expected to determine the overall pattern of land use and population growth distribution over the next 20 years without substantial change. Within this region the major transportation corridor, Interstate 5, runs diagonally between the border at Blaine and the City of Bellingham. Ferndale has developed as a population node adjacent to the highway. Major land use categories form a mosaic of lands designated rural, agriculture, and five-acre smallholdings, with suburban and potential suburban far less common and concentrated in the areas surrounding existing cities around Birch Bay and on the Lummi Indian Reservation. To the south of Bellingham, on both sides of the highway, is an area designated multiple use forestry which is a zone of wooded, mountainous terrain with several lakes. Transecting the region almost at right angles to Interstate 5 is the Nooksack River and its associated floodplain. The only area designated for industry outside the City of Bellingham is the existing industrial complex at Cherry Point.

The distinctions between the various land use categories are important as a reflection of the present orientation toward residential suburban growth in the county. The difference between suburban and potential suburban as land use categories is that the former is reserved for the areas of major population concentration which have an existing framework of urban services and in which the county desires to encourage infilling development. The potential suburban category defines areas which are clearly destined for residential development but where urban services are not presently available. The intent of the potential suburban classification is to preclude non-residential development in these areas. The county intends that each of these areas should first develop at a relatively low density (about one family per five acres) with individual water supply and wastewater disposal. Once the dispersed phase of low-density growth has been completed, a second phase of re-subdivision should be preceded by the extension of urban services, probably from the adjacent municipality and accompanied by annexation. Once the public provisions of community services becomes a viable reality, then the density of development approved by the county and reflected in the zoning rises to three families per gross acre.

An equally important distinction is between the three categories -- agricultural, rural, and five-acre small holding. Areas designated agricultural allow development at a maximum density of one family per 20 acres and are intended to maintain their productive agriculture use. To some degree this comprehensive plan classification corresponds to the lands which have been placed in open space preserve status. The category five-acre small holding corresponds to areas slated for limited development while protecting intermittent agriculture. Any industrial or commercial development should be oriented toward the needs or products of the

area, either food or forest products. The rural classification is largely for lands whose urban development status is uncertain. These are lands which have historically been used for agriculture but which have recently become subject to land speculation. At present, very little acreage is in agriculture preserve status and present land uses comprise a mixture of part-time farming and rural (non-farm) residential with occasional rural industry or commercial business. In recognition of the potential for future urban development in areas where land economics have made farming marginal, county policies indicate development at a permissible density of one dwelling unit per net acre according to the availability of the appropriate utilities and services and have designated that all categories of industrial development which fit into their classification "select industrial" are acceptable in the rural area.

The City of Ferndale adopted a zoning ordinance in 1974 which embodies the intent of land use planning for a small urban municipality and which has been rigorously enforced. All of the city lands are zoned for either residential or commercial development with the exception of the flood zone of the Nooksack River which runs diagonally through city land. Zoning categories in the city are generally much higher density than those permitted in the unincorporated areas; they range from "suburban estate" -- one family per acre -- in the extreme northeast corner, to a maximum of 1000 square feet per family in multi-family dwellings. Such high-density development within the incorporated boundary is favored from a planning perspective by both city and county government since it concentrates the population and facilitates the delivery of urban services from both the point of view of physical facilities configuration and economics. Roughly 30% of all the land within the city limits of Ferndale is presently developed and an additional population of 10,000 could be accommodated by infilling development alone with no extension of the urban boundary. Additional new residences could be accommodated in the unincorporated areas with no change in land use policy or zoning, provided that urban services could be made available.

(2) Specific Petroleum Development Sites and Vicinity. The Mountain View industrial district of Whatcom County (so-called by the County Planning Department) is the coastal area between Birch Bay and Lummi Bay. The total area designated primarily industrial in the comprehensive plan extends from Grandview Road on the north, south nearly to Slater Road, and lies roughly between Jackson Road on the west, except for the portion directly touching the coast, and the Burlington-Northern right-of-way on the east. Cherry Point, in the center of the industrial district, is roughly nine miles south of Blaine and seven miles west of Ferndale.

There is an additional tract of land which adjoins the Birch Bay suburban community zoned select industrial reserve north of Grandview Road, and north of the developed portion of the Atlantic Richfield Refinery. Two additional areas also designated select industrial include the land lying between Jackson Road and the Point Whitehorn residential neighborhood and south and east of the Mobil facility. Categories in the vicinity of the industrial zone include a large area designated rural

by the Comprehensive Plan, lying to the east and north. Suburban and potential suburban categories exist largely in a band following the shoreline to the north and south of the industrial area, and at the outskirts of incorporated Ferndale. Several square miles of land designated long-term agriculture are located south of Slater Road and in the flood plain of the Nooksack River. The Lummi Indian Reservation occupies the peninsula of land separating Lummi Bay from Bellingham Bay. The entire shoreline of the reservation is designated suburban in the Comprehensive Plan with the interior potential suburban, as a result of the land use policies practiced by the Lummi Tribal Council.

Individual industrial sites within the Mountain View district are not all intensively developed at present. The most northern refinery site, the Atlantic Richfield property, comprises about 630 acres plus shore side access at Cherry Point. Roughly three-quarters of the site is intensively used for the plant (factory buildings, tank farm, access roads, and other associated structures); the remaining fourth is approximately two-thirds cleared land (fallow and grazing land) and one-third second growth woodland.

Standard Oil owns a large piece of property just south of the Atlantic Richfield site -- roughly 920 acres of land suitable for refinery development -- and about 35 acres of backup for shore access at Cherry Point. Standard Oil holdings are presently completely undeveloped and they are a mosaic of fallow land and extensive agriculture interspersed with second growth woodland of varying age (see separate description of forest land under terrestrial biology). The southernmost refinery site, Mobil Oil, is a rectangular parcel roughly 630 acres in size of which half is intensively developed as the plant proper. The majority of the undeveloped land is heavily wooded with some cleared land on the periphery.

The remaining lands with industrial classification in the Mountain View district are also presently undeveloped and form a mosaic of wooded and cleared areas. The exception is the Intalco Aluminum plant site which occupies 150 acres. The agricultural lands within the industrial zone are largely either grazed or left unutilized. The presence of previously cleared land left fallow also has allowed for forest recolonization now at different stages of maturity depending on the recency of tree species invasions.

The purpose of the three separate industrial classifications for land as applied to the Mountain View district is to restrict and regulate the future uses of the undeveloped portions of the industrial zone. The category of primary industry is given only to the already developed site and to the remaining potential refinery site owned by Standard Oil. Within the zone designated for heavy industry, the county policies stress minimization of air and water pollution as well as the avoidance of conflict between adjoining uses -- either other industries or different categories of land use. The designation select industrial implies that although future industrial development of the sites is permissible, it must be of a type producing little or no public nuisance or pollution. The select industrial classification was created to provide a transitional area between primary industry and unrelated land uses in the surroundings. The

remaining category, select industrial reserve, specifically applies to areas suitable for select industrial development but which do not presently have the framework of necessary utilities such as power, water, etc. These areas could have their classification changed to select industrial once their services become available.

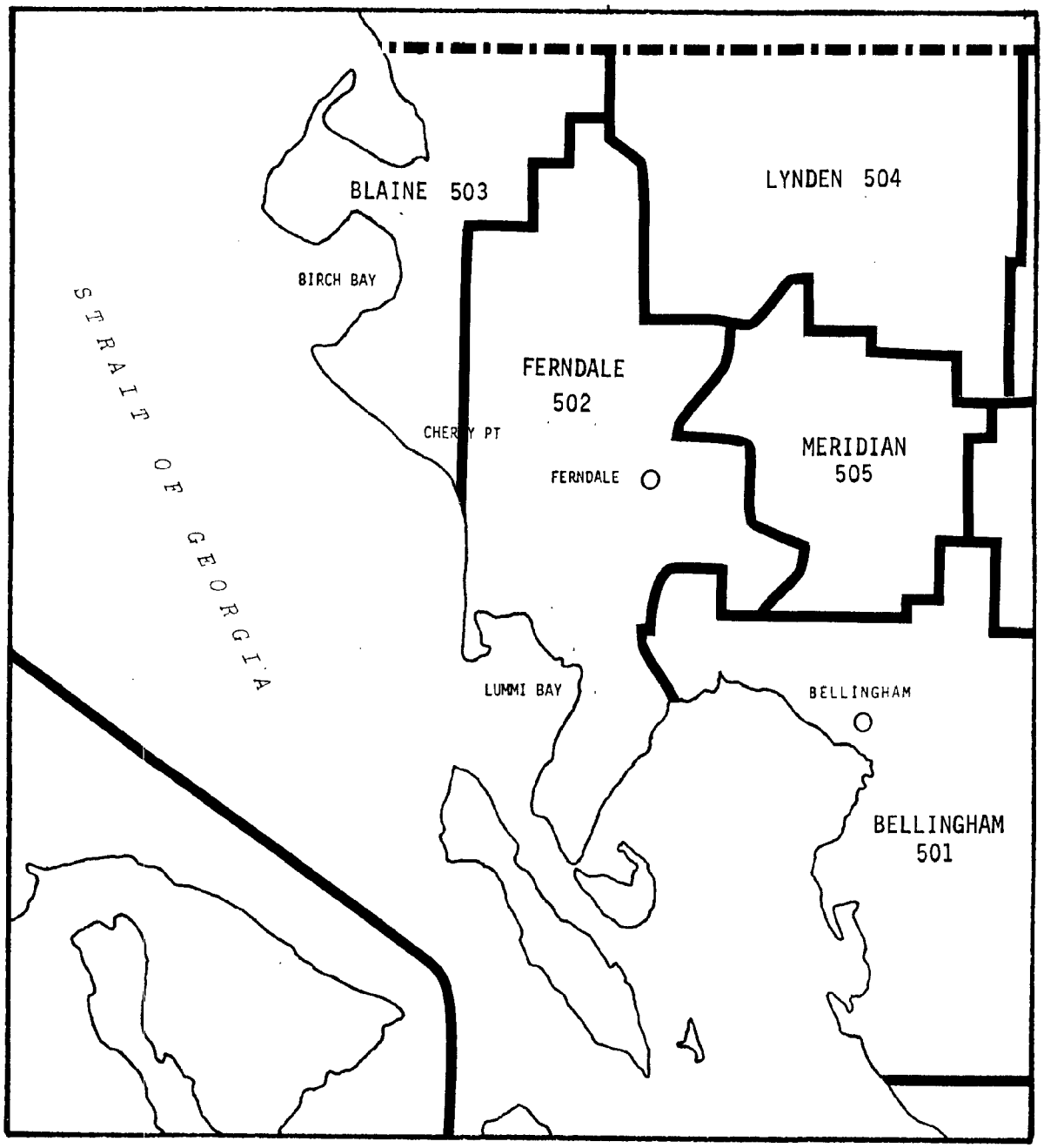
b. Infrastructure

(1) Schools. Four school districts in Whatcom County are potentially affected by future petroleum activities in the vicinity of Cherry Point -- Bellingham, Ferndale, Meridian, and Blaine. (See Figure VII-6.) Of these, Bellingham and Blaine have experienced enrollment decline over the last five years; Ferndale and Meridian have had significant growth. All districts were growing by at least 1% per year in total population in the same time interval, again showing the effect of a diminishing birth rate coupled with an advancing age structure of the community due to a demographic transition brought about by young adults leaving the county to seek employment elsewhere, leaving a higher proportion of post-reproductive parents with children gradually passing school age. Even in Ferndale where growth in school enrollment was 3.3% per year, the proportional rate of enrollment growth was only about two-thirds the rate of population growth (see Table VII-46 and Tables VII-49 and VII-50).

Blaine is presently just at capacity with respect to its existing facilities, and the other three districts are all over capacity by 8-10%. Only Bellingham district is using portable classrooms, and these serve only 64 of the 732 pupil equivalents over its satisfactory existing capacity (see Tables VII-51 and VII-52). Since Whatcom County, owing to numerous factors discussed under land use, is experiencing more rapid growth and urbanization pressure than neighboring Skagit, this is to some degree reflected in the attitude toward new capital development of school facilities. All four districts have passed a bond issue as recently as 1973 (Bellingham, May 1976). To alleviate existing deficiencies in school capacities, as well as in anticipation of new growth leading to higher enrollments, all four districts have expended funds between $0.4 and $1.6 million in the last five years for new facilities construction and have committed between $0.5 and $4.2 million additional with the passage of the most recent bond issues.

The total true and fair value of taxable property in all four school districts rose 40-50% in the single year 1974-75, most likely due to a change in the method of property valuation in the same year, as well as to the effects of inflation and new construction (see Tables VII-53 VII-54). In the following year (1975-76) the value of taxable property rose again with the minimum rise of 5% in Blaine and the maximum 21% in the Meridian district.

In Whatcom County, the wealth of the district, expressed as property value/pupil, may not correlate well with the ability of the district to pay its way. Of the four districts, only Ferndale had revenues per pupil in excess of its expenditure per pupil for 1974-75 (see Table VII-55).



SOURCES:
State of Washington, Superintendent of Public Instruction, "Boundaries of the 303 School Districts in Existence on October 15, 1976".

FIGURE VII-6 SCHOOL DISTRICTS: CHERRY POINT

TABLE VII-49

SCHOOL DISTRICT HISTORICAL ENROLLMENT - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Historical Enrollment (October 1) 1971	1972	1973	1974	1975	Total (K-12) 1976	Percent Change 1971-76	Percent Annual Change (Exponential)
WHATCOM COUNTY								
Bellingham 501	9028	8694	8684	8554	8657	8673	-3.9	-0.8
Ferndale 502	3138	3215	3285	3362	3571	3695	+17.8	+3.3
Meridian 505	1135	1160	1137	1197	1208	1183	+4.2	+0.4
Blaine 503	1185	1107	1083	1130	1122	1168	-1.4	-0.3

Source:State of Washington, Superintendent of Public Instruction

TABLE VII-50

CURRENT ENROLLMENT AND AVERAGE DAILY ATTENDANCE - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Current Enrollment (October, 1976)			1976 Total (K-12)	Average Daily Attendance 1975-76
WHATCOM COUNTY					
Bellingham 501	3844 (K-5)	2013 (6-8)	2816 (9-12)	8673	8057
Ferndale 502	1787 (K-5)	874 (6-8)	1034 (9-12)	3695	3293
Meridian 505	434 (K-4)	376 (5-8)	373 (9-12)	1183	1114
Blaine 503	402 (K-4)	368 (5-8)	398 (9-12)	1168	1043

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-51

SCHOOL DISTRICT EXISTING CAPACITY - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Satisfactory Existing School District Capacity 1976	Capacity Remaining Absolute Number of Pupils	Percentage	Temporary Facilities (1975-76 Inventory)
WHATCOM COUNTY				
Bellingham 501	7941	-732	-8.4	9 portable class rooms 6960 sf
Ferndale 502	3314	-381	-10.3	
Meridian 505	1074	-109	-9.2	
Blaine 505	1166	-2	-0.17	

Source: State of Washington, Superintendent of Public Instruction.

TABLE VII-52

SCHOOL DISTRICT CERTIFICATED STAFF RATIOS - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Teachers				Other**			
	High School	Jr. High School	Middle School	Elem. School	High School	Jr. High School	Middle School	Elem. School
WHATCOM COUNTY/ CHERRY PT.								
Bellingham 501	41.08	-	43.95	43.12	7.36	-	7.15	4.59
Ferndale 502	41.63	-	40.35	42.69	7.84	-	5.34	5.34
Meridian 505				Same as Sequim				
Blaine 503				Same as Sequim				

*FTE = Full Time Equivalent

**Other = School Administrators, Supervisors, and Support Services

SOURCE: State of Washington, Superintendent of Public Instruction

TABLE VII-53

TAXABLE PROPERTY - MARKET VALUE - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Taxable Property Total Market Value ($ Thousands) 1974	1975	Δ% 1974-75	1976	Δ% 1975-76
WHATCOM COUNTY					
Cherry Point/ Bellingham 344	511,358.2	738,942.5	+44.5	797,599.5	+7.9
Ferndale 502	302,455.2	434,699.6	+43.7	461,399.6	+6.1
Meridian 505	37,944.0	53,693.8	+41.5	64,829.0	+20.8
Blaine 503	270,733.4	402,316.3	+48.6	423,795.8	+5.4

Source: State of Washington, Superintendent of Public Instruction

TABLE VII-54

ASSESSED VALUE - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Indicated Ratios* (Assessed Value/Market Value 1973	1974	1975	Taxable Property Assessed Valuation ($ Thousands) 1974	1975	1976
WHATCOM COUNTY	37.7	56.5	57.1			
Bellingham 501				192,781.7	417,502.5	455,429.3
Ferndale 502				114,025.6	245,605.3	263,459.2
Meridian 505				14,304.9	30,325.7	37,017.3
Blaine 503				102,066.5	227,308.7	241.987.4

*Weighted ratio including components for real and personal property

Source: State of Washington, Department of Revenue.

TABLE VII-55

SCHOOL DISTRICT REVENUE AND COST - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	SOURCES OF REVENUE - 1974-75 (% of total)					REVENUE VS COST ($) 1974-75			
	Local Taxes	County Admin. Funds	State Funds	Federal Funds	Other*	Market Value per Pupil	Revenue per Pupil	Expenditure per Pupil**	Net Cost per Pupil**
WHATCOM COUNTY									
Bellingham 501	33.51	4.51	47.63	6.86	7.49	48,808	1391	1408	1177
Ferndale 502	43.67	4.73	39.24	7.06	5.3	73,053	1374	1349	1147
Meridian 505	25.63	5.65	55.75	7.61	5.36	25,335	1033	1103	931
Blaine	58.93	4.33	25.79	6.42	4.53	201,158	1484	1659	1567

Source: State of Washington, Superintendent of Public Instruction

*Other=Local non-tax revenue, non-revenue receipts, and payment from districts.

**See text for explanation of difference between expenditure and net cost.

The poorest district, Meridian, had a deficit of $70 per pupil between revenues and expenditures, but Blaine, the wealthiest district in terms of property value/pupil, had a deficit of $175/pupil between revenues and expenditures. This is due to the fact that some revenues are not returned to the district in direct proportion to the taxes collected. For the 1976 school year between 46% (Blaine) and 58% (Bellingham) of property taxes collected for school operations were through the local special levy. All four districts approved their 1976 special levy appropriations in the first election in 1975.

In spite of the fact that bonded indebtedness has increased markedly in all of the four districts through the passage of recent bond issues, three of the four have remaining excess bonding capacities over $7 million, owing to their high value of real property. Meridian has an excess bonding capacity 10 times less since the value of its taxable property is an order of magnitude less than that of the other districts; it has already committed nearly half of its total bonding capacity (see Table VII-56).

The proportion of total operations and maintenance funds derived from each revenue source is similar in all four districts with respect to the proportion derived from county administrative funds (4-6%) and federal grants (6-8%), but differs with respect to the most significant sources -- local taxes and state funds (see Table VII-57). The relative importance of these two sources was directly related to the wealth of the district (Mountain View/pupil) as Meridian, the poorest of the four, received 26% from local taxes and 56% from state assistance, and in Blaine, the wealthiest district, these proportions were roughly reversed. Ferndale and Bellingham were intermediate between these two extremes.

(2) Water Supply. The source of Ferndale's drinking water is the Nooksack River. The City of Ferndale purchases industrial quality water from the Whatcom County PUD and filters this for use as drinking water. The capacity of Ferndale's filtration plant, which was completed in 1974, is 4 MGD -- more than adequate for the city for at least the next five years. The City of Ferndale serves its own city limits and a small number of people outside the city, a total population of about 3580. In addition, Ferndale sells some water wholesale outside the city limits to suburban water associations. There are no individual wells in use in this area.

Ferndale received some federal (HUD) funds and about 40% state "Referendum 27" grant money to cover 40% of the $1.5 million contruction costs of its water filtration plant. Because this plant was partially financed with Referendum 27 funds, Ferndale must be a regional supplier. Although the city is obligated to supply water to developments, communities, or individuals outside the city limits if economically feasible, Ferndale is not as yet a regional supplier.

The source of Blaine's drinking water supply is a system of eight wells, with a total capacity of 4.3 MGD. Because some of the series of eight wells were recently constructed with Referendum 27 monies, Blaine is required to serve as a regional supplier. Blaine presently supplies

TABLE VII-56

SCHOOL DISTRICT BONDING STATUS - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	Bonded Debt 7/1/76 ($ Millions)	Amount Last Bond Issue	Date Passed
WHATCOM COUNTY/ CHERRY POINT			
Bellingham 501	7.745	4.200	5/1/76
Ferndale 502	4.862	3.893	1974
Meridian 505	.719	.600	1973
Blaine 503	.644	.510	1974

SOURCE: State of Washington, Superintendent of Public Instruction

TABLE VII-57

SCHOOL DISTRICT TAX RATES - WHATCOM COUNTY

ACTIVITY ZONE/ SCHOOL DISTRICT	TAX RATES-1976 Collections ($/1000 of assessed Valuation)		
	State Levy	Bond Retirement	Special Levy(Local)
WHATCOM COUNTY CHERRY POINT			
Bellingham 501	6.306	1.100	8.712
Ferndale 502	6.306	2.460	5.418
Meridian 505	6.306	2.448	6.577
Blaine 503	6.306	0.330	6.577

SOURCE: Tax Assessor's Office/Clallam, Skagit, Whatcom Counties

water to Whatcom County Water District No. 8, and sells water wholesale to small water associations in an unincorporated area near Blaine. The service population of Blaine is about 2400; the total served from the eight wells is about 4200 with as many as 8000 served during the summer tourist season. Average production from these wells is about 0.8 MGD; peak production reaches 2.5 MGD. Residential consumption rates average about 160 gallons per capita per day. Because the wells were recently constructed, there are currently no capacity problems or plans to expand; no water quality problems are apparent in the water supply.

In the unincorporated areas of Whatcom County between Blaine and Ferndale, water supply is provided by individual wells for farms and tracts of about five acres. However, many water associations are found in this region because of the presence of dairy farms which must have an improved water supply. Water associations typically buy improved water from the nearer town of Blaine or Ferndale, or from Water District No. 8 which Blaine supplies. Some associations have their own sources of supply such as streams, diversions, lakes, or wells.

Domestic water supply for the City of Bellingham is provided by the city as a municipal service. The city presently serves all of the unincorporated population (42,100 persons; 10,400 customers) as well as about 8000 persons (3500 customers) outside its incorporated limits. Average per capita daily water consumption is 190 gallons -- a system total of 9.5 MGD. This drops to about 125 G/PD during the winter months when outside watering is not necessary.

The municipal supply comes from Lake Whatcom and a diversion dam on the middle fork of the Nooksack River. The city has water rights to the top four feet of the lake and also diverts the Nooksack River water into the lake to simplify distribution. All of Bellingham, including residential, commercial, and industrial development within the city, purchases water from this source. The largest single user is Georgia Pacific, which consumes an average of 53 MGD. Georgia Pacific diverts its supply before it has been run through the city filtration plant, which ensures that the drinking water supply will meet public health standards. The nominal capacity of the filtration plant is 24 MGD. Thus, at present the plant is operating at 40% of capacity.

The engineer for the Public Works Department of Bellingham, John Wiseman, indicated that the main problem for this service district is peak demand in summer coupled with low flow. The 10-year low available flow in summer and fall months was 54 MGD, while the 10-year peak demand which occurred in August 1971 was 24 MGD, excluding the Georgia Pacific requirement (20-year peak in August 1959 was 26 MGD). The peak including the pulp mill is thus 77-79 MGD. Peak demand, coupled with low inflow, gradually depletes Lake Whatcom which has strong volume in the top four feet of 6.5 billion gallons. In 1971, the lake was depleted and did not return to its normal level until January 1972.

A recent study completed for the city projected a 1990 average daily requirement of 12.6 MGD (excluding Georgia Pacific) and an increase in demand by the pulp mill to a total of 55 MGD. The implication of the study was that by 1990 a supplemental source might be needed, particularly in low flow, peak demand periods.

At the present time, water supply conservation in dry years or during low flow periods is voluntary only. Most single family residences are not metered; multiple residences are on a single meter, and commercial and industrial establishments are individually metered. The city is exploring the possibility of a more extensive metering system.

(3) Wastewater. The City of Ferndale operates a secondary sewage treatment plant which discharges into the Nooksack River. While this plant is apparently serving a greater number of people than its design population (see Table VII-58), John Glenn, of the Department of Ecology, states that the Ferndale plant may or may not be put on a grant list for expansion or upgrading. The plant's average flow is only about 0.3 MGD, and apparently is experiencing no problems. Performance is improving recently with a new operator, and the plant is apparently in compliance with its NPDES permit (see Table VII-59).

In response to a problem of failing septic tank drain fields, the unincorporated community of Birch Bay has begun operation of a secondary treatment plant with discharge off Point Whitehorn. This plant also serves the Birch Bay State Park and the Blaine Air Force Base. Because connections are still being completed and the plant is just beginning operations, this secondary treatment plant has not yet demonstrated compliance with its NPDES permit.

The Lummi Indian Reservation, south of Water District No. 8 and currently on septic tanks, has been declared a public health emergency area. A facilities plan has been completed for construction of a new secondary sewage treatment facility. In addition, a non-Indian housing development built on leased land within the Reservation, called Sandy Shores, has formed a water district. The subdivision requires sewage treatment, and it is not clear whether this will comprise an independent plant or system or connection to the future Reservation facility.

In general, apart from Water District No. 8, the unincorporated areas of Whatcom County between Blaine and Ferndale use septic tanks for sewage disposal. In the Ferndale vicinity, the residences outside the city limits may receive city sewer service within the next 10 years, as Ferndale has corresponding annexation plans. These plans for extension of city services include all parts of the city's periphery with emphasis on the east and north.

The City of Blaine operates the primary treatment plant which discharges into the mouth of Drayton Harbor. The design flow of the plant is 0.25 MGD; however, its average daily flow currently exceeds its design capacity due to infiltration and inflow. The plant was built in 1964, and is currently in compliance with its NPDES permit.

TABLE VII-58

WASTEWATER DISPOSAL - SERVICE POPULATION: CHERRY POINT/FERNDALE

Basin	Municipal Plant	Unsewered Population[a]	Existing Wastewater Generation Rates: Flow (mgd)[b]	Sewered Population[c]	Flow (gpcd)[d]	Design Population
Nooksack	Blaine AFB	ND	.012	ND	ND	250
	Lummi Indian Reservation	NA	NA	NA	NA	5,000
	Community of Birch Bay (Water District #8)	NA	NA	NA	NA	5,000
	Ferndale	73	.30	2,927	102.5	2,730
	Birch Bay State Park	ND	ND	ND	ND	ND

a 1975 estimate, within incorporated limits
b Average daily flow for 1975 in million gallons per day
c 1975 estimate
d Gallons per capita per day

NA = notavailable; ND = no data

Source: Nooksack Basin Water Quality Management Plan

TABLE VII-59

WASTEWATER DISPOSAL - DISCHARGE LOCATION: CHERRY POINT/FERNDALE

Basin	Municipal Plant	Existing Level of Treatment	Discharge Location	NPDES Permit Status: Have Permit	NPDES Permit Status: In Compliance	District Upgrading or Expansion Plans
Nooksack	Blaine AFB	Secondary	Creek to Birch Bay	No	NA	Will connect to Water District No. 8 system due to insufficient dilution of effluent in creek
	Lummi Indian Reservation	Septic Tank	Ground	No	NA	A DSHS "Public Health Emergency Area". New sewage facility needed. Grant funds and 201 Plan in process
	Community of Birch Bay (Water District No. 8)	Septic Tank	Ground New future plant: Straits	Yes (for future plant)	NA	New secondary treatment and collection system being constructed to correct failing septic tank drain fields
	Ferndale	Secondary	Nooksack River	Yes	Apparently	WQMP states that septic tank drain fields should be included in service area since they are failing. These areas to immediate east and west of town are declared DSHS "Health Hazard" areas
	Birch Bay State Park	Secondary	Off Whitehorn Point	No	NA	ND

DSHS = Department of Social and Health Services
WQMP = Water Quality Management Plan
NA = not available
ND = no data

Source: Nooksack Basin Water Quality Management Plan

A facilities plan has just been completed stipulating the construction of a new plant to eliminate the infiltration inflow problem. The new plant will be located at a different site from the present facility with a different outfall, but its capacity will still not exceed 1 MGD. Plans and specifications will be completed at the end of the summer of 1977, and the new plant will be operating in 1979. The Blaine treatment plant will be serving any population within their drainage area; this goes beyond the city limits to the border of Water District No. 8 to the south but does not extend far to the east.

Wastewater disposal is handled by the City of Bellingham as a municipal service. The city currently serves a total population of 39,600, of which 2200 are outside the corporate limits of Bellingham (mostly within the Lake Whatcom sewer district). Thus, approximately 4700 persons within Bellingham are not served by sewer but rely on septic tanks.

The city's plant offers primary treatment only and, thus, by definition cannot be meeting NPDES and federal clean water quality standards since these require secondary treatment. The plant, which has a design flow of 18 MGD and a peak hydraulic flow (including storm water) of 55 MGD empties into Puget Sound. Current wastewater volume in the district averages 4 MGD in summer and 10 MGD in winter, including all domestic, commercial, and industrial connections. The only large industrial facility in Bellingham not served by this plant is the Georgia Pacific pulp mill which operates its own sewage treatment facility. Wastewater volume alone thus averages 101 gallons per capita day.

The engineer for the Bellingham Public Works Department, John Wiseman, indicated that the combined sewer and storm inflow occasionally exceeds the 55 MGD design hydraulic flow and overflows into Puget Sound. The city is operating under a discharge permit which specifies that a facilities plan be prepared which would allow upgrading to secondary wastewater treatment. Mr. Wiseman indicated that the facilities plan would not be completed prior to the end of 1978, and that possible upgrading would be dependent on the availability of grant funding. Since the district discharges to salt water, Mr. Wiseman felt that grant funding would probably not be made available. The hydraulic design flow of the secondary treatment plant would be 43 MGD, but the design load for the plant cannot be specified at this time, owing to uncertainties about the degree of future population growth in Bellingham which would be eligible for grant funding.

(4) Solid Waste. The Cherry Point vicinity has four solid waste disposal sites. The Lummi open dump, located about five miles away on the Lummi Indian Reservation, has been closed. The Ferndale site, just outside of the city, is an open dump and is in use, as is the thermal reduction incinerator located about two miles southeast of Ferndale. There is also an actively used open dump about 10 miles north of Cherry Point on Birch Bay.

No information was available regarding the expected life times, service areas, or leachate problems of these sites in the 303(e) reports. However, it is to be noted that all are open dumps and not sanitary landfills.

The Whatcom County Solid Waste Management Plan (1973) refers to the phasing out of small open dumps and replacement with larger central sanitary landfills in the near future. This change would replace self-hauling with a county collection system and user fees; waste handling capacity would be increased while environmental hazards could be reduced.

Solid waste disposal for Bellingham is provided as a municipal service by the city, which contracts collection to private companies and charges a fixed price per can per household, renegotiated each year. The garbage is transported to a site on Highway 540, five miles north of Bellingham, where a thermal reduction plant is operated by Wilder Construction Company. "Moose" Zurline, solid waste director for the firm, stated that the facility now incinerates 120 tons per day, operating nine-and-one-half hours per day, five days per week. This volume is 20% over the design capacity of the plant, which is supposed to run 100 tons per eight-hour day, on a five-day per week schedule. Mr. Zurline indicated that capacity could be increased up to a point by extra hours of operation, and at present the plant is meeting the air emissions standards of the Northwest Air Pollution Control Authority and the U.S. EPA.

The present service population of the Wilder plant is 43,000 (12,000 homes), which includes all of Bellingham and a few hundred unincorporated county dwellings. The plant could reportedly accommodate a 10% increase in service population before having to add new capacity. The plant employs modular incinerators; each incinerator increases the effective service population by 5000. Currently, the county is exploring a proposal to provide funding to increase the plant's capacity to 160 tons per day. Presumably most of this incremental capacity would be reserved for the unincorporated areas and would serve either county growth or existing residences now forced to use sanitary landfills or dumps.

(5) Transportation. Ferndale is located about half a mile west of Interstate 5. No state highways traverse this area; the main arteries in the Ferndale vicinity are county or city roads, including the Mountain View road and Blaine-Ferndale road. Birch Bay, an unincorporated community to the northwest of Ferndale, is located about four miles from Interstate 5. While no state highways run near Birch Bay, major local roads are the Blaine-Ferndale road which becomes the Birch Bay road nearer to Birch Bay, the Birch Bay-Lynden road, the Drayton road, and Birch Point road, which goes along the coast and out to Birch Point. A local road also parallels the Burlington-Northern Railroad just southwest of Interstate 5. These are all medium-duty rural roads.

Interstate 5 goes through the Town of Blaine in the extreme northwest of Whatcom County; the Burlington-Northern Railroad and the local road paralleling it skirts the western edge of town along the waterfront. The main local road into Blaine is the Blaine-Lynden road southwest of town.

For a discussion of problems of capacity and safety occurring in rural road networks such as these, see the transportation section of infrastructure under issues/approach. According to L. Davis, long-range program engineer of the State Highway Department, some needs for road expansion may exist in

the Ferndale area (see Table VII-60), but there are no expansion plans because no monies are available. The money presently available for this part of Whatcom County is sufficient only for resurfacing and maintenance of existing local roads.

c. Terrestrial Biology

The area planned for continuing intensive industrial use in the vicinity of Cherry Point is in the ownership of three oil companies as well as Intalco Aluminum and several other large holdings. At the extreme north and west is the Atlantic Richfield property and vicinity, an area of approximately 2400 acres of which 400 are now intensively used by Atlantic Richfield. The remainder is a mosaic of approximately 50% woodland (1000 acres) and 1000 acres of cleared and grazing land. The latter includes the proposed refinery site owned by Standard Oil. Much of the vegetation of the wooded parts of this property is a deciduous woodland representing a relatively early seral stage including many of the characteristics species listed in the species list table for broad leaf forest and shrubland habitats.

In some parts, the larger trees, including alder and big leaf maple, are quite mature indicating an age for the strand of more than 50 years. Some of the open areas are grazed and thereby maintained in the earliest successional stage as disturbed pasture grassland. Other of the grazed areas have been lying fallow for several years and are currently being invaded by alder and some shrub species. The Standard Oil coastal parcel suitable for terminal access is presently a large, open field with a few scattered young alders and one or two quite young western red cedars. The high bluff overlooking the shore harbors a mixed deciduous tree and shrub community including some weedy species such as gorse and a high proportion of the native baldhip rose.

To the south, the area between the Intalco Aluminum plant and the northern boundary of the Mobil property at Unick Road is largely grazing land with a few scattered woodland areas serving as wind breaks. These woods are roughly in the same successional stage as those on the Standard property to the north. Notable species include mature adler, some red cedars, and paper birch which is at the southern end of its range in this area and, therfore, rare in western Washington. In general, the pasture lands in this section are overgrown and in the process of conversion to wood lots. The wind breaks contain young, mostly deciduous forest species.

Further south, the undeveloped portion of the Mobil Oil refinery site is approximately 300 acres in size, enclosed largely by the rectangle formed by Kickerville, Slater, and Lake Terrell roads. Of this, about 80% (250 acres) is wooded and the remaining 20% is pasture land. The Mobil property between Kickerville Road and the shore includes their present terminal access area and pier. South of the pier line there lies approximately 70 acres of which 40% is wooded and the remainder is grazing land; roughly one-fourth of the wooded acreage is coastal bluff. North of the pier, Mobil's property comprises about 55 acres of wooded land and 35 acres of cleared land between Creamer and Unick roads, to the south and north and enclosed by the shore and Kickerville Road. The vegetation of these zones is similar to that described for the other oil company properties.

TABLE VII-60

HIGHWAY VOLUME/CAPACITY RATIOS - WHATCOM COUNTY

Road No.	Control Section	Volume/Capacity Ratio Maximum	Mean	Standard Deviation
	Whatcom County			
I-5	3702	.44	.37	.05
	3703	.22	.15	.05
504	3741	.26	.23	.02
543	3735	.16	.12	.04

d. Air Quality

As there is little population within 10 miles, air quality in the vicinity of Ferndale is principally determined by the existing industry. Aluminum production at Intalco on Cherry Point and the Atlantic Richfield and Mobil refineries all result in large sulfur oxide emissions (see Table VII-61). The refineries also emit substantial amounts of hydrocarbons.

Ventilating winds in the area are relatively good, and basin potential for pollutant retention and oxidant formation is moderate to low. The large port and urban community of Bellingham lie 15 miles to the east. Oxidant is monitored in Bellingham; no violations of federal standards have yet been observed (see Table VII-62). Under common meteorologic conditions, that community lies within the same air basin as Cherry Point, but the role of existing hydrocarbon sources on Cherry Point in causing oxidant at Bellingham is not known.

e. Water Quality/Marine Biology

The Cherry Point/Ferndale site is in the Nooksack River basin (see Table VII-63). The dominant beneficial uses in this one segment are navigation, commercial shipping, sport and commercial fishing, and recreational boating, with some scenic viewing. The coastal segment near Ferndale and Cherry Point has an aquatic resources inventory similar to that of March Point and Anacortes. In addition to shellfish culture, there are salmon, commercial bottom-fish, and herring fisheries. There is also a major waterfowl area in the immediate vicinity.

Three major industries discharge into the segment's waters. Intalco, an aluminum smelter, discharges 12.5 MGD of smelter and sanitary wastes. Smelter wastes receive chemical treatment, while sanitary wastes receive oxidation and chlorination. Atlantic Richfield discharges 10.8 MGD of refinery process waters, tanker ballast waste, and storm runoff, which receive secondary treatment with pH and phenol control. Mobil discharges 2.6 MGD of secondary effluent, also with pH and phenol control. Blaine Air Force Base and Birch Bay State Park discharge small amounts of municipal effluent into vicinity waters. Blaine Air Force Base's effluent receives secondary treatment.

Although no water quality data exist for this segment of Nooksack Basin, the waters are classified Class A and are considered effluent limited. Some 1974 data from the Birch Bay area indicate waters of excellent quality with no significant abnormalities. These waters are ranked sixth of eight segments in the Nooksack River basin for problem severity. There is one public underwater recreation area to be protected from oil-related pollution; there are no other water quality issues apparent for this sgement.

Although Cherry Point itself is not exceptional, the region surrounding Cherry Point is rich. The relatively undisturbed complex of islands, straits, bays, and estuaries supports a large, diverse assemblage of plant and animal species. Bellingham, Birch, Lummi, and Semiahoo bays provide

TABLE VII-61

ANNUAL EMISSIONS FROM EXISTING SOURCES AT CHERRY POINT

Source	Particulate	SO_2	NO_x	HC	CO
Atlantic Richfield (ARCO)	130	4630	1420	2250	-
Mobil Oil Corp.	280	6180	950	2080	-
Intalco Aluminum Corp.	890	4210	470	890	90,350

Source: Teknekron, 1976.

TABLE VII-62

AIR MONITORING DATA - BELLINGHAM

OZONE

	Annual Max. Hour	# Hours > 8 pphm
1974	8	0
1975	7	0
(5 months) 1976	7	0

SULFUR DIOXIDE

	Annual maximum hourly average	# hours > 40 pphm	Annual maximum 24 hour average	Annual Average
1974	14	0	4	1
1975	8	0	4	1
1976	10	0	4	1

Source: State of Washington, Department of Ecology.

TABLE VII-63

WATER QUALITY - CHERRY POINT

NOOKSACK RIVER BASIN - WATER RESOURCE INVENTORY AREA 1

Existing Water Quality

Segment 07 - Cherry Point: Class A, effluent limited. 1974 unofficial data from Birch Bay indicate waters of "excellent quality with no significant abnormalities." Ranked 6th of 8 in problem severity.

Issues

None apparent

Beneficial Uses

Navigation
Commercial shipping
Sport and commercial fishing
Boating
Scenic viewing
Shellfish culture
Fish migration
Food fish reproduction and harvesting

Aquatic Resources

Pacific Oyster Culture
Intertidal hardshell clams
Dungeness crabs
Scallops
Salmon fishery
Commercial bottom-fishery
Herring spawning and commercial fishery
Major waterfront area

Public Recreation/Protected Areas

Birch Bay underwater recreation area

Discharges Within 10 Miles of Marine Terminal

Discharger	Quantity (mgd)	Effluent
Intalco	12.5	Smelter wastes, sanitary wastes
Mobil	2.6	pH and phenol control; secondary treatment
Arco	10.8	Process wastes, ballast and storm runoff (secondary treatment)
Blaine Air Force Base	0.012	Secondary effluent
Birch Bay State Park	-no data-	Secondary effluent

Sources: Department of Ecology, 303(e) Nooksack Basin; Department of Natural Resources, Marine Atlas, 1974; Department of Ecology, Fauna Survey, 1975.

habitat for many seabirds, including loons, grebes, cormorants, gulls, terns, alcids, and seaducks. Further south, the San Juan Islands provide nesting habitat for numerous birds, including cormorants, puffins, guillemots, oystercatchers, and glaucous winged gulls. The islands also support numerous winter residents and provide resting areas for migratory species. These include rock sandpipers, black turnstones, and surfbirds. Harbor seals are the most significant species of aquatic mammals on the islands.

B. ENVIRONMENTAL IMPACT OF PETROLEUM DEVELOPMENT SCENARIOS

The sudden availability of large quantities of Alaskan crude oil gives rise to the several petroleum development scenarios described in Chapter IV. One or more of the scenarios involve each of the three petroleum industry activity zones and may potentially significantly affect the environment at those locations. The environmental analysis in the following section uses the preceding environmental setting description as a basis. The components of each scenario that serve as generators or sources of environmental impact are described in Chapter VI. Although a significant petroleum development involves a broad spectrum of activites, the principal potential for environmental impact tends to focus on several critical areas; the impact potential on other areas is far less likely to be significant. This includes many potential environmental issues as described in Chapter V which, because of the nature of the activity and most importantly because of the characteristics of the existing environment, will not be a major concern for the petroleum development scenarios addressed in this study.

As will be seen, the principal potential impact on the marine terminal sites themselves will come from scenarios with a large crude oil throughput. Maintenance of the present petroleum activity offers practically no incremental impact. The environmental factors most likely to be affected are only the most sensitive element of infrastructure: schools and the hourly state standard for sulfur dioxide in air quality. Because current services for infrastructure and conditions of both terrain and meteorology for air quality differ among the three zones, the relative sensitivity to large crude oil throughput varies as well.

Oil pollution is not a major concern for the marine terminal itself. The impact of tanker transit is significant and is addressed separately under transportation corridors in Chapter VIII. Generally, the amount of oil released by operational spillage in the marine terminal vicinity is smaller than the estimate of existing oil discharge from other sources such as industrial processes, urban runoff, or other marine activities. The aggregate level of oil pollution appears to be below the threshold level for chronic effects.

The land required for onshore facilities and for new residential areas to serve induced growth is significant by comparison with the extent of present urbanization, but in every case there appears to be sufficient acreage of vacant, cleared, or second-growth land available, and few conflicts with existing land use and insignificant terrestrial biological impacts are expected. Again, the magnitude of impact depends upon the level of activity and the complex of land use trends in each petroleum activity zone.

1. Port Angeles-Clallam County

Among the petroleum development scenarios, only the Northern Tier Pipeline project will bring activity to Port Angeles. This study examines two cases: Scenario II-A (crude oil throughput of 400,000 B/D to 800,000 B/D), a transshipment project alone using Port Angeles at the marine terminal for

a pipeline delivering crude to the central United States, and Scenario II-B (crude oil throughput of 690,000 B/D to 1,250,000 B/D), a transshipment pipeline with Puget Spur Pipeline allowing a marine terminal at Port Angeles to serve as a superport for receiving the crude oil supply required by regional refineries.

It should be noted that the other scenarios which do not require vessel calls at Port Angeles in fact entail significant vessel movements through the Strait of Juan de Fuca past Port Angeles. Some of these vessels will require the Puget Sound pilot service which is based on Ediz Hook but otherwise will have no economic or social impact on the city. There are minor air quality impacts from tanker transit and potentially signficiant oil spill impacts on water quality and marine biology that may involve the Port Angeles harbor and adjoining coast line. Those impacts are discussed in Chapter VIII.

a. Land Use

(1) Direct Impacts. The major onshore facilities required for oil transshipment at Port Angeles (exclusive of the pipeline) are pumpage facilities to assist offloading and surge/storage. Port Angeles is involved only in Scenarios II-A and II-B, which describe the Northern Tier Pipeline originating at Port Angeles, with and without the Puget Spur Pipeline. The land requirement is a function of oil throughput as shown in Table VII-64, which indicates the range of land acreage required as determined by possible throughput phasing. (See Chapter VI.)

In the minimum scenario (II-A, 1980), 90 acres would be required for these facilities (7 tanks @ 10 acres/tank + 20 acres for access roads, pump stations, etc.). In the maximum scenario (II-B, 1990), 220 acres would be required (20 tanks + 20 acres). Table VII-65 indicates the availability of land at the four possible subalternative sites for these onshore facilities, as developed under Chapter VII-A.

Comparison between Tables VII-64 and VII-65 shows that all four subalternatives provide adequate land for the onshore facilities in the minimum scenario (II-A, 1980). Development for larger throughput will require careful siting and possibly tankage at separated locations. Ediz Hook, the main proposal for the Northern Tier terminus at Port Angeles, has the least land available on the Hook itself, so that in Scenario II-A after 1980 and in all of II-B the remaining tankage would have to be constructed further inland, probably on the bluff west of the city and north of the airport. This arrangement would probably demand a larger pump station on the Hook. The Morse Creek subalternative site probably does not provide enough suitable flat land for Scenario II-B (Northern Tier with the Puget Spur). Freshwater Bay (Angeles Point) is the only subalternative site with plenty of contiguous land for the maximum scenario (II-B, 1990).

Since there is no zoning presently in effect in Clallam County, the land use impacts of the land conversion for surge/storage and pump station construction can only be evaluated in the light of the impacts on existing land uses at the proposed subalternative sites and, to some degree, on local land use planning concepts.

TABLE VII-64

INDUSTRIAL SITE LAND CONSUMPTION
ONSHORE FACILITIES[a]
PORT ANGELES

Scenario	Crude Throughput (1000 B/D) 1980	1985	1990	New Tankage Required	New Tankage Land Required[b] (Acres)
I. Regional Supply					
A. Unrestricted Fleet	0	0	0	no	-
B. Restricted Fleet	0	0	0	no	
II. Northern Tier at Port Angeles					
A. Regional Supply by Tanker	400	800	800	yes	90 - 150
B. Regional Supply by Puget Spur Pipeline	690	1090	1250	yes	140 - 220
III. Transshipment at Cherry Point	0	0	0	no	
IV. Regional Supply Trans Mountain Pipeline	0	0	0	no	

(a) Onshore facilities include surge/storage (tank farm), pump stations and access roads
(b) Assumptions: 625,000 bbl/tank
Ratio tank capacity: throughput = 10:1
10 acres/tank + 200 acres for access roads, pump stations etc.

Source: Arthur D. Little, Inc.

TABLE VII-65

SUITABLE ACREAGE AVAILABLE FOR ONSHORE FACILITIES
(Port Angeles Subalternatives)

Subalternative	Acres Available	Present Land Use
Freshwater Bay	350	Agriculture (intensive)
Ediz Hook*	100	Fallow
Green Point (Morse Creek)	120	Fallow grassland
Green Point (Siebert Creek)	175	Woodland

*Main proposal for Port Angeles. Others are subalternatives to Ediz Hook which were rejected by the Northern Tier Pipeline Company. The 100 acres includes the lagoon and vacant land at the base of the Hook.

The tank farm at the Ediz Hook location would be compatible with the adjoining use which is the tank storage for the adjacent Crown Zellerbach plant, but might conflict with plans of Crown Zellerbach itself to use this vacant land. Land use on the bluff near the airport is mixed agriculture and privately-held timberland. The property would have to be purchased from the present owner, and its use as a tank farm site could run into significant opposition from the owners of adjoining lands because of the high visual impact of oil tanks on these non-industrial lands.

Both the Morse Creek and Green Point subalternatives suffer from the low availability of suitable flat land, and also may raise land use conflicts because the predominant vicinity land use is low-density residential. To the degree to which the tanks are visible, they will be viewed as a nuisance, particularly by residents who have paid a premium for the view qualities of a waterfront location or an overlook of the Strait.

The Freshwater Bay (Elwha River) site would provide adequate land for the onshore facilities in the maximum scenario, but would result in the loss of agricultural productivity on a small fraction of the remaining agricultural lands within Clallam County (0.3%). However, the total acreage in farms within the county has been steadily declining in recent years as the land undergoes all types of urban conversion or is sold and kept non-productive by speculators in the hope of future urban conversion. In this light, further encroachment on prime, flat crop land, such as by a tank farm, should be viewed with the same caution as with any development.

The greatest potential land use conflicts arising from a Northern Tier or other oil proposal at Port Angeles have already been identified by the local citizenry as conflicts for the use of Port Angeles harbor itself. Both the City of Port Angeles and Clallam County have adopted ordinances banning an oil port at Port Angeles or elsewhere within Clallam County. The several conflicts associated with oil tanker use of the harbor include interference with the log booming operation of ITT Rayonier and Peninsula Plywood, with small boat rental, with fishing charter boat activities, and with activities of the Port Angeles Pilot Station.

With about 300 employees, ITT Rayonier is one of the chief Port Angeles employers. The company claims that if oil tanker interference with its log booming inside Ediz Hook forced it to move to a dry land-based booming system, this would cost them an additional $1 million per year and could price them out of existence. Since ITT Rayonier is important to Port Angeles, both as an employer and as a part of the tax base, the local citizens would view the departure of this company as an extreme hardship; its replacement by an oil port would provide for less permanent local employment. The contribution to the tax base would be high, in proportion to the inventory tax on the oil, but still less than the Rayonier facility.

Tourism is the most important industry to Port Angeles in terms of providing local employment. Therefore, any use of the only deepwater, sheltered harbor along the Strait which has an obvious direct adverse effect on tourism such as the movement or berthing of small boats and charter boats is viewed as a serious economic threat by the population of

the area. Similarly, the navigation pilots based within Port Angeles harbor serve a vital function with respect to navigation safety in the Strait of Juan de Fuca and the movement of goods to and from the Seattle/Tacoma port areas. Port Angeles harbor is the most logical place for the deployment of their boats so that to the degree to which the movement and berthing of oil tankers hinders the pilots' activities, their concerns appear justified. Navigation safety for multi-based ship traffic between the Strait and the inner Sound would have priority over the movement of a single commodity. Overall, an oil port at Port Angeles harbor would consume most of the remaining waterfront of Ediz Hook and would foreclose the future option to reserve this waterfront for other port-related activities which are more labor-intensive.

In all, the land requirements of the onshore facilities at Port Angeles represent a 14-23% increase in industrial land use in Clallam County (Scenario II-A) and a 22-34% increase in the total industrial acreage within the county in Scenario II-B. While there is no scarcity of land which could be put to industrial uses within the county, in most locations a large tank farm would constitute a major departure from the present low-density residential and other non-urban uses of these lands. At present, an oil port and all of its associated structures have been enjoined from Clallam County or the incorporated limited of Port Angeles by local legislative mandate. However, action at the state level may override the local bans.

The Clallam County Shoreline Master Program designates Port Angeles harbor, including all of Ediz Hook and the bluff, as "urban." An oil terminal inside the harbor would be consistent with the urban designation, particularly since the general regulations given within the Clallam Master Program state that "emphasis shall be given to development within already developed areas and particularly to water-dependent industrial and commercial uses requiring frontage on navigable waters."

The other areas designated in the Clallam County Shoreline Master Program potentially affected by the subalternative sites for marine terminals or onshore facilities in Scenarios II-A and II-B are the Elwha River, designated "conservancy"; Freshwater Bay and shoreline, designated "rural"; the mouth of Morse Creek, designated "rural"; and the shoreline east of Port Angeles, designated "conservancy." In addition, the Strait of Juan de Fuca and adjacent salt waters and the downstream portion of the Elwha River have been designated shorelines of statewide significance.

The onshore facilities proposed in the vicinity of Morse Creek will not conflict with master program policies if they bypass the floodplain of the creek or do not intrude within 200 feet of the shoreline. If, however, the tank farm or associated structures or access road impinges on either of these areas, it may violate the intent of the rural designation -- that is for rural areas to "function as a buffer between urban areas, and to restrict intensive development on shorelines presently in an undeveloped state" (Clallam County Shoreline Master Program). The surge/storage facilities could impinge on conservancy areas in the vicinity of

the Elwha River or at the mouth of Siebert Creek. In this case, intensive industrial use such as a tank farm appears inconsistent with the stated purpose of the conservancy environment -- that is, "that the preferred uses are nonconsumptive of the physical and biological resources of the area, and are activities and uses of a non-permanent nature which do not substantially degrade the existing character of the areas." In addition, the Elwha River has been designated a shoreline of statewide significance. Policies in this regard which may tend to discourage an intensive industrial use of this site if it impinges directly on the Elwha floodplain or riparian zone are the following: (a) "Actions which would convert resources into irreversible uses or detrimentally alter natural conditions characteristic of shorelines of statewide significance shall be severely limited," (b) "Aesthetic considerations for the general enhancement of the shorelines must be actively promoted when contemplating new development or redevelopment of existing facilities," and (c) "Erosion and sedimentation that would alter the natural function of the water system must be prevented."

Also designated as shorelines of statewide significance are the entire Strait of Juan de Fuca and adjacent salt waters north to the Canadian line and lying seaward from the line of extreme low tide (Clallam County Shoreline Master Program). In light of the risk of oil spill damage to this environment due to tanker transport activities, the following additional policies are relevant and tend to restrict or entirely eliminate new activities of this type from the environment: (a) Quotation No. (a) above, (b) "The short-term economic gain or convenience of developments must be evaluated in their relationship to long term and potentially costly impairments to the natural environment, and (c) "Regulations must be based on the premise of preserving the shorelines for future generations."

In summary, the only designated shoreline area where proposed project facilities are clearly in conformance with Shoreline Program and Coastal Act land use categories and their associated regulatory policies is in Port Angeles harbor. At the remaining possible subalternative sites, both on- and offshore, conformance needs to be more clearly and specifically proven or negated through the local and state regulatory review process.

(2) Indirect Impacts. Scenarios II-A (Northern Tier Pipeline at Port Angeles, no Puget Spur) and II-B (Northern Tier Pipeline at Port Angeles, Puget Spur) are the only two scenarios which will produce population growth impacts in the Port Angeles/Clallam County activity zone. The size and demographic characteristics of the new population generated by direct and indirect employment are summarized in Tables VII-66 through VII-68. The peak impact (peak construction) year in both Scenarios II-A and II-B is 1979, which would yield population growth increments of 2530 persons in II-B and 2300 persons in II-A (91% of the II-B increase). The maximum case (II-B) peak will thus yield an increase of 865 households in the area which will produce population and infrastructure impacts. Excluding the direct construction employment group leaves a total of 2110 persons or 760 new households which will both consume land for new housing and contribute to the local property tax base.

TABLE VII-66

DEMOGRAPHIC CHARACTERISTICS - DIRECT EMPLOYMENT
PORT ANGELES

Scenario	Employees	Growth Component[a]	Number of Households	Persons Per Household	Total Persons	Port Angeles Incorporated	Port Angeles School District Unincorporated	Sequim School District Unincorporated	Increase as % of 1975 County Population (37,000)	Wages Per Household
		Permanent Employment				Location of Households[b]				
IA Regional-Unrestricted	None									
IB Regional-Restricted	None									
IIA Northern Tier	137	0.7[a]	96	4.0	384	48	24	24	+1.04%	$27,187[c]
IIB N. Tier w/Puget Spur	157		110		440	55	28	27	+1.19	
III Transshipment/Cherry Point	None									
IV Regional-Trans Mountain	None									
		Construction Peaks								
IA,IB	None									
IIA 1978	589	0.2[d]	118	4.0	472	59	30	29	+1.28%	$16,956[e]
1979	466		93		372	47	23	23	+1.01	
IIB 1978	603		121		484	61	30	30	+1.31	
1979	523		105		420	53	26	26	+1.14	
		Totals (Permanent + Construction Peaks)								
IIA 1978	726		214		856	107	54	53	+2.32%	
1979	603		189		756	95	47	47	+2.05	
IIB 1978	760		231		924	116	58	57	+2.50	
1979	680		215		860	108	54	53	+2.33	

Footnotes

a 70% of permanent direct employment is in-migration
b Assumes 50% will locate in incorporated Port Angeles, 25% in the unincorporated area around Port Angeles (Port Angeles School District) and 25% in the Sequim area (Sequim School District) - applies to all Port Angeles employment
c $27,187 = $24,400 (Oil industry average salary - Cherry Point - plus $2,788); .27 second wage earners per household x 10,325 (Average Employment Security Act salary - Clallam County)
d 20% of construction employees are in-migrants with families
e $16,956 = $11,690 - 1975 Construction wages for Clallam County + $5,266 ($10,325 x 0.51 second wage earners per household (Clallam Co.))

Source: Arthur D. Little, Inc.

TABLE VII-67

DEMOGRAPHIC CHARACTERISTICS - INDIRECT EMPLOYMENT
PORT ANGELES

Scenario		Permanent Employment: Employees	Growth Component[a]	Persons Supported[b]	Persons per Household average (1976)	Total Households	Location of Households: Port Angeles Incorporated	Port Angeles School District Unincorporated	Sequim School District Unincorporated	Household Income	Wage Earners Per Household
IA	Regional-Unrestricted	0			--no Direct or Indirect--						
IB	Regional-Restricted	0			--no Direct or Indirect--						
IIA	Northern Tier	295	89	210	2.57	82	41	21	20	$15,538	1.51
IIB	N. Tier w/Puget Spur	335	101	238		93	46	24	23		
III	Transshipment w/Puget Spur	None			--no Direct or Indirect--						
IV	Regional-Trans Mountain	None									
					Construction Peaks						
IIA	1978	1261	378	892		347	174	87	87		
	1979	1881	564	1331		518	259	130	129		
	1980	546	164	387		151	75	38	37		
	1981	387	116	274		107	53	27	27		
	1982	181	54	128		50	25	13	12		
IIB	1978	1290	387	913		355	178	89	89		
	1979	2023	607	1432		557	279	139	139		
	1980	587	176	416		162	81	41	40		
	1981	444	133	314		122	61	31	30		
	1982	207	62	147		57	29	14	14		
					Total Indirect (Permanent + Construction Peaks)						
IIA	1978	1556	467	1102		429	215	108	107		
	1979	2176	653	1541		600	300	151	149		
	1980	841	253	597		233	116	59	57		
	1981	682	205	484		189	94	38	47		
	1982	476	143	338		132	66	34	32		
IIB	1978	1625	488	1151		448	224	113	112		
	1979	2358	708	1670		650	325	163	162		
	1980	922	277	654		255	127	65	63		
	1981	779	234	552		215	107	55	53		
	1982	542	163	385		150	75	38	37		

Footnotes

Assumptions -

a 30% of industry employment is assumed to be in-migration (see Text for further discussion)
b 2.36 persons supported per job (see Text for further discussion)

Source: Arthur D. Little, Inc.

TABLE VII-68

POPULATION AND HOUSEHOLD TOTALS
PORT ANGELES
PERMANENT DIRECT AND ALL INDIRECT EMPLOYMENT
(Land Use Impacts)

Scenario	Employees	Persons Supported	Total Households	Location of Households: Port Angeles Incorporated	Port Angeles Unincorporated School District	Sequim Unincorporated School District	Household Income (Weighted Average)
IIA Northern Tier							
1978	1693	1486	525	263	131	131	
1979	2313	1925	696	348	174	174	
1980	978	981	329	165	82	82	
1981	819	868	285	143	71	71	
1982	613	722	228	114	57	57	$19,329
IIB N. Tier w/Puget Spur							
1978	1782	1591	558	279	140	139	
1979	2515	2110	760	380	190	190	$17,011
1980	1079	1094	265	133	66	66	
1981	936	992	325	163	81	81	
1982	699	825	260	130	65	65	
GRAND TOTAL ALL DIRECT + ALL INDIRECT EMPLOYMENT (INFRASTRUCTURE IMPACTS)							
IIA							
1978	2282	1958	643	322	161	160	
1979	2279	2297	789	395	196	196	
1980	978	981	329	165	82	82	
1981	819	868	285	143	71	71	
1982	613	722	228	114	57	57	
IIB							
1978	2385	2075	679	340	170	169	
1979	3038	2530	865	433	216	216	$16,852
1980	1079	1094	265	133	66	66	
1981	936	992	325	163	81	81	
1982	699	825	260	130	65	65	

Source: Arthur D. Little, Inc.

The location of these new households was allocated according to both the present distribution of households which concentrates the majority of the region's population in the urban area of Port Angeles, and recent growth trends in the surrounding unincorporated area, east to the Sequim-Dungeness Valley, based on information from the planning departments of both Clallam County and the City of Port Angeles. (See existing condition text and Tables VII-1 through VII-5.) With this information as a base, 50% of the new households were allocated to incorporated Port Angeles, 25% to the unincorporated area around the city within the Port Angeles school district, and 25% to the unincorporated area of the Sequim school district. On the assumption that families seeking urban amenities would locate in the City of Port Angeles in preference to the City of Sequim, very few or no families were assumed to move to Sequim itself.

The significance matrix for Port Angeles/Clallam County (Table VII-69) shows that all five years of both Scenarios II-A and II-B will have significant population, land use, and infrastructure impacts on the City of Port Angeles and the Port Angeles school district area. Only the peak year 1979 involves population increases in the Sequim school district area large enough to produce significant land use and infrastructure impacts, based on the annual growth criterion of significance developed in Chapter VI. Population growth levels in 1978, considering all direct and all indirect employment (including direct construction), will be large enough to exceed the criterion of significance for the Sequim area as well. At the historical growth rate in Clallam County, the levels of growth allocated to the three areas described above will have significant land use impacts on the county as a whole, at least during peak construction (1978-80).

Port Angeles has experienced extremely slow growth in the recent past with the exception of 1975-76 when the rate increased to 1.6% (see Table VII-4). At the historic growth rate of the early 1970s of only 0.14% per year, the 1979 scenario population, an increase of 5.9% over the present population (households) is equivalent to 42 years of growth in this city. This peak year population increment is equivalent to over nine years of growth in the surrounding unincorporated areas of the Port Angeles school district area, but only 1.3 year equivalent to the Sequim school district area.

The 171 acres of land conversion projected for Port Angeles represent an increase of 14.3% in the residential land use within the city and consume 7.8% of the remaining undeveloped lands within the city limits. (See Table VII-70.) While this is a considerable degree of new urbanization, it does not consume valuable timber or intensively farmed crop land since nearly all undeveloped lands within Port Angeles proper are chiefly being held for future residential development. The conversion of these lands is within the stated policies of both the city and county to encourage infilling development in urban areas in preference to low-density suburban encroachment on rural unincorporated lands.

TABLE VII-69

SIGNIFICANCE MATRIX - LAND USE AND INFRASTRUCTURE
PORT ANGELES

Significant Scenario/ year	Community		Unincorporated	
	Port Angeles	Port Angeles School District	Sequim School District	Clallam County
IIA Northern Tier				
1978	X	X	*	X
1979	X	X	X	X
1980	X	X	-	X
1981	X	X	-	X
1982	X	X	-	X
IIB N. Tier w/Puget Spur				
1978	X	X	*	X
1979	X	X	X	X
1980	X	X	-	X
1981	X	X	-	*
1982	X	X	-	-

X = Significant for both Land Use and Infrastructure
* = Significant for Infrastructure only
- = Not significant

Source: Arthur D. Little, Inc.

TABLE VII-70

LAND USE - MAXIMUM IMPACT ON COMMUNITIES
PORT ANGELES

MAXIMUM IMPACT SCENARIO IIB Transshipment/Port Angeles	Total New Persons (Direct permanent and all Indirect	Total as % of 1975 Clallam County Population	Historical growth rate % (average) 1970-1976	New Households in Community	Existing Community Households	% Increase	Growth Equivalence at Historical Rate	Acreage Consumed[c]	% increase in residential Acreage
year 1979	2110	5.7%	2.3%						
Port Angeles			0.14%	380	6,423	5.9%	42.1y	171	14.3
Port Angeles SD			1.6	190	2,044	9.3%	5.8	114	1.7 (Countywide)
Sequim SD			5.0%	190	3020[b]	6.3	1.3	114	

Footnotes

[a] Derived considering enrollment and population trends combined

[b] Derived from enrollment figures, Port Angeles family size, and Clallam County schoolchildren per household

[c] Parcel Size = 1/4 acre in Port Angeles, 0.4 acres in unincorporated acreas

Source: Arthur D. Little, Inc.

Land use conversion in the Port Angeles and Sequim school district unincorporated areas would consume a total of 228 acres of undeveloped lands according to the expected number of households and the parcel size used to determine conversion (see discussion in Chapter VI). This amount of land conversion represents a 1.7% increase in residential land use within the county, but consumes only a very small fraction of all open lands. Assuming that all the lands converted are relatively flat agricultural lands within the coastal terrace and stream valleys, this acreage represents 0.4% of the remaining lands used for agriculture and small private forest (0.8% of crop lands only). The indirect impact is thus slightly greater than the direct impact described previously.

While these values are quite small on a percentage basis, all future land conversions of agricultural lands continue a trend of urban encroachments on this productive land use which encourages ongoing speculation on agricultural acreage which in turn makes farming economically difficult by causing a rise in property values. Excessive speculation, already recognized as a problem by the county, discourages landowners from preserving highly fertile lands for agriculture under RCW 84.34 and stimulates further farm land conversion. In addition, in contrast to development within incorporated Port Angeles, urban development of this type projected for the surrounding unincorporated lands is the type of suburban encroachment on rural lands specifically discouraged by current county planning policies.

b. Infrastructure (Secondary) Population Growth Impacts

As described under land use/demography impacts, the two scenarios with significant population growth/infrastructure impacts on the Port Angeles/Clallam County activity zone are II-A and II-B (Northern Tier Pipeline at Port Angeles, with and without the Puget Spur). The 1979 peak year impact will represent an influx of 865 households with demands for the various community services and utilities. Of these, 760 will make a contribution to the local property tax base (Tables VII-68 and VII-71). Based on a weighted average income of $17,010 per household, this yields an affordable house price of $37,800, a total market value increase of $28.7 million and a total increase in assessed valuation for the area of $27.1 million. These increases are allocated to Port Angeles (incorporated), Port Angeles school district area (unincorporated), and Sequim school district area (unincorporated). (See Table VII-71.)

(1) School Impacts. Impacts on local school districts are in many ways the most important infrastructure impacts of new growth for several reasons. Schools are among the most costly of community services and demand a high proportion of property tax revenues. Education is important, and there is uniform community concern in areas with a high proportion of young families that the children be provided with adequate school facilities offering quality educational programs. Schooling must be provided by the community; unlike low-density water supply and wastewater disposal, it cannot properly be provided on a family by family basis.

Port Angeles/Clallam County impacts of Scenarios II-A and II-B on the local school districts are given in Tables VII-72 and VII-73. Based on the significance matrix (Table VII-69), the school impacts for nearly

TABLE VII-71

INFRASTRUCTURE - VALUE OF HOUSING
PORT ANGELES

	Market Value of Housing (Project Component) (weighted average)		Assessed Valuation of Housing (Project Component)	
	Per Household $	Total ($ Thousands)	Per Household $	($ Thousands)
	$37,800	$28,728.0	$35,645.	$27,090.5
Port Angeles	"	$14,364.0	"	$13,545.3
Port Angeles SD	"	$ 7,182.0	"	$ 6,772.6
Sequim SD	"	$ 7,182.0	"	6,772.6
Total		28,728		27,090.5

Source: Arthur D. Little, Inc.

TABLE VII-72

SCHOOL IMPACTS - FACILITIES AND ENROLLMENT
PORT ANGELES
MAXIMUM IMPACT YEAR/SCENARIO
1979

Community	School District	Households	School age children per household	New students generated	Total Enrollment Including Project	% Increase in 1976 Enrollment	Capacity remaining before project (Pupils)	New Teachers or Classrooms required Elementary	Secondary
	Port Angeles	162 Dir.	1.79	290					
		488 Ind.	0.57	278					
				568	5394	11.8	-1516	11	13
	Sequim	53 Dir.	1.79	95					
		162 Ind.	0.57	92					
				187	1911	10.9	-442	4	4

Source: Arthur D. Little, Inc.

TABLE VII-73

SCHOOL IMPACT - FISCAL AND CAPITAL DEVELOPMENT
PORT ANGELES
MAXIMUM IMPACT YEAR/SCENARIO
1979

School District	Assessed Valuation Total Project Contribution ($ Thousands)	% Increase in District Assessed Valuation	Project Market Value per Pupil	Local Property Tax revenue per Pupil	% Difference from average local revenue per Pupil	Space and Land Requirement: Elementary Square Ft. Classroom Space	Elementary Acres School land	Secondary Square Ft. Classroom Space	Secondary Acres School Land	Increase in Bonding Capacity ($ Thousands)	Square Footage paid for @ $46/SF
Port Angeles	$20,317.9	6.7%	37,933	$342	-0.34%	23,515	8	39,874	13	$1,077.3	23,420
Sequim	6,772.6	4.0%	38,406	$167	-32.8 %	7,742	6	13,127	1	359.1	7,807

Source: Arthur D. Little, Inc.

all years of both Scenarios II-A and II-B will be significant in both the Port Angeles and Sequim school districts. The peak year population levels add 568 students to the enrollment of the Port Angeles school district (an increase of 12% over 1976 enrollment) and 187 students to the Sequim district (an 11% increase). Both of these districts are presently suffering from an extreme facilities deficit -- over-enrollment of 1500 and 450 students, respectively. Concurrently, the new demand for housing by the proportion of these families requiring new housing will increase the district assessed valuation by 6.7% and 4%, respectively. Thus, the increase in enrollment contributed is proportionately 1.7 to 2.7 times larger than the increased assessed valuation contributed.

Similarly, the market value per pupil contributed for the new employees' families is significantly lower than the existing market value/pupil in the districts. (Compare Table VII-73 to Table VII-13.) The local property tax revenue contributed by the growth increment in each district is 33% lower than the present local tax revenue in the district. Thus, on the weighted average method for family income used in this study (see Chapter VI), the new residents of the area, as a result of the oil development activity in Scenarios II-A and II-B, appear less able to pay for the education of their children than the present residents. The actual difference may be less than apparent because of the contribution to local property tax revenues for schools by the project itself, by the timber roll, and by existing industry in the districts, which contribute money but not enrollment. Moreover, since the mix of new employees will have a slightly higher than average income for the area, they will contribute relatively more to the state general fund, which is also apportioned to the school districts.

The new enrollment generated under the peak scenario year will demand an additional 63,400 square feet of classroom space in the Port Angeles school district and 15,500 square feet in the Sequim district. Port Angeles passed a $2.7 million bond issue early in 1976 to provide for new school construction to begin to handle its extreme overcrowding. The district had been forestalling expansion, probably because of its slowly declining enrollment in the early 1970s (-0.7% per year). The Scenario II-B enrollment would add $1.1 million to the district's bonding capacity, which could pay for 23,400 square feet of classroom space if land costs (2%) are not considered.

The Sequim school district faces severe facilities problems from any new enrollment since the district has refused to pass a bond issue since 1955, and has also consistently voted down its special annual levy. This anti-school expansion attitude reflects the high proportion of so-called empty nesters and retired people living in the Sequim area, but is still surprising in view of the 3.3% annual growth rate experienced in the district since 1970. In view of the financial and facilities problems faced by the Sequim district, the nearly 200 new students contributed by oil-related employment in the area will aggravate an already serious problem in this district. While the new families probably would form a group more favorable to passing bond issues, their vote alone will not guarantee the necessary funds nor provide the facilities for at least five years after

their arrival. The increased bonding capacity provided by the growth in the district ($0.36 million) would pay for 7800 of the 21,000 additional square feet of classroom space required (37%) or 7500 square feet if the land cost of seven additional acres of school land is subtracted.

(2) Water Supply. Under Scenario II-B in 1979, the addition of 649 households to Port Angeles and immediate unincorporated vicinity would aggravate the water supply shortage which now exists due to the inadequacy of Morse Creek. An intolerable water supply situation would exist, especially if unmetered consumption were to continue at the high rate of 900 gallons per residents per day. The oil terminal-stimulated population could be demanding over half a million gallons of creek water per day. Furthermore, Port Angeles' water supply is so limited that even the lower demand generated if a metered system cut usage to one-third (an added demand of about 200,000 gallons per day) would cause grave problems in a water system that is required to expand to meet even its present needs. Scenario II-A in 1979 would add roughly one-tenth the number of households. Impact would be proportionally less but would still require expansion of an already overtaxed water supply.

(3) Wastewater Disposal. Since the design population for Port Angeles' present treatment plant is 24,000 and it is currently serving about 16,000, the addition of even the maximum case (Scenario II-B in 1979) of 1895 new residents would not tax the wastewater treatment system of Port Angeles. This population increment (649 households) would consume 24% of the remaining service capacity of the plant. Although a new secondary-level plant is planned for Port Angeles, to be built by about 1980 pending grant money, the extent of its expansion of capacity will be based upon official population projections for the city independent of any oil scenarios. Since the Scenario II-B of 1979, the added population resulting from direct and indirect oil terminal employment would exceed one year's projected population growth, the new treatment plant capacity would be allocated sooner than it would if the oil terminal were not located at Port Angeles. The new or existing wastewater treatment system would not be taxed by the added population (roughly 65 households) of Scenario II-A in 1979.

The wastewater treatment system in Sequim now has capacity problems which would be slightly exacerbated with the addition of 216 households under Scenario II-B in 1979, and probably not significantly affected by the addition of about 20 new households under Scenario II-A in 1979. Sequim will also be upgrading and doubling or tripling the capacity of its treatment system by approximately 1980; this new system would be more than adequate for the added population.

(4) Solid Waste. The 60-acre municipal landfill serving Port Angeles is, according to R. Wright, the Clallam County utilities supervisor, expected to have no problems with capacity to serve future population growth in Port Angeles. The landfill now serves all of east Clallam County as well as Port Angeles, a total of about 30,000 people. The addition of 1895 new people under Scenario II-B would represent only about a 1% increase in service population. The useful life of Port Angeles' landfill (about 15-20 years from the present) should not be significantly reduced by this increase.

Impacts from the new population (649 households in Port Angeles) are not expected to be adverse on fire protection, flood control, transportation (roads), or energy supply infrastructure elements. The added service population would not cause problems or overtax any system, but would serve to bring somewhat closer the time when these systems (for example, roads) would have to be expanded.

c. Terrestrial Biology

As described under land use impacts and given in Table VII-65, Scenario II-A will require the conversion of 90-150 acres of now open lands to intensive industrial use. Scenario II-B will require the conversion of 140-220 acres. Below is a table of the proposed site for the onshore facilities (Ediz Hook) and the three subalternatives, giving the acreage available and the existing vegetation communities on the site.

TABLE VII-74

EXISTING VEGETATION OF PROPOSED SUBALTERNATIVE SITES
FOR ONSHORE FACILITIES
(Clallam County)

Subalternative Site	Acreage Available	Existing Vegetation
Freshwater Bay	350	Non-natural (intensive agriculture) surrounding lands in second-growth mixed coniferous/deciduous forest
Ediz Hook	100*	Cleared, weedy
Morse Creek	120	Riparian, grassland, shrubland (bluff)
Green Point (Siebert Creek)	175	Late second-growth mixed deciduous/coniferous forest

*Includes 20-acre lagoon at base of Hook.

As discussed under land use impacts, only the Freshwater Bay subalternative has clearly enough suitable acreage to accommodate the maximum development necessitated by the throughput in Scenario II-B in 1990. The minimum project, Scenario II-A in 1980, could be accommodated at all four subalternative locations. In discussing the relative impact on terrestrial biology, facilities acreage limitations are assumed to be a separate problem, and the sites may be compared as if they were all equally possible.

Terrestrial biology impacts would be minimal at the Ediz Hook location for the pump station and partial surge/storage since this site is the most disturbed of the four and has almost no value for terrestrial wildlife. There is some use of the breakwater/Bay and breakwater/Strait interface by shorebirds, but this use would be little affected by the conversion of the upland to a tank farm except that the birds would probably avoid the area during the period of maximum construction activity. The utilization of this site as a tank farm for the Northern Tier Pipeline proposal is comparable to the existing, rather low-density industrial use of much of the Ediz Hook spit and its land connection. Incremental impacts on local wildlife would be minor.

None of the three remaining subalternative sites would be subject to major terrestrial biology impact in a regional sense. Of the three, Freshwater Bay is in some ways the least sensitive since it is already in a non-natural although open space use as crop land. The impacts of agricultural land conversion are land use, not terrestrial biology impacts, since the taking of wildlife and ecological community value has already occurred in the original clearing for agriculture itself. In addition to the tank farm site, a typical pipeline corridor would have to be cleared between the surge/storage and the shore, leading to the connection with the offshore SPM. The short length of pipeline corridor would also pass through agricultural lands.

The analysis of the Northern Tier Pipeline presented in Chapter VIII terminates at Morse Creek. The Freshwater Bay subalternative would require extension of the corridor by several miles to the west where it would traverse areas of agriculture interspersed with dense second-growth forest, composed of both coniferous and deciduous species. The impacts of creating a new cleared corridor through forested lands are discussed in Chapter VIII.

Both the riparian and shrubland vegetation at the Morse Creek site and the late second-growth forest of the Green Point site have moderate ecological importance and wildlife value. However, all of the lands in proximity to the waterfront in the area east of Port Angeles are undergoing accelerated pressure for residential development. There is already considerable low-density residential development in the area of these sites, as well as a railroad right-of-way and arterial roads which have reduced the overall value of the locality as natural habitats.

The introduction of onshore oil facilities represents a more intensive use of the land than this type of residential development since it creates a larger area of contiguous paved surface within which no vegetation is allowed to return. Creation of the industrial facility thus essentially constitutes an irreversible conversion of 100-200 acres of a natural community to a developed site; no mitigation by revegetation of the area of intensive use is possible.

The significance of the impact then reduces to a question of the relative importance of the loss of 200 acres of moderately valuable second-growth forest or of riparian and shrub communities in a regional context. Conversion of relatively mature second-growth forest is perhaps more significant than loss of riparian or shrubland since the product of the

time-energy investment in an ecological sense is greater. The length of time required for a cleared area to return to that state of successional maturity is far longer. On a regional scale, areas of similar maturity second-growth forest are extremely common in Clallam County and throughput the Olympic Peninsula. The conversion of 200 acres represents the loss of only 0.02% of all the timberlands in Clallam County alone. (However, within the coastal area where woodland is viewed as a residential amenity the transition from common forest to "uncommon" oil tanks may be seen as far more significant, though again this is not primarily a biological impact.)

Riparian habitat is far less common than second-growth forest in proportion to the sporadic occurrence of watercourses in comparison to the nearly ubiquitous occurrence of forest lands in this part of Washington. Morse Creek is a moderately important creek in the watershed draining into the Strait of Juan de Fuca, but the amount of riparian habitat actually affected by the onshore facilities is only a few acres. It is also located quite close to the mouth of the creek so that in the extremely rare event where an oil tank ruptured and the dike failed to contain the oil, the upstream resources of Morse Creek would not be affected. However, the oil would run into the Strait east of Port Angeles harbor. Its effects would be similar to those discussed for in-harbor spills (see Chapter VIII).

Siebert Creek is a less important drainage than Morse Creek -- a smaller watershed area and lower flow. Little riparian vegetation would be removed in constructing the tank farm. With respect to unlikely oil releases resulting from tank failure, the same considerations apply as for Morse Creek but the marine impact zone affected by oil entering the Strait in runoff from Siebert Creek would be slightly to the east.

In proportion to its sporadic but still regular periodic occurrence, the impact of loss of riparian land is greater than for the loss of forest land. However, owing to generally high precipitation levels, riparian and deciduous forest vegetation may have many species in common and a riparian zone can be said to extend for some distance on either side of a stream. This, combined with the fact that significant watercourses occur at intervals of one mile or so in this region, indicates that the removal of a small amount of riparian vegetation from a single stream corridor is still not significant. Moreover, to avoid problems of drainage and flooding, the tank farm would probably be sited above the average flood zone of the stream in which the true riparian vegetation is most dense.

Habitat sensitivity is related to overall wildlife value and the presence of rare (threatened) or endangered species. The areas of second-growth forest, shrubland, and riparian vegetation potentially affected by the onshore facilities would be expected to be utilized by a "representative" sample of the wildlife species given in the species list table in the appendix for these habitats. None of these areas would be expected to be unusually rich; the number of species found there should be simply related to the size of the forest, shrub, or riparian zone according to the functional relationship between animal species diversity and area. The affected localities may actually be poorer in wildlife species than expected, particularly large mammals or birds which avoid man's activities since the areas are already urbanized at low density.

A number of species identified by either the U.S. Department of Interior or the State of Washington as threatened, endangered, or potentially threatened have been recorded or are suspected to occur in the general area along the Strait of Juan de Fuca. These include the following species: endangered -- Aleutian Canada goose, Peregrine falcon. Peale's Peregrine falcon; threatened -- none; and potentially threatened -- osprey, pileated woodpecker. None of these records localizes the birds more closely than the region of occurrence, i.e., Olympic Mountains, Strait of Juan de Fuca. (See Table VIII-8.) While it is possible that one or more of these species may actually be found on one of the possible sites proposed for the on-shore facilities, this could be established only by an extremely thorough survey of the sites and vicinity, perhaps over several seasons to determine whether the animals occur there at all and whether their observed roosting or foraging territories include these sites. Some of these animals, particularly the falcons, are so rare that even a detailed survey might not reveal them. Such surveys are, by their nature, difficult, time-consuming, and usually impractical unless there is already a strong indication that the species may in fact utilize a particular area. Both of the critically endangered falcon species are thought to breed in the Olympic Mountain area. However, their nests are likely to be in far more remote, protected locations than close to Port Angeles.

In summary, the subalternative sites at Ediz Hook and Freshwater Bay have low biologic sensitivity. The Morse Creek and Green Point sites, as well as the auxiliary site for Ediz Hook on the bluff east of the airport, have moderate sensitivity. The combination of low to moderate sensitivity and extreme commonness of the habitat types leads to a conclusion of low terrestrial biology impact from the conversion of about 200 acres for the onshore facilities of a Norther Tier Pipeline terminus.

d. Air Quality

(1) Activity. Among the petroleum activity scenarios, only the Northern Tier (Scenario II) involves Port Angeles. Region supply (Scenario I) transshipment at Cherry Point (Scenario II) will entail significant vessel traffic through the Strait of Juan de Fuca past Port Angeles. The air quality impact of tanker transit is discussed in Chapter VIII; it does not materially affect the air quality of Port Angeles.

The Northern Tier proposal entails transportation of some 400,000-800,000 B/D of crude by pipeline to the Northern Tier states. Because of the low sulfur requirements of the Northern Tier refineries, a substantial portion (roughly one-third) of the crude transported must be low sulfur, presumable foreign import; the remainder could be Alaskan North Slope crude. Thus, a portion of the air quality impact of the transshipment activity is attributable to the movement of Alaskan crude itself. Unfortunately, air quality impact is highly non-linear. It is not possible to take a proportion of the air quality impacts, based upon the arithmetic ratio of Alaskan crude to total crude movement, nor is it possible to consider the vessel movement associated with Alaskan crude only since that would grossly underestimate the actual air quality impact resulting from the superimposition of the two types of crude oil movement.

The Northern Tier proposal calls for the construction of two fixed berths inside Ediz Hook with possible expansion to three berths if a large throughput is required in future years. The initial operation of the Northern Tier proposal either for transshipment alone (Scenario II-A) or with the Puget Spur Pipeline serving regional refineries (Scenario II-B) is assumed to use two berths only, with approximately 152 and 207 vessel calls per year, respectively. Later years of operation are assumed to require three berths, since vessel activity ranges from 240 to 375 vessel calls per year. Service to that throughput level by two berths only would entail delays in vessel unloading; waiting time could range from 5-15% and the long-term cost of such vessel delays would probably justify the cost of construction of the third berth.

The fleet type for the Northern Tier proposal is specified in Chapter VI. For transshipment only (II-A), initial operation would serve the intermediate vessel size fleet. With an average vessel deadweight tonnage of 137,300, that fleet corresponds to the present U.S. Flag fleet capable of service to the Alaska/Washington trade. For Scenario II-B, regional supply via Port Angeles and the Puget Spur Pipeline, as well as for later years' operation of the transshipment project alone, the large fleet is assumed. This implies an average vessel deadweight tonnage of 179,600 and includes vessels of 250,000 DWT, corresponding to a major complement of the present world fleet and to possible larger vessels constructed for the U.S. trade. As described in Chapter VI, it is the fleet type and the number of vessels per year at the port that determine the overall magnitude of air pollutant emissions and more particularly that determine the statistical distribution of emissions rates as a function of time.

(2) Local Air Quality Impact. The majority of air emissions concentrated in space and time come from the tanker stacks. The pollutants generated during combustion of fuel is the tankers' boilers to provide energy for maneuvering cargo offloading or for maintaining the ship at idle. The local impact of these pollutants is determined principally by consideration of their dispersion. The fundamental model uses Gaussian plume equations which relate the elevation of the plume center line above the terrain, the source strength, the wind speed, the air stability class, and the distance from the source to provide an estimate of the concentration of pollutant at the ground.

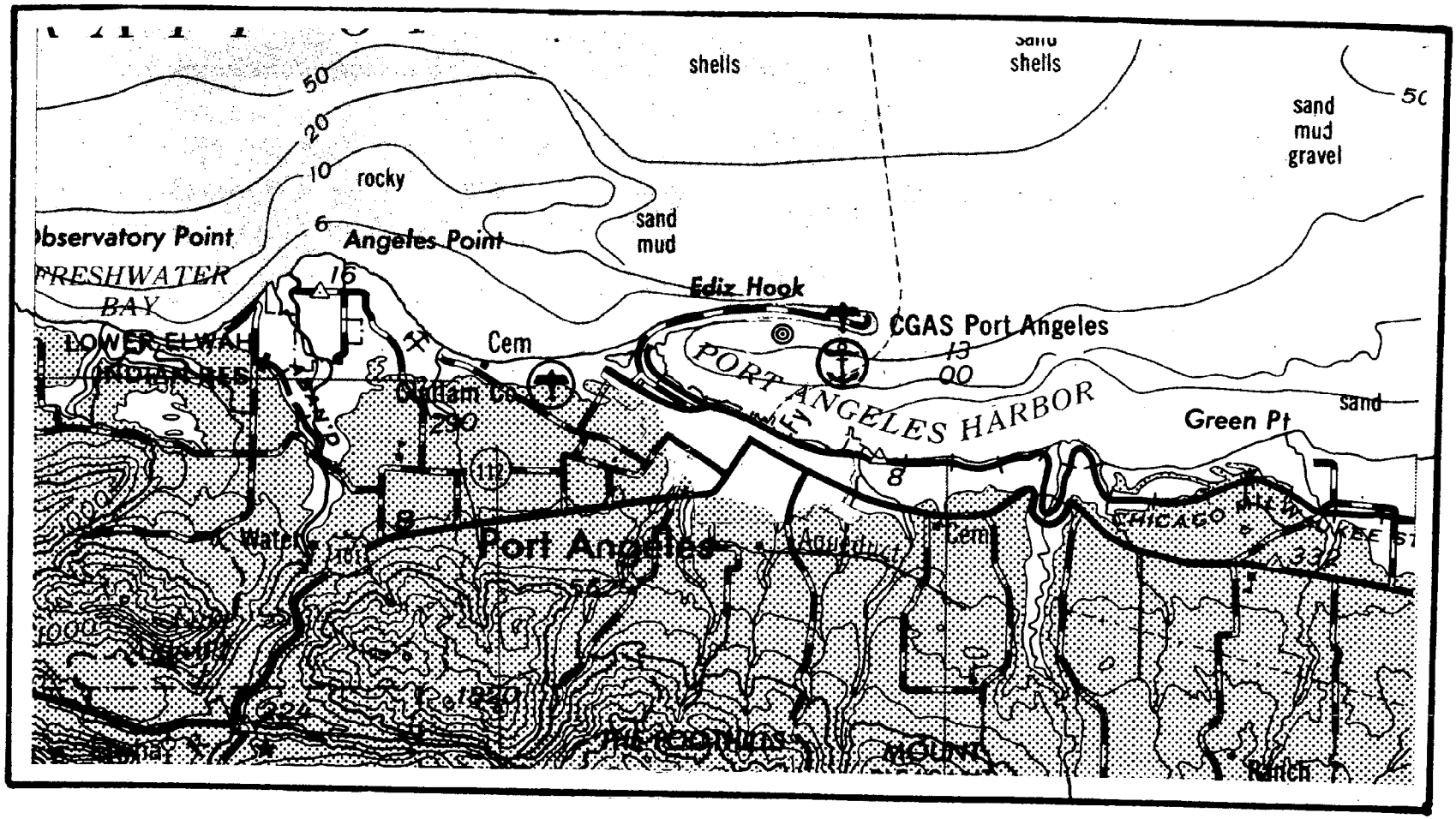
Of these factors, source strength and wind speed and air stability are variable over time. They may be defined statistically, however, by consideration of the probability of emissions combinations resulting from tanker traffic for a given fleet type and throughput on one hand and by consideration of the area's meteorology on the other hand. Terrain elevation and distance from the source are fixed for a given area and a proposed terminal site. According to the Gaussian plume model, the variable's source strength and wind speed can be eliminated from a first order consideration yielding a normalized ground level concentration. The normalized ground concentration simply indicates the potential of an area to be polluted by a designated source, given the meteorologic air stability class, regardless of the source's actual strength and regardless of the wind actually prevailing at the time. The normalized ground concentration for the Port Angeles vicinity was computed for the proposed Northern Tier terminal inside Ediz Hook.

The terrain of Port Angeles is characterized by an extremely narrow strip of low, level land along the waterfront backed by a steep bluff which leads to a plateau upon which the larger portion of the city is located (see Figure VII-7). The plateau rises steadily toward the foothills of the Olympic Mountains, such that elevations of 1000 feet may be found slightly over three miles from the Port Angeles waterfront. The abruptly elevated terrain of the city and environs sharply reduces the effective stack height for tanker emissions and sharply increases the ground level concentration. Since ground level concentration is a function of distance, the siting of the tanker berths on Ediz Hook on the opposite side of Port Angeles harbor is an important factor in determining the emissions impact. That location places the emissions approximately one mile from the waterfront of the city itself. For dispersion under low stability conditions (classes A through C), the peak concentration is reached over water in the harbor or along the narrow strip of Ediz Hook itself. The initial rise of the bluff within the city is close enough to the source of emissions that dispersion under stability class D still amounts to a substantial potential ground level concentration. Beyond one or two miles, however, even the sharply elevating terrain fails to offset the rapid dilution that is characteristic of the low stability diffusion case.

Under higher stability conditions, the plume disperses far more slowly and thus retains pollutant concentrations at great distances from the emissions source. If elevating terrain brings the ground level in toward the center line of the plume, then the ground level concentration can be significant. This phenomenon dominates the local air quality impact at Port Angeles at distances greater than roughly two miles from the tanker terminal.

Figure VII-8 depicts the ground level concentration in four classes indicating the potential for local air pollutant impacts raning from minimal to high. The zones in Figure VII-8 represent the maximum ground level concentration at each point as determined by either stability class D or stability class F. (As mentioned above, the impacts of stability class F dominate.) Because of the elevation of the effective point of release for tanker emissions, the entire area at sea level falls within the minimal potential impact zone. Qualitatively, this implies that the air emissions from major tanker operations are seldom expected to cause violations of the state standards within the minimal impact zone. The low impact zone is defined in the near vicinity of the terminal by low elevations and by higher elevations at greater distances from the terminal when plume dispersion has become significant, even under stability class F. Within this zone there is a potential for adverse air quality impacts, but one which is largely mitigatible by restriction of the sulfur content of tanker fuel.

The medium impact zone is quite broad for Port Angeles since the majority of the city suburbs rise as a broad bowl around the harbor intersecting the concentrated portion of the tanker plume. Only a small portion of the city falls within the high potential impact zone, that which is located on a steep hill located to the west and south of the



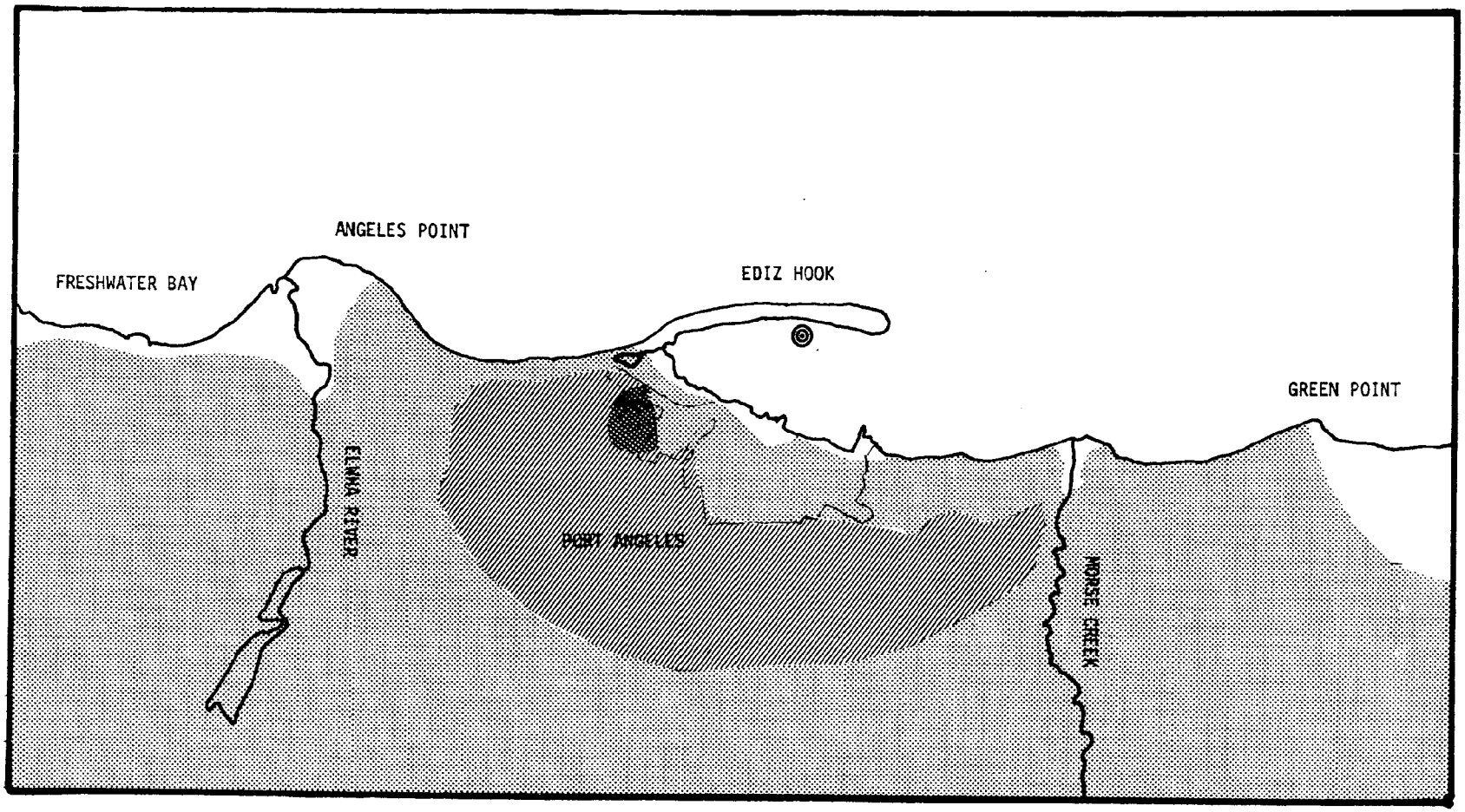
Marine Terminal

Greater than 200 ft. elevation

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

FIGURE VII-7 LOCATION AND TOPOGRAPHY: PORT ANGELES



Normalized Ground Concentration (10^{-6} m^{-2})

minimal	<7	Zone 2 medium	25 - 70
Zone 1 low	7 - 25	Zone 3 high	>70

Marine Terminal

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

SOURCES:
Arthur D. Little, Inc.

FIGURE VII - 8 NORMALIZED GROUND CONCENTRATION: PORT ANGELES

intersection of C Street and 7th Street. This zone comprises a small residential area and excludes the Lincoln Public School. As will be described later, the statistical likelihood of actual violations in this zone is fairly small due to its limited extent, but the occurrence of those few violations is extremely difficult to mitigate except by drastic reduction in the sulfur content of tanker fuel.

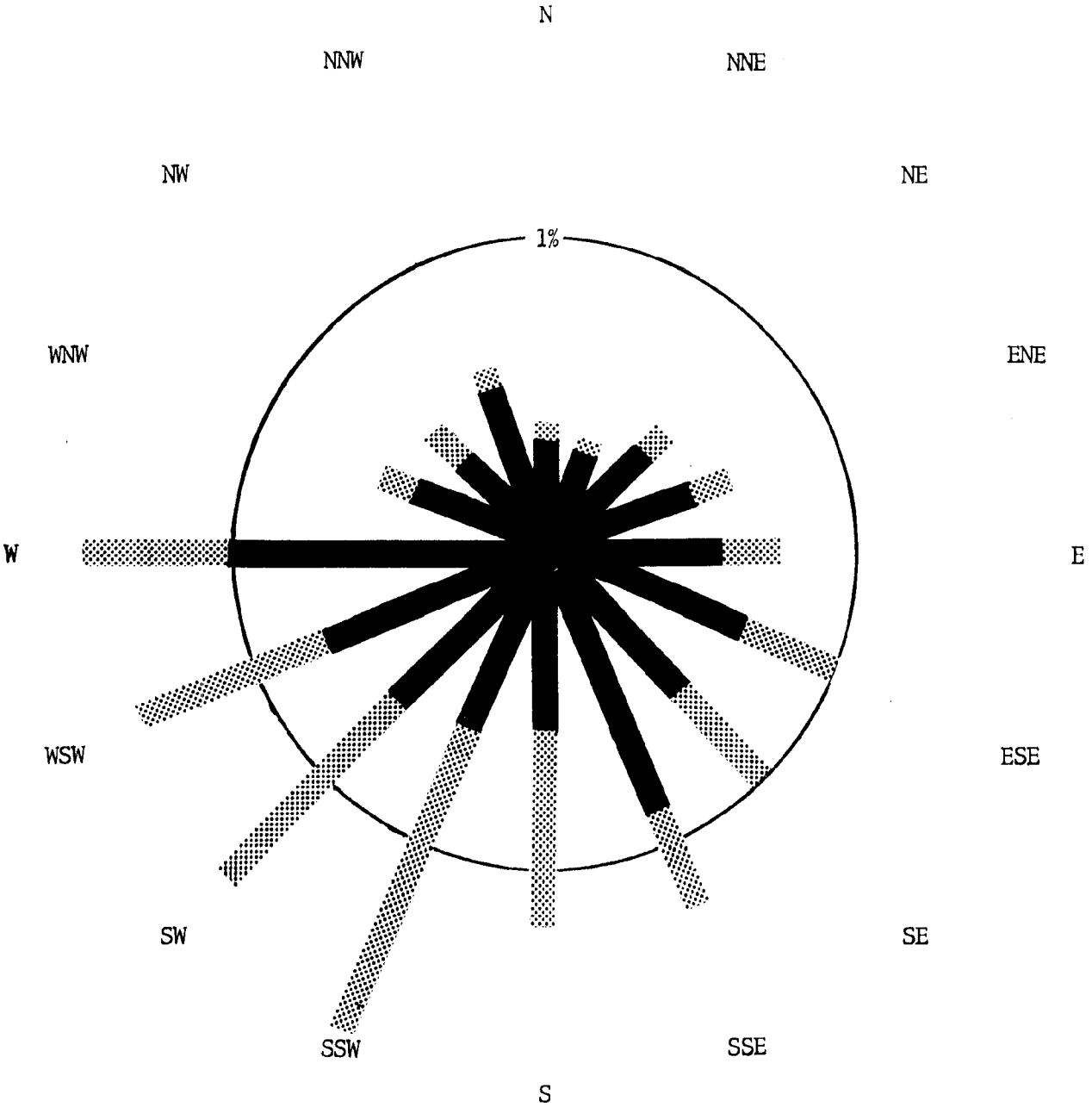
Anticipating the emissions distribution from tanker operation, the principal impact on local ambient air quality will occur when wind speed is low. Wind speeds in excess of three meters per second, roughly six miles per hour, reduce the wind adjusted source strength for even the maximal emissions of several vessels operating simultaneously to levels at which no violation of the state sulfur dioxide one-hour standard would be expected. Indeed, it is primarily the occurrence of winds from near calm to approximately one-and-one-half meters per second that affords the greatest statistical probability of high wind adjusted source strength. The statistical distribution of winds over this velocity range is given by the wind rose in Figure VII-9. The low velocity data for the neutral and high stability classes only is presented since these are the only ones which will affect the local ambient air quality of Port Angeles.

Recalling that a wind rose depicts the direction <u>from</u> which the winds come, it is clear that the predominant direction of low velocity winds is from the land toward the sea, and thus the statistical probability of low velocity air emissions impact on the land is reduced. As noted before, the plume dispersion over open water will seldom reach significant concentrations and will be completely dispersed by the time the plume reaches the shore of Vancouver Island in British Columbia. Despite the low frequency, however, there are still some 100 hours per year during which winds of low velocity and high stability would direct the tanker plume toward land.

A statistical consideration of the probability of there being zero, one, two, or three vessels in port (depending on the number of berths available) and consideration of the probability of combined emissions of vessels operating simultaneously allows exact computation of the probability of vessel emissions equaling or exceeding a given level. (Refer to discussion in Chapter VI.)

The state one-hour standard for sulfur dioxide is 40 parts per hundred million (pphm), equivalent to 1048 micrograms per cubic meter ($\mu g/m^3$). Using that value as a criterion and dividing by the normalized ground concentration represented by the impact zones in Figure VII-8, it is possible to obtain a value for the wind adjusted source strength which will cause a violation of the state standard. In this instance, using a wind strength of one meter per second, representative of the low velocity winds occurring in this region, it is possible to compute the probability of occurrence of tankers emitting sulfur dioxide equal to or exceeding that value. That probability is dependent not only on the type of vessel, defined by the fleet type, but also by the throughput which determines the frequency of multiple vessels operating simultaneously.

FIGURE VII-9 FREQUENCY OF OCCURENCE OF WINDS FROM 0 TO 3 KNOTS FOR STABILITY CLASSES D THROUGH G AT OP PORT ANGELES, WASHINGTON



Stability Classes D & E :

Stability Classes F & G :

Source: Teknekron, 1976.

Arthur D Little, Inc.

Since the source strength will lead to violation of the state standard only under high stability, low velocity winds and only in those regions depicted on the map in Figure VII-8, it is necessary to adjust the probability of that source strength by the probability that winds will blow in the direction of the relevant potential air quality impact zones. The combined probability of the appropriate source strength and meteorologic conditions can be expressed as a number of hours per year during which there will be an hourly average sulfur dioxide concentration in excess of 40 pphm. Washington State standards, like the federal standards, specify a value which may be exceeded only once in a year. Thus, if the number of hours per year of projected exceedance of the 40 pphm value is two or more then it implies a violation of the state standard.

The number of hours per year exceedance of the state 40 pphm level is specified in Table VII-75 for the various potential air impact zones according to the crude oil transportation scenarios. The sulfur content of tanker fuel assumed in this calculation is 2%. This is a high but reasonably common value for bunker "C" commonly available to the maritime trade. Examining Table VII-75, it can be seen that only the largest throughput in Scenario II-B in 1990 results in a two-hour per year frequency of standard exceedance in potential impact Zone 1. This is primarily due to the low level of ground level concentration represented by the lower limit of that zone; statistically the number of occurrences of vessels in port simultaneously which would lead to high concentrations for this zone is very low. The large geographic extent of Zone 1 implies a relatively frequent occurrence of meteorologic conditions that would direct tanker plumes in that direction, but the plume itself is seldom sufficiently concentrated to provide violation of the state standard.

The situation with impact Zone 2 is quite different, however. In this instance, the sensitivity to stack emissions is greater by virtue of its greater ground level concentration so that the probability of sufficient source strength is far greater. The broad geographic extent of impact Zone 2 leads to a fairly frequent occurrence of meteorologic conditions resulting in a large number of potential violations of the state standard, with 2% sulfur content of tanker fuel. The impact sensitivity of emission of impact Zone 3 is far greater than for the preceding zones. The probability of vessels equaling or exceeding that source strength is quite high; yet its extremely limited geographic range in the vicinity of Port Angeles implies that there will only be a few hours per year when low velocity, high stability winds impinge upon that zone. When they do, however, the chances are that the tanker emissions will be too large.

It must be remembered that the impact zones are defined by fundamental terrain and distance considerations. The projection of as many as 20 hours per year in excess of the 40 pphm standard for impact Zone 2 with the activity of Scenario II-B in 1990 does not mean that the entire area within impact Zone 2 will be exposed to that level for that period of time. It implies only that there is an expectation of some 20 hours per year when that concentration will be reached <u>somewhere</u> within the zone. Although in prinicpal it would be possible to localize the zone of maximal individual exposure, such an effort would probably be invalidated by the

TABLE VII-75

ACUTE AIR QUALITY IMPACT
PORT ANGELES

Scenario	Vessel calls per year	Fleet type[a]	Number of berths	% Fully occupied	Hours/year SO_2[b] over standard[c] in Impact zone 1	2	3	% Sulfur fuel for no violation[c] in Impact zone 1	2	3	Hours/year high NO_2[d]
I. Regional Supply				--no activity--							
II. Northern Tier											
A. Regional by Tanker											
1980	152	I	2	10	0	8	2	>3	1.2	2.5	1
1985-90	240	L	3	5	½	14	3	2.2	0.8	0.5	2
B. With Puget Spur											
1980	207	L	2	16	0	12	2½	2.4	0.9	1.6	1
1985	327	L	3	11	1	17	4	2.1	0.7	0.4	2½
1990	375	L	3	14	2	20	4	2.0	0.6	0.3	3
III. Transship at Cherry Point				--no activity--							
IV. Supply via Trans Mountain				--no activity--							

a *I = Intermediate Vessel Size*
L = Large Vessel Size

b *for fuel with 2% Sulfur Content*

c *State 1 hour standard is 40 pphm*

d *high NO_x is 25 pphm over one hour - does not correspond to applicable standard*

Source: Arthur D. Little, Inc.

increasing error in extending statistical models to ultra-low frequencies and the actual effect would probably be masked by the contribution of sulfur dioxide from the other industrial sources in the area. In fact, the maximum project impact would occur when the tanker plume combined with the emissions from an industrial source by winds that brought the two stacks in line. This implies a greater proportional probability of impact to the east and west of the City of Port Angeles itself.

The projections of hours per year exceedance of the state standard are based upon a 2% sulfur content in tanker fuel. The simplest measure for mitigating sulfur dioxide emissions is to restrict the sulfur content of fuel used in port. Many vessels in both the intermediate and large fleet types have segregated fuel compartments which allow selective utilization of different fuels. It would be possible for the vessels involved to routinely use low sulfur fuels in port or to selectively use low sulfur fuels when either meteorologic conditions or high berth occupancy indicated that an air quality problem may be created. In order to explore this concept, the complex probability distribution may be computed backward, i.e., it is possible to calculate the percent sulfur content of tanker fuel that will lead to an expectation of less than two hours per year actual ground level concentration in excess of 40 pphm in any air quality potential impact zone. Those data are also presented in Table VII-75. Generally, the low sensitivity of the low potential impact Zone 1 implies that restriction of fuel below 2% sulfur is probably not necessary. For impact Zones 2 and 3, the high sensitivity and high frequency of adverse meteorologic conditions implies that a sharp reduction in sulfur content may be necessary, particularly for the higher throughput expected in the later years of operation of a Northern Tier transshipment project.

At present, the Washington State standard for nitrogen oxide is identical to the federal standard -- 5 pphm annual average concentration. As explained in Chapter V, the actual harmful effects of nitrogen oxides are not well understood. The annual average standard is a tentative estimate of an acceptable level of long-term exposure. The absence of a federal standard for short-term exposure is based upon the absence of clear indications of permissible levels and generally upon the rare occurrence of high concentrations of nitrogen oxides from point sources. California, however, has established a state hourly standard of 25 pphm for nitrogen dioxide. Although not based upon precise clinical evidence, this value may be taken as a "high" level of nitrogen oxides. Since nitrogen oxides are the second most concentrated pollutant in tanker stack emissions, it is reasonable to consider the concentration of that pollutant that will occur for the various transportation scenarios. An indication of the number of hours per year with nitrogen oxide concentrations in excess of 25 pphm is given as the final column in Table VII-75. In general, the nitrogen oxide emissions are fairly small and the number of hours of high nitrogen oxide concentration is correspondingly low. Nitrogen oxides are far more difficult to mitigate, although certain technological features of tanker combustion chambers may be effected. The low values in Table VII-75 imply that nitogen oxides are not likely to be a major problem, but further study in that area would be required for the actual implementation of a transshipment project at Port Angeles.

Emissions of all other pollutants from tanker stacks -- particulate, hydrocarbons, carbon monoxide and organic compounds -- occur in far smaller volumes than either nitrogen oxide or sulfur dioxide. The short-term levels of these pollutants will not reach unacceptable levels based upon an analysis of the distribution of tanker emissions alone. There is, however, a major source of reactive organic gases or hydrocarbons from the tank farm that must accompany an oil transshipment project. As described in Chapter VI, each crude oil storage tank is subject to substantial standing emissions based upon a complex of factors including wind speed.

At present, the exact site of a tank farm for Port Angeles is not specified in the Northern Tier application. Possible locations for an Ediz Hook terminal would be for some tankage at the base of Ediz Hook, near the Crown Zellerbach plant, and for the remaining tanks placed on the bluff above, west of the city and north of the airport. The emissions from the tanks may be assumed to derive from a broad cylinder with an effective stack height of approximately 20 meters (65 feet). Depending on the exact configuration of tanks, several individual units will result in an aggregate source strength of several tens of grams per second under some conditions. Considering the low effective stack height for the tanks, the emissions plume will impinge upon the ground fairly close to the tanks under all conditions of air stability. Considering further the occurrence of low velocity wind conditions (on the order of six knots or less), it is quite probable that ground level concentration will reach one to two parts per million reactive organic gases in the vicinity of the tanks (1 to 5 kilometers distance). That concentration is four to eight times greater than the federal and State of Washington standard for three-hour average non-menthane hydrocarbons between the hours of 6:00 a.m. and 9:00 a.m. Conditions suitable for three-hour averages in that range of concentration will occur at Port Angeles on the order of 100 hours per year.

As discussed in Chapter V, the 6:00 a.m. to 9:00 a.m. hydrocarbon standard is oriented toward the problem of regional ozone or oxidant formation. The concentration for that standard is set by consideration of historical oxidant data from several large cities in the United States. The actual areawide oxidant experience in a rural region may not be critically dependent upon the 6:00 a.m. to 9:00 a.m. hydrocarbon concentration in a small portion. The problem of regional air quality impacts will be discussed in the following section.

(3) Regional Air Quality Impact. The regional air quality impact of tanker operations at Port Angeles derives from the contribution of substantial quantities of some pollutants to the regional air basin pollutant burden. Table VII-76 presents the average daily emissions for the various scenarios for the four pollutants of major contribution and major air quality concern. The level of emissions for carbon monoxide is insignificant. Numerically, the greatest impact is the large volume of reactive organic gas or hydrocarbon vapor which will be emitted by the storage tanks and by vessel purging if it occurs in the terminal vicinity.

TABLE VII-76

AIR POLLUTANT EMISSIONS - MARINE TERMINAL
PORT ANGELES
(tons/day)

	Pollutant					
				Hydrocarbons		
	SO_x	NO_x	Particulates	Fuel	Purging	Storage & Misc.
Scenario I-A	No activity at Port Angeles					
Scenario I-B	No activity at Port Angeles					
Scenario II-A						
1980	1.240	0.872	0.212	0.068	4.296	7.164
1985	2.200	1.552	0.376	0.120	8.784	11.704
1990	2.200	1.552	0.376	0.120	8.784	11.704
Scenario II-B						
1980	1.898	1.339	0.324	0.104	7.576	10.480
1985	2.998	2.115	0.512	0.512	11.968	15.280
1990	3.438	2.425	0.588	0.588	13.725	17.113
Scenario III	No activity at Port Angeles					
Scenario IV	No activity at Port Angeles					

Source: Arthur D. Little, Inc.

Although a short-term standard for hydrocarbons is promulgated by the U.S. EPA, it pertains to the formation of photochemical oxidant and not to any direct health or property impact.

Since reactive organic gases are the limiting precursor for the formation of photochemical oxidant, the large volume of emissions from a transshipment project raises the question of whether high oxidant levels will result. At present, it is not possible to conduct a detailed statistical analysis since there is no monitoring for oxidants in the area and the inventories of reactive organic gases in the air basin cannot be compared with any direct oxidant concentration that may result. It is possible to make a comparative study of certain features of the Port Angeles meteorology with other areas for which oxidant data are available, and by inference to estimate the probable impact on regional air quality of the project hydrocarbon emissions.

Two factors act to sharply limit the potential oxidant formation. One is the sparse settlement throughout the air basin; the second is the relatively low frequency of weather conditions suitable for the formation of high oxidant levels. Among these two, it is the former, the low-density of development, that is probably most significant in reducing the oxidant potential for the Port Angeles region. Since photochemical oxidant is formed only after lengthy reaction times (usually on the order of 3 to 10 hours, depending on temperature and concentration of reactants), the actual zone of maximal impact is necessarily displaced from the point of emissions origin by the movement of the air parcel over that period of time.

In a nonurbanized area, the air parcel containing point source hydrocarbon emissions is subject to substantial dilution with distance and is not afforded augmentation by either emissions from new sources over which the parcel passes or by lateral exchange with other adjoining parcels of equally contaminated air. It is primarily in large, uniformly developed basins such as the Los Angeles basin that the concentration of principal reactants can be maintained at an adequate level throughout the 20-50 mile reaction trajectory. In the instance of emissions at Port Angeles, the large volume of hydrocarbons would not receive the necessary augmentation of reactant components to afford its maximal production of photochemical oxidant even under ideal conditions.

Ideal conditions for oxidant formation are high temperatures, bright sunshine, and a low thermal inversion layer persistent throughout the day which traps reactant gases throughout the long reaction period. Conditions such as these are not common at Port Angeles. Although sunshine is not rare, the frequency of windless, hot, bright sunny days is far smaller in the Port Angeles area than it is at many locations along the Pacific Coast of the United States. Statistically, this sharply reduces the probability of occurrence of smog conditions. Furthermore, Port Angeles lies on the steep foothills adjoining the Olympic Range along the Strait of Juan de Fuca. The Strait is well ventilated by prevailing winds and the prevailing trajectories do not direct emissions into enclosed

valleys where they may become trapped by a thermal inversion in the air above. The expansive terrain and pattern of prevailing winds afford a far greater dissipation and dilution potential for regional emissions than is common at many other locations which have well described photochemical oxidant problems.

Nonetheless, there are occasionally conditions which are suitable for oxidant formation. The principal node of impact may be either the Sequim-Dungeness Peninsula, 10-30 miles to the east, or it may be the City of Port Angeles itself through a reflux phenomenon common along the coast where nighttime drainage winds carry reactant gases offshore which may be brought inland again by the prevailing winds as they dominate during the mid-morning. Although meteorologic records have not been examined for the combination of factors required, a casual inspection implies that it is quite possible to have oxidant formation on the order of several days per year in this area and in the Sequim-Dungeness area to the east. The actual oxidant experience will be limited by the presence of reactant percursors.

The large quantity of reactive organic gases from the project would provide an ample supply of reactant substances for the formation of photochemical oxidant. Under the proper conditions, quantities of organic gases such as those depicted for Scenario II in Table VII-76 could easily form oxidant concentrations on the order of 1 to 3 pphm, drawing primarily upon ambient availability of nitrogen oxides from the urban population and the industry associated with Port Angeles. Since the project would be the major hydrocarbon source, the background ozone level contributed by urban development would probably be on the same order as those derived from the project itself and the aggregate is still likely to fall below the state and federal standard of 8 pphm for oxidant or ozone from man-made sources.

In the presence of the project, it is likely that the annual geometric need of oxidant concentration would still be quite low simply because the average conditions are not suitable for the formation of photochemical oxidant. Conditions that are suitable are rare, but probably exist with significant frequency. This would imply that the distribution of oxidant at Port Angeles would have a fairly large standard geometric deviation. Even in the future if urbanization or even a large recreational trade develops and oxidant is monitored, it is likely that substantial development could occur with oxidant exceeding the federal standard only a few days per year. This statistical lack of sensitivity is characteristic of locations with a low geometric mean and high standard deviation.

The project contribution of sulfur dioxide is significant in direct proportion to the sulfur content of tanker fuel. If a typical value of 2% is used, a transshipment project will contribute several tons per day. This is roughly equivalent to the level of emissions from one of the major industrial operators in Port Angeles at present. Since air monitoring has only recently been initiated for sulfur dioxide, it is not possible to describe long-term trends. The extremely high values occasionally noted

for sulfur dioxide as well as the unacceptable long-term averages imply that this pollutant is a problem which may not be easily solved. Addition of the project (without substantial mitigation by reduction in sulfur content for fuel) would not only cause violation of short-term standards, but would also cause an aggravation of long-term standards since it would act as a geographically and statistically separate source of similar magnitude to the two or three major sources operating at present.

Regional contribution of particulates and nitrogen dioxide are probably not significant in and of themselves. The particulate quantity is quite small, particularly by comparison with the quantity of particulates emitted by other sources. Nitrogen oxides are likely to be significant only inasmuch as they contribute a necessary reactant precursor to the formation of photochemical oxidant from the large volume of reactive organic gases that would stem from the operation of the project at Port Angeles.

Since the transshipment scenarios will induce significant population growth in the area, there will be an increase in the level of urban air emissions. Some of these will be commute trips by oil terminal employees. The vast majority, however, will be vehicular activity normally associated with low to moderate density urban living. The presently low level of urbanization and, hence, the low level of existing area source urban pollutants is important in minimizing the impact of hydrocarbon emissions and in preserving air quality standards for oxidant and carbon monxide. The level of population pollutant emissions from induced growth is small, however, by comparison with the quantity of emissions generated by the seasonal tourist industry, for example, and certainly by comparison with the quantity of emissions from the transshipment project itself, since those emissions of sulfur dioxide directly pertain to an established air quality problem in Port Angeles. A factor representing the emissions from ancillary employee activity at the marine terminal is included in the emissions estimate in Table VII-76.

e. Water Quality/Marine Biology

(1) Impact Generators. An oil transshipment terminal at Port Angeles would introduce two new sources of oil release into the water surrounding Ediz Hook -- operational and in-port casualty spillage. While both types of spills would contribute similar average amounts of oil to the waters over a given period (see Tables VII-77 and VII-78), the larger casualty spills would occur only on the order of once every 9 to 17 years, while operational spills are expected to occur once every 8 to 19 weeks. Although the larger casualty spill would affect a larger number of marine organisms at the time of the spill, the repeated exposure to oil resulting from the high frequency of operational spills means that operational spills are of more concern as chronic impact generators than are casualty spills. (Note that this discussion is concerned only with local effects of operation of the marine terminal itself. The far more significant oil spills and impact of tanker transportation are discussed in Chapter VIII.)

TABLE VII-77

OPERATIONAL SPILLS AT MARINE TERMINAL
PORT ANGELES

Scenario	Throughput (1000 B/D)	Operational Spills Number	Operational Spills Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	0	0	0
B. Restricted Fleet	0	0	0
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	400 (I)	2.73	740
1985-1990	800 (L)	4.32	1180
B. Regional Supply by Puget Spur Pipeline			
1980	690 (L)	3.73	1010
1985	1090 (L)	5.89	1600
1990	1250 (L)	6.75	1840
III. Transshipment at Cherry Point			
1980	0	0	0
1985	0	0	0
1990	0	0	0
IV. Regional Supply by Trans Mountain Pipeline	0	0	0

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

Source: Arthur D. Little, Inc.

TABLE VII-78

CASUALTY SPILLS IN PORT
PORT ANGELES

Scenario	Throughput (1000 B/D)	Casualty Spills Number	Casualty Spills Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	0	0	0
B. Restricted Fleet	0	0	0
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	400 (I)	0.0932	580
1985-1990	800 (L)	0.0682	910
B. Regional Supply by Puget Spur Pipeline			
1980	690 (L)	0.0588	780
1985	1090 (L)	0.0929	1240
1990	1250 (L)	0.1065	1420
III. Transshipment at Cherry Point			
1980	0	0	0
1985	0	0	0
1990	0	0	0
IV. Regional Supply by Trans Mountain Pipeline	0	0	0

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

Source: Arthur D .Little, Inc.

As indicated in Table VII-79, the amounts of oil released into Port Angeles' waters by spillage from an oil terminal are somewhat greater than the amounts expected to be released from March Point or from Cherry Point. This is due to the high throughput of crude at Port Angeles in Scenarios II-A and II-B. The total amount of oil entering Port Angeles' waters, however, is substantially lower because Port Angeles has a relatively low background contribution of oil. Port Angeles has no refineries, and in the absence of monitoring of accidental or illegal oil release resulting from shipping activities in the port, the only estimable source of oil pollution at Port Angeles is the oil contained in urban runoff.

According to Stan Springer of the Department of Ecology's Southwest Region, the oil load in storm sewers after the first rainfall of the rainy season may approach the discharge rate of a refinery, although this loading has not been measured. The Puget Sound refineries may discharge up to a rate of 153 to 254 pounds per day (according to their NPDES permits). Considering other port activities as well, 150 pounds per day was chosen to estimate the average oil release from the small City of Port Angeles. This amount constitutes the background oil discharge at Port Angeles, and would continue to represent at least two-thirds of the total amount of oil entering the vicinity's waters, even if a transshipment terminal is located at Port Angeles.

For the purpose of obtaining a worst case chronic concentration of oil resulting from both background and terminal oil releases, the average amounts of oil spilled and discharged over a 10-day period were used. In 10 days, receiving waters would undergo complete exchange and the quantity of oil on surfaces and in sediments would be significantly less soluble. The amounts of oil used for calculations of concentrations are probably overestimated because the receiving waters are probably replaced with new waters more rapidly than 10 days and the operational and casualty spillage rates reflect the highest throughput at Port Angeles (Scenario II-B in 1990). Amounts of oil spilled from the Port Angeles terminal would usually be less than those for the maximum scenario.

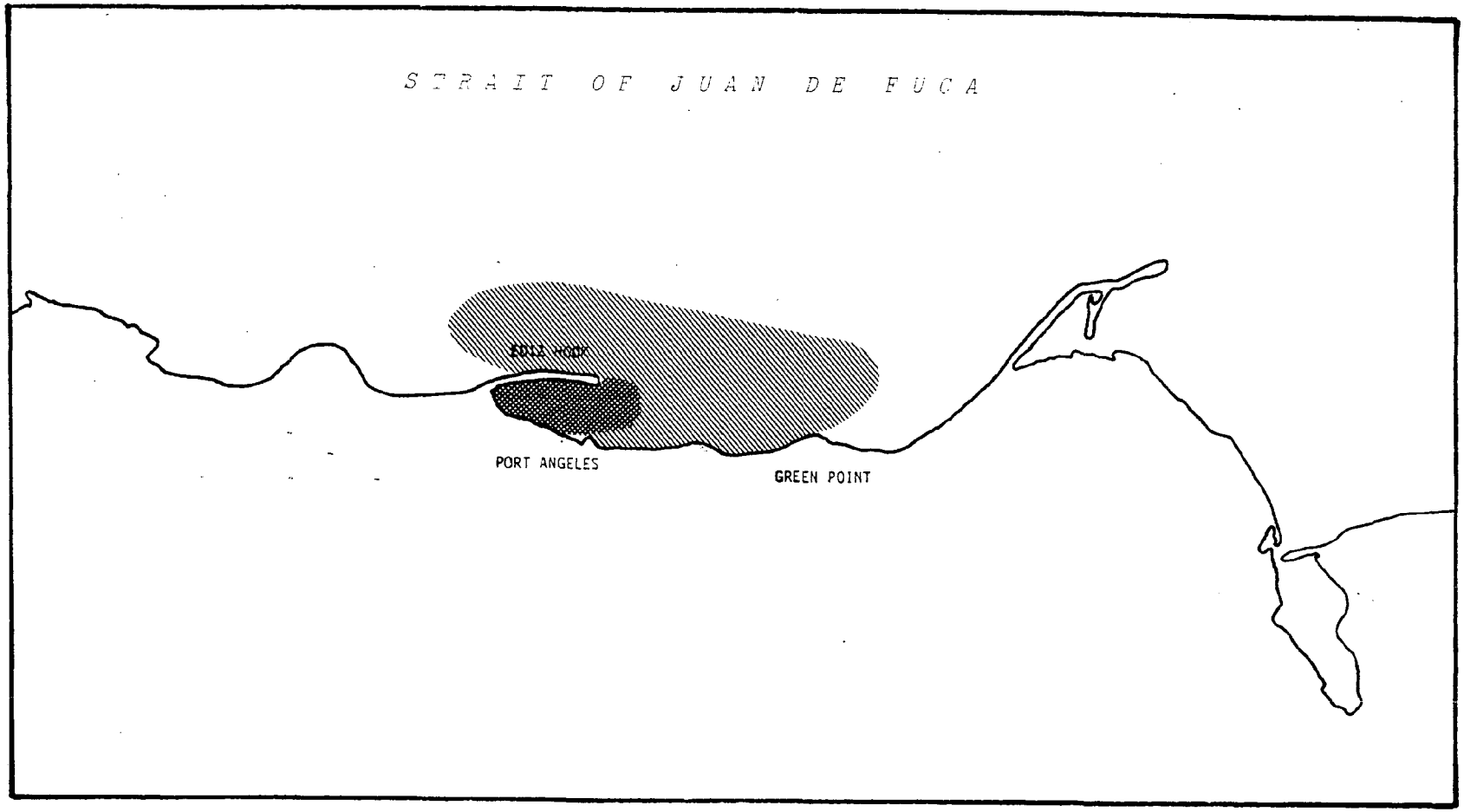
The water volume used to calculate the steady state or chronic oil concentrations with and without a Port Angeles terminal is established by the zone of probable impact, the dark grey area on Figure VII-10. This zone represents the area through which oil spilled at Port Angeles would most probably be moved over the course of one day. (See discussion of oil spill mobility in Chapter VIII.) Oil concentrations were calculated using this volume (the zone's area and average depth) and the 10-day oil releases from background and terminal sources.

As seen in Table VII-49, the levels of oil reached through chronic oil spillage and runoff at Port Angeles are extremely low, below 4 parts per billion (ppb), with both background and terminal oil concentrations added together. The absence of refineries at Port Angeles results in a chronic oil concentration about one-third that of March Point or Cherry Point. However, all three steady state concentrations are very low. Furthermore, the concentration of oil in Port Angeles' waters would be even lower if a receiving water residence time of less than 10 days is assumed and if a scenario with less throughput than Scenario II-B in 1990 were chosen.

TABLE VII-79

OIL DISCHARGE IN TERMINAL VICINITY
PORT ANGELES

BACKGROUND	lbs/da	kg/10da
Urban Runoff	150	680
Refineries (NPDES permit)		
TERMINAL		
Operational Spills		176
Casualty Spills		135
TOTAL		991



Operational Oil Spills at Marine Terminal

Possible impact zone

Probable impact zone

0 2 4 6 mi
0 3 6 9 km

NORTH

SOURCES:
Arthur D. Little, Inc.

FIGURE VII-10 POSSIBLE AND PROBABLE IMPACT ZONE: PORT ANGELES

Chronic exposure to a crude oil concentration of 4 ppb would not affect the marine resources of the area in any way. The lowest concentration of crude oil producing deleterious effects of phytoplankton (microscopic plant life) were 100,000 ppb, as found by LaCaze (1969). Mironov (1970) found that some species of phytoplankton suffered reduced cell division at 10 ppb, but the substance used was kerosene which is confined to the highly toxic, volatile fraction of crude oil and would not represent the lower toxicity of crude. The threshold concentration for ill effects suffered by other groups of plants and animals when exposed to crude or its fractions are all orders of magnitude higher than any chronic concentration resulting from an oil terminal at Port Angeles.

While steady state concentrations of oil resulting from terminal spillage at Port Angeles are not considered adverse impact generators, the extreme concentrations of oil present immediately after a spill would harm any organisms present at the time of the spill. Within the possible impact zone, exposure of biota to the mechanical (surface-coating) and acute chemical toxicity effects of freshly spilled crude would occur on the average of every 8 to 19 weeks from operational spillage as well as every 9 to 17 years from casualty spillage in the Port Angeles terminal. While casualty spills would be larger, both spill types would be located somewhere within the possible impact zone within one day after the spills took place. After one day, the oil may either be cleaned up or be further dispersed by winds and tides (see Chapter VIII). The spilled oil would be located not only on the water's surface but would be partially whipped by wave action into tiny droplets mixed as an oil-water emulsion into the water column itself.

A major transshipment project would also result in two sources of wastewater. The increased population in the area would naturally increase the domestic sewage load. As discussed under infrastructure, the population increment is within the design capacity of current treatment facilities at Port Angeles. Although these do not provide a secondary level of treatment, the water quality impact of their effluent is considered slight and upgrading will be deferred while higher priority treatment facilities in the state receive grant monies. The incremental load will probably not have a significant adverse affect on the water quality impact of domestic sewage.

A second source of wastewater is storm water runoff from the tank farm and pump stations on shore and wastes discharged from the tankers in port. Storm water runoff will be collected within a dike containment system around the tank farm. It will undoubtedly require at least filtration and probably a more advanced form of treatment depending on the apparent level of oil contamination. Tanker wastes include domestic sewage which will be piped onshore for conveyance to and disposal at the Port Angeles treatment facility. Since vessels will unload only at Port Angeles, there will be no oily ballast wastewater pumped from cargo tanks. Maintenance of the vessels will result in sporatic and unpredictable releases of oil and toxic chemicals, but the overall level is expected to be small by comparison with the level of marine and industrial waste discharged into the Port Angeles harbor.

TABLE VII-80

CHRONIC CONCENTRATION IN PROBABLE IMPACT ZONE
PORT ANGELES

Scenario	II B 1990
Background[a]	2.36
TERMINAL	
Operational Spills	0.611
Casualty Spills	0.469
%Background of Total	69
TOTAL	3.44 (ppb)

[a] urban run-off only

Source: Arthur D. Little, Inc.

(2) Impact Receptors. The possible impact zone represents the maximum expected mobility of the center of an oil slick of any size originating from Port Angeles, based on the net movements of the winds and tides of this particular segment of the Strait of Juan de Fuca over the span of one day. The oil slick would not fill up the entire zone, and actual size depends on volume spilled. The zone represents an outer limit; the spill could be located anywhere within the zone. Thus, all organisms found in the possible impact zone must be considered at risk of exposure to the acute effects of freshly spilled oil if a terminal is located at Port Angeles. (See Figures VIII-1, VIII-3, VIII-5, VIII-7, and VIII-10 for the locations of the most important of this area's marine resources, as adapted from the Marine Atlas, published by the State of Washington Department of Natural Resources.)

Because both the probable and the possible impact zones have their centers inside Port Angeles, the small pocket of crabs inhabiting the port would most certainly be affected by oil spilled in Port Angeles. Following a spill from the Port Angeles terminal, these crabs may either be killed by direct contact with masses of oil or, quite likely, suffer acute chemical toxicity with possible long-term effects (such as abnormal feeding and mating behavior) through ingestion and contact with the highly toxic fresh crude emulsified in the water column. Crabs that survived a major spill would very likely have tainted flesh and would, therefore, be unmarketable for some time afterward. This small pocket of crabs in Port Angeles is locally significant and since the entire crab resource of the Strait of Juan de Fuca from Cape Flattery to Dungeness Spit is not large, this pocket represents a moderately large proportion of the crab resource in this part of the Strait. It should be noted from Figure VIII-7 that no shrimp or scallops are present in the possible impact zone or in the Strait of Juan de Fuca region.

Of the intertidal and subtidal resources in the Port Angeles vicinity, oysters and herring spawning grounds would not be affected, whereas a substantial proportion of the Strait's sparse clam resource would receive the acute and tainting impact of Port Angeles' oil spills. About half of the small clam bed between Port Angeles and Dungeness Spit lies within the probable impact zone. While this is a small area, it represents a locally important resource even though not a regionally significant portion of the total clam resource.

The resource with the largest area affected by Port Angeles oil spills would be the sport salmon fishery surrounding Ediz Hook and vicinity; almost the entire possible impact zone is filled with sport salmon fishing. This portion of the sport salmon fishery is probably regionally significant in the Strait of Juan de Fuca and is most certainly locally signfiicant, as is the sport bottom fishery resource which also lies within the possible impact zone of Port Angeles oil spills. Neither commercial salmon fishery nor commercial bottom fishery resources would be affected by oil spilled at Port Angeles. The sports fisheries could be subject to temporary fish tainting problems after an oil spill at Port Angeles but would probably not decline because adult finfish such as salmon and cod are able to escape an oil slick of small extent and short duration.

Neither eelgrass beds nor waterfowl areas, both sparse resources in the Strait of Juan de Fuca, would be affected by oil spilled at Port Angeles. The zone of possible impact does not extend as far east as the productive eelgrass beds and waterfowl areas of Dungeness Spit.

In summary, the marine resources chiefly subject to the mechanical and chemical toxicity of spilled oil at Port Angeles would be the sport salmon fishery and locally important pockets of crab and clams.

2. March Point-Skagit County

The petroleum development scenarios entail little activity for March Point beyond the current level of tanker crude oil imports to serve the existing Shell and Texaco refineries. Since no transshipment is considered, the greatest volume of throughput is thus 170,000 B/D required to meet maximum regional demand. The greatest vessel activity with this throughput would occur if a state law restricting tankers to less than 125,000 DWT were to remain in effect (Scenario II-B).

The several cases of regional supply via a common terminal, such as Scenario II-B (Northern Tier Pipeline with the Puget Spur) and Scenario III (Transshipment Terminal at Cherry Point), and regional supply via the Trans Mountain Pipeline (Scenario IV) will involve only minimal activity at March Point.

a. Land Use

(1) Direct Impacts. Additional onshore facilities associated with increased oil shipment by tanker to March Point refineries are only required in Scenarios I and II-A (Scenario I - Regional Supply and Scenario II-A - Northern Tier at Port Angeles, no Puget Spur). In each case, however, only a minimal amount of land is required for new tankage, pumping, and access since the existing tankage is adequate for up to 120,000 B/D throughput, and both Scenarios I and II-A specify 170,000 B/D, an increase of 50,000 B/D. This increment would require 10 acres additional surge/storage of 500,000 B/D plus possibly 20 acres of ancillary facilities (see Table VII-81). This tankage and access is assumed to be evenly divided between the two refineries at March Point, i.e., 15 acres from each site.

Shell and Texaco each presently own about 400 acres of undeveloped land adjacent to the 250 acres intensively developed for each plant. Thus, 15 acres represent only 4% of the undeveloped holdings of each company. All of the land on the March Point peninsula has been zoned for heavy industry by Skagit County. Its present use is either as pasture land or as fallow land (second-growth forest areas). There would be no conflict with existing use, ownership, zoning, or comprehensive planning. The addition of a tank site from Scenarios I and II-A represents only a 6% additon to the existing plant of either Texaco or Shell so that by comparison with the present 250-acre facilities the visual or other land use impacts of these scenarios is minimal.

TABLE VII-81

INDUSTRIAL SITE LAND CONSUMPTION
ONSHORE FACILITIES[a]
MARCH POINT

	Scenario	Crude Throughput (1000 B/D) 1980	1985	1990	New Tankage Required	New Tankage Land Required[b] (Acres)
I.	Regional Supply Only					
	A. Unrestricted Fleet	170	170	170	yes	30[c]
	B. Restricted Fleet	170	170	170	yes	30[c]
II.	Northern Tier at Port Angeles					
	A. Regional Supply by Tanker	170	170	170	yes	30
	B. Regional Supply by Puget Spur Pipeline	30	30	30	no	-
III.	Transshipment at Cherry Point	30	30	30	no	-
IV.	Regional Supply Trans Mountain Pipeline	30	30	30	no	-

(a) Onshore facilities inlcude surge/storage (tank farm), pump station and access roads
(b) Assumptions: 625,000 bbl/tank
Ratio tank capacity: throughput = 10:1
10 acres/tank + 200 acres for access roads, pump stations etc.
(c) Additional tankage assumped adequate for 150,000 bbl/day throughput

Source: Arthur D. Little, Inc.

The total acreage conversion represented by the onshore facilities of Scenarios I and II-A is equivalent to a 3% increase in total industrial land use within Skagit County.

Although the onshore facilities do not present any land use problems, there is one area of potential conflict with local comprehensive planning with respect to expansion of terminal offloading facilities and new pipeline construction in Padilla Bay. As described in this report under land use-environmental setting, the area of Padilla Bay west of the center of the Swinomish Channel is zoned industrial reserve with the stipulation that the area be approved for filling only when all alternative sites have been exhausted; the intent of the Comprehensive Plan is to protect the productive biotic uses of Padilla Bay, and to discourage or prohibit activities which upset the normal ecological balance within the Bay. For the project outlined in Scenarios I and II-A, no filling of Padilla Bay would be required.

The new project facilities at March Point in Scenarios I-A and I-B are guardedly in conformance with the Coastal Zone Management Act and Skagit County Shoreline Master Program. Padilla Bay is a shoreline of statewide significance in which the natural resources and ecological systems must be protected according to the coastal Act. The expansion of offshore terminal facilities for the existing refineries at March Point will entail only a temporary dredging impact during extension to deeper water of the existing fixed berth trestles. Since no filling of the Bay is required, the dredging impacts may be considered short term, reversible, and therefore permissible.

The minor additional tankage involved in Scenario I-A would probably not be within the defined 200 feet coastal zone since it more likely would be adjacent to the existing tankage on the hills further inland, making it possible for the tanks to empty through gravity flow.

In addition to Padilla Bay, Skagit Bay and all other marine waters, water column, and beds seaward of the extreme low tide line within Skagit County are shorelines of statewide significance. A major proportion of these areas are within the potential oil spill impact zone for tanker route segments 3, 4, 5, and 6 in Scenarios I-A, I-B, and III. The definite risk of severe damage to the natural resources of these designated shoreline areas in catastrophic oil spills appears to be in conflict with stated policies for protection of the areas, including the following additional specific policies: the statewide interest should be recognized and protected over the local interest, and the uses of shoreline of statewide significance should result in long-term benefits to the people of the state.

Although regional supply or transshipment proposals involving a Burrows Bay terminal site are not defined in any of the scenarios of this study, any such proposals would have far greater land use impact than similar proposals at March Point (or Cherry Point in Whatcom County, discussed below). Land use in the unincorporated county portion of Fidalgo Island is low-density, rural residential with small farms and high quality

single family housing which depends heavily on the unspoiled, scenic, and country-like quality of the setting for its attraction. Any obtrusive oil industry activities, including the presence of a fixed berth terminal with a pier and trestle offshore in Burrows Bay, with large tankers frequently in sight, a tank farm among the agricultural or wooded lands inland, or above-ground pipeline spanning the cliff, would change the existing unspoiled character of the landscape.

(2) Indirect Impacts. Oil development Scenarios I-A (regional supply, unrestricted tanker size), I-B (regional supply, tanker size restriction), and II-A (Northern Tier Pipeline at Port Angeles, no Puget Spur) will have small population growth impacts on the March Point/ Anacortes activity zone. The size and demographic characteristics of the new population generated are indicated in Tables VII-82 through VII-85. The maximum impact year is 1979, which was calculated to produce a net population increase in the activity zone of only 71 persons (22 households) of which only 60 (20 households) will require new housing. (The difference between 20 and 22 households is the in-migrant component of direct construction employment.)

These households have been allocated to Anacortes, Mount Vernon, and other Skagit County in the ratio 2:1:1, based on the present distribution of place of residence of the employees of Shell Oil at the March Point refinery. This allocation also agrees with what would be predicted from land use trend information obtained from the local planning agencies. Thus, in the maximum impact year the total population contribution is 10 households in the City of Anacortes, five in Mount Vernon, and five distributed throughout the surrounding portions of western Skagit County. Given the criterion of significance as defined in Chapter VI, the impact of this small population growth increment is not significant in any of the communities or in the county, even for the peak employment year.

Mount Vernon has been the most rapidly growing urban area within Skagit County with an average annual growth rate of 2.7% since 1970. Five new households thus represent only 15 days of "normal" growth. Even in Anacortes, with its history of very slow growth (0.7% since 1970), 10 households represent only four months' growth at this rate.

b. Infrastructure

The population increases generated by new employment in the March Point-Anacortes activity zone under the relevant scenarios (I-A, I-B, and II-A) were shown to be insignificant in the previous section. Therefore, a quantitative discussion of infrastructure impacts is not required. In general, the only aspect of significance about such small increases in resident population with respect to the entire spectrum of community services is that if a service or utility is already near or over capacity to serve the present population, then any increases will strain it still further. For example, at the present time the La Conner, Mount Vernon, and Burlington-Edison school districts all have an excess of students in comparison to their facilities capacity (see Table VII-30). The former

TABLE VII-82

DEMOGRAPHIC CHARACTERISTICS - DIRECT EMPLOYMENT
MARCH POINT

Scenario	Permanent Employment: Employees at March Point	Permanent Employment: Growth Component	Permanent Employment: Total New Households	Permanent Employment: Persons per Household	Location of Households[a]: Total Persons	Location of Households[a]: Anacortes	Location of Households[a]: Mt. Vernon	Location of Households[a]: Other Skagit County	Wages per Household (1976 $)	Increase as % of 1975 County Population (53,4000)
IA Regional-Unrestricted	5	0.7[b]	4	3.8[c]	19	3	1	0	$27,664[d]	+0.036%
IIA Northern Tier	Same									
IIB N. Tier w/Puget Spur	0									
III Transshipment/Cherry Point	0									
Construction Peaks										
IA 1978	15	0.2[e]	3	3.8	11	2	0	1	$20,252[f]	
1979	11		2		8	1	0	1		
IB	None									
IIA	As in IA									
III	None									
IV	None									
Total Direct										
IA 1978	20		7		20	5	1	1		+0.037%
1979	16		6		27	4	1	1		+0.051

Footnotes

a Anacortes 50%, Mount Vernon 25%, Other Skagit Co. 25% - based on Industry data (Table VI -)
b 70% of new direct employment is growth (in-migration)
c Washington average for families with adults aged 20-45
d Permanent-Household Incomes = $24,286 (average for Industry employees at March Point) + $3,378 (.27 second wage earners per family x $12,514) (1976 average Employment Security Act wages for Skagit County)
e 20% of construction peak employees relocate to area with families
f Construction-Household Incomes = $14,245 (1976 Employment Security Act wage for Construction in Skagit County) + $6,006 (.48 second wage earners per family x $12,514)

Source: Arthur D. Little, Inc.

TABLE VII-83

DEMOGRAPHIC CHARACTERISTICS - INDIRECT EMPLOYMENT
MARCH POINT

Scenario		Permanent Employment: Employees	Growth Component[b]	Persons Supported[c]	Persons per Household average (1976)	Total Households	Location of Households[a]: Anacortes	Mt. Vernon	Other Skagit County	Household Income	Wage Earners Per Household	Increase of % of 1975 Skagit County Population
IA	Regional-Unrestricted	10	3	7	2.55[d]	3	2	0	1	$18,470	1.48	0.013%
IB	Regional-Restricted	As in IA										
IIA	Northern Tier	As in IA										
IIB	N. Tier w/Puget Spur	None										
III	Transshipment/Cherry Point	None										
IV	Regional-Trans Mountain	None										
					Construction Peaks							
IA	1978	29	9	21	2.55	8	4	2	2	$18,470	1.48	0.039
	1979	45	14	33		13	7	3	3			0.062
	1980	20	6	14		5	3	1	1			0.026
	1981	21	6	14		5	3	1	1			0.026
	1982	7	2	5		2	1	1	0			0.009
IB		As in IA										
IIA		As in IA										
					Total (Permanent + Peaks)							
IA	1978	39	12	28		11	6	2	3	$18,470	1.48	0.052
	1979	55	17	40		16	9	3	4			0.075
	1980	30	9	21		8	5	1	2			0.039
	1981	31	9	21		8	5	1	2			0.039
	1982	17	5	12		5	3	1	1			0.022
IB		As in IA										
IIA		As in IA										

Footnotes

Assumptions -

a Distribution : 50% Anacortes, 25% Mt. Vernon, 25% other Skagit based on Industry data
b 30% of Indirect employment is in-migration
c 2.36 persons supported per job
d 2.55 is 1975-76 average for Skagit cities (Anacortes, Mt. Vernon)

Source: Arthur D. Little, Inc.

TABLE VII-84

POPULATION AND HOUSEHOLD TOTALS
MARCH POINT
PERMANENT DIRECT AND ALL INDIRECT EMPLOYMENT
(Land Use Impacts)

Scenario	Employees	Persons Supported	Total Households	Location of Households: Anacortes	Mt. Vernon	Other Skagit	Household Income (Weighted Average)
IA Regional-Unrestricted							
1978	44	47	15	8	4	3	
1979	60	59	20	10	5	5	
1980	35	40	12	6	3	3	
1981	36	40	12	6	3	3	
1982	22	31	9	5	2	2	
GRAND TOTAL ALL DIRECT + ALL INDIRECT EMPLOYMENT (INFRASTRUCTURE IMPACTS)							
IA							
1978	59	48	18	9	5	4	$20,922
1979	71	67	22	11	6	5	$20,309
1980	35	40	12	6	3	3	
1981	36	40	12	6	3	3	
1982	22	31	9	5	2	2	
IB Regional-Restricted							
IIA	As in IA						
IIB	None						
III Transshipment/Cherry Point	None						
IV Regional-Trans Mountain	None						

Source: Arthur D. Little, Inc.

TABLE VII-85

LAND USE - MAXIMUM IMPACT ON COMMUNITIES
MARCH POINT

MAXIMUM IMPACT SCENARIO IA Regional-Unrestricted March Point	Total New Persons (Direct permanent and all Indirect	Total as % of 1975 Skagit County Population	Historical growth rate % (average) 1970-1976	New Households in Community	Existing Community Households	% Increase	Growth Equivalence at Historical Rate	Acreage Consumed	% increase in residential Acreage
year 1979	59	+0.11%							
Anacortes			+0.7%	10	3019	0.3%.	0.43 y.	4	.13
Mt. Vernon			+2.7%	5	3892	0.1%	0.04 y.	2	-
Other Skagit Co.			0*	5	14000	0.029%	-		-

Significance - None Below criterion of significance

*Growth in Skagit County has almost entirely been in incorporated areas

Source: Arthur D. Little, Inc.

two have been experiencing slow enrollment growth since 1970 and the latter has seen a slight annual decline. The Anacortes district still has the capacity to serve 400 new students, and its enrollment has been declining at the annual rate of 1.8% since 1970.

c. Terrestrial Biology

As discussed under land use impacts and as shown in Table VII-81, the total land requirements for new onshore facilities (surge/storage and ancillary facilities) development at March Point is only about 30 acres in both Scenarios I (regional supply) and II-A (Northern Tier at Port Angeles, no Puget Spur). In the other scenarios, no new construction would be required. This 30 acres is divided into 15 of the 400 undeveloped acres of Shell Oil's March Point property, and 15 of the 400 undeveloped acres belonging to Texco Oil. All of these lands are either disturbed pasture-grassland or very early second-growth forest.

The impacts of conversion of this small acreage on regional terrestrial biology are minimal for several reasons: (1) These habitats are extremely common and have low to moderate wildlife value. Thirty acres represents only 3.8% of the undeveloped portions of the refineries' holdings, and only 0.03% of the open lands (agriculture and timber) in western Skagit County, and (2) The new facilities would undoubtedly be developed close to the existing plant. Such proximity to lands already developed to such a heavy industrial use already have reduced wildlife value.

There are several potentially threatened, threatened, or endangered species which could occur on Fidalgo Island or in the environs of Padilla Bay (see Table VIII-8). Endangered species include the California condor, peregrine and Peale's peregrine falcon, the threatened (in Washington) golden eagle, and the potentially threatened northern bald eagle, osprey, spotted owl, and pileated woodpecker. Most of these are large raptorial species which are extremely wary of man's activities and would be rarely seen in the vicinity of a refinery. While early second-growth forest and open meadow-grassland constitute foraging habitat for these species, they would be unlikely to utilize the 15 acres immediately adjacent to a plant. Thus, it is unlikely that individual birds belonging to any of these populations would be directly displaced or otherwise disturbed or injured by this project. The loss of 15 acres of potential foraging habitat next to two existing oil refineries cannot be considered a significant habitat loss.

d. Air Quality

(1) Activity. In all scenarios addressed by this study, the petroleum industry activity at March Point is limited to service of existing refineries. Both Shell and Texaco have fixed berths in Fidalgo Bay off March Point. It is likely that Shell at least will expand and extend its berth into deeper water to accommodate vessels of 150,000 or greater deadweight tonnage. Those scenarios that require the full complement of crude oil for the refineries to be brought in by tanker all entail the same throughput.

Scenarios I-A and II-A would have this crude brought by vessels of intermediate size requiring some 65.5 vessel calls per year. In the event of a restriction on tanker size within Puget Sound, the same volume would require 111 vessel calls per year; this is described as Scenario I-B.

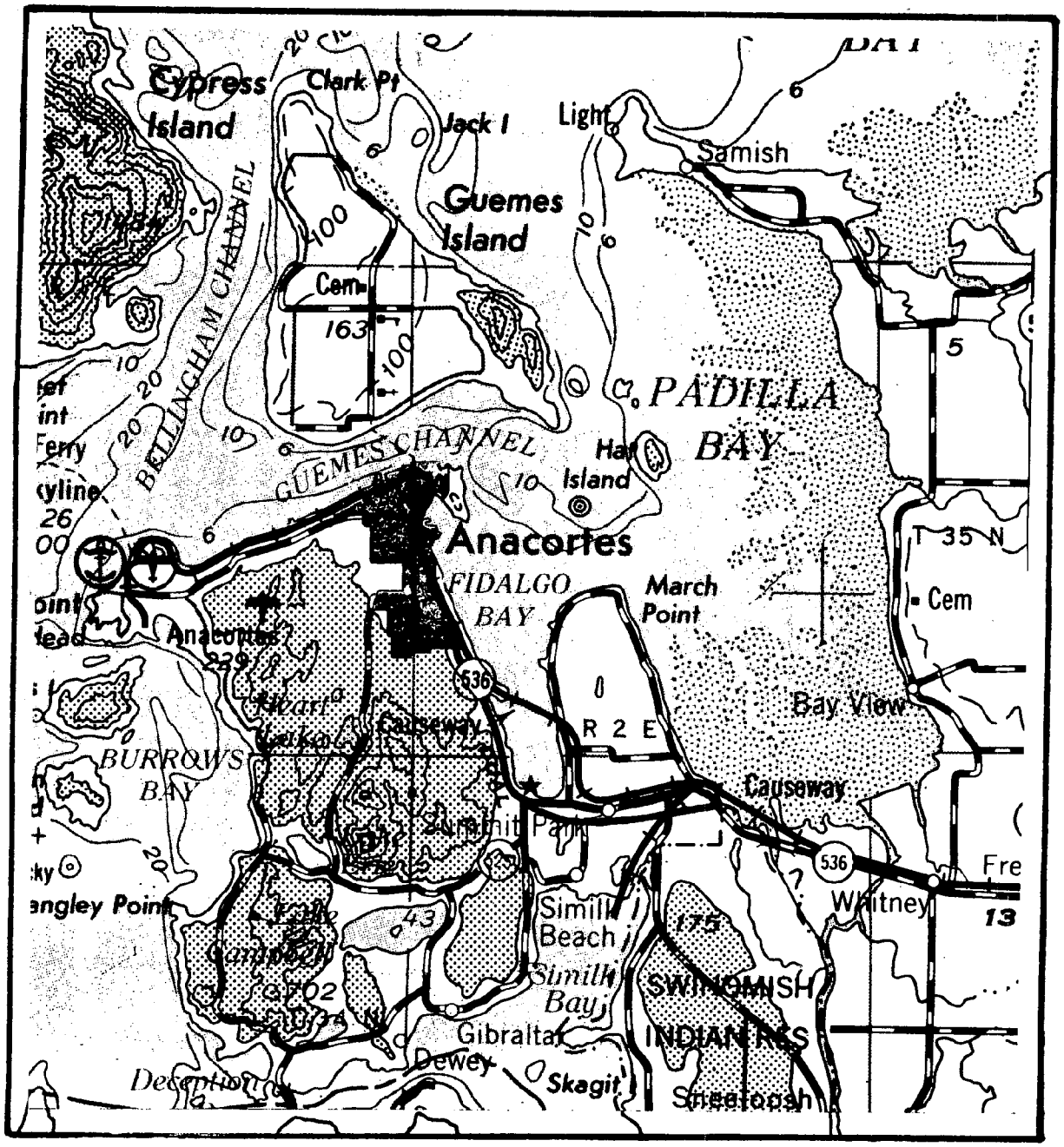
If the Northern Tier terminal at Point Angeles was to serve existing refineries via the Puget Spur Pipeline, it is still probable that some crude oil will be imported to March Point. This may comprise specialty crudes which, because of their chemical composition or physical characteristics, are not easily shipped through the pipeline, or may constitute crudes carried by small vessels which cannot be conveniently served or expeditously served by the Northern Tier terminal itself. It is likely that any crude movements continued to March Point under Scenario II-B would, in fact, not comprise Alaskan crude. Specialty crudes would undoubtedly be carried in a fleet comprising restricted sized vessels since the operation of a Puget Spur Pipeline would probably entail a restriction on tanker traffic.

If transshipment at Cherry Point or continuing regional supply via the Trans Mountain Pipeline (Scenarios III and IV) were used to provide the majority of the crude supply for March Point, the specialty imports would probably continue for the same reasons. It is possible that the fleet size could be of the intermediate type and the vessel calls per year would diminish.

Since both Shell and Texaco were constructed in the early 1950s to utilize light, sweet Canadian crude, the proportion of sour North Slope Alaskan crude that they may run is restricted. It is probable, in fact, that of the Alaskan crude used for regional supply, perhaps only 20% of it would end up at March Point, Thus, the air quality impacts and indeed the other crude transportation impacts described for March Point are only partially attributable to Alaskan crude activity per se.

(2) Local Impacts. The major potential local air quality impact at March Point will be the possible short-term concentrations of sulfur dioxide from tanker stack emissions. The susceptability to high concentrations of sulfur dioxide pertains not only to vessel emission and prevailing meteorology but also to the relationship of the surrounding terrain to the site of point source emissions (see Figure VII-11). Using Gaussian plume emissions dynamic models as described for the analysis of Port Angeles, it is possible to define zones of potential air quality impact for the March Point vicinity (see Figure VII-12). The site of terminal emissions used for the analysis is a probable location of a deeper water terminal off March Point. Even the present day terminals closer to shore, however, have a majority of their immediate vicinity as open water and the dominant air impact pattern occurs primarily under stability Class F in areas of elevated terrain over a mile or more from the terminal itself.

Due to the surrounding islands, the extent of the low potential impact zone occupies nearly a full circle around the terminal site. Only the highlands of March Point itself, and the steep hills above the City of Anacortes,



Marine Terminal

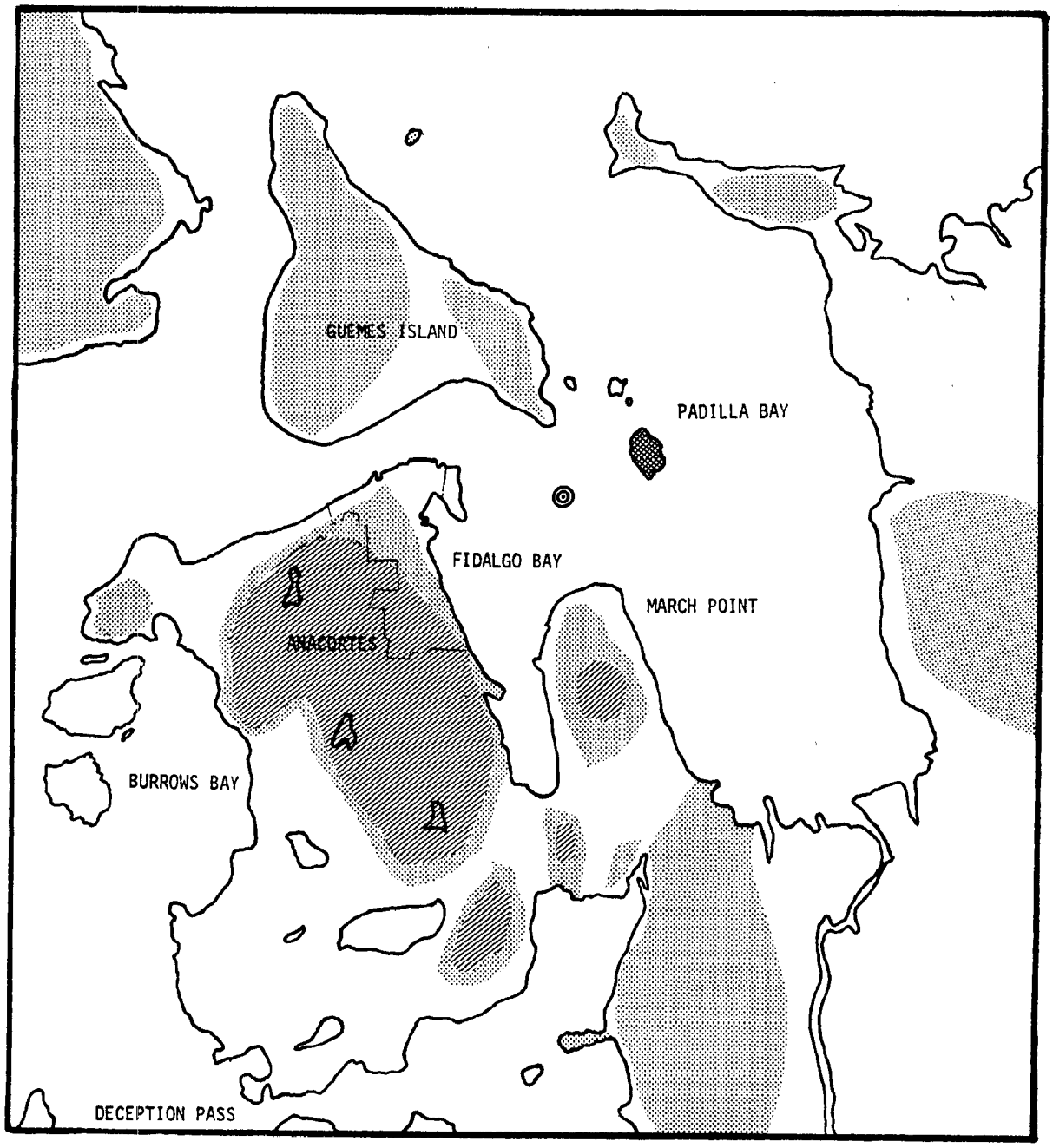
Greater than 200 ft. elevation

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

FIGURE VII-11 LOCATION AND TOPOGRAPHY: MARCH POINT

FIGURE VII-12 NORMALIZED GROUND CONCENTRATION: MARCH POINT



Normalized Ground Concentration (10^{-6} m^{-2})

	minimal	<7
	Zone 1 low	7 - 25
	Zone 2 medium	25 - 70
	Zone 3 high	>70
◎	Marine Terminal	

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

SOURCES:

Arthur D. Little, Inc.

fall within the immediate impact zone in terms of pollution potential. The hills are not steep and are sufficiently set back that they do not result in any portions which would fall into a high potential impact zone. They do include a portion of the City of Anacortes, however. The only portion of the March Point vicinity which would fall into a high impact zone is the small uninhabited island in Fidalgo Bay called Hat Island, located one mile from the terminal. With elevations of slightly less than 300 feet, Hat Island juts into the center line of the tanker plume and is essentially blasted by stack gases under center wind conditions.

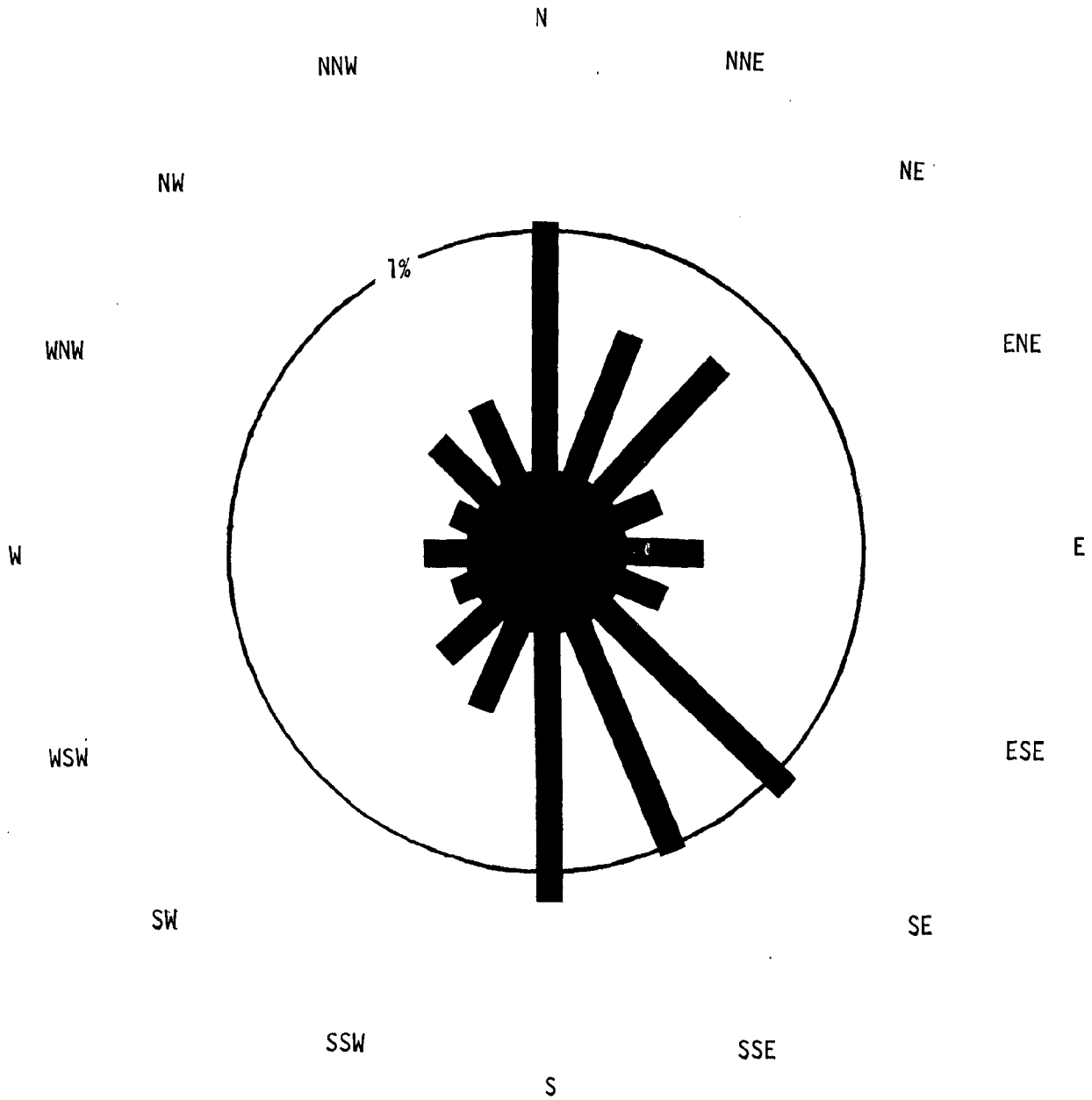
The emission spectrum of the fleet itself is weighted toward low values by the relatively few number of vessels per year which must call at March Point in any of the scenarios examined. Two berths are used for this analysis, but even the maximal throughput with a restricted fleet entails only 6% full occupancy. Thus, the statistical probability of high emission rates is fairly low.

Meteorologic data were not readily available for March Point. Data for the naval air station on Whidbey Island, to the south, and for Bellingham, to the northeast, show a similar pattern of wind distribution for low frequencies, particularly if one takes into account the gradual angular shift that occurs as prevailing winds flow in through the Strait of Juan de Fuca and diverge northward and southward in the vicinity of Whidbey Island. In order to simulate the wind conditions at March Point, the Bellingham station data was rotated by one compass point ($22\frac{1}{2}^{o}$) in a clockwise direction. Furthermore, the records available for Bellingham and Whidby Island do not indicate any occurrence of low velocity winds under stability Class F; rather they attribute all low velocity winds to Classes D and E. This is at variance with the typical pattern on wind and stability class distributions, wherein the attribution of stability Classes F and G in fact requires the wind speed to be low and usually results in a frequency of stability Class F and G of approximately 15-25% of the time overall.

The wind rose for Bellingham (see Figure VII-13) was modified to represent the probable distribution of stability Class F low velocity winds at March Point by the application of a scaling factor which would bring the overall proportion of Class F stability to 15% for this location. The necessity of these assumptions is unfortunate. We feel that the data available for Whidbey and Bellingham are insufficient for such an analysis, but in this instance the low volume of vessel traffic at March Point in fact renders most emissions impacts insignificant, as will be described following.

It is possible to calculate a level of source strength required to result in violation of the state standard of 40 pphm for each of the three impact zones, as was done in the analysis of Port Angeles. The source strength can be compared with the emissions spectrum for each scenario and can be combined with the probability of wind orientation in order to yield an estimate of the number of hours per year of local concentrations in excess of the state standard. The data in Table VII-86 present the frequency estimates based upon a 2% sulfur content for tanker fuel. As

FIGURE VII-13 FREQUENCY OF OCCURRENCE OF WINDS FROM 0 TO 3 KNOTS FOR STABILITY CLASSES D AND E AT BELLINGHAM, WASHINGTON



Source: Teknekron, 1976.

TABLE VII-86

ACUTE AIR QUALITY IMPACT
MARCH POINT

Scenario	Vessel calls per year	Fleet type[a]	Number of berths	% Fully occupied	Hours/year SO_2[b] over standard[c] in Impact zone 1	2	3	% Sulfur fuel for no violation[c] in Impact zone 1	2	3	Hours/year high NO_2[d]
I. Regional Supply											
A. No Restrictions	64.5	I	2	2	0	2½	1	>3	2.2	>3	½
B. Restricted fleet	111	R	2	6	0	3	2	>3	1.8	2.4	1
II. Northern Tier											
A. Tanker Supply	64.5	I	2	2	0	2½	1	>3	2.2	>3	½
B. Puget Spur	20	R	2	<1	--insignificant emissions impact--						
III. Transshipment at Cherry Point	11	I	2	<1	--insignificant emissions impact--						
IV. Supply via Trans Mountain	11	I	2	<1	--insignificant emissions impact--						

a R = Restricted Vessel Size
I = Intermediate Vessel Size
b for fuel with 2% Sulfur Content
c State 1 hour standard is 40 pphm
d high NO_x is 25 pphm over one hour - does not correspond to applicable standard

Source: Arthur D. Little, Inc.

may be expected, the relatively low emissions strength of the small vessel volume at March Point results in a low level of sulfur dioxide concentration. Only in impact Zone 2, where elevated terrain and fairly broad geographic extent combine to yield high potential ground level concentration, is there an air quality problem. The greatest impact is principally associated with a tanker restriction and complete regional supply by tanker which necessitates the maximum number of vessel calls per year. Such a situation could result in violation of the state standard, with as many as three hours per year of concentrations in excess of 40 pphm. In order to mitigate such an impact, it would be necessary to restrict tanker fuel to 1.8% sulfur content, at least under conditions of multiple vessels in port or for adverse meteorology.

The other pollutants in tanker stack gases will cause no appreciable problem in local air quality. The final column of Table VII-86 shows that high nitrogen oxides will be only rarely achieved for some scenarios. Other pollutants will have insignificant levels from tanker activity alone. The crude oil storage tanks associated with refinery use will essentially remain as at present. It is probable that there are frequent conditions leading to concentrations of reactive, non-methane hydrocarbons in excess of the state and federal 6:00 a.m. to 9:00 a.m. standard. The tanks present at Shell and Texaco were not specifically examined with respect to violation of the standard. Also as noted in Chapter V, the non-methane hydrocarbon standard relates to a regional oxidant problem and it does not represent a local, acute air quality problem per se.

(3) Regional Air Quality Impact. Average emissions from crude oil transportation into March Point are presented in Table VII-87. The modest vessel activity results in correspondingly modest average emissions. It might be noted, however, that the smaller vessel size of the restricted fleet results in a greater tonnage of emissions per thousand barrels of crude oil throughput, but the low volume offsets this tendency. The magnitude of sulfur emissions is modest by comparison with other industries in the area, particularly by comparison with the refineries themselves. Since present day emissions appear to cause only a minimal sulfur dioxide problem, it is likely that the continued contribution of tanker emissions associated with the major scenarios will in fact cause only minimal regional air quality impact.

Hydrocarbon emissions from tanker purging or from onshore crude oil storage have a potential impact on regional oxidant formation. Monitoring data for the area are sparse and no oxidant information is presently available. Conditions suitable for the formation of photochemical oxidant certainly occur, but overall oxidant formation is probably low in the March Point vicinity, as was described for the Port Angeles vicinity. The region here, however, is slightly more uniformly and densely urbanized. There are other hydrocarbon sources, primarily area sources of petroleum product handling and vehicular emissions which may augment a plume of reacting hydrocarbons issuing from the March Point terminal tank farm. It is possible that the plume of reactants from March Point may impinge upon the communities of Mount Vernon or Bellingham and contribute to the ozone levels at those locations.

TABLE VII-87

AIR POLLUTANT EMISSIONS - MARINE TERMINAL
MARCH POINT
(tons/day)

	Pollutant					
				Hydrocarbons		
	SO_x	NO_x	Particulates	Fuel	Purging	Storage & Misc.
Scenario I-A	0.527	0.371	0.090	0.029	1.826	4.385
Scenario I-B	0.682	0.476	1.114	0.034	1.785	4.349
Scenario II-A						
1980	0.527	0.371	0.090	0.029	1.826	4.385
1985	0.527	0.371	0.090	0.029	1.826	4.385
1990	0.527	0.371	0.090	0.029	1.826	4.385
Scenario II-B						
1980	0.120	0.084	0.020	0.006	0.315	2.851
1985	0.120	0.084	0.020	0.006	0.315	2.851
1990	0.120	0.084	0.020	0.006	0.315	2.851
Scenario III						
1980	0.120	0.084	0.002	0.001	0.315	2.846
1985	0.120	0.084	0.002	0.001	0.315	2.846
1990	0.120	0.084	0.002	0.001	0.315	2.846

Source: Arthur D. Little, Inc.

The present hydrocarbon emissions from the Shell and Texaco refineries are far greater than the emissions from crude oil handling and storage alone. The continuation of tanker service to March Point represents a small portion of the regional air basin burden for hydrocarbon and represents a correspondingly small potential increment in the oxidant levels in the basin.

From a statistical viewpoint, the oxidant experience for the region probably has a higher geometric mean than does the oxidant distribution described for Port Angeles. This is partially due to the slightly more favorable average conditions (insolation and lower wind speed) but largely due to the quantity of reactive organic gases already emitted into the basin. Since the oxidant distribution in most of the Puget Sound area would be expected to have a fairly large standard geometic division, it is quite likely that there are conditions at present with oxidant reaching near the federal and state 8 pphm level on several days in the year. At present, the monitoring network is sufficiently sparse that the occurrences are not noted. The project at March Point would result in a very small increment in both the magnitude and the frequency of high oxidant experience.

All scenarios in this study induce little growth at March Point. Thus, there is an insignificant increment to the urban pollution load contributed by vehicular activity of the population.

e. Water Quality/Marine Biology

(1) Impact Generators. An oil transshipment terminal located at March Point would result in oil release into the waters immediately surrounding Fidalgo Island in addition to the existing refinery discharge of oil and grease and runoff from the urban parts of Anacortes. The two sources of new oil release, operational spillage and in-port casualty spillage, would contribute similar amounts of spilled crude to the waters over a year's time (see Tables VII-88 and VII-89). As would be expected, the sources differ greatly in expected frequency of occurrence and in spill size. While casualty spills in port would be larger than operational spills, they would occur only once every 30 to 50 years at March Point, whereas operational spills would tend to occur on the order of once every 6 to 10 months. Although a larger spill, if uncontained and not cleaned up, would affect larger numbers of organisms, the potentially high frequency of exposure imposed on the local biota by operational spills makes them the more significant impact generator over a period of time.

Amounts of oil released into March Point/Anacortes vicinity waters by existing sources and by an oil transshipment terminal are shown in Table VII-90. Background oil release is composed not only of the discharges of the two local refineries, represented here by the maximum amount allowed under their NPDES permits, but also of the oil and oil products in urban runoff. According to Stan Springer of the Department of Ecology's Southwest Region, the oil discharged from storm sewer outfalls of a small city after the first winter rain could approach the amount discharged by an oil refinery.

TABLE VII-88

OPERATIONAL SPILLS AT MARINE TERMINAL
MARCH POINT

Scenario	Throughput (1000 B/D)	Operational Spills Number	Operational Spills Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	170 (I)	1.16	315
B. Restricted Fleet	170 (R)	2.00	540
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	170 (I)	1.16	315
1985-1990	170 (I)	1.16	315
B. Regional Supply by Puget Spur Pipeline			
1980	30 (R)	0.35	96
1985	30 (R)	0.35	96
1990	30 (R)	0.35	96
III. Transshipment at Cherry Point			
1980	30 (R)	0.35	96
1985	30 (R)	0.35	96
1990	30 (R)	0.35	96
IV. Regional Supply by Trans Mountain Pipeline	30 (I)	0.35	96

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

Source: Arthur D. Little, Inc.

TABLE VII-89

CASUALTY SPILLS IN PORT
MARCH POINT

Scenario	Throughput (1000 B/D)	Casualty Spills Number	Casualty Spills Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	0	0.0183	240
B. Restricted Fleet	0	0.0315	420
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	400 (I)	0.0183	240
1985-1990	800 (L)	0.0183	240
B. Regional Supply by Puget Spur Pipeline			
1980	690 (L)	0.0057	80
1985	1090 (L)	0.0057	80
1990	1250 (L)	0.0057	80
III. Transshipment at Cherry Point			
1980	0	0.0057	80
1985	0	0.0057	80
1990	0	0.0057	80
IV. Regional Supply by Trans Mountain Pipeline	0	0.0031	40

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

Source: Arthur D. Little, Inc.

TABLE VII-90

OIL DISCHARGE IN TERMINAL VICINITY
MARCH POINT

BACKGROUND	lbs/da	kg/10da
Urban Runoff	175	794
Refineries (NPDES permit)[a]	153 Texaco	694 Texaco
	190 Shell	862 Shell
		1556
TERMINAL		
Operational Spills		52
Casualty Spills		40
TOTAL		2442

[a] Permitted levels of daily discharge of oil + grease averaged over one month. Includes ballast and storm water allocations for Arco and Texaco, based on average flows at Mobil refinery.

Source: Arthur D. Little, Inc.

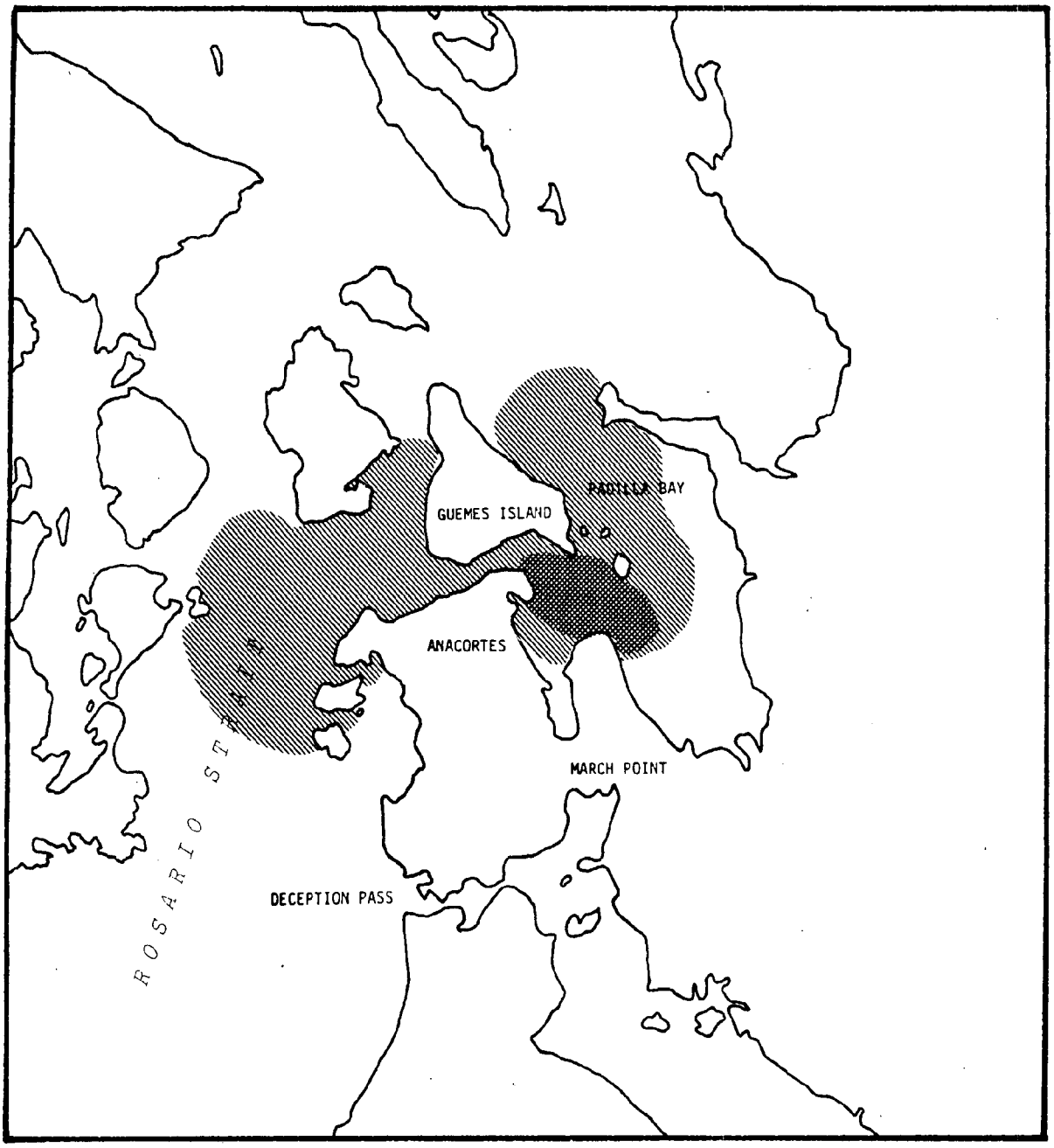
The four northern Washington refineries have allowed NPDES discharge rates ranging from 153 to 253 pounds per day; 175 pounds per day was chosen as an average rate of oil discharge due to Anacortes' urban runoff and general marine activity -- a non-point pollution source not monitored. It can be seen from Table VII-90 that the projected spill amounts at a March Point terminal are far less than the amounts currently discharged or running off into adjacent waters -- only 4% of the total amount released.

To calculate the concentration of oil resulting from background and terminal releases, the amounts of oil discharged or spilled over a 10-day period were used. After 10 days, the original mass of oil would be weathered and dispersed. The 10-day amounts released are clearly overestimated in that new water probably replaces oil-laden water in far less than 10 days, and the refineries appear to be discharging less than the amount allowed in their permits. Furthermore, the amounts spilled from the terminal would usually be less since the "worst case" of Scenario I-B, with the highest crude throughput for March Point, was deliberately chosen.

The water volume used to calculate the steady state or chronic oil concentrations with and without a March Point terminal is the zone of probable impact, the dark grey area on Figure VII-14. This area represents the confines within which oil spilled at March Point would most probably be located at the end of one day, based on net movements of winds and tides in this part of Puget Sound. The volume of this probable impact zone was calculated using the area and average depth, and the concentrations were calculated using this volume and the 10-day oil releases from background sources and terminal spillage.

As Table VII-91 indicates, the concentration due to chronic oil release into the March Point-Anacortes waters is low, only 10 ppb with all sources added together. Most important, 96% of the chronic oil level is due to existing discharges. It should also be recalled that the actual concentration would probably be even lower since worst case conditions for refinery discharge, terminal spillage, and receiving water residence time were chosen.

Even if the chronic oil concentration were 10 ppb as calculated, no portion of the biota of the receiving waters would suffer ill effects. The research results of Mironov (1970) show that even the most sensitive of plant or animal species, phytoplankton (microscopic plant life), do not show damage such as reduced cell division until exposed to 10 ppb of kerosene. Since kerosene is a constituent of the highly toxic volatile fraction of crude oil, the concentration of crude required to produce deleterious effects in phytoplankton would be substantially higher -- about 100,000 ppb, as found by LaCaze (1969). This concentration and the threshold concentrations for ill effects sustained by higher plants and animals are all much higher than the oil levels expected from chronic oil release with a terminal at March Point. Chronic oil release from operational and in-port casualty spillage is thus not considered a major adverse impact on marine biota at March Point.



Operational Oil Spills at Marine Terminal

Possible impact zone

Probable impact zone

0 2 4 6 mi
0 3 6 9 km

NORTH

SOURCES:

Arthur D. Little, Inc.

FIGURE VII-14 POSSIBLE AND PROBABLE IMPACT ZONE: MARCH POINT

Arthur D Little, Inc.

TABLE VII-91

CHRONIC CONCENTRATION IN PROBABLE IMPACT ZONE: MARCH POINT

Scenario	IB
Background[a]	9.13
TERMINAL	
Operational Spills	0.202
Casualty Spills	0.156
%Background of Total	96
TOTAL	9.49 (ppb)

[a] 2 refineries + urban run-off (Anacortes)

Source: Arthur D. Little, Inc.

In contrast to the chronic concentration present in the probable impact zone, the concentration on the water's surface immediately following any spill would be high. In addition, droplets of crude would be whipped into an emulsion and spread throughout the water column by wave action. Exposure of local biota to the mechanical (surface coating) and acute chemical toxicity effects of freshly spilled crude would occur on the average of every 6 to 10 months from operational spillage as well as every 30 to 50 years due to casualties at a March Point terminal. While the casualty spills would be larger, both spill types would be located within the possible impact zone in one day's time, after which the oil would be either cleaned up or further dispersed by winds and tides.

Little population growth is sustained by any of the scenarios addressed in this study in the March Point vicinity. Current plans for Anacortes to upgrade the treatment plant will certainly offset the additional load of domestic wastewater contributed by induced growth. Similarly, any increment in storm water runoff or processed wastes from increased marine terminal activity are small by comparison with the level of discharge from the existing refinery activities.

(2) Impact Receptors. The "possible" impact zone represents the maximum mobility of the center of mass of an oil slick of any size originating from March Point, based on the net movements of local winds and tides in the span of one day. While the spilled oil would not fill up the entire zone (the light grey area in Figure VII-14), the slick could be located anywhere within it with equal probability. Thus, all organisms inhabiting the possible impact zone must be considered at risk to the acute effects of freshly spilled oil if a terminal is located at March Point. (See Figures VIII-2, VIII-4, VIII-6, VIII-8, and VIII-11 for the locations of the most important of this area's marine resources, as compiled in the Marine Atlas published by the State of Washington's Department of Ecology.)

Because both the probable and possible impact zones are centered on one side of productive Padilla Bay, a substantial proportion (about 60%) of Padilla Bay's crab resource would be affected by oil spilled from March Point. This represents a small but not insignificant proportion of the total crab resource area of northern Puget Sound. Following a March Point spill, these crabs could be killed directly by sinking masses of oil, or otherwise would very likely suffer acute chemical toxicity and long-term chemical toxicity (such as abnormal feeding and mating behavior) through contact with the low molecular-weight fraction of crude emulsified in the water column. In addition, crabs that survived would most probably be tainted and therefore unmarketable. The shrimp resource area just west of Fidalgo Island in Burrows Bay would not be affected by oil spilled from March Point under most wind and tide conditions; no scallops would be affected.

Of the intertidal shellfish, only very small clam areas, regionally insignificant, would be destroyed or tainted by March Point oil spills; it should be noted that the oyster bed in lower Fidalgo Bay apparently would be missed under all but anomalous weather and tide conditions along with a very large spill. This applies also to the small herring spawning ground area in the southwest corner of Padilla Bay.

Small, regionally insignificant but possible locally significant, areas of both sport and commercial salmon fishing lie within the March Point zone of possible impact, as do very small areas of sport bottom fishing and small areas of commercial bottom fishing that may be locally important. Although finfish such as these can suffer surface-coating effects of spilled oil or become tainted and thus unmarketable, they are also mobile and, unlike the shellfish and intertidal resources, can swim away from oil contamination until it clears. The possibility of fishery disruption and temporary tainting problems exists because of the persistence of oil droplets in the water column and the ingestion of oil contaminated food by the desirable fish. However, the fishery areas affected would be so small that these impacts would be insignificant in the whole of northen Puget Sound.

The two most heavily impacted marine resources in the March Point terminal vicinity would be the eelgrass beds and waterfowl areas of Padilla Bay. About half of the Bay's eelgrass bed area risk the damaging effects of oil spilled at March Point -- direct damage to the leaves or irreversible, indirect damage through the root system could cause the decline of the outer parts of these beds. Loss of eelgrass beds would be a highly adverse impact since they provide a productive habitat offering food, resting grounds, and sheltered waters for the breeding and other critical activities of a large variety of fish, crustaceans, and waterfowl. Padilla Bay's eelgrass beds also represent a large proportion of the eelgrass bed resource of northern Puget Sound. The only other large eelgrass area is in Skagit Bay which would not receive March Point oil.

Northern Puget Sound's largest continuous waterfowl area is in Padilla Bay; about 40-50% of this area lies within the zone of possible impact of oil spilled at March Point. Waterfowl are among the organisms most sensitive to all the effects of oil: surface coating causes loss of insulation and buoyancy properties of feathers and usually death; chemical toxicity results upon eating contaminated fish and other food; and long-term, population reducing effects such as abnormal mating and reproductive behavior can also result. Decline of the waterfowl areas affected would very likely be permanent if spills from March Point reached them with the frequency expected for operational spills (once every 6 to 10 months). The likelihood of decline in the outer portion of this waterfowl area is quite high since it lies within the zone of probable impact, the area within which March Point oil spills would most certainly exert their effects.

Possible dredging by Shell for pier extension to allow berthing of deeper draft tankers and the construction of new pipeline on a trestle from berth to shore will disturb the sediments and increase turbidity in this portion of the Bay. Resources and resource activities which would be disturbed by such activities in this portion of the Bay include oyster beds, crabs, herring spawning, and feeding by juvenile salmon and steelhead. The dredging disturbance is temporary -- limited to the construction period -- so that these resources should be able to return to their pre-construction population levels. After construction, movement of the deep draft vessels using the new berths will markedly increase turbulence in their wake which could mechanically injure small fish or other forms of life concentrated for feeding in the rich, shallow mudflats of the Bay.

3. Cherry Point-Whatcom County

The greatest level of activity at Cherry Point would come from the transshipment project such as that considered under Scenario III in this study. The crude oil throughput may range from 150,000 B/D for transshipment associated with a small project such as the Trans Mountain alternating reversal (yo-yo) to as much as 800,000 B/D associated with a new pipeline such as the Northern Tier Pipeline presently proposed to serve Port Angeles.

In other instances, the activity at Cherry Point is limited to service of the existing Atlantic Richfield and Mobil oil refineries. The maximum activity under regional supply alone would be with a tanker restriction (Scenario I-B). Tanker activity would be sharply curtailed if a superport at Port Angeles were to serve refinery needs via the Puget Spur or if it were possible to receive crude supply via the Trans Mountain Pipeline once again.

a. Land Use

(1) Direct Impacts. Expanded onshore facilities at Cherry Point are involved in Scenarios I, II-A, and III (I-regional supply; II-A-Northern Tier at Port Angeles, no Puget Spur; III-transshipment at Cherry Point). As can be seen from Table VII-92, Scenarios I and II-A have identical requirements for a minimal 30-acre addition to existing surge/storage and associated facilities; Scenario III requires 70 additional acres of onshore land for the Phase 1 (1980) facilities, and a maximum of 180 acres for the Phase 3 (1990) proposed throughput. The 30-acre minimum figure given for Scenarios I and II-A assumes that the two existing refineries at Cherry Point (Mountain View industrial district) in Whatcom County have enough surge/storage facilities to handle a tanker delivered throughput of 150,000 B/D. The 170,000 B/D throughput defined for Scenarios I and II-A represents an addition of 20,000 B/D, requiring a single tank plus pad and dike (total 10 acres) and possibly some additional 20 acres of accessory facilities (access roads, pump station). With this small increment in throughput, the latter may be minimal.

Assuming this land requirement is split between the two Mountain View district refineries, Atlantic Richfield and Mobil, each will need to develop 15 acres. At present, Atlantic Richfield has undeveloped holdings of 150 acres largely interspersed with and surrounding the developed portion of its plant; 15 acres represent 10% of this, or an increase of less than 4% in the developed portion. Three hundred out of Mobil's holdings to the south of Atlantic Richfield are undeveloped. Fifteen acres represent only 5% of the undeveloped portion.

In both cases, the land to be occupied by the new facilities is already owned by an oil refinery and designated as primary industrial in the county comprehensive plan. Atlantic Richfield also owns a parcel north of Grandview Road which is designated as select industrial reserve in the comprehensive plan, which means that at such time as it became necessary to industrially develop the parcel, the industry should be nonpolluting and compatible with surrounding uses. A tank farm would probably be

TABLE VII-92

INDUSTRIAL SITE LAND CONSUMPTION ONSHORE FACILITIES - CHERRY POINT

Scenario	Crude Throughput (1000 B/D) 1980	1985	1990	New Tankage Required	New Tankage Land Required[b] (Acres)
I. Regionaly Supply Only					
A. Unrestricted Fleet	170	170	170	yes	30[c]
B. Restricted Fleet	170	170	170	yes	30[c]
II. Northern Tier at Port Angeles					
A. Regional Supply by Tanker	170	170	170	yes	30
B. Regional Supply by Puget Spur Pipeline	20	20	20	no	-
III. Transshipment at Cherry Point	460	660	1110	yes	70 - 180
IV. Regional Supply Trans Mountain Pipeline	20	20	20	no	-

(a) Onshore facilities include surge/storage (tank farm), pump stations and access roads
(b) Assumptions: 625,000 bbl/tank
Ratio tank capacity: throughput = 10:1
10 acres/ tank + 200 acres for access roads, pump stations etc.
(c) Existing tankage assumed adequate for 150,000 bbl/day throughput

Source: Arthur D. Little, Inc.

acknowledged as fulfilling those criteria, but the minimal new development can easily be accommodated within Atlantic Richfield lands which are already zoned primary industrial. Thus, the onshore land use impacts of Scenarios I and II-A are quite small; no land taking in conflict with adjoining uses or local land use planning policies are involved.

In Scenario III, the much greater new land requirements for additional surge/storage needed in accordance with an oil transshipment proposal for Cherry Point can still be met with only minor land use impacts. While the immediate backup area of shoreside access to the marine terminal above the bluff is only 35 acres, this is adequate for a pump station plus access road which consumes only a few acres. The balance of the maximum 180-acre surge/storage could be located just inland on Standard Oil's main 900-acre parcel, also designated as primary industrial in the Whatcom County Comprehensive Plan but presently completely undeveloped. The land would have to be obtained from Standard Oil by the Pipeline Company.

In all, the onshore facilities of Scenario I and II-A represent less than a 1% increase in the total industrial acreage in Whatcom County. The facilities of Scenario III represent a 2-5% increase (1980 versus 1990 phase) in the lands presently in primary industrial use.

The project areas directly within the coastal zone at the Cherry Point industrial site are the bluff and backup area at Cherry Point, owned by Standard Oil, which could be used for a pump station and partial surge/storage site in Scenario III. This entire stretch of shoreline between Bay Road and Slater Road has been designated conservancy in the Whatcom County Shoreline Master Program. The site of the marine terminal immediately offshore has been designated aquatic in the Shoreline Master Program. According to the Coastal Zone Management Act and the county Shoreline Master Program, multiple uses of the shoreline in conservancy areas should be strongly encouraged. The overall intensity of development or use of these areas should be maintained low and the areas should be protected from "uses which require substantial alterations to the area's natural character, (those which alter) its topography and land-water edge should be directed to 'urban' or 'rural' areas." The possible project facilities at Cherry Point within the coastal zone will contain sufficiently small acreage that they will probably not conflict with the stated policies of the Act for protection of conservancy areas.

The purpose of the aquatic designation is to encourage and protect appropriate multiple uses or dominant uses in limited areas of navigable or open waters and to preserve limited water resources, tidelands, and shorelands from encroachment. In recognition of this purpose, the following policies were adopted: (1) "that development should be sharply limited to those uses which are compatible with conservation of area resources including water, fish, and wildlife," and (2) "offshore development should be limited to those areas which are truly water surface dependent or which provide broad and substantial compensating benefits to the community or region."

Marine terminal construction requires minor dredging and other mechanical disturbance of aquatic areas but no filling or irreversible disturbance is involved. Therefore, marine terminal construction should not conflict with the stated policies for aquatic designated areas, particularly since an oil tanker terminal is a water dependent use.

Oil transportation by tanker or tanker activities at the terminal which result in oil spillage are the most significant source of impact which conflicts with Coastal Zone Management Act policies to preserve aquatic areas and shorelines of statewide significance. The latter include Birch Bay from Birch Point to Point Whitehorn and the Nooksack River estuary as well as all other marine waters, water column and beds seaward of the extreme low tide within Whatcom County. The risk of oil spill is sufficiently high in Scenario III that the resulting impact on aquatic life may interfere with state policy to "protect the resources and ecological systems of shorelines of statewide significance."

Lake Whatcom, northeast of Bellingham, has also been designated a shoreline of statewide significance. Possible further residential development along the shore of this lake which could be stimulated by population growth in the Bellingham area from Scenarios III, I-A, and II-A could also potentially conflict with the policies for nonconsuming uses of this shoreline.

(2) Indirect Impacts. The size and demographic characteristics of the new population generated by the direct and indirect employment provided in the various oil development scenarios for Port Angeles are summarized in Tables VII-93 through VII-95. Scenarios I-A, II-A, and III will have population growth impacts on Whatcom County communities, but only Scenario III will have significant impacts as defined by Chapter VI. The peak construction year in Scenario III is 1979; the new population generated in Whatcom County by this level of petroleum development activity will have significant impacts on the communities of Bellingham, Ferndale, and Blaine and on the county as a whole, as defined by the significance criterion of this analysis (see Table VII-96).

The allocation of households given in data from the Whatcom County oil refineries on the residence of new employees at Cherry Point suggests that 82% of the new households in the area would reside in Bellingham, 8% in Ferndale, and 5% each in Blaine and other Chatcom County (mostly unincorporated). The indirect employment residence is expected to have approximately the same distribution as the direct employment residence since the indirect employees will largely serve the direct employees and their families where they live (store clerks, teachers, school staff), and may also tend to show similar residence preferences for the same reason. The high proportion of all new households expected to reside in Bellingham yields a significant impact in Bellingham for all of the years 1978-82 of Scenario III. The two construction years (1978 and 1979) are reflected in significant countywide growth impacts.

As shown in Table VII-95, the peak year would represent an influx of of 695 new households into Whatcom County, of which 569 would locate in Bellingham, 56 in Ferndale, and about 35 each in Blaine and the remainder

TABLE VII-93

DEMOGRAPHIC CHARACTERISTICS - DIRECT EMPLOYMENT - CHERRY POINT

Scenario	Employees at Cherry Point	Growth Component	Total New Households	Persons per Household	Total Persons	Location of Households[a]: Bellingham	Ferndale	Blaine	Other Whatcom County	Wages per Household (1976 $)	Increase as % of 1975 County Population (86,200)
IA Regional-Unrestricted	19	13[b]	13	3.8	49	11	1	0	1	$27,270[c]	.057%
IIA Northern Tier	As in IA										
IIB N. Tier w/Puget Spur	0										
III Transshipment/Cherry Point	194	136	136	3.8	517	111	11	7	7		0.6 %
Construction Peaks											
IA 1978	55	39[d]	11	3.8	42	9	1	0	1	$17,891[e]	0.049%
1979	44	31	9		34	7	1	0	1		0.039%
IB Regional-Restricted	None										
IIA	As in IA										
III 1978	490	98	98	3.8	372	80	8	5	5		0.043%
1979	448	90	90	3.8	340	74	7	4	5		0.039%
IV Regional-Trans Mountain	None										
Total (Permanent + Peaks)											
IA 1978	74	52	24		91	20	2	0	2		0.11%
IIA 1979	63	44	22		83	18	2	0	2		0.10%%
III 1978	684	234	234		889	191	19	12	12		1.03%
1979	642	228	226		857	185	18	11	12		0.99%

Source: Arthur D. Little, Inc.

TABLE VII-94

DEMOGRAPHIC CHARACTERISTICS - INDIRECT EMPLOYMENT - CHERRY POINT

Scenario	Permanent Employment: Employees	Growth Proportion[b]	Persons Supported[c]	Persons per Household Average (1976)	Households	Location of Households[a]: Bellingham	Ferndale	Blaine	Other Whatcom Co	1976 Household Income[d]	Increase in population as % of 1975 Whatcom County Population	Wage Earners per Household (1976)
IA Regional-Unrestricted	41	12	29	2.67	11	9	1	0	1	$15,563	.034%	1.46
IIA Northern Tier	As in IA											
IIB N. Tier w/Puget Spur	0											
III Transshipment/Cherry Point	415	125	294	2.67	110	90	9	5	6	$15,563	.034%	1.46
Construction Peaks												
IA 1978	120	36	85	2.67	32	26	3	1	2	$15,563		
1979	179	54	127		48	39	5	3	2			
1980	81	24	57		21	17	2	1	1			
1981	83	25	59		22	18	2	1	0			
1982	29	9	21		8	7	1	0	0			
IB None												
IIA As in IA												
IIB Minor												
III 1978	1050	315	743		278	228	22	14	14	$15,563	0.86%	
1979	1694	508	1199		449	368	36	22	22		1.39%	
1980	441	132	312		117	96	9	6	6		0.36%	
1981	359	108	255		96	79	8	5	5		0.3 %	
1982	167	50	118		44	36	4	2	2		0.14%	

Total (Permanent and Construction Peak)

Scenario	Persons Supported	Total Households	Location of Households: Bellingham	Ferndale	Blaine	Other Whatcom Co.	Totals % of Whatcom Co. 1975 Population
IA Regional-Unrestricted							
1978	114	43	35	4	1	3	0.13%
1979	156	59	48	6	3	3	0.18%
1980	86	32	26	3	1	2	0.10%
1981	88	33	27	3	1	1	0.10%
1982	50	19	16	2	0	1	0.58%
III Transshipment/Cherry Point							
1978	1037	388	318	31	19	20	1.2%
1979	1493	559	458	45	27	28	1.7%
1980	606	227	186	18	11	12	0.7%
1981	549	206	169	17	10	11	.64%
1982	412	154	126	13	7	8	.48%

Footnotes

a Same distribution as for Direct. Distribution is 82% Bellingham, 8% Ferndale, 5% Blaine, 5% Other Whatcom Co. (based on Industry data). See Table (VI -)

b 30% of Indirect Employment is in-migration

c 2.67 is 1975-76 for Bellingham and Ferndale

d Household Income is persons per household x per capita personal income (Whatcom Co. average) (See Table VII-)

Source: Arthur D. Little, Inc

TABLE VII-95

POPULATION AND HOUSEHOLD TOTALS - CHERRY POINT
PERMANENT DIRECT + ALL INDIRECT EMPLOYMENT (LAND USE IMPACTS)

Scenario	Employees	Persons Supported	Total Households	Location of Households: Bellingham	Ferndale	Blaine	Other Whatcom
IA Regional-Unrestricted							
1978	180	163	56	46	5	1	4
1979	239	205	72	59	7	3	4
1980	141	135	45	37	4	1	3
1981	143	137	46	38	4	1	2
1982	89	99	29	27	3	0	2
III Transshipment/Cherry Point							
1978	1244	1554	524	429	42	26	27
1979	2303	2010	695	569	56	34	35
1980	1050	1123	363	297	29	18	19
1981	968	1066	342	280	28	17	18
1982	776	929	290	237	24	14	15
GRAND TOTAL ALL DIRECT + ALL INDIRECT EMPLOYMENT (INFRASTRUCTURE IMPACTS)							
IA							
1978	235	205	67	55	6	1	5
1979	283	239	81	66	8	3	5
1980	122	135	45	37	4	1	3
1981	124	137	46	38	4	1	2
1982	170	99	32	27	3	0	2
III							
1978	1734	1926	622	509	50	31	32
1979	2751	2350	785	643	63	38	40
1980	856	1123	363	297	29	18	19
1981	774	1066	342	280	28	17	18
1982	582	929	290	237	24	14	15

Source: Arthur D. Little, Inc.

TABLE VII-96

SIGNIFICANCE MATRIX - LAND USE AND INFRASTRUCTURE - CHERRY POINT

Significant Scenario III Transshipment/ Cherry Point	Community			Unincorporated	All County
	Bellingham	Ferndale	Blaine	County	
1978	X	-	-	-	X
1979	X	X	X	-	X
1980	X	-	-	-	-
1981	X	-	-	-	-
1982	X	-	-	-	-

X = SIGNIFICANCE = Growth equivalent to 1 year's average annual growth or more

\- Not significant by this definition

Source: Arthur D. Little, Inc.

of the west county. With this distribution of households, this amount of growth is equivalent to less than a year's historic growth in unincorporated Whatcom County, but three-and-one-quarter year's average growth in Bellingham. This growth would be expected to occur in prime areas for residential development, identified previously in Table VII-44 as northeast between Interstate 5 and Lake Whatcom, the south central valley area, and southwest along the Bay. The total land converted is nearly 300 acres, and represents nearly 6% of the remaining residential acreage within the city limits (2.5% increase in existing residential land use). The total acreage converted is 340 acres in all the affected Whatcom County areas under Scenario III in 1979.

While this is significant land use conversion for a single project in the City of Bellingham and represents a sharp influx for a single year, it is not a severe impact and is consistent with the overall low-density residential development pattern of the city today. The city's Planning and Development office reported that Bellingham has a population holding capacity of 150,000 according to the 1967 Comprehensive Plan. The maximum scenario/year would add only 1648 permanent new residents to the present population of 42,100, which would still allow over 100,000 persons according to the 1967 holding capacity. Land use conversion in the city would take residentially zoned lands that are not in intensive use at present for either timber production or agriculture. Land use conversion in the other affected cities and the unincorporated county must be considered minor, even under the maximum year of Scenario III.

b. Infrastructure (Secondary) Population Growth Impacts

As described previously, Scenario III (transshipment at Cherry Point) is the only source of significant population growth impacts in Whatcom County. The peak construction year and peak influx of new population to the Cherry Point/Whatcom County area is 1979 (see Tables VII-93 through VII-95 and VII-97). As shown in Table VII-95, and as discussed in the project impact characterization (Chapter VI), the total influx of families with demands for new services will be 785, but the proportion making a significant contribution to the local property tax base will be only 89% of this (695 households). At the weighted average income given for these 695 households of $17,685, the affordable housing price is $39,300. The 1975 indicated ratio for property assessed valuation (0.57) yields an assessed valuation for tax purposes of $22,400 per dwelling unit for the new population. The total market value of the housing and total assessed valuation for property taxation is given in Table VII-98.

(1) School Impacts. Impacts on local school districts are in many ways the most important infrastructure impacts of new growth for several reasons: (a) schools are among the most costly of community services, and demand a high proportion of property tax revenues, (b) education is important and there is uniform community concern among communities with a high proportion of young families that the children be provided with adequate school facilities offering quality educational programs, and (c) schooling requires broad community support.

TABLE VII-97

LAND USE - MAXIMUM IMPACT ON COMMUNITIES - CHERRY POINT

MAXIMUM IMPACT SCENARIO III Transshipment/Cherry Point	Total New Persons (Direct permanent and all Indirect)	Total as % of 1975 County Population	Historical growth rate % (average)	New Households in community	Existing Community Households (1976)	% Increase	Growth Equivalence at Historical Rate	Acreage Consumed	% increase in residential Acreage	% off Remaining Residential Acreage Consumed
year 1979	2010	+2.33%	1.6%							
Bellingham			1.1%	569	15775	3.6%	3.27 y.	285	2.53	5.7
Ferndale			6.2	56	1161	4.8	0.77 y.	22	N	N
Blaine			2.5	34	848	4.0	1.6 y.	14	N	N
Unincorporated Whatcom			1.5	35	13916[a]	0.25	0.17 y.	19	0.09	N
				695						

N = Not possible to determine

Source: Arthur D. Little, Inc.

TABLE VII-98

INFRASTRUCTURE - VALUE OF HOUSING - CHERRY POINT

School District	Market Value of Housing (Project Component) (weighted average) Per Household $	Total ($ Thousands)	Assessed Valuation of Housing (Project Component)	
Bellingham	$39,300	$22,361.7	22,400	12,745.6
Ferndale	"	2,200.8	"	1,254.4
Blaine	"	1,336.2	"	761.6
Other Whatcom	"	1,375.5	"	784.0

Source: Arthur D. Little, Inc.

The impacts of the maximum scenario, peak year (III, 1979) on the Bellingham, Ferndale, and Blaine school districts are given in Tables VII-99 and VII-100. The enrollment and financial impacts on the other western Whatcom County school districts, including Meridian, cannot be allocated since it is not possible to locate this growth component on a school district specific basis. Nonetheless, the total number of students contributed to all of these districts is quite small -- 35 pupils at all grade levels K-12, the same as for Blaine.

The impact of new enrollment on school districts depends strongly on the concurrent addition to district assessed valuation and hence on fiscal contribution of the growth. Owing to the complex method of school funding in Washington, there is not a one-to-one relationship between the impact of increased enrollment and the counterbalancing effect of increased assessed valuation, but if the two increases are proportionately the same this is an indication of the ability of the new growth to pay its way.

In all three districts, the contribution of this level of growth to enrollment far exceeds the contribution to the district's assessed valuation. In the Bellingham school district, the enrollment contribution is two-and-one-half times the assessed valuation contribution, three times in the Ferndale district, and 9.4 times in the Blaine district. A comparison of Table VII-100 with Table VII-55 shows that the market value/pupil of the new enrollment is significantly lower than the existing market value/pupil in all three districts -- 22% to 80% lower. Thus, the average wealth of the new population appears to be lower than the existing population of these districts. Correspondingly, the lower tax revenue per pupil contributed (Table VII-100) is also 26-66% lower than the existing district contribution per pupil in all three districts. This difference is more apparent than real because of the present industrial contribution to the school tax base which adds revenue, but does not increase enrollment.

The enrollment contribution is made more or less significant, depending on the past enrollment history and the capacity remaining to serve new students. The greatest increase in enrollment (6.8%) will be in the Bellingham district which has had an historical decline in enrollment over the last five years of 0.8% per year, average, but even at its present enrollment level it still lacks permanent facilities to serve 732 of its 8700 students (Tables VII-50 and VII-51). Bellingham district has recently passed a $4.2 million bond issue to construct new schools to alleviate this shortage and presumably will receive matching state funds of at least 33% (excluding land cost). Some of these facilities should be completed by early 1979, but the influx of nearly 600 additional students in one year will strain even the expanded system.

The Bellingham district presently has over $7 million in excess bonding capacity at the legal limit of 5% of district market value. The project growth market value contribution further increases the bonding capacity of the Bellingham district by $1.1 million. If this were translated through the passage of bond issues into building revenues, it could pay for 24,300 of the required 65,250 square feet of new classroom space required to serve the new student contribution of 37% (excluding land cost). (See Table VII-100.) Depending on the relative wealth of the Bellingham

TABLE VII-99

SCHOOL IMPACTS - FACILITIES AND ENROLLMENT - CHERRY POINT
MAXIMUM IMPACT YEAR/SCENARIO 1979

Community	School District	Households	School age children per household	New students generated	Total Enrollment Including Project	% Increase in 1976 Enrollment	Capacity remaining before project (Pupils)	New Teachers or Classrooms required Elementary	Secondary
Bellingham	Bellingham	185 Dir. 458 Ind.	1.58 0.64	292 293 585	9258	6.75%	-732	12	11
Ferndale	Ferndale	18 Dir. 45 Ind.	1.58 0.64	28 29 57	3752	1.5%	-381	1	1
Blaine	Blaine	11 Dir. 27 Ind.	1.58 0.64	17 17 34	1202	2.9%	- 2	1	1
Other Whatcom		cannot be allocated							

Source: Arthur D. Little, Inc.

TABLE VII-100

SCHOOL IMPACT - FISCAL AND CAPITAL DEVELOPMENT - CHERRY POINT
MAXIMUM IMPACT YEAR/SCENARIO 1979

						Space and Land Requirement					
						Elementary		Secondary			
School District	Assessed Valuation Total Project Contribution ($ Thousands)	% Increase in District Assessed Valuation	Project Market Value per Pupil	Local Property Tax revenue per pupil	% Difference from average local revenue per pupil	Square Ft. Classroom Space	Acres School land	Square Ft. Classroom Space	Acres School Land	Increase in Bonding Capacity ($) Thousands	Square Footage paid for @ $46/ SF
Bellingham	$12,745.6	2.8%	$38,223	$351	-25.6%	24,300	8	40,950	13	$1,118.09	24,306
Ferndale	1,254.4	0.48	38,610	312	-48.0%	2,340	5	4,030	10	110.4	2,392
Blaine	761.6	0.31	39,300	296	-66.2	1,408	5	2,387	10	66.81	1,452
Other Whatcom	cannot be allocated										

Source: Arthur D. Little, Inc.

district compared to all other Washington state districts, state funds could cover from one-half to all of the remaining construction cost. If school site land acquisition is also required, the cost of the 21 acres of land needed at the current facilities planning standard would range from $42,000 ($2,000/acre) to $315,000 ($15,000/acre), the going price for undeveloped residential land in Bellingham. With land cost included, the new families could pay for only 7400 to 23,400 square feet of the new classroom space required.

The Ferndale school district has been strained in recent years due to an annual growth rate in enrollment of 3.3% per year, which has left it in 1976 with a capacity deficit of 381 pupils. In this context, the peak year growth contributed by oil industry direct and indirect employment would be less than half of the recently experienced annual growth. The Ferndale district passed a $3.8 million bond issue in 1974 which should soon result in a capacity increase large enough to accommodate the existing deficit as well as the project growth component. The incremental bonding capacity contributed by the growth itself would pay for only 2400 of the 4400 square feet of new classrooms required (55%) and only 1750 square feet (40%) if land cost (15 acres) is included (Table VII-100).

The Blaine district is an extremely wealthy district, in terms of its assessed valuation per pupil, and is presently at capacity enrollment (Table VII-51). It passed a 1974 bond issue of $0.51 million which should provide a sufficient increase in capacity to accommodate the minor growth contribution from the maximum scenario growth impact (34 students). (See Table VII-99.)

(2) Water Supply. The addition of 63 new households or 155 new people under Scenario II-B in 1979 would represent a service population increase of about 4%. While this increase would not tax Ferndale's filtration system (adequate until about 1982), it may serve to slightly shorten the time before further plant expansion is needed.

Blaine's system of eight wells also serves the surrounding region; the addition of 93 new persons to Blaine would represent only a 2% increase in the wells' total service population of 4200. No plans exist for expansion and this slight increase should not require it.

Under Scenario III, the maximum population increase of 1925 persons (1979) or 643 households in Bellingham would create an incremental demand for 0.37 MGD of drinking water assuming summer demand of 190 GPCD. This is a 3.9% increase in district consumption and represents only 1.5% of the capacity of the water filtration plant. At present consumption rates, the plant has the capacity to serve an additional 76,300 persons. Thus, under most conditions the population increment attributable to the maximum oil scenario at Cherry Point will not have a significant impact on the Bellingham water supply.

During periods of peak demand and low flow to the degree to which the present capacity of the total system is strained, any additional population growth will place more demand on an already strained system. The Scenario III population growth will also increase the daily demand in peak periods by 3.9%, and will thus consume the storage capacity of Lake Whatcom slightly faster during the peak demand months.

Scenarios I-A and II-A at Cherry Point will have only one-tenth the population increase of Scenario III and cannot be considered to significantly affect the Bellingham water supply.

(3) Wastewater. Since Ferndale's sewage treatment plant is now operating over design capacity, an increase of 155 in the service population under Scenario III in 1979 may pose some capacity problems for the system. Although the 0.3 MGD plant is experiencing no problems at present, a 5% increase in service population may cause capacity overload, and may be the stimulus needed to elicit funds for expansion and upgrading currently being considered.

The addition of 93 new people to Blaine in 1979 would probably not tax the capacity of the sewage treatment system as a new upgraded system will then be in operation in Blaine. This growth will consume only about 0.9% of the plant's 1 MGD capacity.

Under Scenario III, the addition of 643 households (1925 persons) to the City of Bellingham will increase municipal wastewater flow by 0.19 MGD (a 17% increase) at current wastewater generation rates per capita. Thus, the average low flow (i.e., wastewater flow only, excluding storm water inflow) would increase from 4 to 4.19 MGD out of the existing plant design capacity of 18 MGD. The trend in Bellingham is to sewer all new construction; hence, it is assumed that all new hosuing that resulted from population in-migration due to oil development would be sewered.

The increase attributable to Scenario III is significant, but it would not strain the capacity of the existing facilities. However, the city already has a problem complying with federal water quality standards since the present plant provides only primary treatment. Therefore, incremental wastewater flow even within the design capacity of the present system will contribute further to water quality problems in Puget Sound in the vicinity of the outfall. The plant's outfall was recently moved to Post Point on Bellingham Bay to mitigate water quality problems associated with a low assimilative capacity of the water at the former outfall.

Scenarios I-A and II-A at Cherry Point would have about one-tenth the impact of Scenario III. Thus, they would add 0.019 MGD to the current flow, or a 1.7% increase which is not significant given the present system capacity.

(4) Solid Waste. Solid waste is dealt with on a county basis and is changing from the open dumps presently in use to a comprehensive system of containers and large central sanitary landfills. Since this new system with an increased waste handling capacity is planned for the near future, solid waste generation by the small numbers of new people should not pose any problems for the system.

The maximum scenario impact year contribution to the Bellingham population (Scenario III in 1979, transshipment at Cherry Point) would add 643 households (1925 persons) to the city. This would represent a 4.1% increase in the present service population of the thermal reduction plant where the city's waste is currently incinerated. Based on the data supplied by the solid waste director for the plant, a 10% increase in service population could be accommodated before new capacity would have to be added so that the Scenario III population increase alone will not necessitate this expansion. Collection is financed by user fees so that growth should pay for the incremental service it demands.

c. Terrestrial Biology

As described under land use impacts and given in Table VII-92, expansion of existing onshore facilities (pump station, surge/storage, access roads) will be required under Scenarios I, II-A, and III. Under Scenarios I and II-A only a minimum of 30 acres of new land would have to be consumed, evenly split between the undeveloped portions of the holdings of Mobil and Atlantic Richfield. Scenario III could consume between 70 and 180 acres of completely undeveloped holdings similar to those of Standard Oil -- less than five acres at the bluff at Cherry Point for a pump station and access road and the major surge/storage facility inland and to the north.

The existing vegetation of all of these various parcels of open land, as described under environmental setting, is a mosaic of about 50% grazed and fallow pasture-grassland and about 50% early second-growth mixed coniferous/deciduous forest. The Cherry Point bluff site is 35 acres of open meadow with scattered young trees, with a mixture of trees and shrubs on the face of the bluff.

The terrestrial biology impact of the conversion of even the maximum 180 acres to intensive industrial use is small in both a regional and a local sense. This acreage represents 20% of the Standard Oil parcel and clearing it will constitute habitat loss for a moderate amount of local wildlife, as well as the probable destruction of at least several hundred individual small rodents and other small mammals and reptiles which are probably not mobile enough to leave the area. If construction takes place in the nesting seasons, resident nesting birds may be lost from populations or suffer reproductive failure if they are unable to take up nesting territory at another location. These losses will not effect the status of these species of even of local populations if the species are common or abundant in the area generally.

The two habitat types, early succession pasture-grassland and second-growth forest in different stages of maturity, are both extremely common in the local area and in the region. While 180 acres represent 20% of the Standard Oil parcel, it is a far smaller proportion (less than 1%) of all such lands in the Mountain View district west of Ferndale and on a regional scale represents only 0.04% of all the open space lands in Whatcom County (agriculture, timber, and rural/non-farm combined). These two habitat types, particularly the forest lands, have significant ecological value if the forest is over 50 to 100 years old, and moderate to high

wildlife value since they are utilized by many species but they are not known to have some particular richness or unusual assemblage of species that makes them unique or sensitive habitats.

These lands are valuable in the sense that they are a larger area of contiguous open lands than smaller pockets of such vegetation closer to the low-density urbanization spreading westward from Ferndale. The Standard Oil parcel is one of the largest remaining contiguous parcels of open space in this area with heavy industry to the north and south, and residential urbanization pressure moving west out of Ferndale and south out of Birch Bay.

The larger a contiguous piece of open space, the more likely it is to harbor threatened or endangered species. Several species with poor population status which are known to occur or have occurred in western Whatcom County include the endangered California condor, peregrine falcon, Peale's peregrine falcon, and the potentially threatened northern bald eagle, spotted owl, and pileated woodpecker. Of these species, none has been reported to occur specifically on or near the proposed sites for onshore facilities. The only species which may also breed in this locality is the northern bald eagle. A survey of the entire coastal district of north Whatcom County might reveal that one or more of these species is at least a seasonal resident of the area. If this is the case, the conversion of a 180-acre parcel of open land which is suitable habitat for the species is more serious. Many species of now threatened or potentially threatened species have suffered their most serious population depletion because of habitat reduction due to urban encroachment of all types. The loss of an additional sizable parcel of suitable habitat may be one more significant increment in the total habitat reductions which are leading to the extinction of the species. In addition, the possible demise of one or a few animals due to land conversion can be extremely serious when the total population numbers in only tens of hundreds.

The impact of the conversion of two 15-acre parcels near the existing facilities of the Atlantic Richfield and Mobil refineries can be considered minor in any circumstance and is similar to the impact of similar conversions at the Shell and Texaco refineries discussed under the March Point/Anacortes activity zone.

d. Air Quality

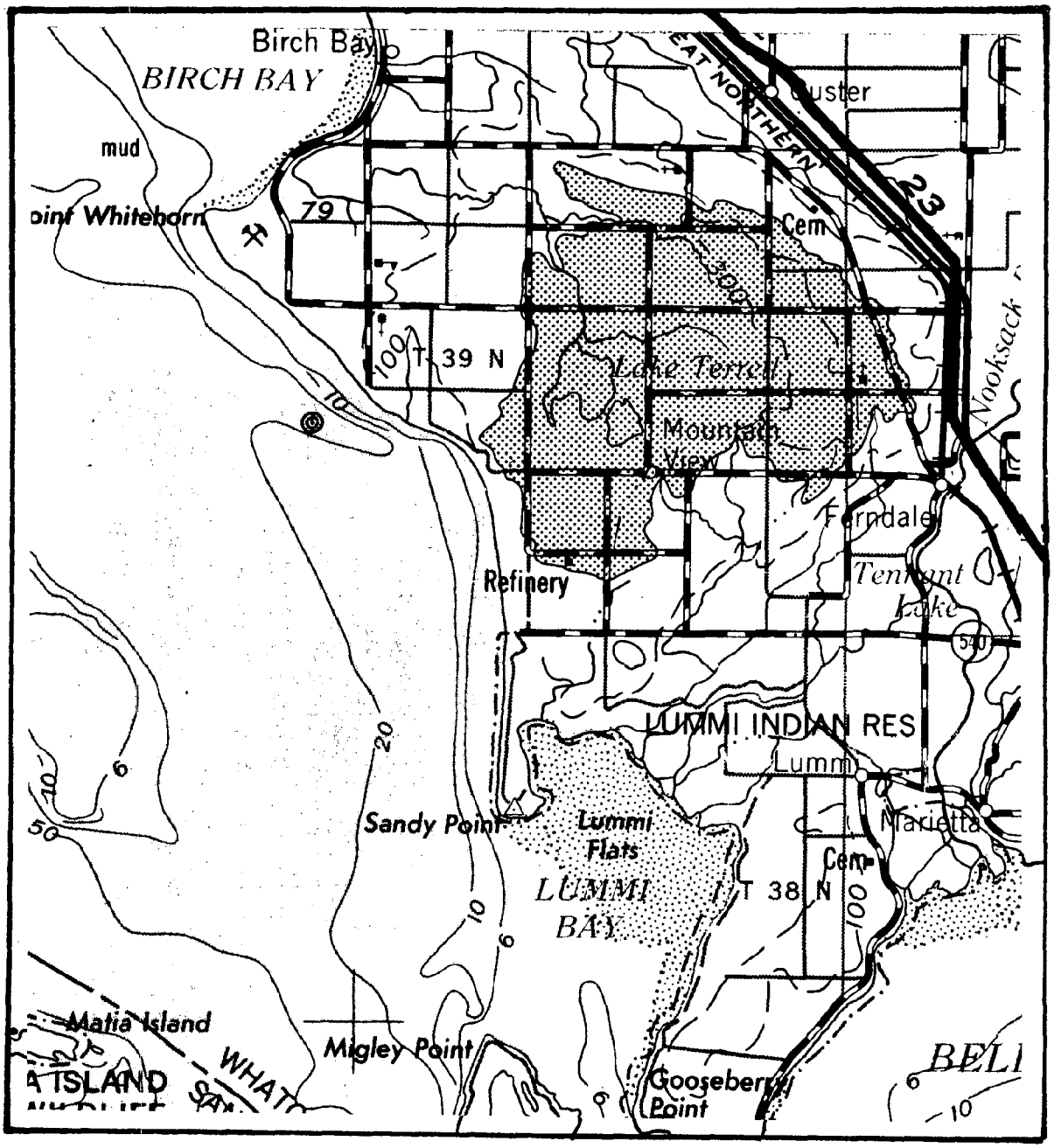
(1) Activity. Two types of petroleum activity occur at Cherry Point in the scenarios discussed by this study. The Atlantic Richfield and Mobil Oil refineries located at Cherry Point will continue to process crude oil. The Atlantic Richfield facility was designed specifically to run on North Slope crude and probably some 80% of the Alaskan crude received in Puget Sound will be utilized at Cherry Point. In Scenario I, regional supply, the activity entails modest vessel movements in order to meet refinery needs alone. In Scenario II with the Northern Tier Pipeline serving only transshipment to the Northern Tier states, the tanker supply to Cherry Point continues as in Scenario I. In Scenario II-B with the

Northern Tier Pipeline serving the existing refineries via the Puget Spur Pipeline, tanker activity at Cherry Point is restricted to only a few vessels carrying specialty blending crudes or those with cargoes that are not expeditiously unloaded at the Northern Tier facility in Port Angeles. At Cherry Point, this entails some 13 vessel calls per year.

If Cherry Point is to be the site of a crude oil transshipment project, however, a far greater level of vessel transport will be required. Scenario III comprises three separate levels of crude oil throughput for transshipment. These roughly correspond to such proposals as the Northern Tier proposal presently intended for Port Angeles and the various Atlantic Richfield proposals such as the reversal and the looping of the Trans Mountain Pipeline. Some form of continued supply to Cherry Point refineries via the Trans Mountain Pipeline is discussed as Scenario IV and requires very little movement of crude via tanker.

At present, Atlantic Richfield and Mobil both operate tanker terminals, separated by several miles from each other along the bluffs bordering the Strait of Georgia adjoining Cherry Point. The Intalco Aluminum Company also operates a marine terminal between the two, yet there is sufficient shoreline and onshore space for tankage remaining that a transshipment project would undoubtedly construct a separate marine terminal if large volumes of crude were required and particularly if deep draft vessels must be accommodated. The terminal would probably be located quite close to Cherry Point proper with a landfall on the property presently owned by Standard Oil or by Puget Light and Power (see Figure VII-15). This location is separate enough from the present terminals operated by Atlantic Richfield and Mobil that the transshipment component of Scenario III essentially operates as an independent source of local air quality impact. This serves to reduce the overall level of impact at Cherry Point, below the level expected at Port Angeles, simply on a statistical basis without considering the aspect of meteorology or surrounding terrain. In the analysis that follows, it will be the most significant component of local supply or transshipment that is subject to air quality examination.

(2) Local Air Quality Impact. The principal source of local adverse impact is the pollutant concentrations emitted as the tanker stack gases during cargo offloading at the terminal. As described for Port Angeles, it is possible to estimate the potential air pollution sensitivity of the terminal vicinity in the absence of specific considerations of source strength and prevailing meteorology. The zones of varying levels of ground level concentration are depicted in Figure VII-16. Much of the terrain on shore rises steeply above the Strait of Georgia to a height of 100 feet or so and then tapers upward several small hills on a broad plateau, stretching between the Nooksack River valley and the Strait of Georgia. As the terrain is lifted up toward the center line of a hypothetical tanker stack plume, the normalized ground concentration becomes greater. Thus, nearly the entire plateau of the Cherry Point-Ferndale area is included within the low potential impact zone. The higher portions are susceptible to adverse impacts under stability Class F; the lower portions, roughly everything west of the site itself, are adversely impacted during stability



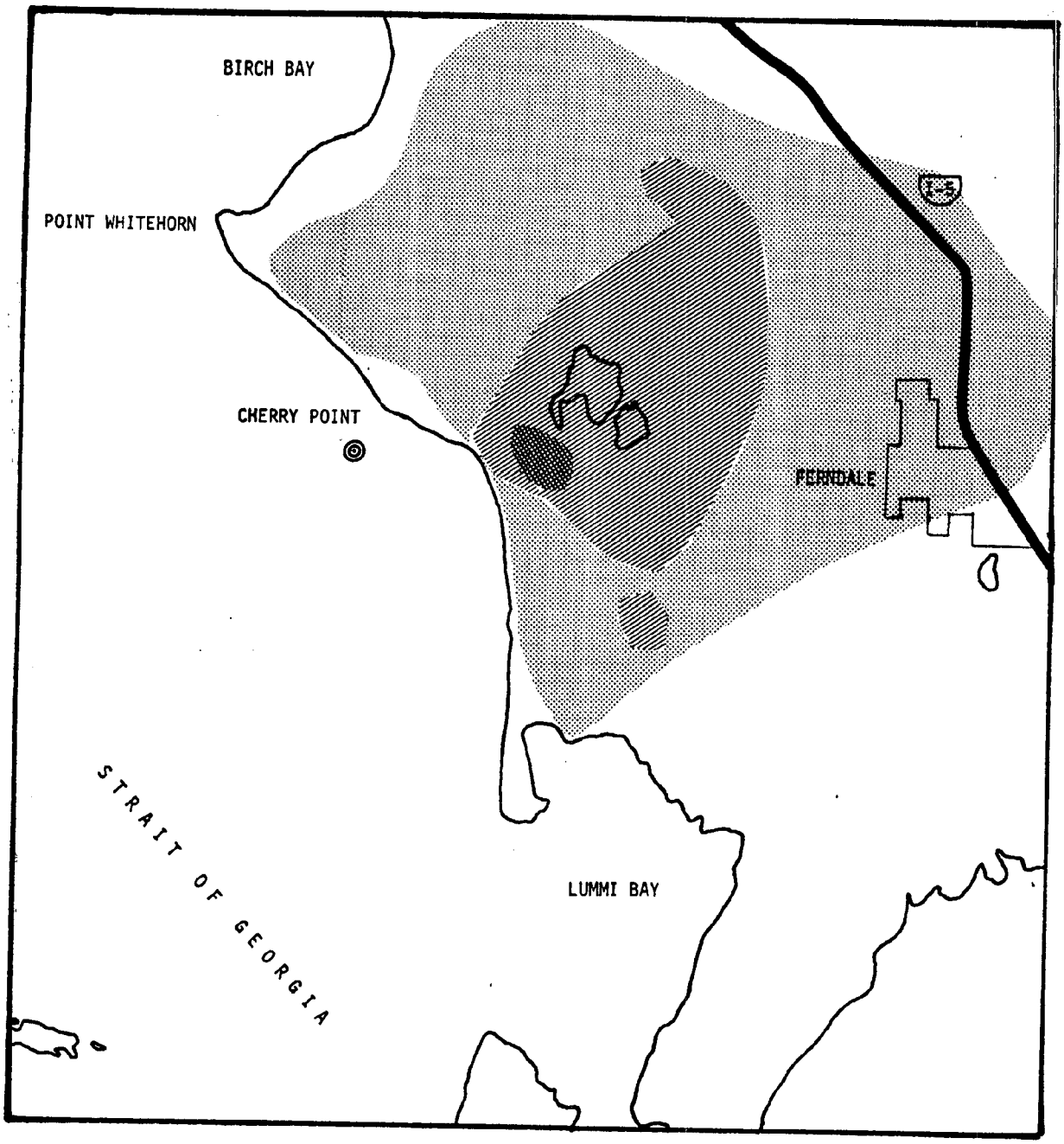
Marine Terminal

Greater than 200 ft. elevation

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

FIGURE VII-15 LOCATION AND TOPOGRAPHY: CHERRY POINT



Normalized Ground Concentration (10^{-6} m^{-2})

	minimal	<7
	Zone 1 low	7 - 25
	Zone 2 medium	25 - 70
	Zone 3 high	>70

◎ Marine Terminal

0 1 2 3 4 mi
0 1 2 3 4 5 6 km

NORTH

SOURCES:
Arthur D. Little, Inc.

FIGURE VII-16 NORMALIZED GROUND CONCENTRATION: CHERRY POINT

Class D. The zones depicted in Figure VII-16 represent the maximal ground level concentration contributed by either stability Class D or F. The upper elevations on the plateau, particularly those closer to the tanker terminal, fall within the medium impact zone. This includes all of Lake Tyrell and its game preserve. The small patch of high potential impact zone is the shoulder of the bluff immediately between Lake Tyrell and the Intalco Aluminum plant.

The fairly large throughput involved in the transshipment scenarios results in a high emissions spectrum. To a large degree the probability of maximal emissions is reduced by the separation of transshipment from the regional refineries supply which utilizes other terminals in the Cherry Point vicinity. Nonetheless, Scenario III entails a range of 130 to 278 vessel calls per year for transshipment alone, most of the latter of the large vessel size fleet type. This will produce an emissions spectrum similar to the moderate throughput levels at Port Angeles.

Meteorological conditions at Cherry Point are difficult to quantify based upon presently available data. As was described for March Point, it was felt appropriate to adapt the Bellingham data to Cherry Point by rotating the wind rose distribution of wind direction in this case, by one point or 22.5% in a counterclockwise direction. This takes into account the gradual counterclockwise curve of prevailing winds diverging at the end of the Strait of Juan de Fuca and flowing upward through the Strait of Georgia. The low wind velocity for stability Class F is totally missing from the Bellingham observations and as described for March Point was synthesized for this study by a scale factor applied to the data for Classes D and E. The resultant probability of stability Class F for all wind velocities was thus brought to 15%, roughly half of which is winds of less than three knots. It is the latter category, low velocity winds, that will produce the greatest true ground level concentrations from the source spectrum of tanker stack emissions.

The state standard for sulfur dioxide is 40 pphm, averaged over one hour. This level may be compared with the ground level concentrations of Figure VII-16 to calculate a source strength required to equal or exceed the state standard. The source strength has a characteristic frequency of occurrence based upon the throughput volume entailed by each scenario. This statistic may be computed and combined with the probability of occurrence of low velocity winds directing the tanker plume toward each of the three potential air quality impact zones. The resultant frequency may be expressed in hours per year and is presented in Table VII-101. If tanker fuel has a 2% sulfur content the number of hours per year is on the order of two to three for the high volume throughput of Scenario III. These values are significantly lower than those calculated for Port Angeles, partially because of the separate marine terminal for regional and transshipment supply but largely because of the meteorological conditions for the area. The medium and high impact zone subtend a relatively small arc from the project site and lie in a direction from which the low velocity winds prevail. Thus the predominant air flow directs the tanker plume away from the zones of medium and high potential high.

TABLE VII-101

ACUTE AIR QUALITY IMPACT - CHERRY POINT

Scenario	Vessel calls per year	Fleet type[a]	Number of berths	% Fully occupied	Hours/year SO_2[b] over standard[2c] in Impact zone 1	2	3	% Sulfur fuel for no violation[c] in Impact zone 1	2	3	Hours/year high NO_2[d]
I. Regional Supply											
A. No Restrictions	64.5	I			--insignificant emission impact--						
B. Restricted Fleet	111	R			<½	0.8	<½	>3	>3	>3	<½
II. Northern Tier											
A. Tanker Supply	64.5	I			--insignificant emission impact--						
B. Puget Spur	13	R			--insignificant emission impact--						
III. Transshipment											
1980	(194)[e]130	I			0	2½	½	>3	2.0	>3	<½
1985	(222) 158	I,L			1½	2½	½	2.5	1.8	>3	½
1990	(342) 278	L			6	3	1	1.3	1.5	>3	1
IV. Supply via Trans Mountain	8	I			--insignificant emission impact--						

a R = Restricted Vessel Size
I = Intermediate Vessel Size
L = Large Vessel Size

b for fuel with 2% Sulfur Content

c State 1 hour standard is 40 pphm

d high NO_x is 25 pphm over one hour - does not correspond to applicable standard

e parentheses denote actual vessel calls at Cherry Point. Terminals for Arco, Mobile (and Transshipment) would be separated sufficiently to act as independent sources - smaller number is used for maximum possible impact

Source: Arthur D. Little, Inc.

Reverse calculation of the probability distribution, using a frequency of two hours per year for standard violation, allows an estimation of the percent sulfur content of tanker fuel that must be attained in order to avoid violation of the state standard. These data are also presented in Table VII-101 and indicate that a sulfur content of roughly 1.3 or 1.5% would be required to mitigate the local air quality impact of transshipment at Cherry Point. This range of concentration is within the range of readily available bunker "C" fuel although it is lower than that sulfur content of many fuels commonly used.

As there is generally only moderate sulfur dioxide impacts, there are insignificant impacts from the other pollutants associated with tanker stack emissions, nitrogen dioxide, particulates, carbon monoxide, and organic substances are all at sufficiently low concentrations that no adverse impact is expected.

It should be noted, however, that the conclusion of only moderate impact at Cherry Point is dependent upon meteorologic assumptions which may in fact differ from actual conditions in the Cherry Point vicinity. If a specific project were to be proposed for Cherry Point, it would require detailed local monitoring or at least the application of more relevant local information in order to provide a precise statistical analysis of meteorologic conditions suitable for comparison with the broader spectrum of tanker stack emissions as is presented below.

(3) Regional Air Quality Impact. At present, Cherry Point is the site of several industrial activities which contribute substantial quantities of sulfur dioxide, reactive organic gases, and other pollutants, particularly carbon monoxide from the Intalco Aluminum Refinery. The broad plateau surrounding Cherry Point and the open Strait of Georgia appeared to provide a good dispersive environment for such air pollutant emissions. There is no local monitoring station for general air quality parameters. The data for Bellingham indicate only minor problems and plant site monitoring apparently indicates very few occurrences of unacceptable levels of immediate pollutants such as sulfur dioxide. The quantity of pollutants emitted by a transshipment project at Cherry Point will be a relatively small increment to the overall pollutant burden of the air basin. It is unlikely that they will amount to a major increase in actual ambient air quality levels for long-term averaging standards. The regional supply component of petroleum activity at Cherry Point included in Scenarios I, II-A, and III is simply a continuation of the present level of activity.

A transshipment project would entail a fairly large volume of tankage for surge/storage. The emissions from such are given in Table VII-102. Combined with the possibility of vessel purging in port, the quantity of hydrocarbons is significant although still less than the existing emissions inventory for that pollutant due primarily to the present refineries. With regard to the possibility of formation of photochemical oxidant, the situation at Cherry Point is similar to that described for March Point -- that is, the relatively large point source reactive organic gas emissions from present operations apparently do not lead to a significant regionwide problem, at least one which is noted through the monitoring program.

TABLE VII-102

AIR POLLUTANT EMISSIONS - MARINE TERMINAL - CHERRY POINT
(Tons/Day)

	Pollutant					
				Hydrocarbons		
	SO_x	NO_x	Particulates	Fuel	Purging	Storage & Misc.
Scenario I-A	0.527	0.371	0.090	0.029	1.826	4.325
Scenario I-B	0.682	0.476	0.114	0.034	1.785	4.289
Scenario II-A						
1980	0.527	0.371	0.090	0.029	1.826	4.325
1985	0.527	0.371	0.090	0.029	1.826	4.325
1990	0.527	0.371	0.090	0.029	1.826	4.325
Scenario II-B	0.080	0.056	0.013	0.004	0.210	2.684
Scenario III						
1980	1.426	1.003	0.244	0.078	4.940	7.488
1985	1.924	1.355	0.329	0.105	7.172	9.747
1990	3.091	2.180	0.528	0.169	12.161	14.800
Scenario IV	0.062	0.044	0.011	0.003	0.215	2.688

Source: Arthur D. Little Inc.

Overall, the average conditions for the formation of photochemical oxidant are probably not particularly favorable at Cherry Point. The prevailing winds direct the trajectory of hydrocarbons toward the north and northwest away from the site and typically away from land. Theoretically, the point of maximum reaction would occur over British Columbia under average conditions. The relatively sparsely developed countryside will afford very little augmentation of reaction components and the overall level of ozone developed is probably small under typical conditions.

As with other Puget Sound locations, however, there are certainly several days per year, at least, when oxidant formation conditions prevail and when winds may direct the reactant trajectory toward the urban centers of Ferndale or Bellingham. Statistically, such phenomena may be described as a distribution of oxidant experience with a fairly large standard geometric deviation. This implies that only a small increase in geometric mean oxidant concentration may, in fact, result in the abrupt appearance of a photocehmical oxidant problem. Considering present background levels, however, the amount of reactive organic gases contributed by a transshipment project here probably do not in themselves represent the increment that will in fact result in a persistent violation of the state and federal oxidant standards. It would be possible to make such a determination only by detailed examination of existing monitoring data and by study of correlation with ambient meteorology. Although such a study may well be required to ultimately determine the carrying capacity of the industrial zone designated for the western shore of Whatcom County, it is beyond the scope of the present study.

The maximum throughput scenario (Scenario III) will result in significant employment on Cherry Point. That population will generate air emissions as part of its commute. Those emissions are included in the factors which lead to Table VII-102. Considering the broad area of Ferndale-Cherry Point, the impact of commute emissions is probably insignificant. The induced growth in the City of Bellingham will add a small proportion from population activities. It is incremental urbanization that leads to the air quality problems so well documented throughout the nation. Growth in Bellingham will result in a worsening of air quality unless technological controls and specific abatement programs are counter-effective.

e. Water Quality/Marine Biology

(1) Impact Generators. Should an oil transshipment facility be located at Cherry Point, both operational spills and casualty spills occurring at the terminal would contribute additional loads of oil to the waters in the immediate vicinity. While the amounts of oil released by operational and casualty spillage would be similar, the higher frequency of operational spills indicates smaller spill size (see Tables VII-103 and VII-104). However, even though the amount of oil in each casualty spill would be greater, this type of spill would be exposing the local biota and other beneficial uses to oil much less frequently -- on the order of once every 10 to 50 years -- as opposed to once every 2 to 10 months for operational spills. Operational spillage of oil in port is therefore the greater impact generator over a given time period.

TABLE VII-103

OPERATIONAL SPILLS AT MARINE TERMINAL - CHERRY POINT

Scenario	Throughput (1000 B/D)	Operational Spills Number	Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	170 (I)	1.16	315
B. Restricted Fleet	170 (R)	2.00	540
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	170 (I)	1.16	315
1985-1990	170 (I)	1.16	315
B. Regional Supply by Puget Spur Pipeline			
1980	20 (R)	0.24	64
1985	20 (R)	0.24	64
1990	20 (R)	0.24	64
III. Transshipment at Cherry Point			
1980	460 (I)	3.14	850
1985	660 (I,L)[b]	4.00	1090
1990	1110 (I,L)[c]	5.99	1630
IV. Regional Supply by Trans Mountain Pipeline	20 (I)	0.24	64

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

(b) 1985: 310 I; 350 L

(c) 1990: 110 I; 1000 L

Source: Arthur D. Little, Inc.

TABLE VII-104

CASUALTY SPILLS IN PORT - CHERRY POINT

Scenario	Throughput (1000 B/D)	Casualty Spills Number	Casualty Spills Gal/Yr
I. Regional Supply Only			
A. Unrestricted Fleet	0	0.0183	240
B. Restricted Fleet	0	0.0315	420
II. Northern Tier at Port Angeles			
A. Regional Supply by Tanker			
1980	400 (I)	0.0183	240
1985-1990	800 (L)	0.0183	240
B. Regional Supply by Puget Spur Pipeline			
1980	690 (L)	0.0037	50
1985	1090 (L)	0.0037	50
1990	1250 (L)	0.0037	50
III. Transshipment at Cherry Point			
1980	0	0.0494	660
1985	0	0.0630	840
1990	0	0.0971	1300
IV. Regional Supply by Trans Mountain Pipeline	0	0.0023	30

(a) R = restricted fleet, average tanker size is 86,700 Dwt
I = intermediate fleet, average tanker size is 137,300 Dwt
L = large fleet, average tanker size is 179,600 Dwt

Source: Arthur D. Little, Inc.

The amounts of oil released into the waters immediately surrounding Cherry Point are shown in Table VII-105. It can be seen that the oil load contributed by both casualty and operational spillage from a transshipment terminal is much less than that discharged by the two refineries in the area, representing only a 12% increment over background oil discharge. To obtain a concentration of oil in the waters off Cherry Point, the amount of oil and grease related in 10 days from both refineries and oil terminal was used. This amount is probably an overestimate because new water would have replaced some of the oil-laden water within 10 days due to tidal exchange, and the background oil release is based on the NPDES permit levels for the two refineries (Atlantic Richfield and Mobil) which may be discharging less than they are allowed under the permit.

The volume of water receiving both the refineries' and the terminal's oil comprises the zone of probable impact (see Figure VII-17). Based on net tidal and wind movements in this part of Puget Sound, this area represents the most probable mobility of oil released at Cherry Point in the span of one day. The volume of this impact zone was estimated using the surface area and the average depth. The concentration of oil in this zone's volume after 10 days' time was calculated using this volume and the 10-day oil releases from the refineries and from casualty and operational spills from the oil terminal, as discussed above.

As can be seen from Table VII-106, the chronic or steady state concentration of oil in the probable impact zone resulting from background discharge plus terminal spills is very low and in fact mostly (89%) due to refinery discharge. This concentration assumes that the refineries discharge as much oil and grease as allowed in their permits. In fact, they are currently discharging less. Thus the concentration of oil off Cherry Point waters would be even lower than 10 ppm. Moreover, chronic levels of oil would usually be lower than this amount if an oil terminal were located at Cherry Point because the project conditions chosen are the maximum case Scenario III-B in 1990, which has the highest throughput of crude through Cherry Point.

Chronic exposure to 10 ppb crude oil of even the most sensitive of marine species, the phytoplankton, would not subject these organisms to deleterious effects or population decline. Phytoplankton, or microscopic plant life, does begin to show signs of damage such as reduced cell division at 10 ppb kerosene for a few sensitive species, and at about 100 ppm or 100,000 ppb kerosene for most of the species in the tests of Mironov (1970). The 100,000 ppb threshold concentration, corroborated by the test results of LaCaze (1969), is more relevant than the 10 ppb threshold since the latter was obtained with crude oil and the former obtained only with kerosene, which is part of the highly toxic volatile portion of crude oil and, therefore, likely to produce effects at lower concentrations. In any event, all of the thresholds for injurious effects of crude or its fractions upon other types of marine organisms are also far above the levels that would be experienced chronically in the water surrounding Cherry Point. It can thus be concluded that while oil spillage will occur and exert its acute effects at the time of each spill, long-term chronic effects upon marine biota due to a steady state concentration of weathered crude at or above threshold levels would not be a concern at Cherry Point.

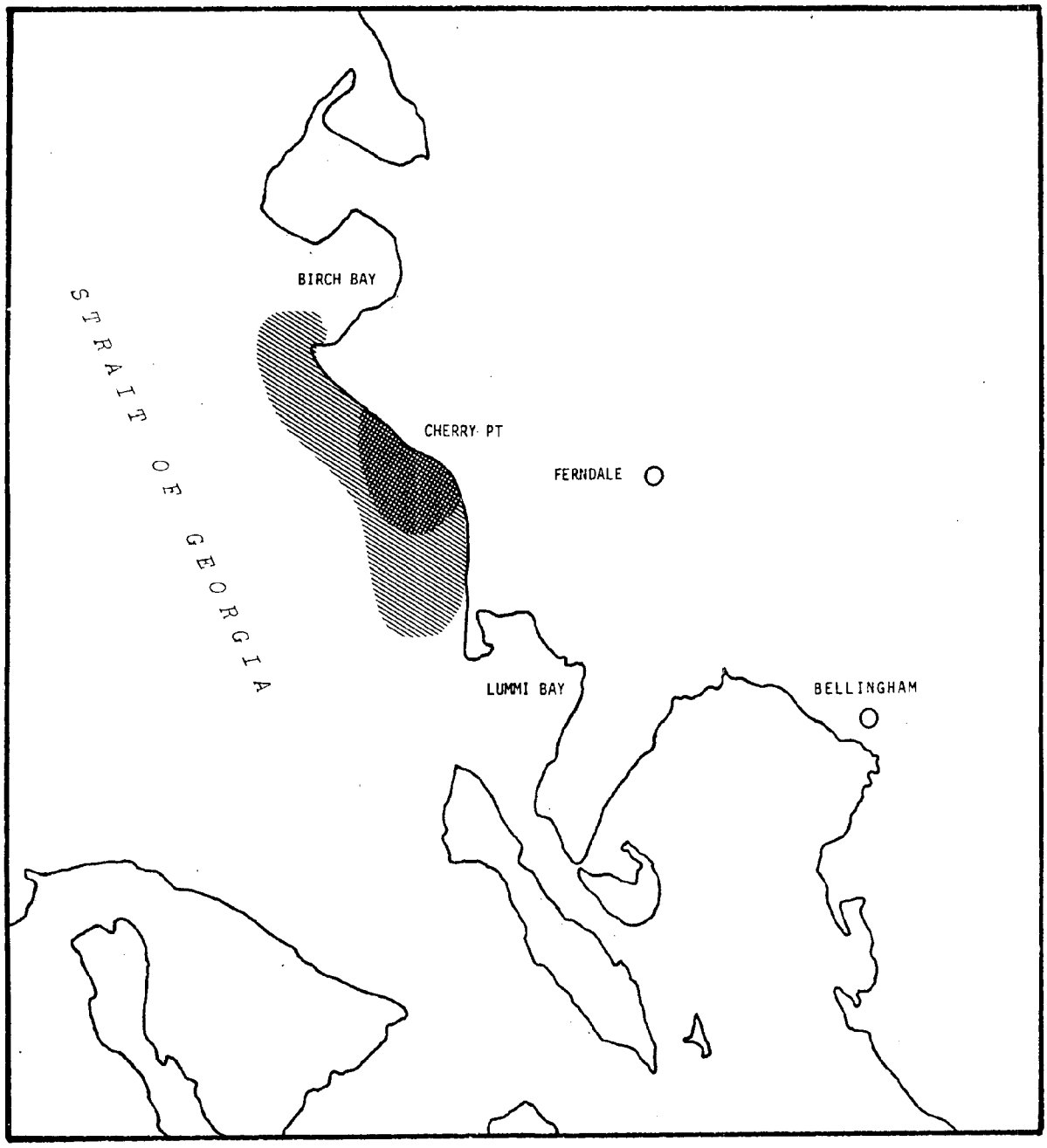
TABLE VII-105

OIL DISCHARGE IN TERMINAL VICINITY - CHERRY POINT

BACKGROUND	lbs/da	kg/10da
Urban Runoff		
Refineries (NPDES permit)[a]	253 Arco	1148 Arco
	250 Mobil	1134 Mobil
		2282
TERMINAL		
Operational Spills		156
Casualty Spills		124
TOTAL		2562

[a] Permitted levels of daily discharge of oil + grease averaged over one month. Includes ballast and storm water allocations for Arco and Texaco, based on average flows at Mobil refinery.

Source: Arthur D. Little, Inc.



Operational Oil Spills at Marine Terminal

Possible impact zone

Probable impact zone

0 1 2 3 4 mi

0 1 2 3 4 5 6 km

NORTH

SOURCES:

Arthur D. Little, Inc.

FIGURE VII-17 PROBABLE AND POSSIBLE IMPACT ZONE/CHERRY POINT

TABLE VII-106

CHRONIC CONCENTRATION IN PROBABLE IMPACT ZONE - CHERRY POINT

Scenario	III 1990
Background[a]	9.24
TERMINAL	
Operational Spills	0.632
Casualty Spills	0.502
%Background of Total	89
TOTAL	10.37 (ppb)

[a] 2 refineries

Source: Arthur D. Little, Inc.

Considering all oil development scenarios, the waters in the possible impact zone around Cherry Point would be exposed to an oil slick of varying size once every 2 to 10 months due to operational spillage. Superimposed upon this exposure would be a casualty spill in port every 10 to 50 years which, while larger in volume than the more frequent operational spills, would be located within the same zone before it was either cleaned up or became dispersed by tides and winds, a span of about one day. Since the concentration of unweathered crude within the slick is extreme, any organisms that come into contact with the main slick or its associated fragments will be exposed to both mechanical (surface-coating) and acute chemical toxicity.

The principal population increase from Scenario III is expected to fall on the cities of Ferndale and Bellingham. As described previously, the present capacity of both wastewater treatment facilities is insufficient to provide complete and adequate treatment for the existing population according to current federal clean water standards. The growth inducement of a major transshipment project will further degrade effluent quality by system overload. The growth may also stimulate and in some measure help defray the cost of system upgrading. Since a transshipment project tanker takes on no cargo, there will be little waste discharged from transshipment tankers at Cherry Point.

(2) Impact Receptors. The possible impact zone off Cherry Point represents the area within which winds and tides working together could move the centroid, or center of mass, of an oil slick during one day. Thus, although the spilled oil might not fill the entire zone (the light grey area on Figure VII-17), if spilled at the terminal site the oil could be moved anywhere within the possible impact zone and most probably would be found either entirely or partially within the probable impact zone. Because of the probabilistic nature of these zones, all organisms inhabiting them must be considered at risk to the mechanical and acute chemical toxicity of freshly spilled oil. (Refer to Figures VIII-2, VIII-4, VIII-6, VIII-8, and VIII-11 for the location of some of the most important marine resources in Puget Sound.)

Small proportions but nevertheless significant amounts of the crab and scallop resources of northern Puget Sound could receive the acute impacts of oil spilled at Cherry Point. Although bottom-dwellers, these shellfish can come into direct contact with any or all fractions of crude: sinking masses of weathered (heavy, less acutely toxic) crude, redeposition of unweathered crude-covered beach sand, or most likely through the persistent presence of an oil-water emulsion in which tiny droplets of fresh crude become whipped into the water column by pounding surf. If the crabs or scallops were not immobilized by the mass of oil itself, they would very likely either die from or become unmarketably contaminated with chemically toxic hydrocarbon compounds via the sediments or the water column. Long-term, sublethal effects which can weaken the local population of shellfish or crustaceans are known to occur. For example, miss-timing of mating coloration and loss of escape reaction in the fiddler crab after an oil spill at Woods Hole, Massachusetts (Blumer, 1970). It should be noted that shrimp, another of the deepwater shellfish inventoried in the Marine Atlas, would not be affected by spills originating at a Cherry Point terminal.

Of the marine resources found in shallower intertidal and subtidal waters, small amounts but significant proportions of northern Puget Sound's clam and herring spawning ground resources would be affected by oil spilled at Cherry Point, whereas no oysters (specifically the beds in Lummi Bay and Drayton Harbor) would be affected. The mechanical and chemical toxicity effects of spilled oil upon clam beds would be similar to that discussed previously for scallops. Herring spawning could be interfered with in a number of ways: mechanical or surface-coating death of adult fish through gill coating, death of eggs and newly hatched herring larvae -- the most sensitive of animal forms -- through mechanical and chemical toxicity, and the chemical interference of hydrocarbons with critical spawning (as well as other) behavior patterns.

Because major fisheries, both salmon and bottom fish, are located farther offshore than shellfish resources, they would not be seriously affected by oil spilled at Cherry Point itself. Only very small proportions of northern Puget Sound's commercial salmon and commercial bottom fisheries come within the possible impact zone while no sport fisheries would be affected. Although finfish can and do suffer mortality and tainting from contact with oil, they are mobile and can escape the parts of the water column where they sense the presence of hydrocarbon compounds. Furthermore, while fisheries are sometimes hindered because oil befouls boats and gear, the exposure of the Cherry Point impact zone to only the edge of the fishery areas would minimize such effects.

Two entire, although small, eelgrass beds and part of a third larger bed are located within the possible impact zone of oil spilled at a Cherry Point terminal. These beds make up a small fraction of northern Puget Sound's total eelgrass bed resource, but their damage would still be important because of the extremely productive habitat they provide for a large variety of marine organisms: crustacean larval forms, adult crabs, fish, as well as waterfowl for which eelgrass (Zostera marina and Z. nana) provides both a resting ground and a major food source. Oil from Cherry Point spills could damage the grass directly when washed up onto the leaf surface or could kill the plants through suffocation (coating) of the roots. Not every spill would reach the area and the frequency of operational spillage at Cherry Point is such that the beds would regenerate.

In addition to damaging effects on the eelgrass itself and direct mortality and morbidity effects on the very sensitive marine life forms harbored by the beds, indirect effects upon animal and bird life depending upon the eelgrass beds would occur in proportion to the extent of eelgrass bed distruction. In the case of the isolated bed just off Cherry Point (see Figure VIII-11), these indirect effects would be significant for organisms, larval forms as opposed to waterfowl, which could not move to the other nearby eelgrass beds which were unaffected by oil.

The only waterfowl area designated as such by the Marine Atlat which could be affected by Cherry Point oil spillage would be the lower one-third (approximately) of the waterfowl area in Birch Bay. Among the

effects of oil upon waterfowl would be surface-coating effects, such as death from exposure due to feather damage and loss of insulation and buoyancy properties. Waterfowl also suffer chemical toxicity through eating contaminated food: fish, shellfish, algae, or eelgrass. Longer term effects on the populations of affected waterfowl would include, for example, loss of reproductive success due to suppression of mating behavior through hydrocarbon interference with hormone activity. Destruction or damage to this locally significant portion of a waterfowl area would be permanent if oil from Cherry Point spills were to reach the northernmost edge of the possible impact zone with the expected frequency of operational spills. Overall, however, this lower tip of the Birch Bay waterfowl area represents a moderately small portion of the waterfowl area resource of northern Puget Sound.

VIII. MARINE ENVIRONMENT

A. INTRODUCTION

Chapter VIII addresses the alternative means of transportation of crude oil into and through the coastal counties of the State of Washington. Oil may be transported either by tanker, by pipeline, or by some combination of the two. Tanker transportation affects the marine environment -- the waters of Puget Sound. The main source of environmental impact on the marine environment is casualty oil spillage associated with marine transit. In Chapter VIII, only casualty spills in the marine transit corridors are considered; casualty and operational spills from tankers in port are discussed in Chapter VII.

Pipeline transportation primarily affects the terrestrial environment, including land use and regional ecology. Pipeline corridors also cross rivers, creeks, and other upland watercourses which empty into Puget Sound, and may thus occasionally have impacts on the marine environment in the rare instances where pipeline failure produces oil contamination of these watercourses and injures aquatic life, including anadromous fish.

Depending upon scenario, tanker transportation affects either the outer Sound (Strait of Juan de Fuca) only, or affects both the strait and the north inner Sound. Section B describes that environmental setting of the strait and the north Sound. These areas are characterized according to existing oceanographic conditions which determine oil spill mobility and according to existing marine biologic resources. Section C discusses the probable environmental impacts of transit oil spills. First the potential impact zone is defined for the six possible tanker route segments, followed by an assessment of the marine biotic resources potentially at risk within these impact zones and the significance of these resources in relation to the total resources of Puget Sound.

Four pipeline links are involved in various combinations in one or more of the petroleum scenarios. These are the Northern Tier Pipeline-Peninsula Link, running from Port Angeles to Selleck, and the Northern Tier Pipeline-East Washington Link, from Selleck to Stampede Pass; the Puget Spur, from Selleck to the existing refineries at March Point and Cherry Point; and the Trans Mountain Link, from the Laurel Pump Station east of Cherry Point to Sumas, near the Canadian border. Section B develops the environmental setting of these pipeline routes. Section C addresses the environmental impacts of pipeline construction, corridor maintenance, and possible oil spills due to accidental rupture of the pipe.

Tanker transportation of petroleum affects the waters of the Strait of Juan de Fuca and north Puget Sound. In Scenario II-B, Northern Tier Pipeline, originating at Port Angeles, regional supply by Puget Spur,

Pipeline, originating at Port Angeles, regional supply by Puget Spur, the tanker route ends at Port Angeles; only the Strait of Juan de Fuca is potentially impacted by transit oil spills. In all the remaining scenarios there is some degree of tanker transportation activity on the inner Sound as well; the area of tanker activity is the north Sound - the area enclosed by north Whidbey Island on the east, the entrance to Admiralty Inlet on the south, the Strait of Georgia on the north, and the Strait of Juan de Fuca-Vancouver Island on the west. South Puget Sound, or the area outside these boundaries, will not be impacted by the tanker routes in any of the petroleum development scenarios.

Scenario IV involves only minor tanker activity; I-A, I-B, II-A and II-B involve moderate tanker traffic, and III-A and III-B call for major tanker movement on both the strait and north Sound.

The following analysis of existing marine resources of the Strait of Juan de Fuca and north Puget Sound considers many of the important kinds of living organisms found in and near these waters, and is meant to provide a satisfactory background for the assessment of oil spill impacts in Section C. This study does not provide, however, an exhaustive characterization of all of the region's marine resources, but stresses the larger, more conspicuous forms, those of economic importance, and those which have been well studied. In particular, the location and relative local abundance of species of commercial or recreational importance are well-known, and also tend to be concentrated in localized areas of the Sound. Unexploited fish and invertebrate species may have similar, or at least comparable, distributions but little data is available. Phytoplankton and zooplankton, the primary producers and consumers at the base of marine food chains, have more patchy distribution in time and space throughout the study area that is not readily documented. While these two groups -- unexploited fish and invertebrates -- and plankton are highly important and essential to marine ecosystems, they are not explicitly addressed in this analysis owing to the absence of reliable data. Areas rich in harvestable resources are often also rich in primary production; hence, an assessment of oil spill effects on the former should yield a first order indication of impacts on the latter.

B. EXISTING CONDITIONS

1. Tanker Transport Corridors

a. Surface Current and Oil Spill Mobility

Crude oil impact on the marine environment depends largely upon its mobility. The acute phase of oil impact is that most commonly associated with the adverse environmental impacts of oil spill: the heavy oil slick on the surface of the water and dense accumulations of oil along the shoreline. The acute phase impact zone is determined by oil mobility in the vicinity of its point of release. Studies indicate that current and winds both contribute to the motion of floating oil in proportion to their velocity. Analysis of surface current patterns in Puget Sound leads to an estimate of the impact zone.

Surface movement is most strongly affected by water movement; roughly 100% of the current determines surface current velocity. On the other hand, wind has a far weaker effect on surface movement -- wind-induced surface currents usually have a velocity approximately 2.5% of the wind speed above the water. Since wind speeds are typically far greater than current, wind can be a major force despite the relatively small 2.5% coupling factor between the wind speed and surface current. Average wind speeds at coastal locations, particularly those lying close to mountain ranges which serve to channel wind flow, range from 6-10 miles per hour (mi/hr). Such velocities will induce surface currents of 0.15-0.25 mi/hr. At most locations along the open coast of the Pacific and at some locations within Puget Sound, the average magnitude of oceanic or tidal currents falls within this range and there wind will play a major role in determining the trajectory of spilled oil. There is great variation in wind speed -- the average velocity reflects frequent periods of near calm as well as frequent periods of winds twice or more greater than average. The effect on surface current is proportional; thus, the wind-induced current ranges from 0-1 mi/hr or greater during storm conditions.

Tidal currents are far stronger within Puget Sound and the Strait of Juan de Fuca than they are along the open coast, and thus constitute a far more significant force in oil slick movement. Most simply, the velocity of tidal current at a point is proportional to the volume of the tidal prism that must be displaced past that point over one tidal cycle, and it is inversely proportional to the cross sectional area of the channel which must carry the tidal flow. Thus, at the entrance to the Strait of Juan de Fuca, tidal current is significant (1 mi/hr) despite the large cross section of the strait because the entire tidal volume of the inner Puget Sound must be moved through that point twice in a tidal cycle (12½ hours). Proceeding eastward toward the inner reaches of the Sound, the typical tidal current diminishes for areas of large cross section. Where channel cross section is reduced by shoaling or by narrowing between points of land, the tidal current will

increase sharply. The channels through the San Juan Islands such as the Haro Strait (2 mi/hr average peak velocity) and the Rosario Strait (3 mi/hr average peak), Deception Pass north of Whidbey Island (4 mi/hr), and Admiralty Inlet south of Whidbey Island (2 mi/hr) all have large tidal velocities.

At the extreme inner reach, tidal current diminishes even in narrow channels such as the Hood Canal and southern Puget Sound. Tidal current is also small in the Strait of Georgia, the expanse of which stretches north from the San Juan Islands past Cherry Point defining the northeastern coast of Vancouver Island. The current is small here not only because the large cross section allows easy movement of even large volumes of water, but also because the Strait of Georgia contains the hydraulic terminus for tidal current set by the tidal phenomena of the Strait of Juan de Fuca. The channel north of Vancouver Island is narrow but immense tidal velocities (12 mi/hr at the Seymore Narrows) result in significant tidal movement through the northwestern portion of the Strait of Georgia. Although current data are sparse for the Strait of Georgia, since currents are generally considered insignificant in that location, it appears that a point somewhat southwest of the City of Vancouver demarks the tidal influence of the Strait of Juan de Fuca from the south and the Seymore Narrows from the north. To the north of this demarcation the tide will ebb and flood through the Seymore Narrows to the north. To the south of this demarcation the tide will ebb and flood through the Strait of Juan de Fuca. In the immediate vicinity of the demarcation, the forces of induced tidal current diminish to zero. The U.S./Canadian boundary approximates the hydraulic boundary of Puget Sound as well as the political boundary.

Tidal current is an oscillatory phenomenon. In an ideal system, a floating object released at low tide will at first experience no current. As the tidal cycle continues toward high tide the flood or incoming current will carry the floating object up the channel with a velocity roughly following a sine function. At high tide, when the flood current has diminished to zero, the object will be displaced a distance up channel representing its average velocity acting over the 6¼ hours of a half tidal cycle. As the cycle swings toward the low tide the ebb or outgoing current develops and carries the floating object back again, reaching its initial starting point at slack water, low tide at the end of the cycle. As will be discussed below, there are a number of phenomena which result in net displacement over the course of a tidal cycle but in a great many tidal systems the net displacement is small compared with the cyclical displacement.

We consider current alone, deferring the discussion of wind-induced effects until later. At any point east of Cape Flattery the immediate fate of an oil spilll(in terms of hours) is determined by the trajectory established by the oscillating tidal current. With a half tidal cycle (6¼ hrs) the tidal current, at nearly every point within the Puget Sound system, has the potential to move an oil slick between 4 and 15 miles.

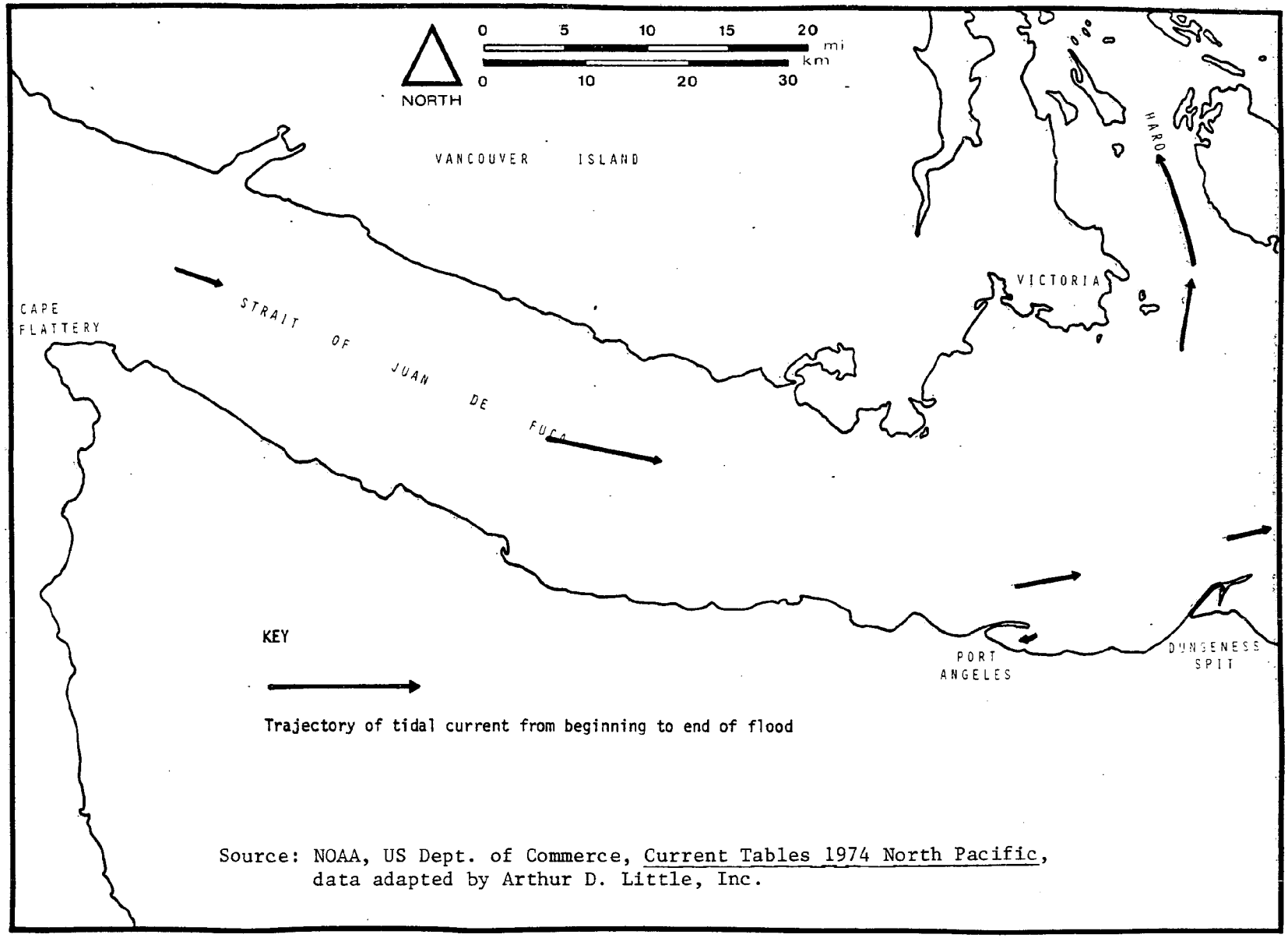
The actual distance displaced and the direction of the distance is of course dependent upon the exact stage of the tide (i.e., begin ebb, mid-flood, etc.). For example, an oil spill occurring at the beginning of flood tide west of Whidbey Island would be carried six miles to the north toward Rosario Strait. If the spill occurred at the beginning of ebb tide, the spill would be carried approximately six miles to the southwest by the end of ebb tide. If the spill were to occur between the beginning and end of either ebb or flood the displacement would be less than the maximum. For any location, the potential half tidal cycle displacement represents the initial range of oil spill dispersion.

Information concerning tidal currents is available from the U.S. Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA). NOAA is presently developing a complex model of Puget Sound current. There are no interim results which could be applied to this study; hence, the material that follows is only a rough approximation intended to provide a general indication of the relative mobility of oil spills. Data for 50 locations within the Strait of Juan de Fuca and northern Puget Sound form the basis for the discussion of tidal effects. Average maximum displacement of a floating object over half a tidal cycle was calculated for various locations within the Strait of Juan de Fuca and northern Puget Sound. (See Figures VIII-1 through VIII-4.) As expected, the half cycle mobility of an oil spill is greatest in those locations where the peak tidal current is greatest, particularly where narrow channels persist over a long portion of the trajectory, such as within the San Juan Islands.

Tidal current is weak within the immediate vicinity of all three petroleum industry activity zones, although for slightly different reasons. Port Angeles is protected from the strong current of the Strait of Juan de Fuca by Ediz Hook. There is little tidal displacement within the hook because the tidal prism is so small. March Point adjoins Padilla Bay, which is a physical dead-end for tidal movement. Cherry Point, although located in an exposed location, in fact lies close to the hydraulic boundary of northern Puget Sound and thus experiences small tidal displacements. The tanker transportation corridors that approach the marine terminals pass through areas of high tidal current throughout most of their length. Tidal action will constitute one of the major definitions of the impact zone for oil spills occurring along the tanker route through Puget Sound and the Strait of Juan de Fuca.

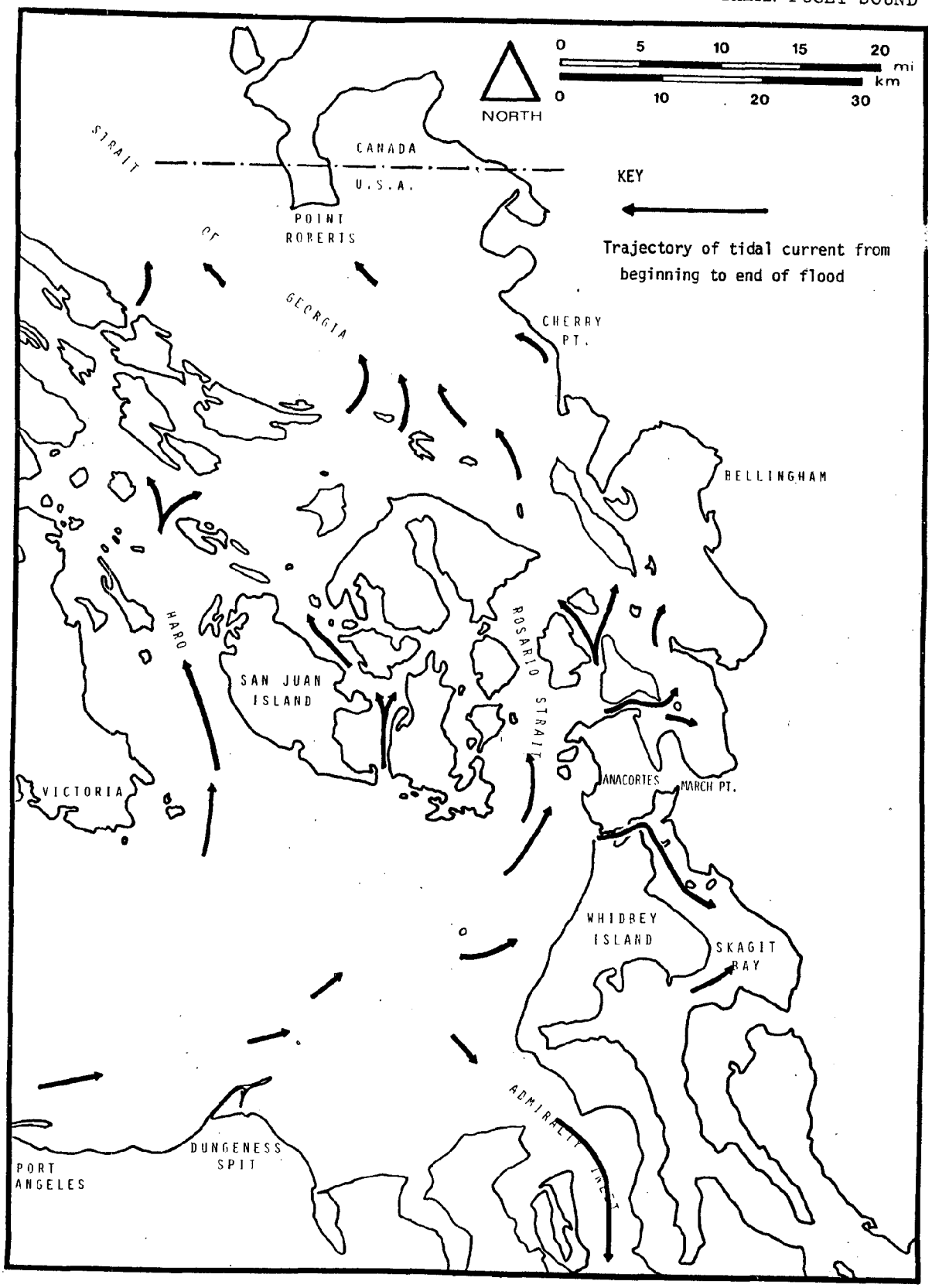
The previous figures show that the half-cycle displacement trajectory for ebb tide differs slightly from that for flood tide. Differences in direction and magnitude are occasionally quite pronounced and are generally due to the presence of two independent factors. The first factor is net outward freshwater flow from the many major rivers that drain into the sound and the Strait of Georgia. The magnitude of net outflow varies from point to point throughout the area depending on the size of the watershed draining through a particular cross section of tidal channel.

FIGURE VIII-1 HALF CYCLE DISPLACEMENT - FLOOD TIDE - STRAIT OF JUAN DE FUCA



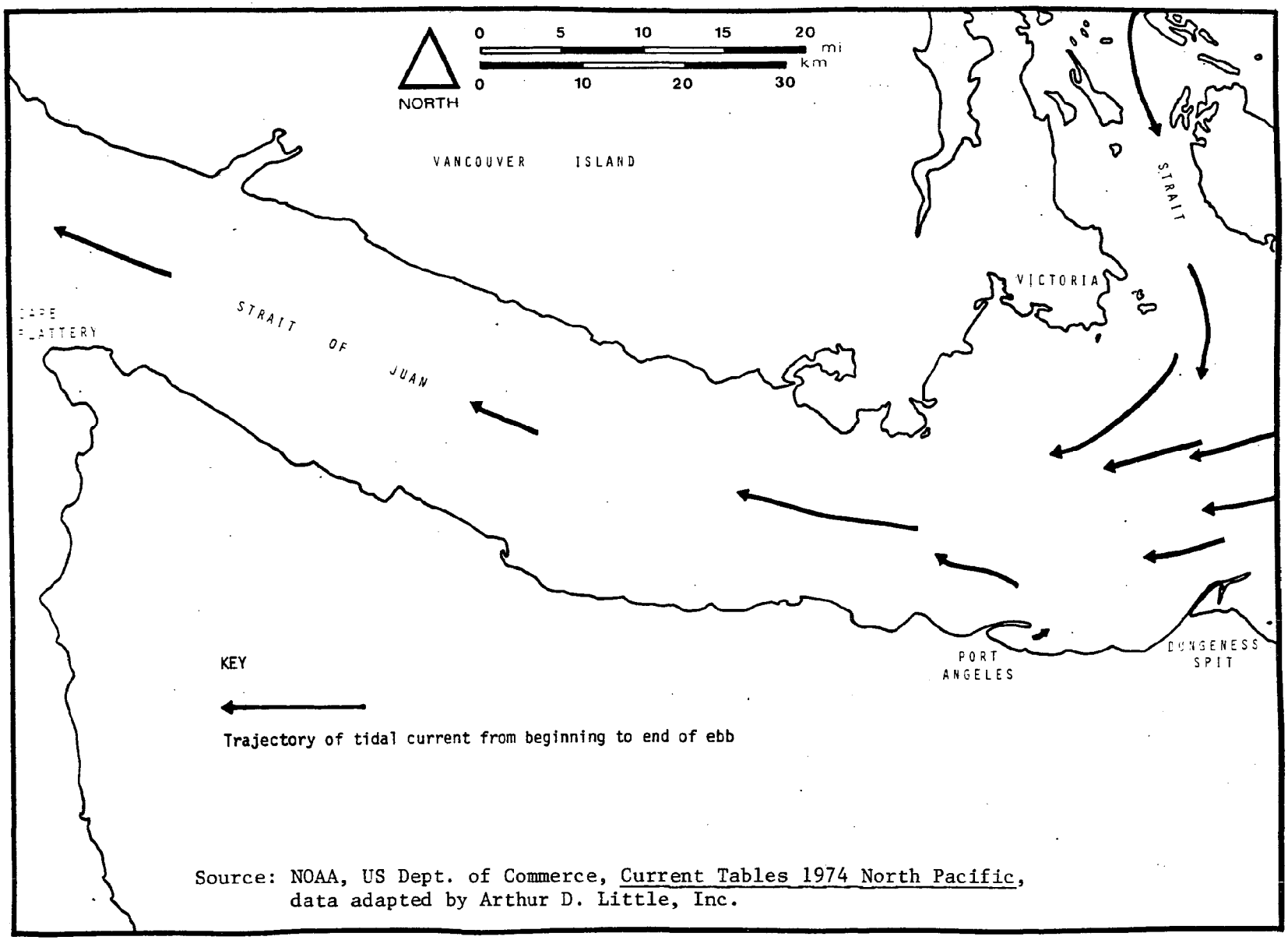
Source: NOAA, US Dept. of Commerce, Current Tables 1974 North Pacific, data adapted by Arthur D. Little, Inc.

FIGURE VIII- 2 HALF CYCLE DISPLACEMENT - FLOOD TIDE - NORTHERN PUGET SOUND



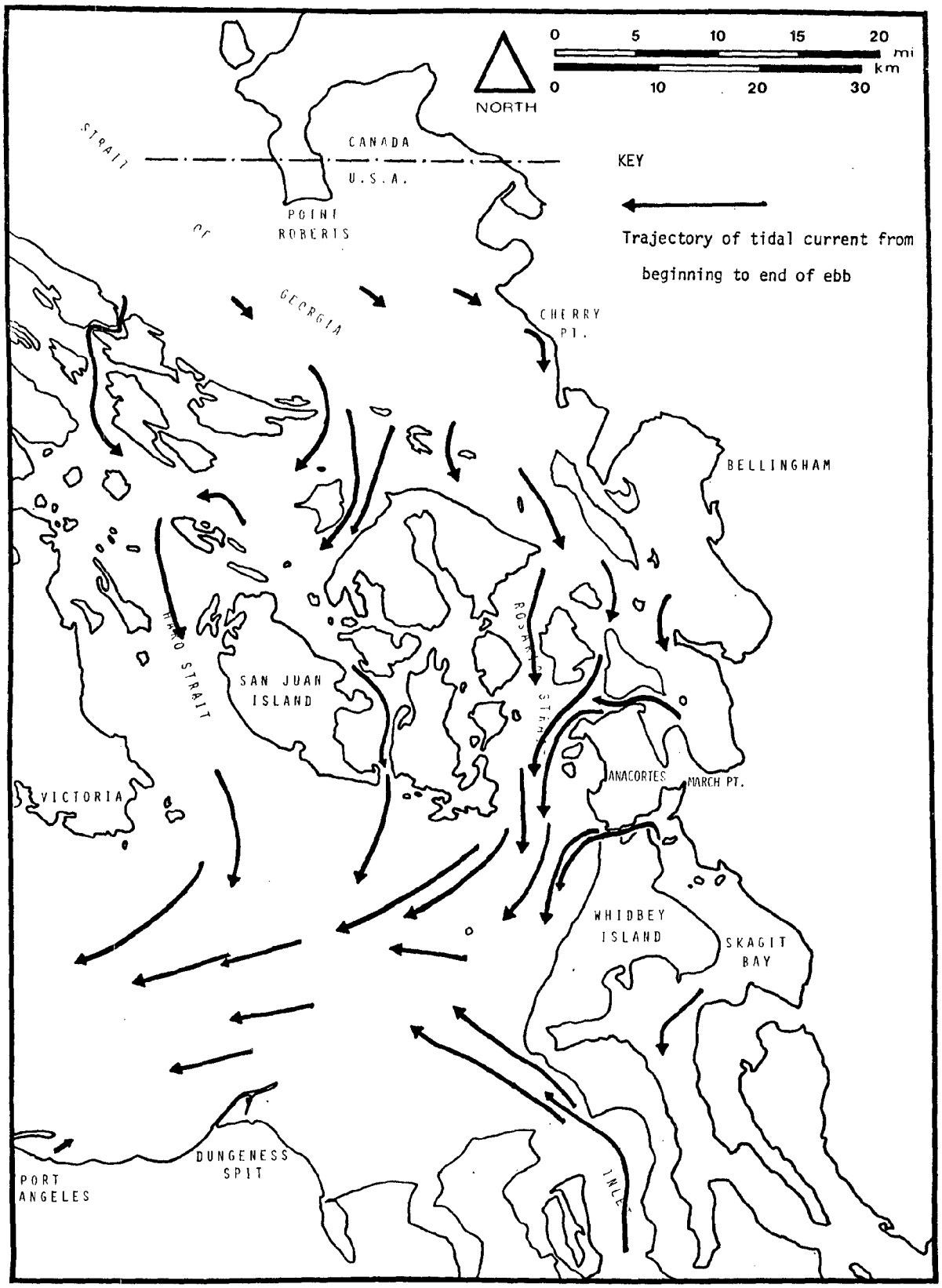
Source: NOAA, US Dept. of Commerce, Current Tables 1974 North Pacific, data adapted by Arthur D. Little, Inc.

FIGURE VIII-3 HALF CYCLE DISPLACEMENT - EBB TIDE - STRAIT OF JUAN DE FUCA



Source: NOAA, US Dept. of Commerce, Current Tables 1974 North Pacific, data adapted by Arthur D. Little, Inc.

FIGURE VIII-4 HALF CYCLE DISPLACEMENT - EBB TIDE - NORTHERN PUGET SOUND



Source: NOAA, US Dept. of Commerce, Current Tables 1974 North Pacific, data adapted by Arthur D. Little, Inc.

Since fresh water is buoyant, the freshwater outflow is concentrated in roughly the upper 200 feet of the water column, thus reducing the effective cross section and increasing the velocity. The effect of net outflow is to augment the ebb tide vector and decrement the flood tide vector. On a regional scale, the net outflow defines the major tendency for pollutants to be flushed from Puget Sound -- a tendency which probably dominates over the dilution caused by partial mixing resulting from cyclical tidal action.

The second factor is caused by rotational currents. When a tidal channel bends sharply the force of the moving body of water is directed against the outside of the curve, resulting in a net radial force, although the water is unable to physically move in that direction. The implication for an oil spill is highly significant since the net surface vector in a curved tidal channel will cause the major impact from an oil slick to occur along the outside shore during either flood or ebb tide. If the rotational motion is in open water, away from the sharp delineation of land masses, the tidal rotation is often called a gyre. Because of its hydraulic origin, a tidal gyre has a tendency to reverse direction with the changing of the tide. Nonetheless, the magnitude and the centroid of the cyclical rotation may differ significantly for the gyre established by flood tide and for that established by ebb tide. The result is significant differences between the tidal motion of ebb and flood in that vicinity.

That phenomenon is extremely common in Puget Sound. Specifically, major gyres of strong current characterize the area of the intersection of the Strait of Juan de Fuca and Puget Sound, stretching between Freshwater Bay, west of Port Angeles, and Whidbey Island. Some degree of net circular motion is observed around several of the islands in the San Juan group as well as around Whidbey Island itself. There are weak gyres at the fringe of the Strait of Georgia, but deep water and weak tidal action within that body generally show greatly diminished tidal effects.

If ebb and flood tide have slightly different displacement vectors, a floating object, such as an oil spill, will follow a zig-zag path since displacement by each successive cycle will not exactly cancel the displacement of the previous cycle. The result is a net motion in a direction defined by the sum of the predominant flood and ebb tidal vectors. Recalling the net freshwater outflow from Puget Sound, it is anticipated that the predominant net tidal current will be outward, toward the Pacific Ocean and away from the inner Sound. Such is the case, although the effects of net circulation caused by gyres or radial outward forces caused by channel curves complicate the problem of predicting net tidal vectors. Since the net tidal current may be significant in transporting spilled oil over the course of several days, an effort was made to estimate the direction and magnitude of that effect. The tidal current data provided by NOAA are only meant to indicate the character of current at certain locations. The data contain a modest amount of error which, when subjected to a differential comparison, can produce results of far greater proportional error. Nonetheless such data are the most readily available

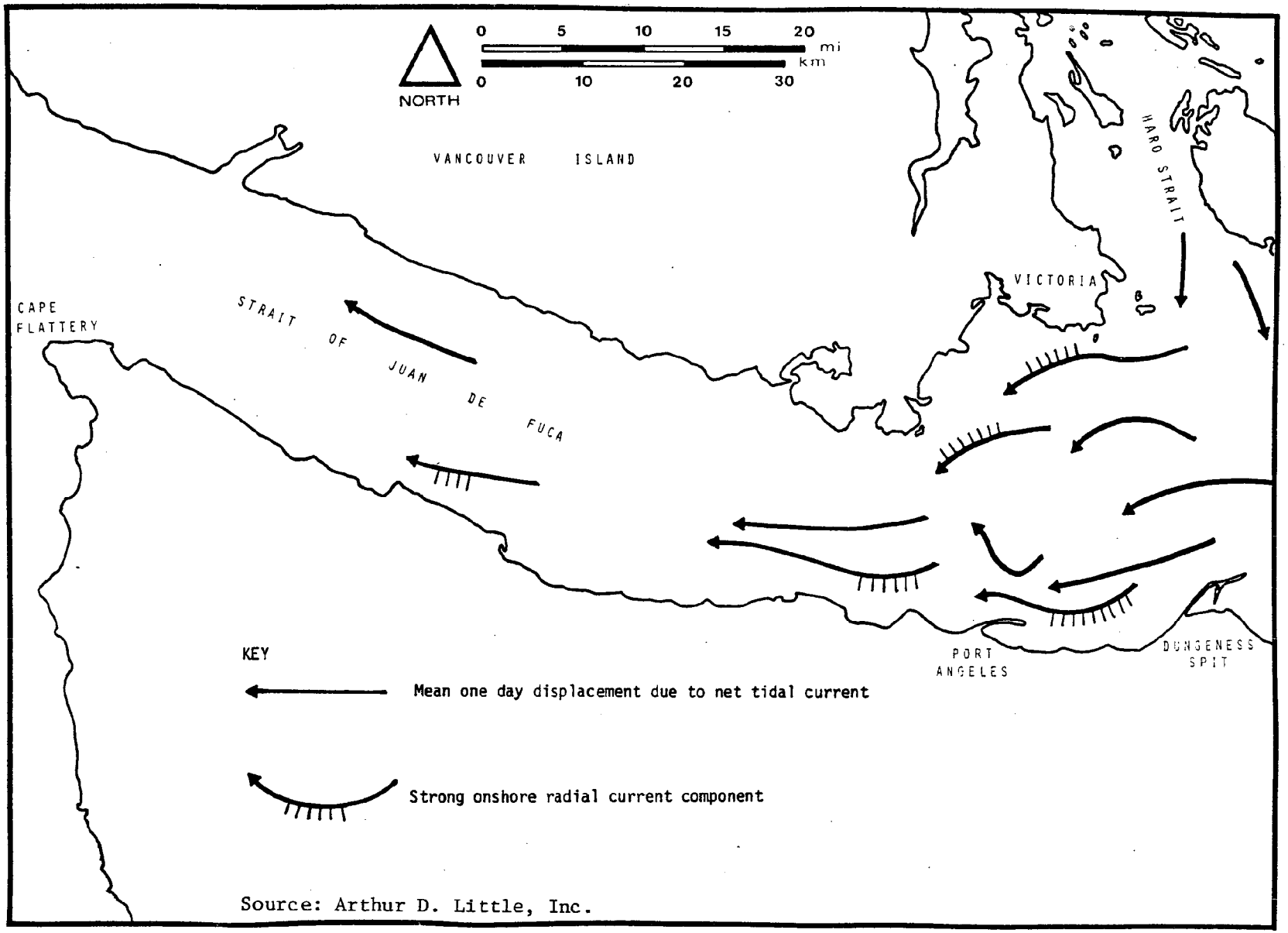
system capable of describing the entire area of northern Puget Sound and the Strait of Juan de Fuca that must be considered by this study. There are ongoing efforts to model tidal motion within Puget Sound such as a highly sophisticated computer model being developed by the NOAA. Currently, the methodology for that model is still at the testing stage and no network description results have been made available yet. At such a time as the model becomes operative, however, it is imperative that the following type of oil spill impact analysis be conducted based upon the far better predicting powers of a unified applied model.

In order to compute net surface current motion, vector sums of ebb and flood tides were obtained for 60 stations within the study area. These vectors were then compared with the streamlines of water motion defined by the tidal cycles themselves. The vector sums were then decomposed into a radial component perpendicular to the streamline that represents the effect of outward acceleration and a parallel component which indicates the effect of net flow such as may be attributed to freshwater outflow or persistent tidal rotation. The resulting set of vectors was used to establish fields of net tidal influence which covered the portion of the Strait of Juan de Fuca and northern Puget Sound that will be affected by tanker traffic bound for the three petroleum industry activity zones. A time scale of one day was selected to provide a measure of net displacement potential and to integrate over the variation in surface motion characteristic of localized areas within the Sound. Figures VIII-5 and VIII-6 present a series of trajectories, each indicating the approximate path and distance of displacement that will be experienced by a floating body over a period of two tidal cycles -- approximately one day.

It is important to note that the path depicted in Figures VIII-5 and VIII-6 in fact represents the mean position of the floating body and that its actual path will have followed a highly active zig-zag caused by tidal fluctuations or oscillations. This distinction is critical for the understanding of oil spill impact zones. The net current allows prediction of the average position of the spill at any time after its release from a known point. The instantaneous position will be found to vary around that mean due to the continual action of the tidal phenomenon. Thus, an envelope drawn around a trajectory of mean position indicates the range of tidal displacement possible. The oil spill will then be expected to remain within that envelope unless the additional effects of wind are considered.

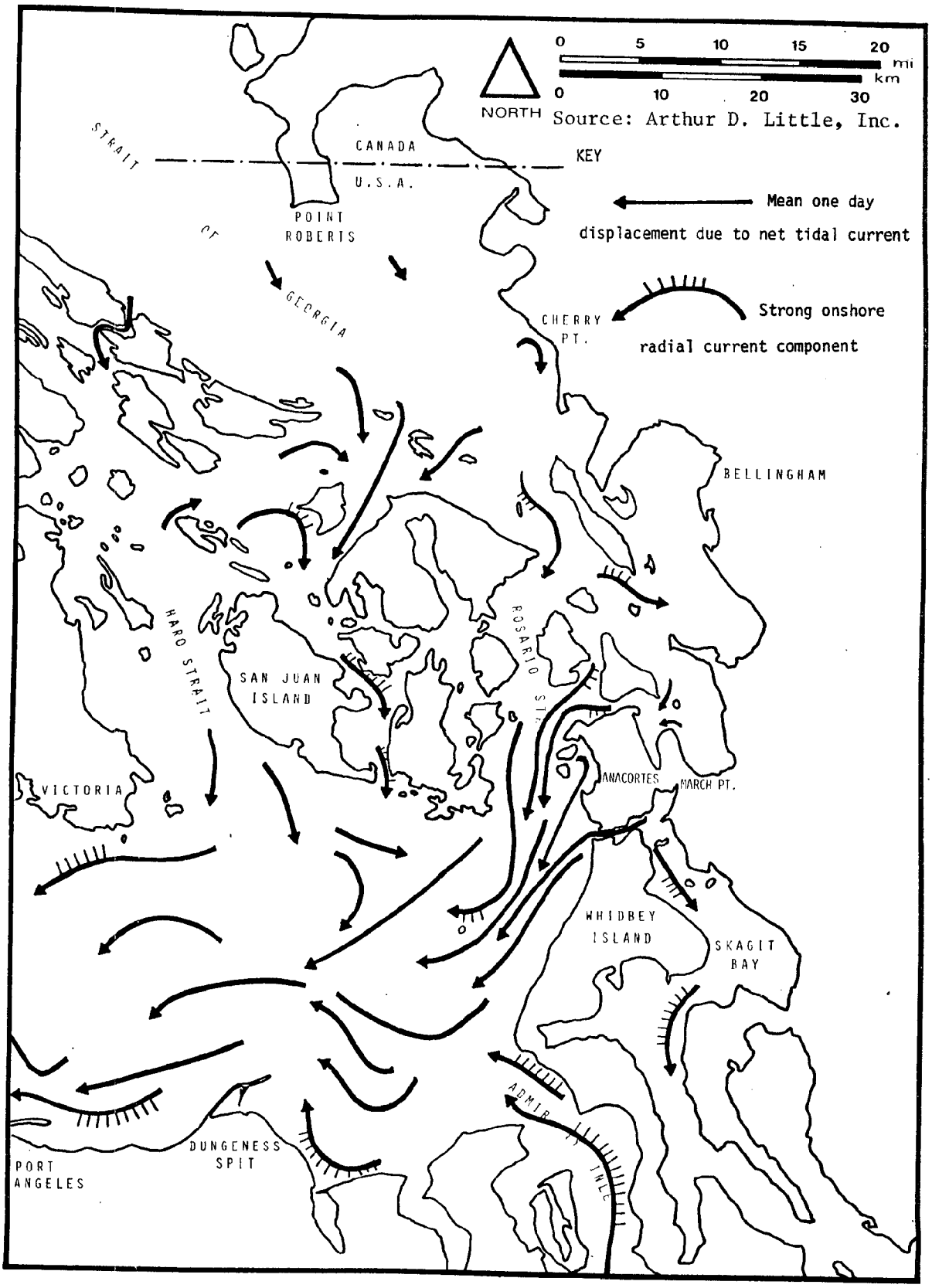
As stated earlier, the wind above the water has a tendency to cause surface currents and motion of a floating oil slick with a velocity approximately 2.5% of the velocity of the wind itself. Wind data for the Strait of Juan de Fuca and northern Puget Sound are not available for such a fine network as is used for tidal data. Fortunately, however, the variation in wind is far more regional, reflecting the effects of masses of mountains rather than the individual orientation of the small

FIGURE VIII-5 NET TIDAL CURRENT SINGLE DAY DISPLACEMENT: STRAIT OF JUAN DE FUCA



Source: Arthur D. Little, Inc.

FIGURE VIII- 6 NET TIDAL CURRENT SINGLE DAY DISPLACEMENT: NORTHERN PUGET SOUND



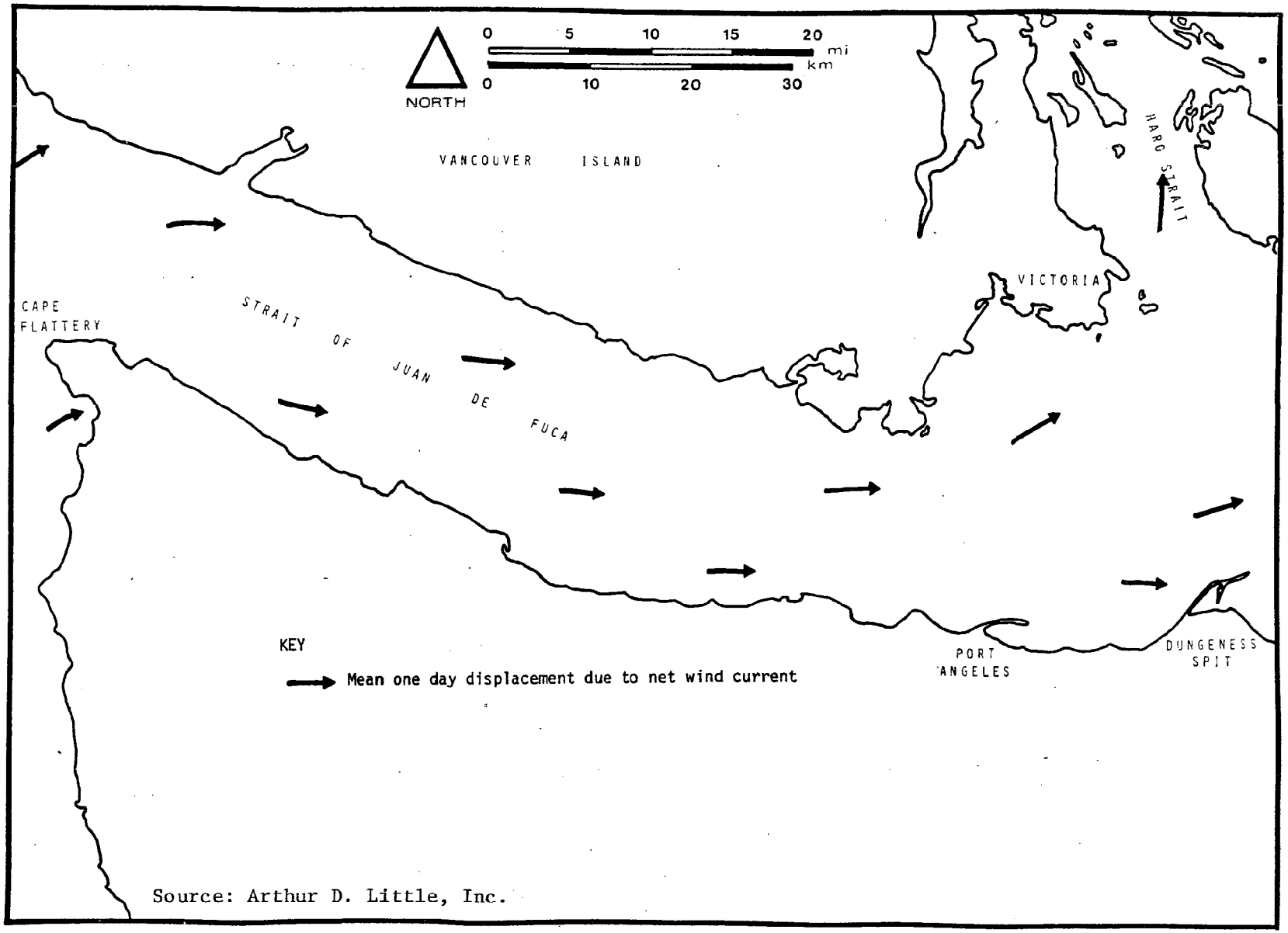
shoals and channels within the Sound. Generally it is possible to define a system of streamlines for the area, illustrating the tendency for air motion to be changed by regional mountain masses.

Prevailing winds strike the northwest coast from the west or southwest. They are channeled through the Strait of Juan de Fuca to flow across Port Angeles from west to east. Upon entering Puget Sound, the winds diverge across Whidbey Island, with the northern portion being bent in a northerly direction and the southern portion being bent in a southerly direction towards Seattle and the lower Sound. This generality is presented in several sources, including the Marine Atlas prepared bv the State of Washington Department of Natural Resources. The generalization is also consistent with an analysis of wind data from three stations: Port Angeles, Whidbey Island, and Bellingham.

For each station, a 16-point wind rose was compiled; frequency of occurrence and average wind speed were then combined to indicate the intrinsic quantity of wind (in units of distance) that will blow across the station on a statistical basis. A sum of the resulting 16 vectors yields a net wind vector with an orientation consistent with the divergence description of prevailing wind and with a magnitude showing the gradual attenuation of wind velocity as friction and divergence reduce unit air mass momentum along the path from the Pacific Ocean to the inner reaches of Puget Sound and the Strait of Georgia. Such information may be taken over a 24-hour time interval and combined with the 2.5% induced surface current coupling factor to yield a vector field illustrating the net displacement over one day caused by wind-induced surface current through the study areas. (See Figures VIII-7 and VIII-8.)

Referring back to Figures VIII-5 and VIII-6, it is clear that the tendency for net wind-induced surface current is practically the direct opposite of the tendency for net current displacement in the same body of water. This is simply explained by the tendency for fresh water to flow from the mountains toward the sea, thus determining the net current, and by the tendency of the prevailing Pacific westerlies to blow from the ocean toward the mountains, thus determining the net wind-induced surface current. If the two vector fields are taken together, a new family of vectors is obtained which indicates the potential one-day displacement of an oil slick at various locations within the Strait of Juan de Fuca and northern Puget Sound. Because the net tidal current in the Sound is stronger than the wind-induced current, the total surface current vector field most closely resembles the net tidal current vector field. The principal effect of wind is to reduce the magnitude of surface displacement in most areas and to cause slight changes in orientation of net surface current vectors. The latter usually is most noticeable when the predicted radial motion of current is shifted from one shore to the other shore of a narrow channel by the predominant effect of the wind. Thus the onshore impact tends to be most pronounced along the shore of Whidbey Island and in the vicinity of Cherry Point along the Strait of Georgia. (See Figures VIII-9 and VIII-10.)

FIGURE VIII-7 NET WIND INDUCED SURFACE CURRENT SINGLE DAY DISPLACEMENT: STRAIT OF JUAN DE FUCA



Source: Arthur D. Little, Inc.

FIGURE VIII-8 NET WIND INDUCED SURFACE CURRENT SINGLE DAY DISPLACEMENT: NORTHERN PUGET SOUND

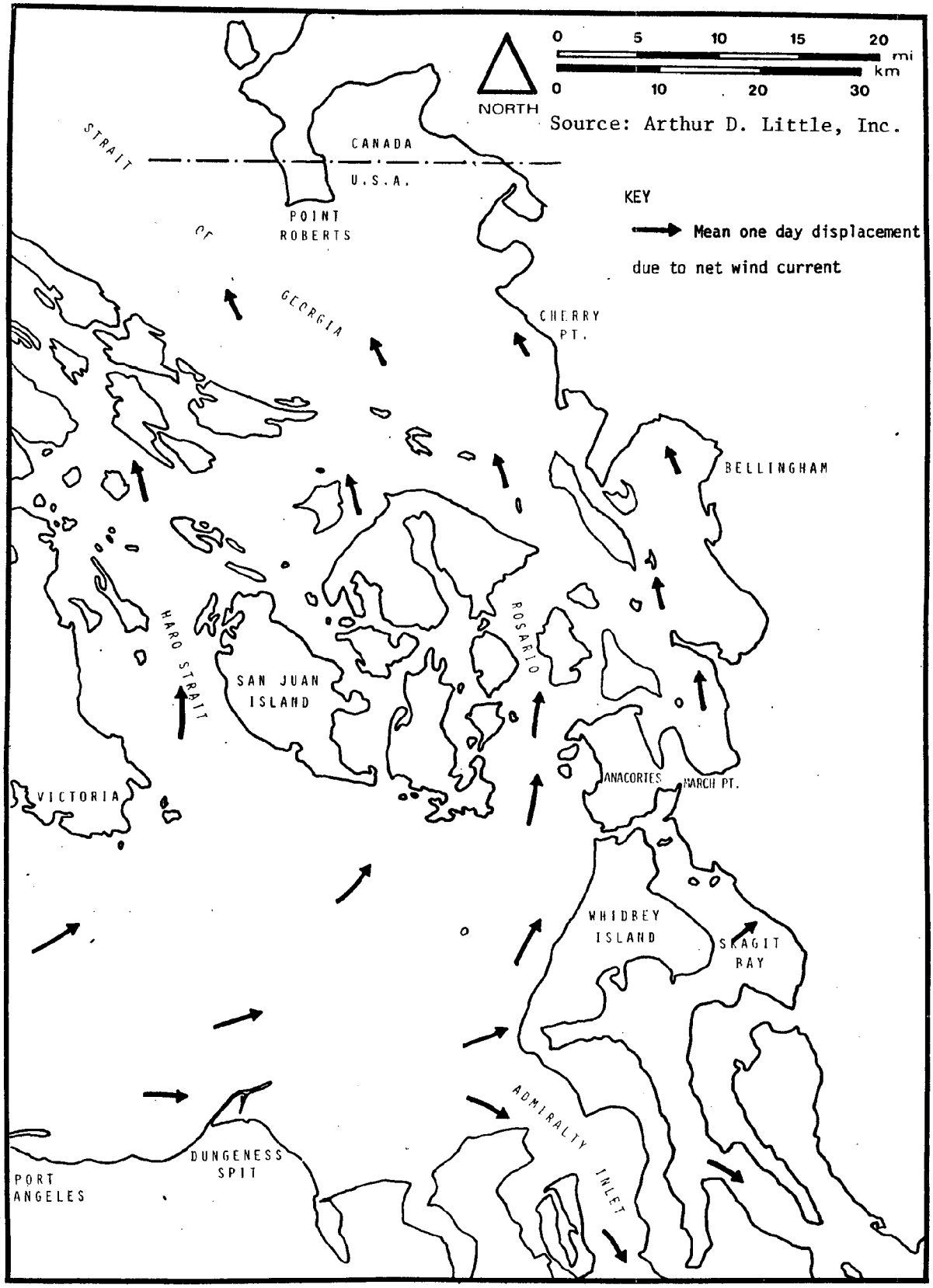
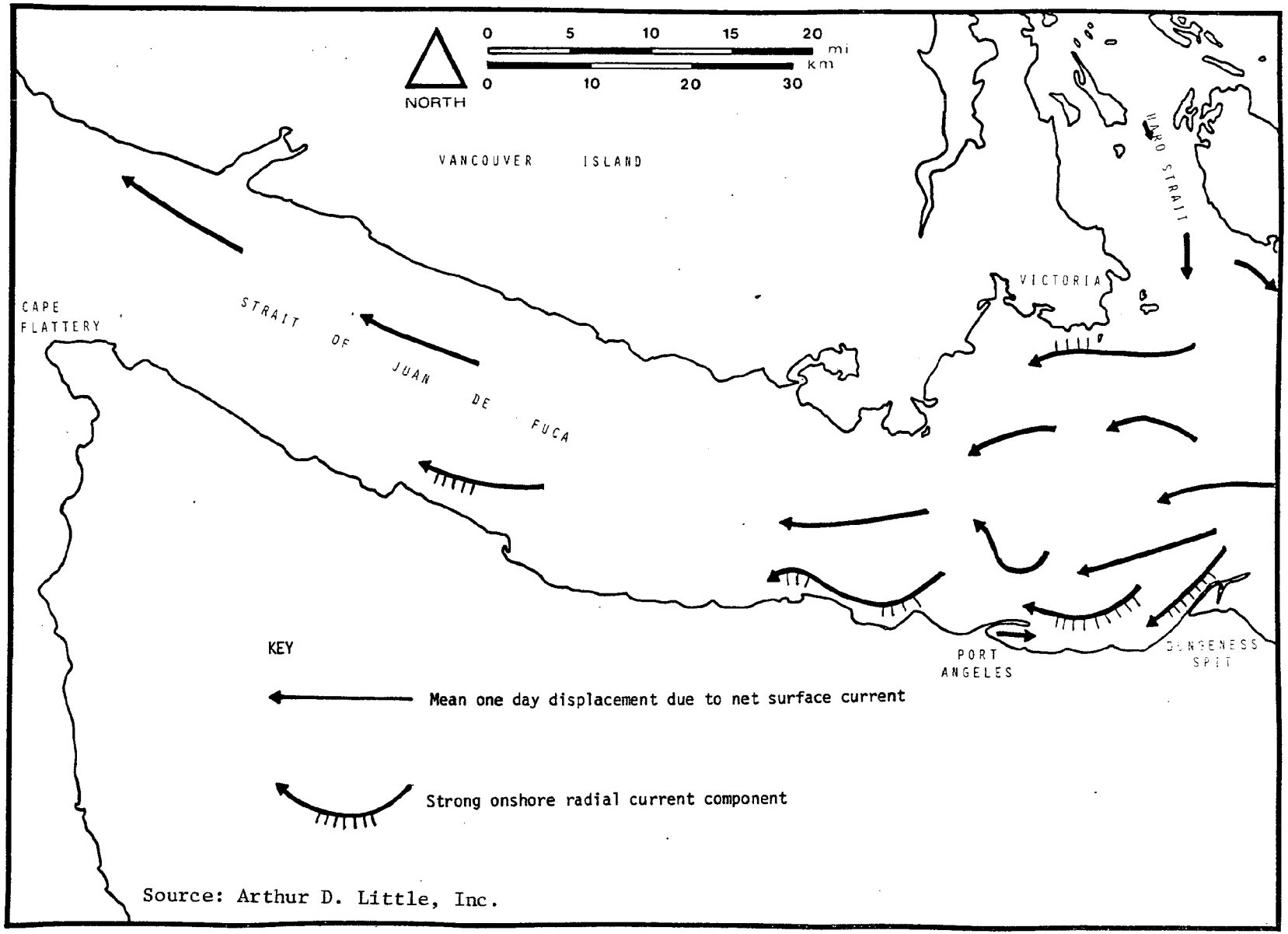
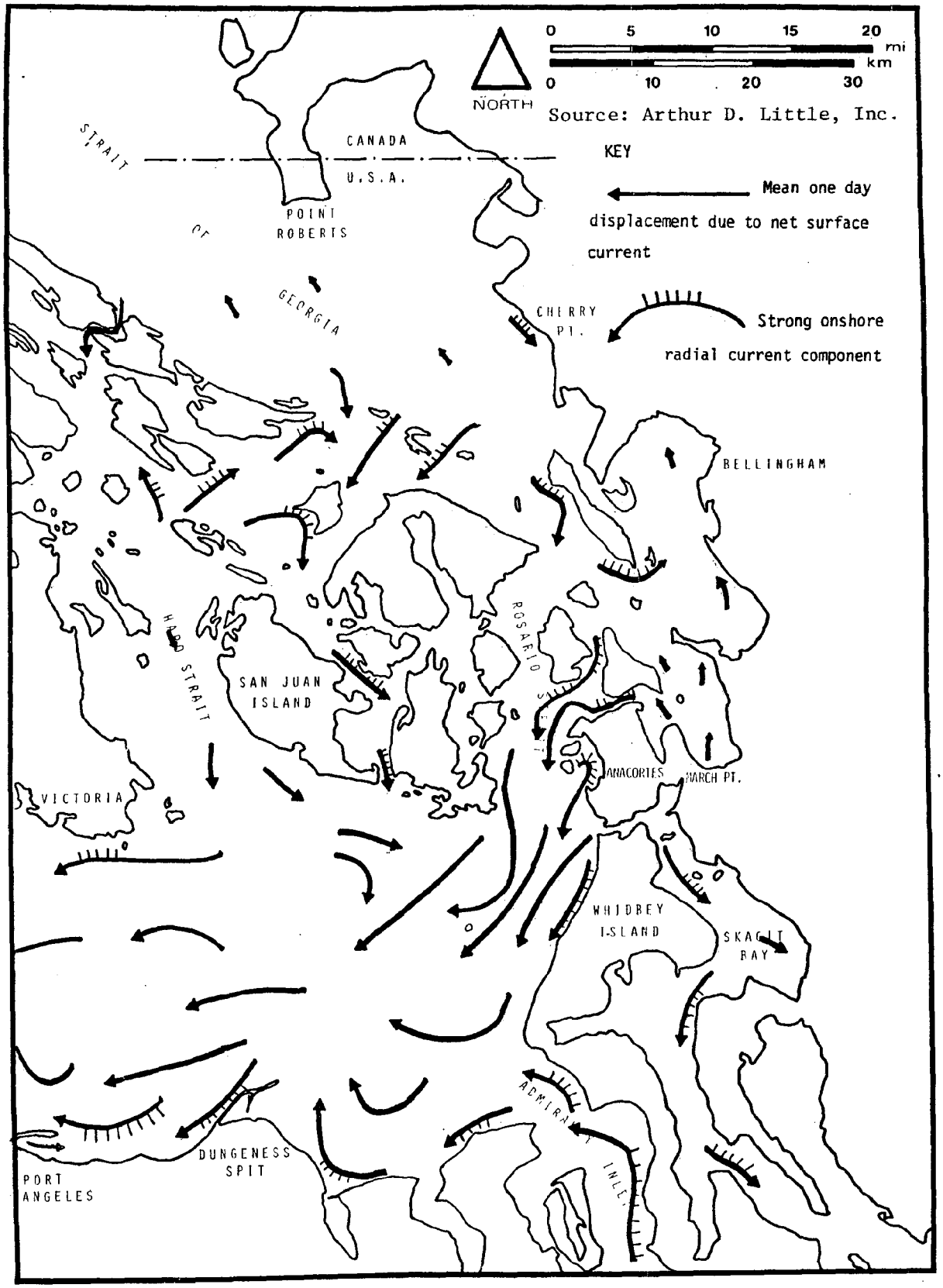


FIGURE VIII-9 NET SURFACE CURRENT SINGLE DAY DISPLACEMENT: STRAIT OF JUAN DE FUCA



Source: Arthur D. Little, Inc.

FIGURE VIII-10 NET SURFACE CURRENT SINGLE DAY DISPLACEMENT: NORTHERN PUGET SOUND

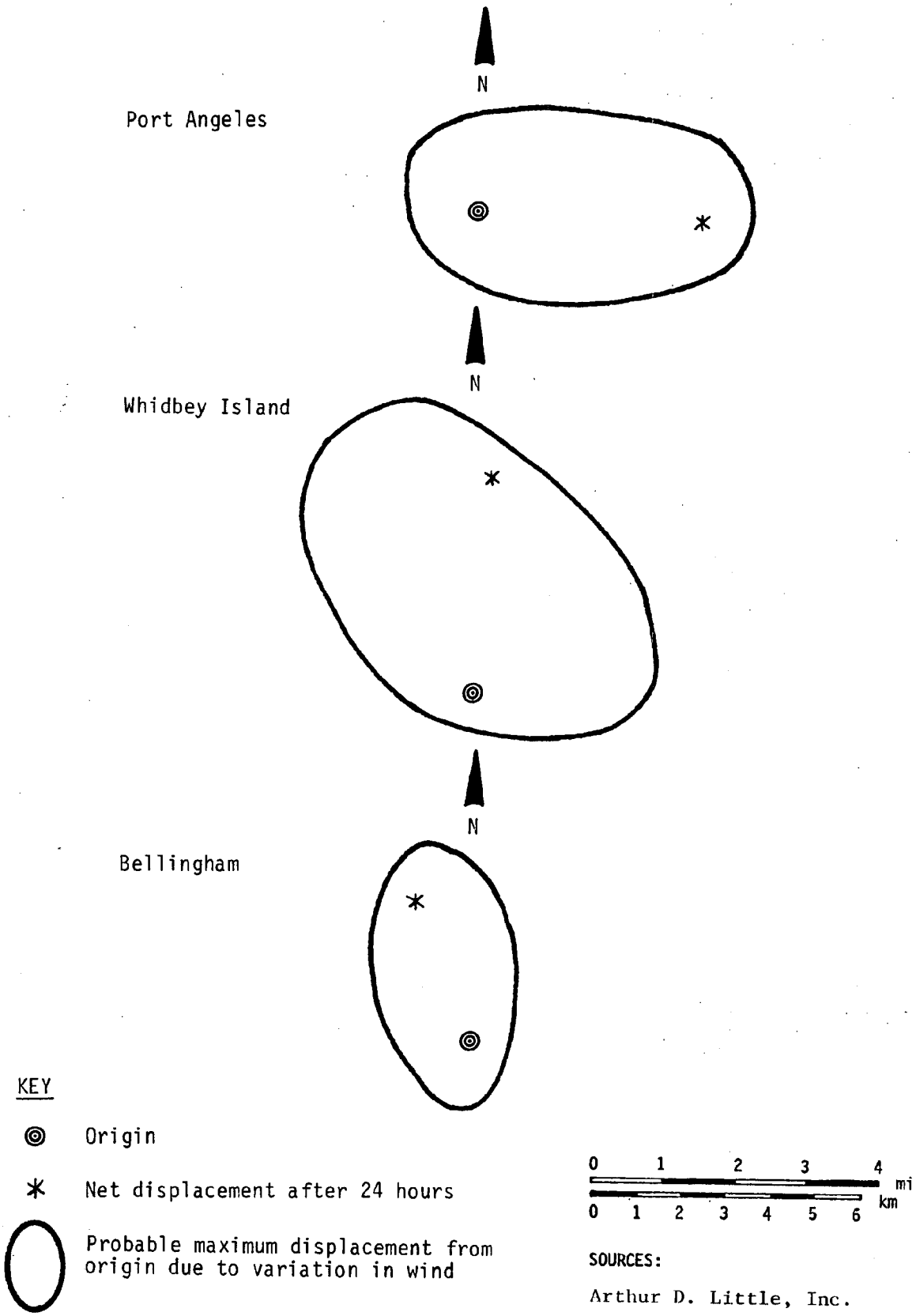


Although a prevailing wind direction can be identified for every portion of the strait and northern Sound, the actual wind experienced at any given time is quite variable. If frequency of occurrence is multiplied by average wind velocity from each direction, a value is obtained for each direction that indicates the quantity of wind (miles) which will be expected over a specified time interval. On the average, the net wind-induced displacement is the vector sum of these quantities, as described above. The resultant vector is somewhat different from the concept of prevailing wind in that its magnitude is diminished by the averaging of winds from opposing directions. The resulting vector indicates the net displacement from the starting point, but variability of the wind will cause the actual position of the floating object to differ significantly from the mean position during much of the time. The amount of variance caused by wind variability is a function of wind speed and persistence of air flow from any given direction. It would be possible to perform a statistical analysis of wind records that would result in a time distribution of distance from the mean position. Since wind data in the appropriate form was not readily available, a different method was used in this study to estimate the variation in position caused by variation in wind.

The product of frequency and average velocity was calculated for an 8-point wind rose, resulting in a series of displacement distance vectors. If three adjoining vectors are taken successively, the sum represents the maximum possible displacement due to wind in the direction of the principal or central vector orientation. The actual distance of this displacement depends upon the averaging time selected for analysis. In this study, 24 hours was used to indicate average conditions and implies a persistence of wind from each octant that ranges between one and four hours depending on its statistical occurrence in the actual wind data. When adjoining vectors are summed for each of the eight points of the wind rose, the eight end points form the vertices of an irregular octagon. This octagon can be smoothed, yielding an enclosed curve which represents the approximate extreme displacement from the center that can result from wind action over a 24-hour period. The actual location of a floating object within the wind displacement envelope is variable. Its actual trajectory may be a wandering or spiral path. On the average, however, its mean position will be that of the total vector sum, which indicates net displacement. (See Figure VIII-11.)

Of course, there are conditions which will lead to displacement outside of the 24-hour wind envelope. An extremely strong and persistent wind, such as would be observed during a storm, could result in a deviation far outside the boundaries shown in Figure VIII-11. On an average basis, however, all weather conditions, storm and fair, are included within the wind rose data and the tendency for extreme displacement away from the mean that occurs during storm conditions is considered in defining the wind displacement envelope in proportion to its frequency of occurrence. Nonetheless, the resulting boundary must be considered suitable for discussion of average conditions and will not describe

FIGURE VIII-11 VARIANCE OF DISPLACEMENT DUE TO WIND INDUCED SURFACE CURRENT



SOURCES:

Arthur D. Little, Inc.

behavior during a storm. In this sense, the wind displacement envelope can be considered equivalent to a two-dimensional representation of the standard deviation of wind displaced position around the mean. On a statistical basis, it is expected that an object moved by the wind would be found within the envelope roughly 50-90% of the time. The precise statistical significance of the displacement envelope depends upon the choice of the averaging period. The choice of 24 hours for this study was not based upon direct calculations but rather was selected because it implies a plausible persistence of wind direction. This assumption, however, is a potential source of error and should be refined before too much reliance is placed upon the result. For the purposes of the impact analysis to follow, the fundamental conclusions are not strongly affected even if the envelope were to vary in size by a factor of two.

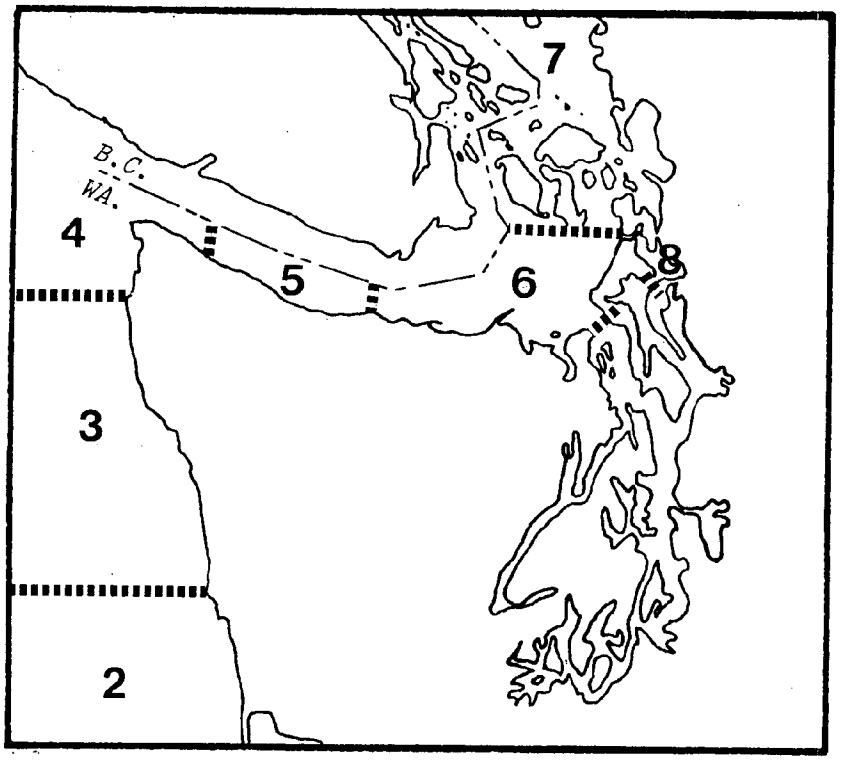
Wind-induced variation can be combined with tidal variation to define an approximate zone of oil spill location. It may be seen that the generally strong winds and strong tides of Puget Sound and the Strait of Juan de Fuca result in high mobility for spilled oil even over the course of a few hours. Over a time period of several days, however, the principal characteristic of the oil spill impact zone will be established by net surface current displacement. The consideration of tidal and wind-induced currents reflects data gathered over long periods of time and therefore indicates average conditions. Generally, the average net current displacement within northern Puget Sound and the Strait of Juan de Fuca is from the east toward the west, from inland to the Pacific Ocean. This means that the near-term fate of spilled oil is gradual ejection from Puget Sound. In the course of this motion, the variation in position caused by wind and tide sweep out a fairly large area which must then be examined for potential impact; that analysis is presented in Section C-1 of this chapter.

b. Marine Resources

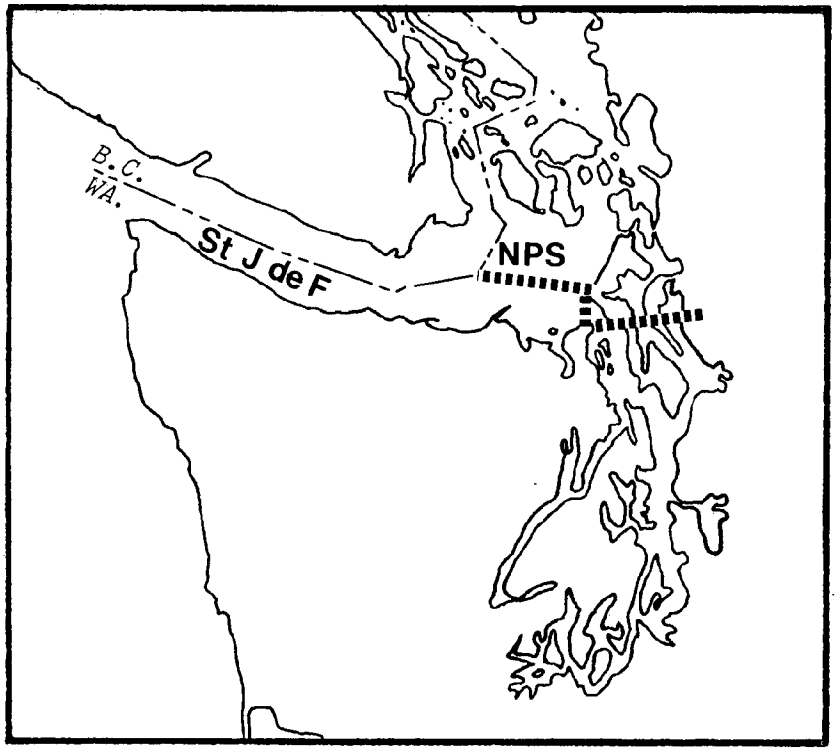
(1) Commercial Fisheries (finfish/shellfish resources). The waters of Puget Sound and the neighboring straits are exceptionally rich in commercial fishery resources. Foremost among the resources harvested are the salmonids, of which all five species (chinook, coho, sockeye, pink, and chum) are taken according to their relative abundance at different localities. The total value of the salmon catch (1971-73 average) was $22.6 million for north Puget Sound and $2.4 million for the Strait of Juan de Fuca. (See Figure VIII-12 for definition of areas.) The total for all Puget Sound-landed salmon was $29.5 million -- the north Sound catch accounts for 77% of the total, the strait for only 8.1%. The location of the major commercial salmon fishing areas is shown in Figures VIII-13 and VIII-14, and the economic value of catch, by area, is shown in Table VIII-1. The areal extent of salmon resources is given in Table VIII-2.

Young fingerling salmon feed on immature forms of other fish and crustaceans in the rich mudflat areas of tidal estuaries associated with anadromous rivers and streams. During the marine phase, all five salmon

FIGURE VIII-12 SPORTS & COMMERCIAL RESOURCES AREAS



SPORTS RESOURCES AREAS



COMMERCIAL RESOURCES AREAS

St J de F = Strait of Juan de Fuca

NPS = Northern Puget Sound

Source: Institute for Marine Studies, University of Washington, Washington Baseline Study: Marine Economic Component, Aug. 11, 1976.

FIGURE VIII-13 SALMON FISHERY - STRAIT OF JUAN DE FUCA

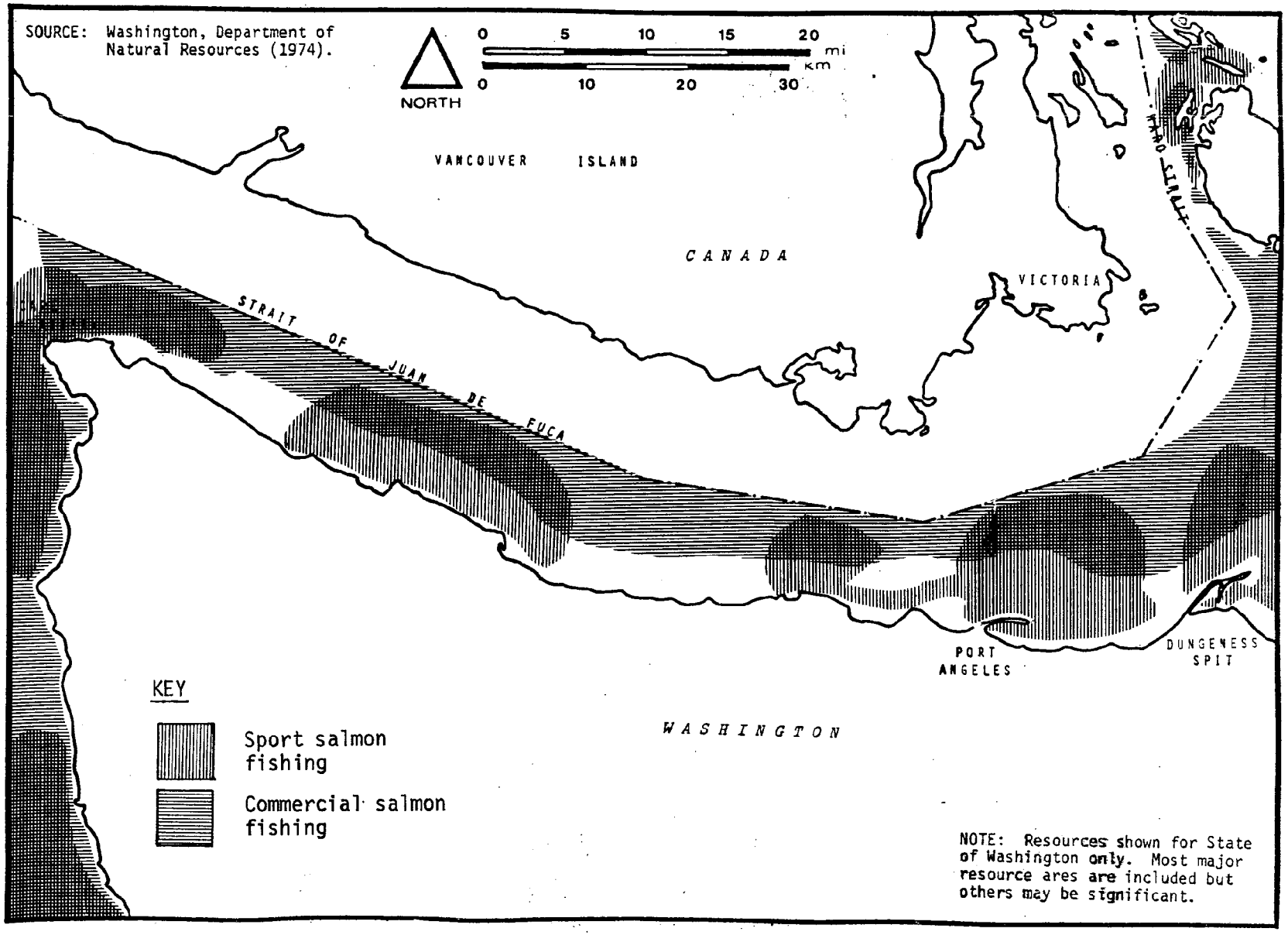


FIGURE VIII-14 SALMON FISHERY - NORTHERN PUGET SOUND

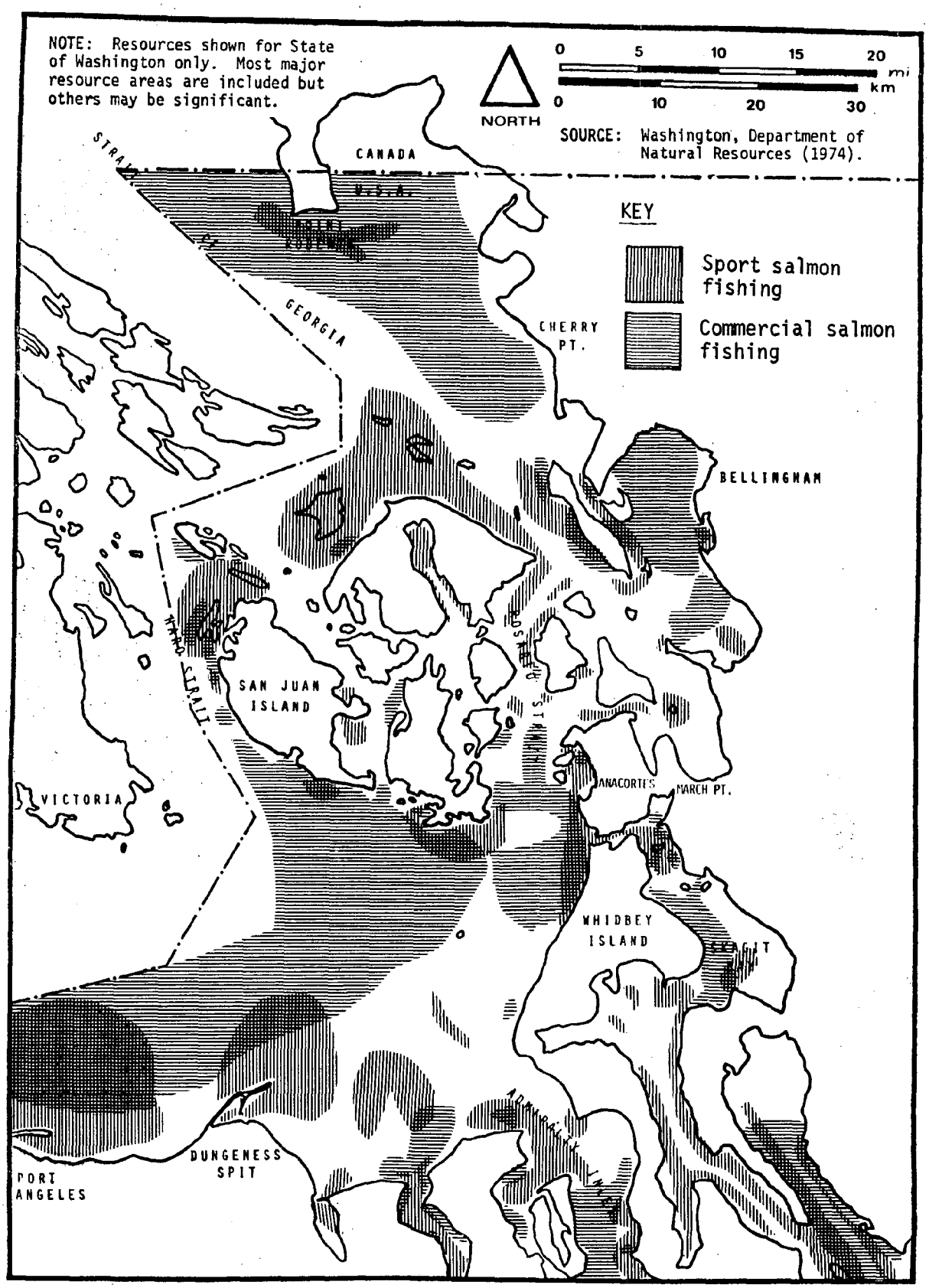


TABLE VIII - 1

Gross Value of Commercial Catch by Fishing Area ($)
(1971 - 1973 Average)

AREA OF CATCH	TANKER ROUTE SEGMENT (Maximum Impact Zone)							SALMONIDS	ALL OTHER	TOTAL
	1	2	3	4	5	6	NA			
Strait of Juan de Fuca										
Swiftsure	1							$ 36,374	$ 7,368	$ 43,742
Cape Flattery	1							989,139	1,498,101	2,483,240
Clallam Bay	1	2						117,885	-	117,885
Discovery Bay		2	3					406,668	-	406,668
Dungeness		2	3					-	11,960	11,960
Port Angeles	1	2	3					132,399	38,327	170,726
Port Discovery		2	3					-	72,999	72,999
Washington Harbor		2	3					-	22,700	22,700
Hoko River	1	2						23,426	-	23,426
Pysht River	1	2	3					33	-	33
Sekiu River	1							1,636	-	1,636
Tatoosh-Sail	1							702,227	-	702,227
Sail River	1							182	-	182
Subtotal								2,405,979	1,651,455	4,057,434
North Puget Sound										
Admiralty Inlet			3	4	5	6		$ 407,836	$ -	$ 407,836
Bellingham Bay			3	4	5			9,024	512,880	521,904
Port Gardner							NA	107,469	109,166	216,635
Point Roberts					5			8,610,802	-	8,610,802
Port Susan							NA	336,763	158,734	495,497
Port Townsend							NA	-	76,295	76,295
Mud Bay			3	4	5	6		-	226,414	226,414
Rosario			3	4	5	6		2,318,309	2,773	2,321,082
Salmon Banks			3	4	5			7,640,694	-	7,640,694
San Juan Channel			3	4	5	6		169,355	29,754	199,109
Skagit Bay					5	6		561,275	44,697	605,972
Saratoga Passage						6		-	10,651	10,651
Stuart Island							NA	475,796	-	475,796
West Beach			3	4	5	6		628,530	110	628,640
Sucia					5			-	70,558	70,558
Samish Bay			3	4	5			157,510	124,131	281,641
Anacortes			3	4	5	6		-	60,927	60,927
Nooksack River			3	4	5			813,719	877	814,596
Hein Bank			3	4	5			-	2,805	2,805
Swinomish Slough			3	4	5	6		-	86	86
Similk Bay			3	4		6		-	45,393	45,393
Subtotal								22,237,182	1,476,251	23,713,433
Gulf of Georgia					5			-	543,511	543,511
All Other Puget Sound Landed (includes south Sound and Canadian catch areas)								4,469,561	5,635,826	10,105,989
Grand Total								$29,112,722	$ 9,307,043	$38,420,367

TABLE VIII-2

EXISTING MARINE RESOURCES:
PERCENT OF TOTAL SOUND'S RESOURCE AREA

RESOURCE	WEST SJF*	DUNGENESS SPIT	TOTAL SJF*	SOUTH PS*	NORTH PS*	SKAGIT BAY	TOTAL (mi^2)
Intertidal clams	6	10	16	53	21	10	450
Subtidal clams	6	11	17	80	2	1	250
Oysters	0	3	3	79	16	2	190
Herring spawning grounds	0	5	5	41	48	5	180
Shrimp	0	0	0	60	18	23	180
Scallops	0	0	0	19	81	0	130
Crab	12	2	14	19	62	5	580
Salmon (sport)	36	10	46	30	19	4	970
Salmon (commercial)	34	7	41	18	37	2	1270
Waterfowl areas	9	11	20	32	33	15	340
Eelgrass beds	1	4	5	50	29	16	200
Bottomfish (sport)	24	3	27	3	67	3	480
Bottomfish (commercial)	10	8	18	5	67	9	540

* SJF = Strait of Juan de Fuca
PS = Puget Sound

Source: Arthur D. Little, Inc.

TABLE VIII-2 (Continued)

MARINE RESOURCE SPECIES

Intertidal clams

- Butter clams
- Littleneck rock clams
- Pacific hardshell clams
- Softshell clams

Subtidal clams

- Geoducs
- Horse clams

Bottomfish

- True cod
- Black cod
- Lingcod
- Red snapper
- Pollock
- Rockfish spp.
- Skate
- Halibut
- Sole spp.
- Flounder
- Turbot

Shrimp

- Spotsided shrimp
- Pink shrimp
- Side stripe shrimp
- Coon stripe shrimp

species are deepwater pelagic. Sockeye, chum, and pink salmon feed on planktonic crustaceans in this environment; coho and chinook salmon feed on herring, other small fish, squid, and crustaceans.

Commercial intertidal marine resources include butter, littleneck, rock, Pacific hardshell, and softshell clams, as well as sea urchins. Subtidal pelagic resources include squid, shrimp species, herring, silver smelt, greenling, and several species of perch. Subtidal benthic resources, which are most commonly harvested by the otter trawl method, include half a dozen species of sole, several species of cod, several species of rockfish, red snapper, halibut, flounder, turbot, pollock and skate, as well as oysters, horse clams, geoduck, and Dungeness crab. The map distribution of these species within north Puget Sound and the Strait of Juan de Fuca is shown in Figures VIII-15 through VIII-20. The areal extent of these resources, grouped according to major categories (i.e., bottomfish, clams, oysters, etc.) are shown in Table VIII-2. The economic value of the resources, by fishing area, is shown in Table VIII-3. The total combined value for all non-salmon fishery resources was $9.3 million (1971-73 average) for all Puget Sound-landed resources. North Puget Sound accounted for $1.5 million (16%) of the total; the Strait of Juan de Fuca for $1.7 million (18%) of the total. With respect to these resources, the south Sound is the richest area, accounting for 38% of the total gross value of non-salmon resources.

(2) Sports Resources. The major sportsfishing resources of the Puget Sound area include the marine sports salmon catch, the steelhead catch in anadromous streams, the non-salmonid, bottomfish harvest, and the shellfish harvest (clam and crab). The major difference between sport and commercial fishing is in the mode of catch. Sportfishing uses baited line; commercial fishing uses various types of nets for many species and is more efficient -- i.e., more fish are caught for the same time spent. Important sports species include 14 species of rockfish, boccaccio, 7 species of sole, speckled sanddab, lingcod, other cod, surf perches, pile and striped seaperch, cabezon, Pacific staghorn sculpin, as well as two greenlings, walleye pollock, and big skate. Major sportsfishing areas were shown in Figures VIII-13 through VIII-16. The areal extent of these grounds was shown in Table VIII-2, the catch by resource area (Figure VIII-12), and imputed economic value at commercial prices is given in Table VIII-4.

Sportsfishing is an extremely important recreational activity for residents of the Puget Sound area and to visitors from out of the area, with nearly 700,000 angler-trips made in 1973. Sportsfishing is also a means by which people obtain marine resources as food at a cost considerably less than ordinary commercial purchase. The total (all Puget Sound) specific catch of 480,400 pounds had an imputed value of $92,000; the incidental catch of 512,000 pounds had an imputed value of $106,300.

Waterfowl hunted for sport include many species of ducks and geese. These birds are considered along with non-hunted birds below. The catch, as given in the Washington Baseline Study: Marine Economic

FIGURE VIII-15 BOTTOM FISH - STRAIT OF JUAN DE FUCA

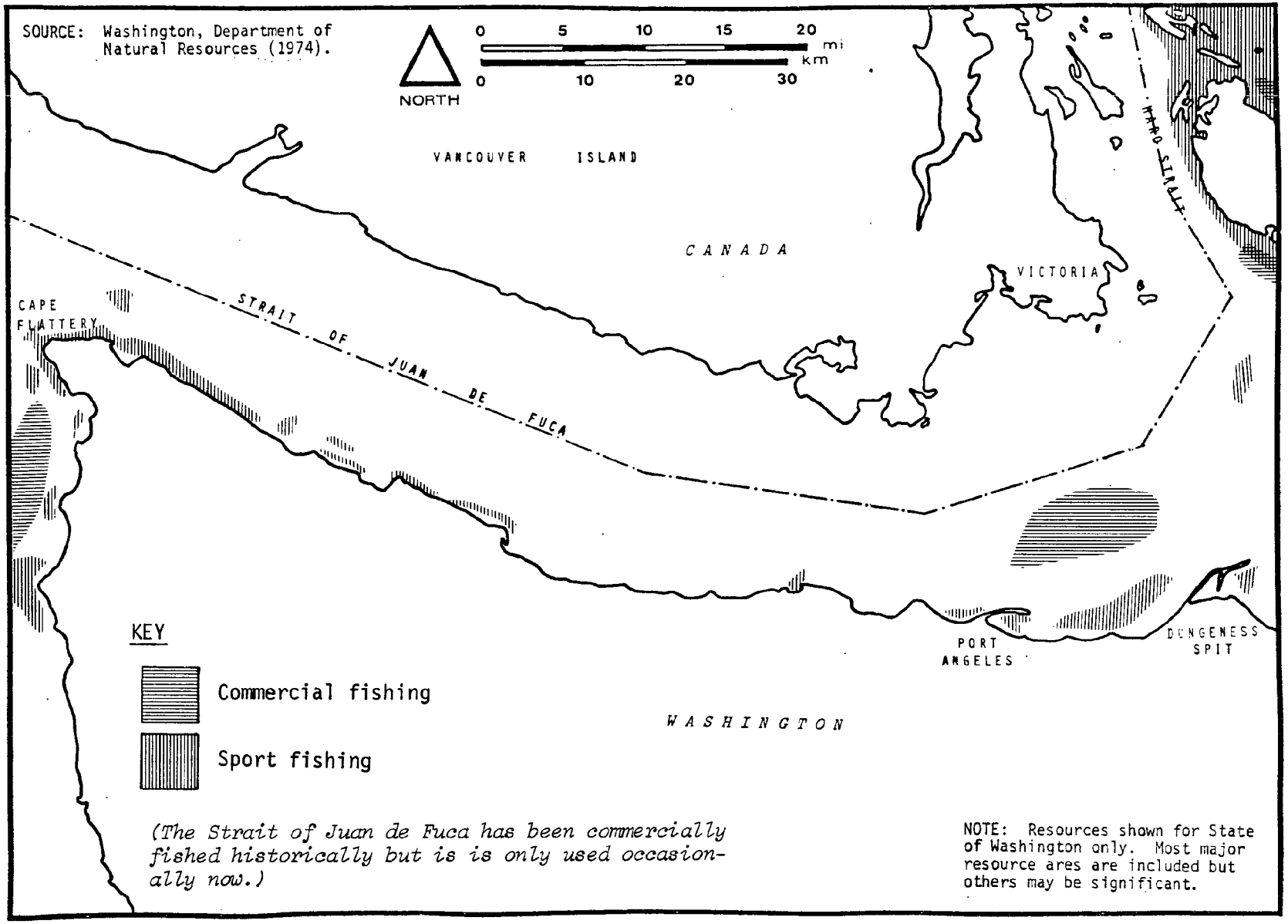


FIGURE VIII- 16 BOTTOM FISH - NORTHERN PUGET SOUND

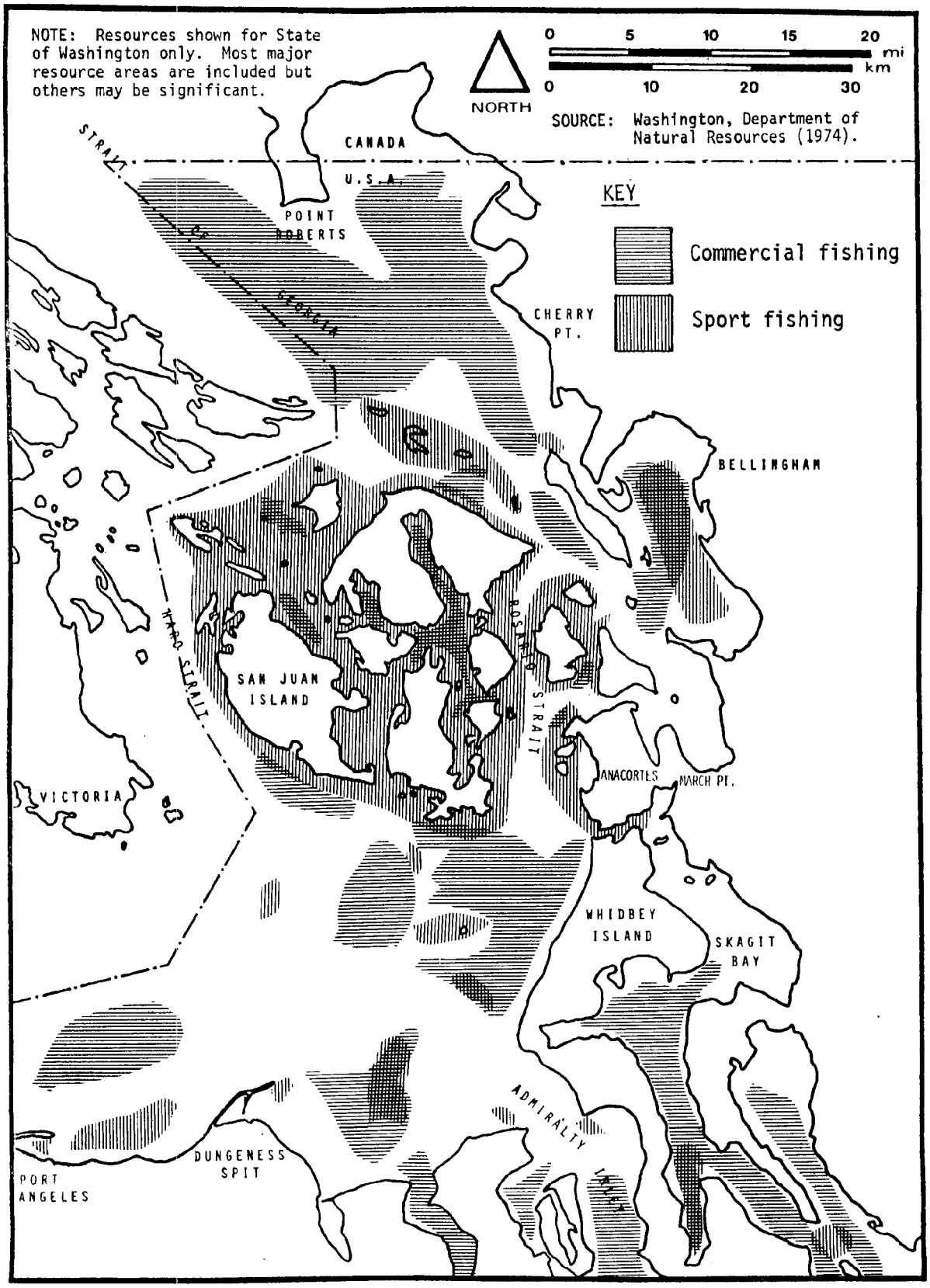


FIGURE VIII-17 INTERTIDAL AND SUBTIDAL RESOURCES - STRAIT OF JUAN DE FUCA

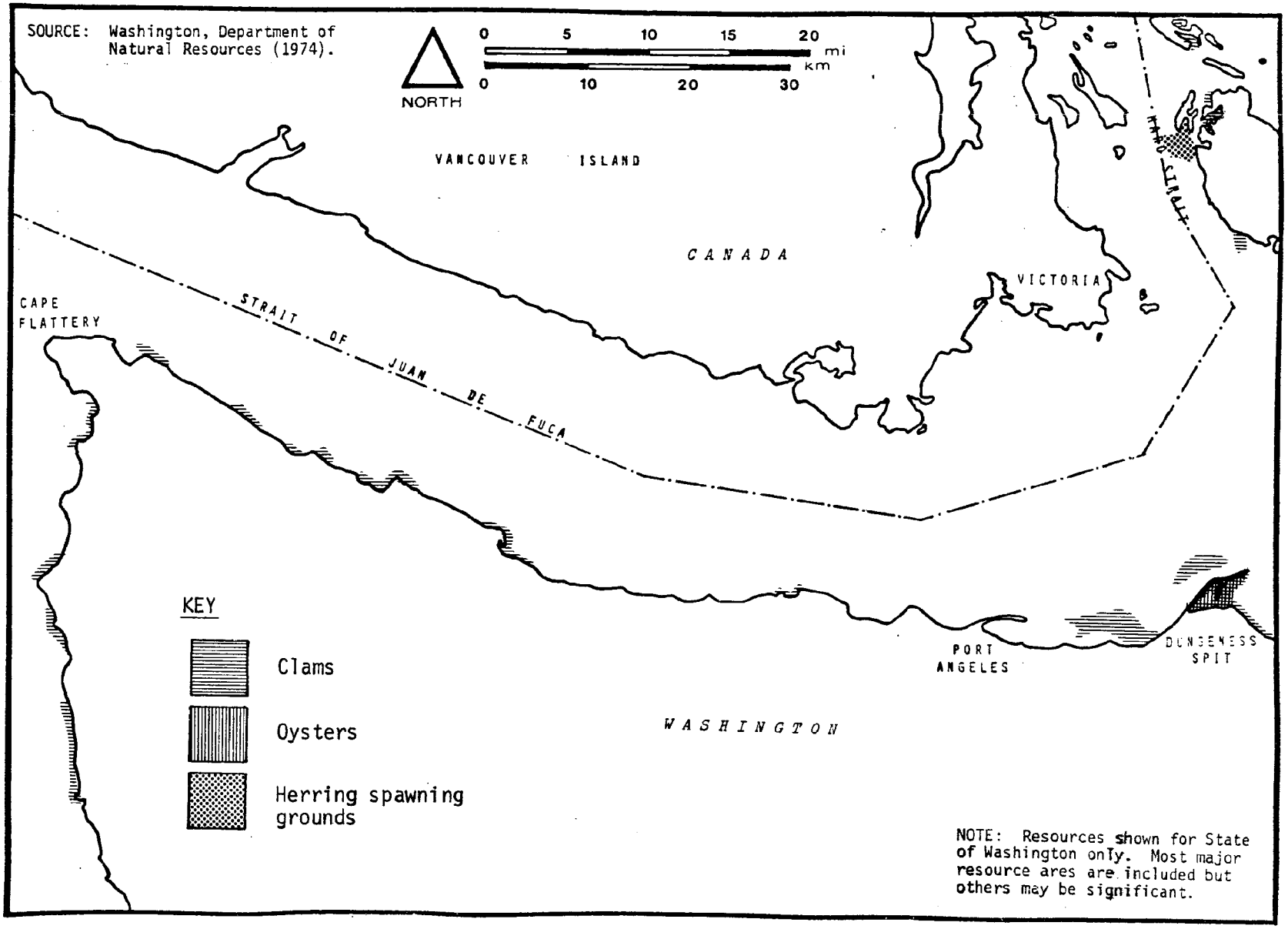


FIGURE VIII-18 INTERTIDAL AND SUBTIDAL RESOURCES - NORTHERN PUGET SOUND

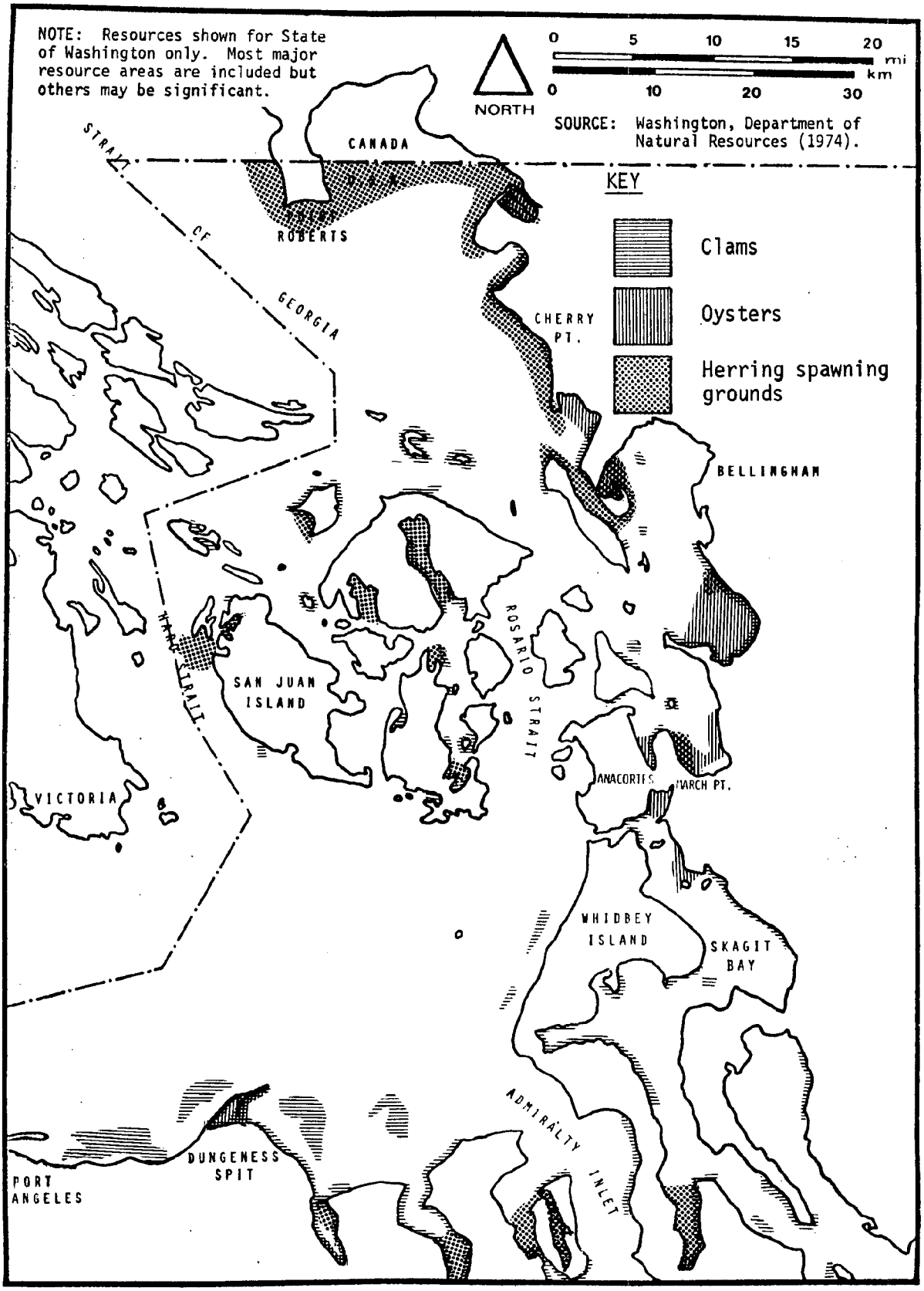


FIGURE VIII-19 DEEPWATER SHELLFISH - STRAIT OF JUAN DE FUCA

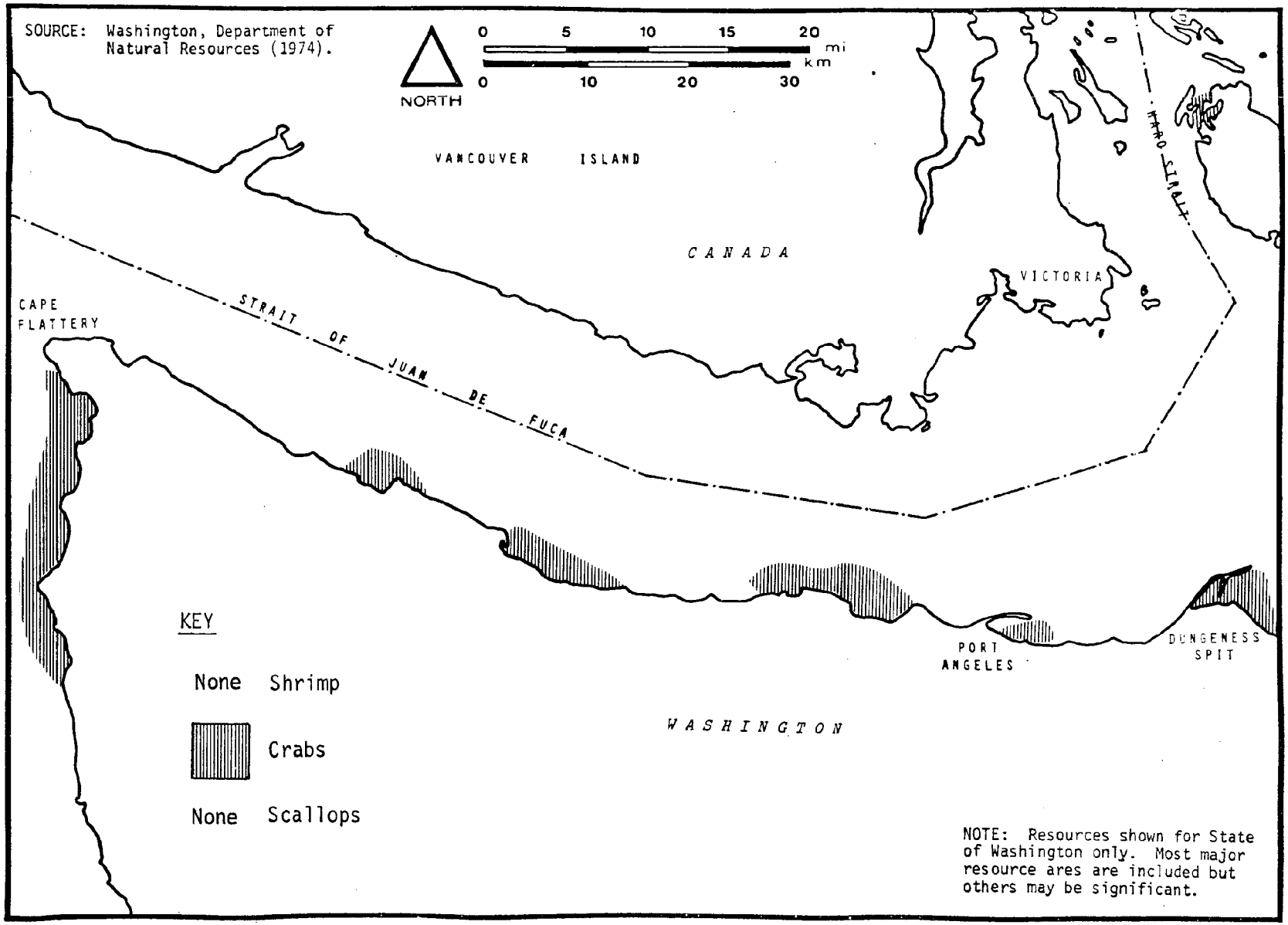


FIGURE VIII-20 DEEPWATER SHELLFISH - NORTHERN PUGET SOUND

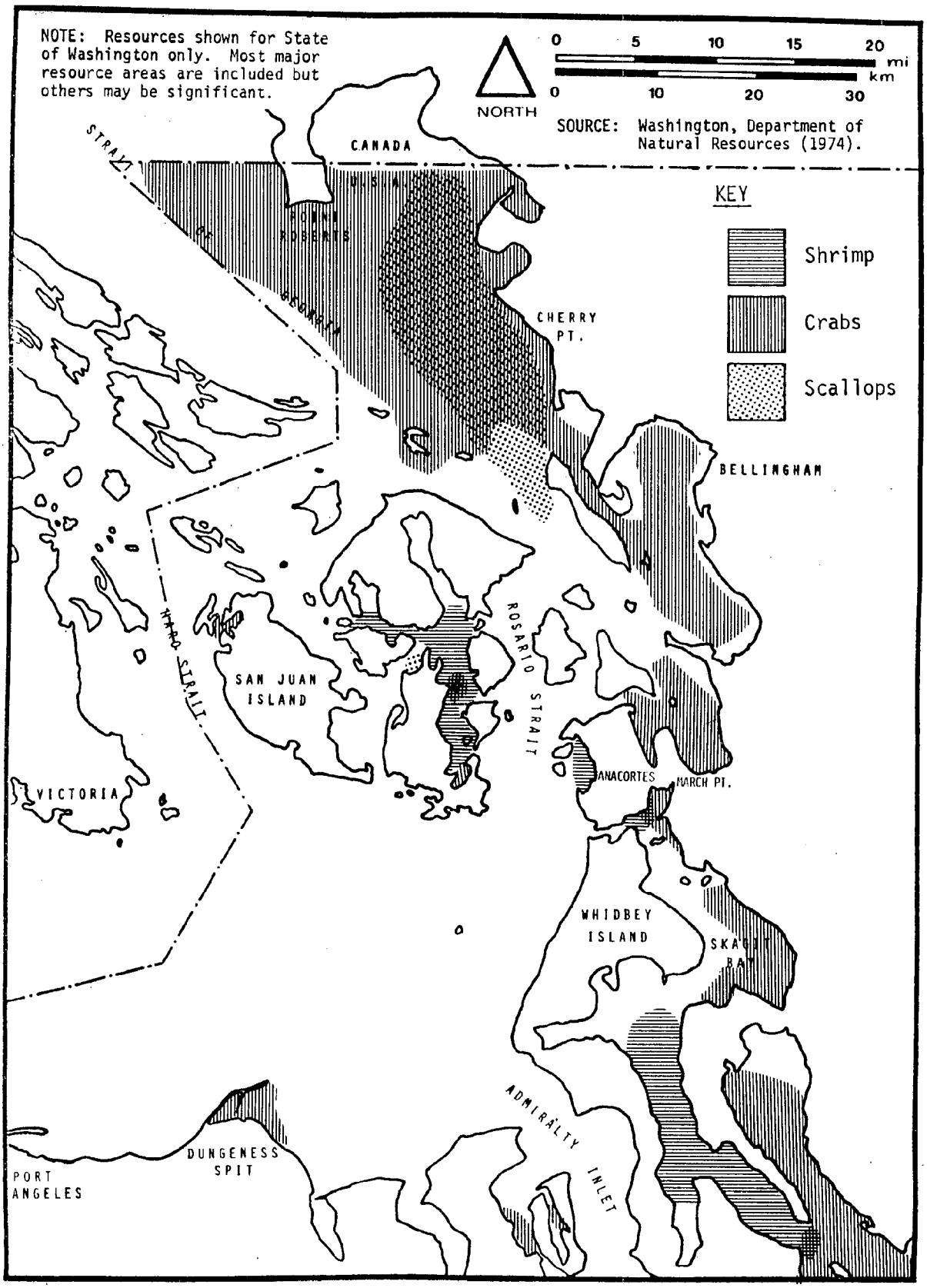


TABLE VIII-3

NON-SALMONID MARINE RESOURCES - ECONOMIC VALUE ($1973)

Strait of Juan de Fuca

SPECIES	TOTAL
Intertidal -	
clams*	55,600
Subtidal benthic -	
bottomfish*	1,632,100
crab	7,100
clams*	0
Olympia oysters	0
Pacific & other oysters	2,500
scallops	0
Subtidal pelagic -	
shrimp*	0
herring	0

North Puget Sound

SPECIES	GULF OF GEORGIA	OTHER NORTH SOUND	TOTAL
Intertidal -			
clams*	0	18,000	18,000
Subtidal benthic -			
bottomfish*	132,900	26,200	159,100
crab	273,200	267,900	541,100
clams*	0	0	0
Olympia oysters	0	0	0
Pacific & other oysters	11,000	415,000	426,000
scallops	100	0	100
Subtidal pelagic -			
shrimp*	0	27,500	27,500
herring	577,100	370,500	947,600

* See Table VIII-2 for listings of species included in this category.

Source: 1973 landings for ports as compiled in:
Institute for Marine Studies, Washington Baseline Study: Marine Economic Component, (Seattle, August 11, 1975).

TABLE VIII-4

SPORT FISHERY - CATCH AND VALUE

Sports Resource Area[a]	Salmon[b]		Specific Bottomfish[c]		Incidental Catch[c]	
	Number	$1000	Pounds	$1000	Pounds	$1000
Area 4	70,246	2,914	4,254	0.6	104,309	20.7
Area 5	58,774	2,438	11,077	2.6	108,909	37.7
Area 6	38,623	1,602	27,643	12.9	59,180	20.2
Area 7	25,792	1,240	60,366	14.6	76,717	17.1
Area 8	4,263	205	5,267	1.1	55,785	13.7

(a) See Figure VIII-12 for definition.

(b) Average 1968-1972 value in 1973 dollars.

(c) 1967 catch weigh is estimate.

Source: State of Washington, Department of Ecology.

Component, Final Report, August 1975, amounts to about 300,000 ducks and 10,000 geese annually, for a total imputed value of about $1 million (ducks) and $100,000 (geese).

(3) Shorebirds and Offshore Feeders. A list of the major shorebirds and offshore feeding birds of the Puget Sound area is given in the appendix table, "Birds of Puget Sound Coastal Waters," which also details seasonality (resident, migrant), breeding status, and relative abundance in the area. Important shorebird habitats, as indicated in the Washington Marine Atlas, are given in Figures VIII-21 and VIII-22. Population counts are given in Table VIII-5. Generally speaking, the large, shallow bays of the north Sound, with their extensive mudflats and areas of eelgrass, are more important for resident shore and marine birds, and the migratory ducks and geese of the Pacific Flyway than are the narrow bays along the shore of the Strait of Juan de Fuca and the Cape Flattery headland area.

Shorebirds are generally those species foraging in the intertidal, along beaches, in tidepools and shallow sloughs, ditches, and mudflats. Offshore feeders include diving and surface feeding birds which may rest or nest on offshore islands or rocks, or may come inshore to sand, cobble beaches or rocky headlands for these activities.

(4) Marine Mammals. The marine mammals which occur in Puget Sound are of two taxonomic orders -- pinnipeds and cetaceans. Pinnipeds comprise seals and sea lions which regularly "haul out" or rest on rocks or beaches, and have land-based rookeries. Cetaceans -- the whales and porpoises -- are entirely pelagic and never normally come out on land. Pinnipeds of the Puget Sound region include harbor seals and northern and California sea lions.

Harbor seals are found in the north Sound, and maintain breeding rookeries on Smith Island (National Wildlife Refuge) and Protection Island. There is a small population in Padilla Bay, and they are also found scattered throughout the San Juan Islands and the Sucias (C. Fiscus, National Marine Fisheries, pers. commun., 1977). Northern and California sea lions do not breed in Puget Sound, but some migrate through the straits (Georgia and Juan de Fuca) during the winter months and can be found hauling out off Victoria Island and one or two islands in the north Sound. These animals leave by May to return to their breeding areas. California sea lions move south while northern sea lions breed to the north on the outer coast, maintaining breeding rookeries on the north end of Vancouver Island and in the Queen Charlotte Islands. These same animals, which number several hundred, are thought to be the same population observed to haul out on small islands off the Washington Coast between Grays Harbor and Cape Flattery. Another mammal, the river otter, which is primarily a freshwater carnivore, occurs throughout the San Juan Islands, probably breeds there, and is known to swim from island to island as part of its foraging habits.

FIGURE VIII-21 WATERFOWL AREAS AND EELGRASS BEDS - STRAIT OF JUAN DE FUCA

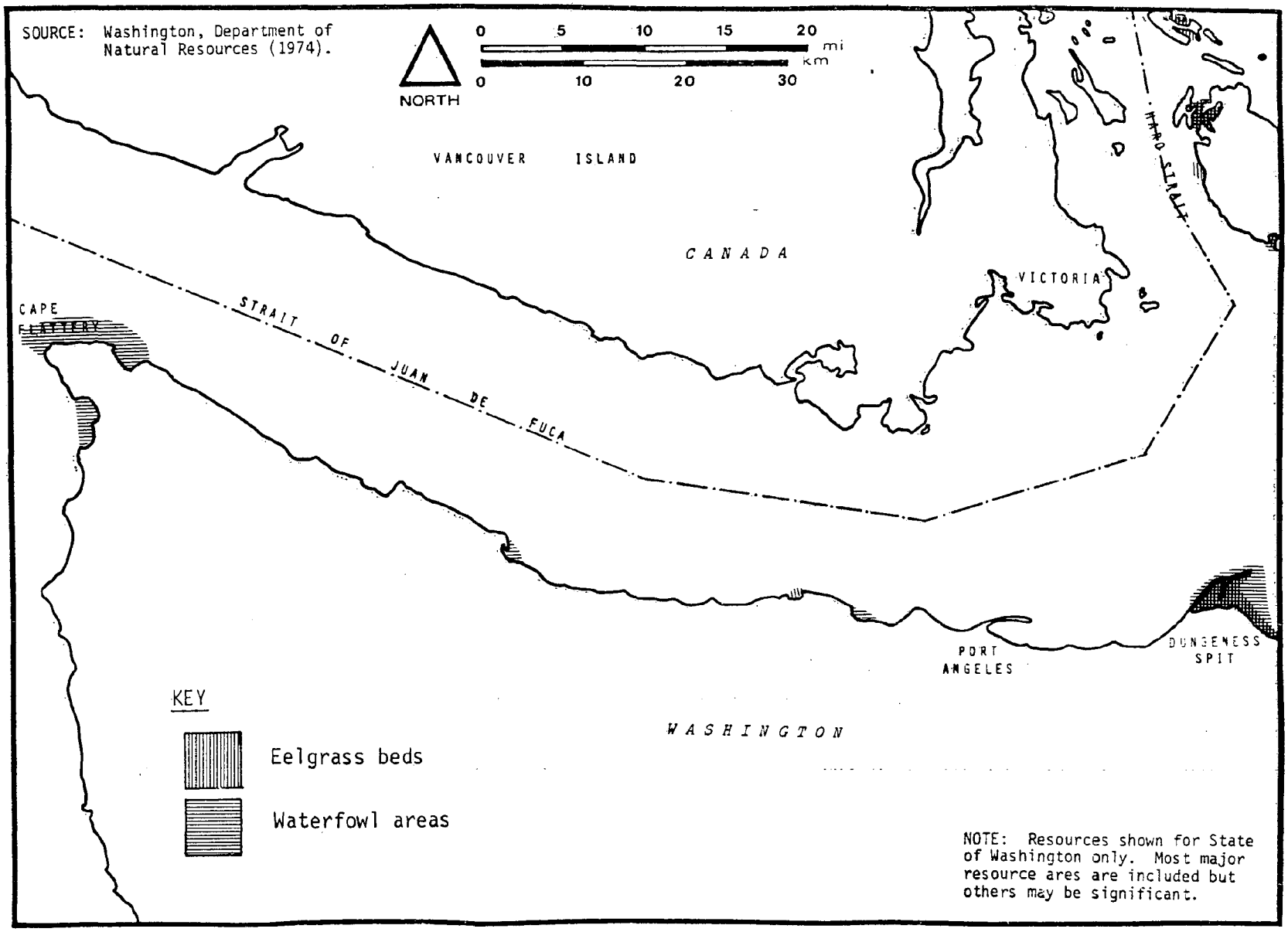


FIGURE VIII-22 WATERFOWL AREAS AND EELGRASS BEDS - NORTHERN PUGET SOUND

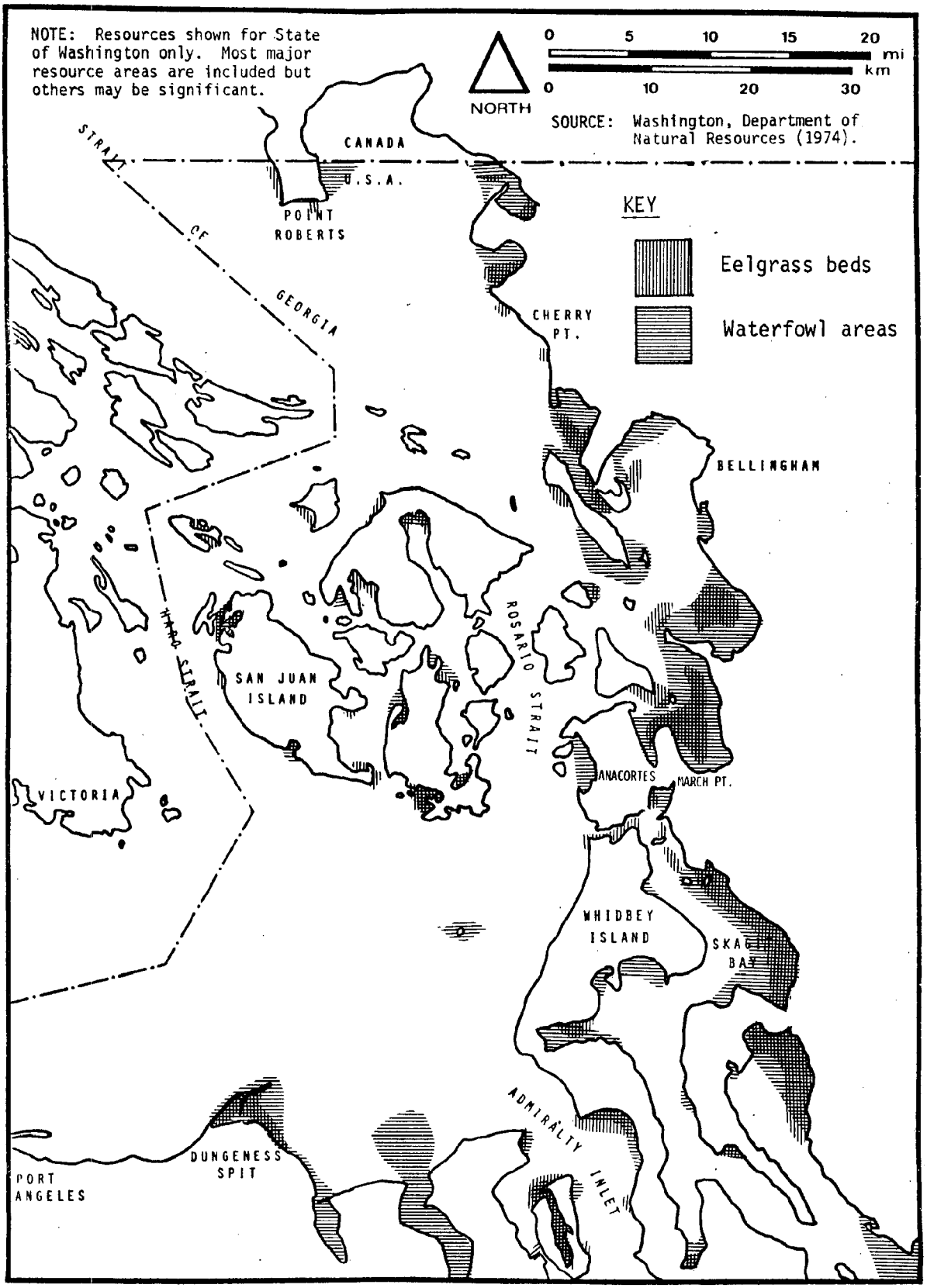


TABLE VIII-5

WATER-RELATED BIRD POPULATIONS FOR SELECTED PUGET SOUND AREAS, 1973, CHRISTMAS BIRD COUNT, AUDUBON SOCIETY[1,2]

Species group	Area observed and number of birds counted					
	Belling-ham, Wash. area	Padilla Bay-Guemes Isl.-Deception Pass	San Juan Island-B.C. (boat)	Seattle, Wash. area	Tacoma, Wash. area	Total
Loons	275	238	125	51	93	782
Grebes	8,051	4,083	383	1,486	915	14,918
Cormorants	231	667	345	131	18	1,392
Egrets and herons	55	104	6	42	38	245
Swans	30	1	0	0	0	31
Geese and brants	226	8,700	0	86	80	9,092
Ducks	10,494	7,898	772	10,414	4,284	33,862
Eagles	9	16	8	0	4	37
Ospreys, hawks, and falcons	14	12	1	1	8	36
Rails, coots, oyster catchers	913	123	0	3,109	690	4,835
Plovers, surfbirds, turnstones	145	179	40	3,212	60	3,635
Yellowlegs, snipes, sandpipers	5,790	11,487	0	86	336	17,699
Gulls and terns	4,650	3,270	1,625	3,722	3,224	16,491
Murres	244	640	1,259	104	255	2,502
Guillamots	6	66	77	14	24	187
Murrelets	27	145	28	13	11	224
Auklets	0	0	9	55	140	204
(Snowy) owls	32	79	0	8	1	120
Kingfishers	17	0	2	12	10	41
Ravens and crows	0	0	12	0	0	12
Blackbirds and cowbirds	1,694	1,750	4	210	307	3,965
Crossbills and song sparrows	717	750	0	514	69	2,050
TOTAL	33,620	40,208	4,696	23,270	10,567	112,361

[1] Two other Puget Sound chapters now exist, but their bird counts are not yet published. They are the Kitsap and Pilchuck chapters, and would cover the Kitsap County and Everett-Port Gardner Bay areas.

[2] The number counted partly reflects the intensity and area of counting activity, although an attempt is made to count the whole population. For example, the San Juan count was done from the ferry, Evergreen State, and the count on some beach birds may be too small for that reason. Numbers of counting-party hours were: Bellingham, 171; Padilla Bay, 118; San Juan Islands, 8; Seattle, 170; Tacoma, 257.

Source: American Birds, April 1974, pp. 496-501. (Table taken from Univeristy of Washington, Washington Baseline Study: Marine Economic Component, 1975).

Cetaceans which occur in Puget Sound include killer, humpback, gray and Minke whales, as well as harbor and Dall porpoises. Killer whales are the best studied by the team at the Seattle Mammal Division of the National Marine Fisheries Service, headed by Allan Wolman and Dale Rice. The whales feed on seals, sea lions, popoises, and sea birds; they occur in Puget Sound at almost all times of the year, with the lowest numbers observed in December through February, and the greatest number in summer. There are thought to be about 65-70 resident killer whales which roam between Race Rocks east of Victoria Islands and southern Puget Sound, probably through Admiralty Inlet. As many as 150 whales have been observed simultaneously in the south Sound, believed by Dr. Michael Bigg of the Canadian research station at Nanaimo to be aggregations of resident and transient animals who have migrated in through the Straits. The resident animals are believed by Dr. Bigg to belong to five family groups (pards) which may breed in Puget Sound; some females have been seen with newborns. The few animals observed in Skagit Bay are thought to have entered by way of Admiralty Inlet and Saratoga Passage, not through Deception Pass.

Humpback whales have been observed off Elliott Bay in the south Sound; these are believed by Rice and Wolman to have entered through the Strait of Juan de Fuca. The other large whale, the gray, also enters the Sound through the Strait of Juan de Fuca, and from there may head north toward the Strait of Georgia or enter the south Sound through Admiralty Inlet. These whales do not venture east of Whidbey Island off of Bellingham or into the Skagit flats because the waters are too shallow. Gray whales breed in Southern California in December and gestation lasts 13 months. Humpback whales also breed in warm waters in winter. Minke whales are found off the southern part of Vancouver Island, in and around the San Juans, including Rosario Strait (Wolman, pers. commun.). There are also reports of a population in southern Puget Sound (SOHIO EIS, Volume 2). They breed in the vicinity of the Southern California Channel Islands.

Harbor porpoises have been observed in a large number of the small bays of Puget Sound, including most of the bays in the Victoria-San Juan belt. This porpoise is believed to breed in these waters. They are largely absent from the west side of Whidbey Island and from Admiralty Inlet south. Dall porposes are found most times of the year within the Strait of Juan de Fuca from Neah Bay to midway between Port Angeles and Victoria Island. Porposes and whales (except the killer) spend most of their time at the water's surface, unless feeding in deep water or near the bottom. Killer whales spend about half the time at the surface and half in deep dives.

(5) Anadromous Fish Streams. A list of the important anadromous fish streams which enter the waters of Puget Sound or the Strait of Juan de Fuca is given in Table VIII-6, which also lists the value of the steelhead catch. Streams located in the north Sound or the strait are potentially within the oil spill impact zone from tanker activities -- the portion of their reach subject to tidal action could be contaminated by oil from a marine spill. Streams with anadromous runs not directly

TABLE VIII-6

TOTAL CATCH AND VALUE OF STEELHEAD CATCH IN WASHINGTON, 1971-1973
(1973 dollars)[1]

North Puget Sound	Average annual catch	Average value 10^3
Cascade River	320	640
•Dakota Creek	37	74
Fisher Slough	4	8
Jim Creek	18	36
Kennedy Creek	6	12
•Nooksack River	1,514	3,028
Nooksack River North Fork	62	124
Nooksack River South Fork	63	126
Pilchuck Creek	259	518
Pilchuck River	1,789	3,578
Raging River	217	434
•Samish River	2,538	3,076
Sauk River	1,415	2,830
•Skagit River	18,193	36,386
Skykomish River	8,993	17,986
Skykomish River North Fork	600	1,200
Skykomish River South Fork	153	306
Snohomish River	4,831	9,662
Snoqualmie River	4,202	8,404
•Squalicum Creek	38	76
Stillaguamish River	3,132	6,264
Stillaquamish River North Fork	5,227	10,454
Stillaquamish River South Fork	1,146	2,292
Suiattle	31	62
Sultan River	99	198
Tokul Creek	1,065	2,130
Tolt River	999	1,998
Wallace River	362	724
•Whatcom Creek	4	8
Whidbey Island	28	56
North Sound Subtotal	57,345	114,690
Other Puget Sound		
Big Beef Creek	22	44
Black River	10	20
Burley Creek	20	40
Carbon Creek	420	840
•Chuckanut Creek	9	18
Cedar River (King County)	1,289	2,578
Coal Creek	1	2

TABLE VIII-6

TOTAL CATCH AND VALUE OF STEELHEAD CATCH IN WASHINGTON, 1971-1973

(1973 dollars)[1] (Continued)

Other Puget Sound	Average annual catch	Average value 10^3
Coulter Creek	30	60
Deschutes River	392	784
Dewatto Creek	184	368
Dosewallips River	519	1,038
Duckabush River	420	840
Duwamish River	142	284
Green River (King County)	14,122	28,244
Hamma Hamma River	102	204
Lake Union Ship Canal	957	1,714
McLane Creek	13	26
Mission Creek	29	58
Nisqually River	1,865	3,730
Puget Sound	1,023	2,046
Puyallup River	6,693	13,386
Quilcene River	273	546
Quilcene River (Little)	28	56
Sammamish River	1,127	2,254
Skokomish River	734	1,468
Skokomish River North Fork	45	90
Skokomish River South Fork	38	76
South Prairie Creek	135	270
Tahuya River	318	636
Union River	271	542
Vance Creek	8	16
Lake Washington	80	160
White (Stuck) River	482	964
Other Puget Sound Subtotal	31,801	63,599
Strait of Juan de Fuca		
•Canyon Creek	210	420
•Clallam River	416	836
•Deep Creek	92	184
•Dungeness River	2,482	4,964
•East Twin River	71	142
•Elwha River	3,136	6,272
•Hoko River	454	908
•Lyre River	2,036	4,072

TABLE VIII-6

TOTAL CATCH AND VALUE OF STEELHEAD CATCH IN WASHINGTON, 1971-1973

(1973 dollars)[1] (Continued)

Strait of Juan de Fuca	Average annual catch	Average value 10^3
•McDonald Creek	56	112
•Morse Creek	121	242
•Pysht River	1,282	2,564
•Sekiu River	73	146
•West Twin River	110	220
Strait of Juan de Fuca Subtotal	10,767	21,534
GRAND TOTAL, All Areas	99,910	1,998,200

• Rivers or streams which empty into waters within marine transit oil spill impact zone.

1 Value of a single steelhead is assumed to be $20. Source: J. Douglas Sheppard, University of Washington and State Department of Fisheries Unit, May 1973. The estimate is a net benefit basis.

Source: Summary of Washington Steelhead Catch (Annual), State of Washington Department of Game, Olympia, Washington. (Table adapted from University of Washington. Washington Baseline Study: Marine Economic Component, 1975)

within the impact zone may still be affected; a major proportion of the total population which supports the runs will continuously be in the marine environment (the 1-4 or more years the immature adults of anadromous fish spend feeding in the ocean or other saline waters).

(6) Spawning Areas. The waters, marshes, and tidal mudflats of the multiple shallow estuarine bays of Puget Sound serve as breeding and nursery areas for many species of finfish and shellfish. The abundance of aquatic food in the form of primary productivity (plants) and secondary productivity (consumers or animals) also makes these areas of intensive use by migratory and resident birds, and by various semi-aquatic or terrestrial mammals.

Specific information in map form is available for herring in Figures VIII-17 and VIII-18, and is somewhat indicative of spawning areas used by other species as well. Herring are important as a commercial bait fish species, but are also important in the marine food chain as the small fish eaten by many larger species which have more direct commercial value as a human food resource, including salmon. Herring spawning occurs in winter and early spring, and the eggs adhere to eelgrass and seaweed in the low intertidal zone.

(7) Threatened or Endangered Species. The occurrence of rare, threatened or endangered species in the Puget Sound area is given in Table VIII-7. Only one fish and one invertebrate species are listed. Both of these occur only in south Puget Sound: the potentially threatened Olympic mudminnow and the Olympia oyster, both of which are associated with shallow waters and mudflats.

Of the whales discussed above under subsection 1-b(4), the gray whale is "potentially threatened" in Washington and "threatened" nationally. Federal surveys conducted along the Washington coast have identified a relatively stable population of less than 500 animals in recent years (State of Washington Department of Ecology, 1975). The humpback whale is classified as threatened by the U.S. Department of Interior, and is also threatened in Washington. The species was given complete protection in 1966 but the number of animals in the North Pacific population appears not to have increased much over the severely depleted level of 1200 individuals. The humpback, a baleen whale, feeds mainly on krill (euphausiids) but also takes anchovies and sardines.

The remaining species listed as threatened or endangered nationally and threatened or potentially threatened in Washington are all birds. The list was compiled from the Washington Department of Ecology publication Marine Shoreline Fauna of Washington: A Status Survey, which lists the known habitats or siting records for these species. A number of the species occur only occasionally or casually in the Puget Sound area; their location cannot be given specifically. The only nationally endangered species which could occur within the potential zone of oil impact are the short-tailed albatross, a casual visitor to Puget Sound; the trumpeter

TABLE VIII-7 OCCURENCE OF RARE OR ENDANGERED SPECIES IN PUGET SOUND AREA

Species	Status Nationally (USDI or IUCN Classification)	Status in Washington State	Preferred Habitats	Food/Feeding Habit	Records of Occurence in Washington	Factors Associated with Decline	Management Recommendations
Short-tailed albatross	Endangered	Accidental	Open ocean, oceanic islands	Squid, whaling ship scraps	Summers offshore; casual visitor in Puget Sound	Decline of whaling Plumage hunting Volcanic destruction of breeding islands	
White pelican	Not threatened	Potentially threatened	Lakes, bays, estuaries, inlets	Non-commercial fish, amphibians, crustaceans	Spring & fall migrant, and summer resident east of Cascades	Habitat loss through reclamation projects	Increase usable breeding sites in eastern WA
California brown pelican	Threatened	Potentially threatened	Shallow salt waters near coastal islands or in tidal rivers	Non-commercial fish, crustaceans; occasionally scavenges	Wanders from Columbia River to Puget Sound between nesting seasons	Breeding ground disturbances Reproductive failure due to DDE contamination	Strict regulation of pesticide usage, chemical waste discharge, and indiscriminate shooting
Trumpeter swan	Endangered (as of 1968)	Potentially threatened	Marshes, lakes, ponds	Digs for roots, tubers, lower parts of aquatic plants	Breeds in eastern WA, migrates throughout state and winters in Skagit area	Plumage hunting Habitat loss through agriculture Lead poisoning	Skagit wintering area should be acquired
Aleutian Canada Goose	Endangered	Unknown; may change to threatened	Coastal salt and freshwater marshes	Grazes on plants	May migrate through coastal Washington; route undetermined	Native killings Predation by introduced foxes	
California condor	USDI: Threatened IUCN: Endangered	Unknown; perhaps extinct	Rocky gorges in mountains	Feeds on carrion	May still occur on east and west sides of Cascades; may be totally extinct in WA	Poisoning Random killing Low natural reproductive rate	Buffer zones around protected lands; no dams or highways built through or around present sanctuary

TABLE VIII-7 (Continued)

Species	Status Nationally (USDI or IUCN Classification)	Status in Washington State	Preferred Habitats	Food/Feeding Habit	Records of Occurence in Washington	Factors Associated with Decline	Management Recommendations
Peale's peregrine falcon	Critically endangered	Unknown but should be considered threatened	Open country: meadows, marshes, beaches, prairies	Birds	WA is southern edge of breeding area, Puget Sound a major wintering area	Habitat destruction Persecution by man Falconry	Eliminate food-chain pesticides Artificial propagation
Arctic peregrine falcon	Following same pattern as Peregrine falcon, now Endangered	Threatened	Tundra	Birds	A rare migrant through Washington	Pesticide effects in wintering grounds	Studies and education Artificial propagation
Mountain quail	Not endangered	Potentially threatened	Dense brush, coniferous forests, canyon thickets, woodland borders	Grubs, insects, berries, seeds	Resides in lower Puget Sound (Olympia, Bremerton), southeast WA; in drainages of Cows Creek, Snake & Columbia Rivers	Habitat destruction through development	Preserve timber and brush growth in southeastern and western WA
Black oyster-catcher	Not endangered	Potentially threatened	Rocky coastlines and islands	Mollusks, crustaceans, marine worms, insects	Permanent resident in St. of Juan de Fuca and San Juan Islands	Loss of habitat	Possible acquisition of key habitat areas
Western snowy plover	Not threatened	Potentially threatened	Sandy dunes above high-water, also upland dunes	Small marine organisms	Winters & breeds in coastal southern WA Fall & spring migrant along coast May be found in dunes of eastern WA	Loss of breeding habitat	Restriction of recreational use of sand dune areas during breeding season Possible acquisition of key habitat areas
California gull	Not endangered	Non-breeders: Satisfactory Breeders: Threatened	Open salt water, sandy shores, mud flats, salt marsh Nests on islands in rivers and lakes inland	Mice, small fish, garbage at dumps	Nests in summer in eastern WA. Non-breeders occur on coast in summer	Dams on Columbia River flooding remaining nesting areas	

TABLE VIII-7 (Continued)

Species	Status Nationally (USDI or IUCN Classification)	Status in Washington State	Preferred Habitat	Food/Feeding Habit	Records of Occurrence in Washington	Factors Associated with Decline	Management Recommendations
Caspian tern	Not threatened	Potentially threatened	Sandy beaches above high tide	Small fish, shrimp, mussels, eggs and young of other birds	WA is northern edge of breeding range Nesting colonies in eastern WA; migrates throught western WA during fall & spring	Human disturbance on beaches Gull competition and predation in nesting areas	Artificial propagation Protection of colonies from human disturbance
Western burrowing owl	Not threatened	Potentially threatened	Arid open country -- adopts old ground squirrel burrows	Insects, small rodents, crayfish	Resident of eastern WA; rarely found in western WA, except in restricted coastal areas in winter	Plowing & cultivation Rancher persecution Pesticide poisoning	Discontinue/limit pesticides Isolate and protect remnant populations
Spotted owl	Very uncommon, vulnerable (USDI)	Potentially threatened	Wet coniferous forests, deeply wooded canyons (virgin timber)	Rodents, insects, small birds	Resides west of Cascades, breeds in North Cascades, along Hoh River and at Ross Lake	Removal of old growth timber in mountains Recreation and construction activities	Absolute protection of environment surrounding nesting sites Preservation of old growth timber
Pileated woodpecker	Not threatened	Potentially threatened	Deep woods, original forest growth	Beetles, ants, fruits, chestnuts, acorns, grubs	Resides and breeds throughout forested areas of WA, east and west of Cascades	Habitat destruction by logging	Refuges of adequate virgin timber stands
Humpback whale	USDI: Threatened IUCN: Endangered	Threatened	Open ocean; migrates in coastal waters	Zooplankton, sardines and anchovies	Accidental occurrence while migrating in St. of San Juan de Fuca, Puget Sound, during spring and fall	Whaling industry overexploitation	Creation of inshore sanctuaries

TABLE VIII-7 (Continued)

Species	Status Nationally (USDI or IUCN Classification)	Status in Washington State	Preferred Habitats	Food/Feeding Habit	Records of Occurrence in Washington	Factors Associated with Decline	Management Recommendations
Golden eagle	Not threatened	Threatened	Arid plateaus with canyons	Birds and small animals	Resident east and west of Cascades Winters in upper Skagit River near Sedro Wooley Breeds in eastern WA	Loss of habitat Reduction of food sources Pesticide poisoning Ranchers' shootings Electrocution	Define, patrol and possibly purchase nesting areas Redesign transmission lines
Northern bald eagle	Not threatened	Potentially threatened	Seacoasts, lakes, rivers	Live and dead mammals, birds and fish	Breeds west of Cascades Winters on Olympic Peninsula, San Juan Islands, and Skagit & Nooksack Rivers	Loss of habitat and food supply Pesticide poisoning and effects Shootings Electrocution	Create "no logging" zones in nesting areas Protect, patrol and/or purchase known nesting spots
Osprey	Not threatened	Potentially threatened	Seacoasts, rivers, lakes, reservoirs, with elevated inaccessible nesting sites	Fish, plus some birds and small mammals	Breeds in WA Found in Strait of Juan de Fuca, Puget Sound, Snoqualmie Nat'l Forest, Snoqualmie Pass, Snohomish River, and Skagit County (<10 nests)	Habitat destruction Predation on eggs Pesticide effects	Continue ban on DDT No logging, no vehicles, no camping in zones (∿ 200 ft) around nesting trees
Peregrine falcon	Endangered	Threatened	Sandy shores, wet coniferous forests, farmland	Large and small birds	Breeds rarely in WA Resides in lowlands both east & west of Cascades, nests in Olympic and Cascade Mountains	Pesticide poisoning and reduction of reproductive success Habitat destruction Shooting, falconry	State-regulated refuges around known nesting sites

TABLE VIII-7 (Continued)

Species	Status Nationally (USDI or IUCN Classification)	Status in Washington State	Preferred Habitat	Food/Feeding Habit	Records of Occurrence in Washington	Factors Associated with Decline	Management Recommendations
Columbian white-tailed deer	Endangered	Potentially threatened	Mosaic of open pasture and wooded cover	Grazing	Reside in flood plains of Lower Columbia River, and possibly as far north as Willapa Bay	Loss of habitat Poisoning by cattle and landowners Hunting	Establish a breeding colony
Olympia oyster	Not listed	Threatened	Bays, sounds, deep channels, tide pools	Phyto- and zooplankton	Found only in southern Puget Sound: Oyster, Mud, South, Oakland, North and Rock Bays	Overharvesting Sulfite waste liquor pollution	Halting sulfite waste liquor discharge into southern Puget Sound

swan which is known to winter in the Skagit area; and possibly the Aleutian Canada goose, which may migrate through coastal Washington. All of these species are at least potentially threatened within Washington.

2. Terrestrial Environment - Pipelines

a. Northern Tier Pipeline-Peninsula Link

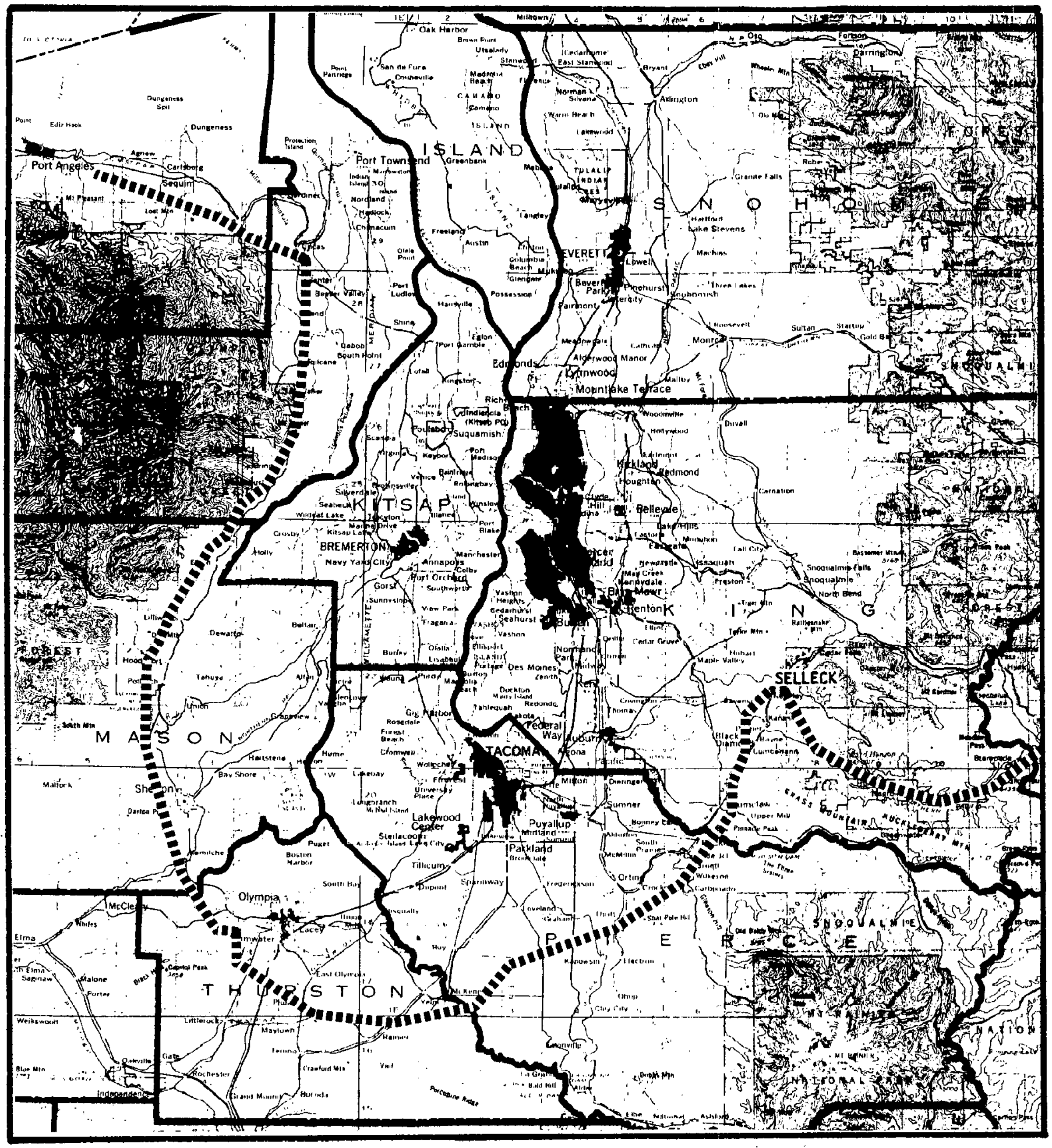
(1) Location. The Northern Tier Pipeline would establish a marine terminal at Port Angeles suitable for off-loading between 500,000 and 1.3 million barrels per day (B/D) from Alaska and foreign sources intended for transshipment to the Northern Tier states. The Peninsula Link is the first portion of that pipeline. It will comprise either a 40-in or a 42-in pipeline, depending upon the implementation of the Puget Spur (discussed in subsection 3) intended to supply the existing refineries along the eastern shore of Puget Sound.

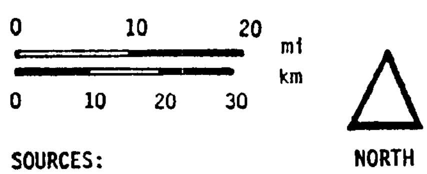
The Peninsula Link itself stretches 170 miles: from Port Angeles along the Strait of Juan de Fuca down the eastern side of the peninsula along the Hood Canal; it runs south of the City of Olympia and skirts the urban areas of the Puyallup River valley to reach an intersection in the vicinity of Selleck or North Bend between the Green and Snoqualmie Rivers (Figures VIII-23 and VIII-24). This intersection is the terminus of the Puget Spur and the origin of the East Washington link discussed below. The route of the Peninsula Link discussed in this study was obtained from maps contained within the Northern Tier site certification -- a part of the application made by the Northern Tier Pipeline Company to the State of Washington Energy Facility Site Evaluation Council. The route appears to be based on preliminary engineering studies and 70% of it follows an existing Bonneville Power Administration transmission line right-of-way or other existing rights-of-way.

If the Northern Tier proposal is to be implemented the pipeline route along the Peninsula Link will be subject to more intensive investigation in order to minimize construction and capital costs and to reduce right-of-way expense and damage; however, a final route would probably be similar to that depicted in this study; other than a submarine pipeline across Admiralty Inlet extending toward the eastern shore of Puget Sound, few alternatives are available. Such a submarine proposal was considered in earlier years but has an element of construction costs and risks which offset a savings of approximately 50 miles of onshore pipeline.

(2) Land Use. Land use information for the five segments of the Northern Tier Pipeline-Peninsula Link is summarized in Tables VIII-8 through VIII-13. Land use is broken down into three major categories -- forest, agriculture, and urban land -- with special designations for riparian corridors and rights-of-way. The information was developed using USGS topographic map information and reflects the level of detail possible with these maps, most of which are at the 1 inch = 2000 feet scale.

FIGURE VIII-23 LOCATION NORTHERN TIER PIPELINE: PENINSULA LINK & EAST WASHINGTON LINK

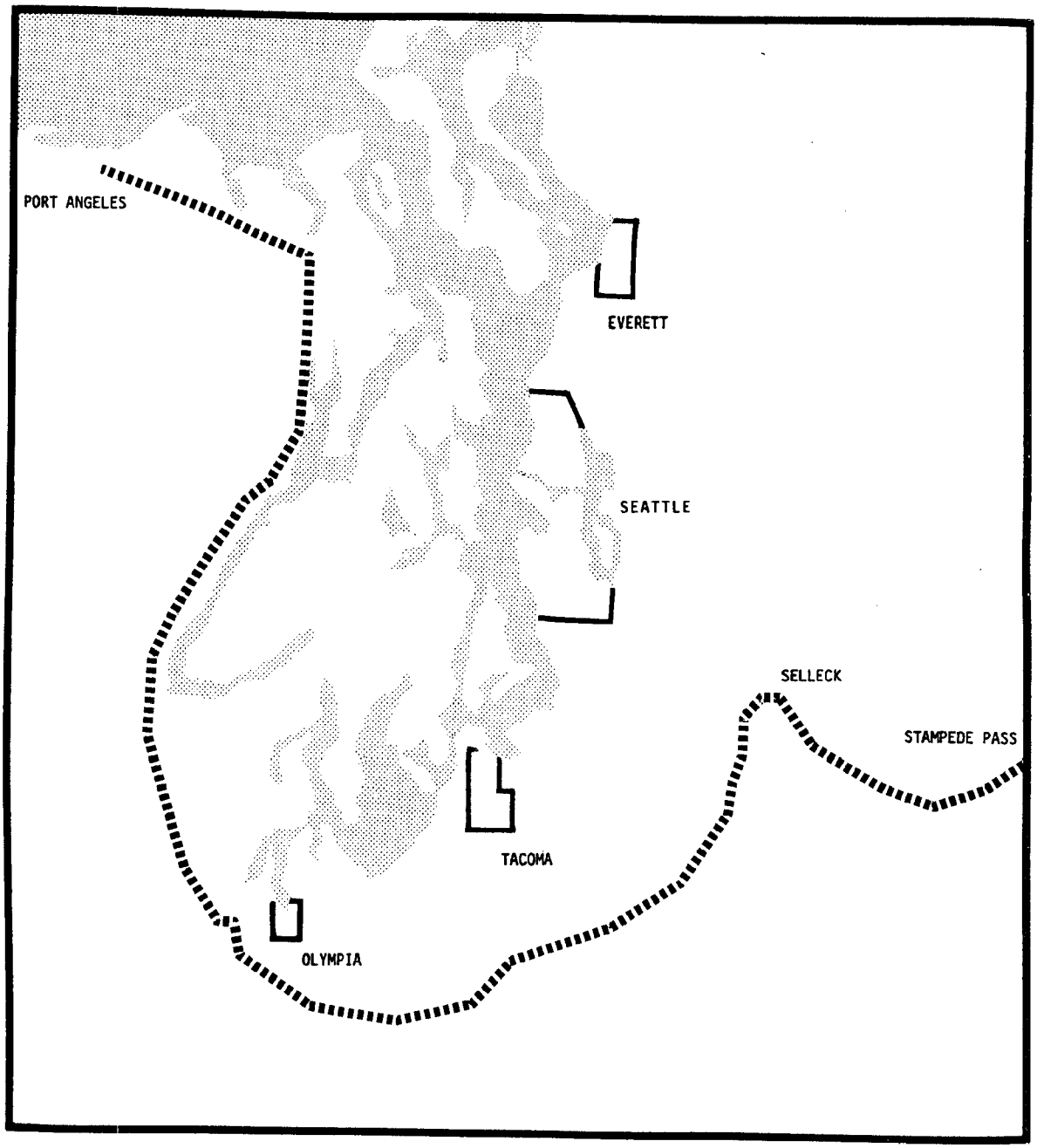




SOURCES:

Northern Tier Pipeline Co., "Site Certification", July 6, 1976.

FIGURE VIII-24 ROUTE SCHEMATIC: PENINSULA LINK & EAST WASHINGTON LINK



0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:

Northern Tier Pipeline Co., "Site Certification", July 6, 1976.

TABLE VIII-8

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 1: Morse Creek to Sequim

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	18.64	100	67	7.9	25	0
New Right-of-Way	0					
Total	18.64	100				

TABLE VIII-8 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 1: Morse Creek to Sequim

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Morse Creek	2000'	Blue Mountain Road			None Significant	
Bagley Ck.	200'	O'Brien Rd.				
Siebart Ck.	400'	Bagley Ck. Rd.				
Emery Ck.	200'	Deer Park Rd.				
Pederson Ck.	300'	East Mt. Pleasant Rd.				
Jimmy-come-lately Ck.	1200'					
Johnson Ck.	200'					
Dean Ck.	200'	Woods Rd.				
4 Unnamed Cks.	200'	Palo Alto Rd.				
		6 Unnamed Rds.				

TABLE VIII-9

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 2:Gardiner to The Brothers

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	33.64	87.6	92	1.5	6.3	0
New Right-of-Way	4.78	12.4	70	7.1	18	5.1
Total	38.42	100				

TABLE VIII-9 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 2: Gardiner to The Brothers

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Salmon Ck.	7000'	West Uncas Rd. (2x)	Quilcene		None Significant	
Snow Ck.	200'	Olympic Highway	Brinnon			
Little Quilcene R .	8200'	Spur Rd. (5x)				
Big Quilcene R .		Highway 101 (2x)				
		Lindsay Rd.				
Duckabush R .	2200'	Duckabush Rd.				
Spencer Ck.	200'	9 Unnamed Rds.				
Jackson Ck.	200'					
Turner Ck.	200'					
McDonald Ck.	200'					
3 Unnamed Cks.	250'					
Waketickeh Ck.	250'					
Hamma Hamma R .	500'					
John Ck.	250'					
2 Unnamed	250'					
Jorsted Ck.	250'					
Eagle Ck.	250'					
NEW RIGHT OF WAY						
Dosewallips R .	5000'	Dosewallips Rd.				
Walkers Ck.	200'	1 Unnamed Rd.				

TABLE VIII-10

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 3: Potlatch to Shelton

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	28.38	74.8	94	0.9	4.3	0.4
New Right-of-Way	9.56	25.2	89	1.2	2.6	10
Total	37.94	100				

TABLE VIII-10 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 3: Potlatch to Shelton

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings: Type	Sensitive Area Crossings: Name	Sensitive Area Crossings: Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Lilliwaup Ck.	520'	1 Unnamed Rd. (2x)			None Significant	
Sund Ck.	520'	1 Unnamed Rd. (6x)	Skokomish Indian Reservation Town			
Finch Ck.	520'	1 Unnamed Rd. (2x)				
Skokomish R.	5200'					
Miller Ck.	520'					
Perry Ck.	520'	Highway 90 Northern Pacific RR U.S. Route 1 Hicklin Rd. 12 Unnamed Rds.				
Kennedy Ck.	1040'					
Skookum Ck.	2600'					
NEW RIGHT OF WAY		NONE				

TABLE VIII-11

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 4: Tumwater to Frederickson

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	16.60	39.1	61	1.4	35	2.3
New Right-of-Way	25.83	60.9	53	2.9	35	8.7
Total	42.42	100				

TABLE VIII-11 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 4: Tumwater to Frederickson

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
McLane Ck.	2200'	McKenzie Rd.	Lamberts Corner		None Significant	
Deschutes R.	4400'	Zeller Rd.				
South Ck.	200'	Algyer Rd.				
		Roy Christy Rd.				
		Harts Lake Loop Rd.				
		Taylor Rd.				
		Hawk Rd.				
		Mathias Webster Rd.				
		Highway 101				
		Davis Rd.				
		Thrift Extension Rd.				
		Orting Kopowsin Rd.				
		CMSP&P RR				
		2 Unnamed Roads				
NEW RIGHT OF WAY						
Black R.	3000'	2 Unnamed Rds.		Marsh	Surrounding Black R.	550 Ac.
Salmon Ck.	2800'	Tilly Rd.		Marsh		175 Ac.
2 Unnamed Cks.	200'	Case Rd.		Prairies (3)		6600'
1 Unnamed Ck.	600'	Nunn Rd.		Prairie	Weir	11,400'
Yelm Ck.	1000'	Interstate 5		Prairie		12,000'
Nisqually R.	3000'	Lathrop Rd.		Marsh		130 Ac.
Centralia Canal	200'	Little Rock Rd.				
Flume Yelm Ditch	200'	Black Lane				
1 Unnamed Ck.	200'	3 Unnamed Rds.				

TABLE VIII-11 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 4: Tumwater to Frederickson (con't)

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
NEW RIGHT OF WAY						
1 Unnamed Ck.	400'	3 Unnamed Rds. Burlington Northern RR Union Pacific RR Offutt Lake Rd. Hubbard Rd. State 507 Morris Rd. Vail Loop Rd. Bald Hill Rd. Hannus Rd. Harts Lake Loop McKennan Rd. Allen Rd. Tisch Rd. Tisch Rd. North 14 Unnamed Rds.		None Significant		

TABLE VIII-12

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 5: Orting to Cumberland

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	19.89	61.3	80	4.0	15	0.4
New Right-of-Way	12.53	38.7	57	3.6	20	20
Total	32.42	100				

TABLE VIII-12 (Continued)

NORTHERN TIER PIPELINE: PENINSULA LINK

Pipeline Segment Summary

Segment 5: Orting to Cumberland

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Puyallup R.	1200'	Fiske Rd.		Marsh		250 Ac.
Coplar Ck.	200'	Highway 162				
Voight Ck.	400'	Northern Pacific RR				
1 Unnamed Ck.	600'	Patterson Rd.				
Carbon R.	1200'	Tubbes Rd.				
2 Unnamed Cks.	200'	Johns Rd.				
Deep Ck.	200'					
Green R.	1000'	Burlington Northern RR				
		Northern Pacific RR				
		9 Unnamed Rds.				
NEW RIGHT OF WAY						
Wilkeson Ck.	600'	Spiketon Rd.	Buckley vicinity			
South Prairie Ck.	600'	Pipeline Rd.	Enumclaw vicinity			
White Rd.	3800'					
Boise Ck.	200'	276th Ave. SE				
Newaukum Ck.	200'	284th Ave. SE				
2 Unnamed Ck.	200'	Highway 410				
Coal Ck.	200'	SE 408th St.				
		SE 392D St.				
		6 Unnamed Rds.				

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TABLE VIII-13

NORTHERN TIER PIPELINE - PENINSULA LINK

Land Use Summary

Segment Name	Segment Length (Miles)	Average Slope of Route %	Miles on Right of-Way	% of Segment	% Forest	% Agric.	% Riparian	% Urban	Stream Crossings Major	Stream Crossings Minor	Road and Railroad Crossings
Morse Creek to Sequim	18.64	5.8	18.64 *0*	100 *0*	67 *0*	25 *0*	7.9 *0*	0	1	11	13
Gardiner to the Brothers	38.42	8.8	33.64 *4.78*	87.6 *12.4*	91.5 *70.2*	6.3 *17.6*	1.5 *7.1*	0 *5.1*	4 *1*	15 *1*	15 *2*
Potlatch to Shelton	37.94	7.6	28.38 *9.56*	74.8 *25.2*	94.4 *88.5*	4.3 *2.6*	0.9 *1.2*	0.4 *10.3*	1 *0*	7 *3*	27 *7*
Tumwater to Frederickson	42.42	2.1	16.60 *25.83*	39.1 *60.9*	61.3 *53.0*	35.0 *35.4*	1.4 *2.9*	2.3 *8.7*	1 *3*	2 *7*	15 *43*
Orting to Cumberland	32.42	4.8	19.89 *12.53*	61.3 *38.7*	80.3 *56.5*	15.3 *19.9*	4.0 *3.6*	0.4 *19.9*	3 *1*	6 *7*	17 *13*
Total	169.84		117.15 *52.69*	69.0 *31.0*					10 *5*	41 *18*	87 *65*

BOLDFACE = Existing Right-of-Way
ITALIC = New Right-of-Way

Figure VIII-25 shows which quadrangles are intersected by the Northern Tier route (Peninsula and East Washington links). The environmental setting is broken down into segments, each roughly corresponding to areas of like terrain or similar degree of urbanization. The segments are named for the quadrangles which serve as inclusive end points.

- Segment 1 - Morse Creek to Sequim

The first segment of the route leaves Port Angeles and runs roughly parallel to the shoreline of the Strait of Juan de Fuca, all on existing transmission line right-of-way. Three-quarters of its 19-mile length is in forest and the remaining quarter is intensive agriculture. Thus, the existing transmission line route crosses 11 public rights-of-way, all of which are light- to medium-duty local roads (Figure VIII-26). It also crosses seven named drainages, the most important of which is the Dungeness River (Figure VIII-27). This segment of the pipeline route traverses no urban areas and is moderately flat.

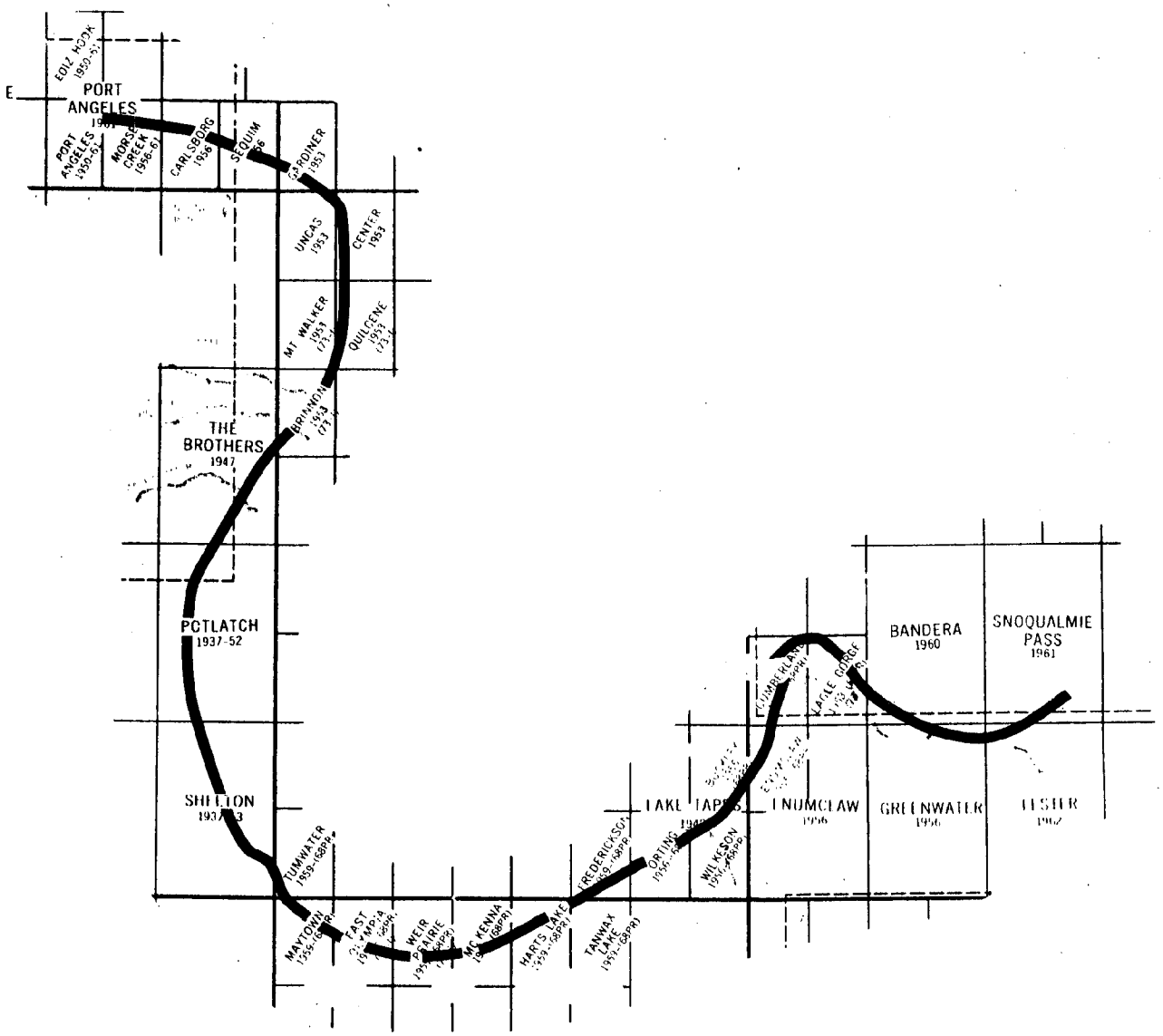
- Segment 2 - Gardiner to the Brothers

The second segment of the route traverses the mountainous area of the Olympic Peninsula just west of the Hood Canal. Seven-eighths (33 miles) of the total corridor length in this segment traverses existing right-of-way. That portion of the line is 93% in timberland and the remainder is in agriculture. Only about 5 miles of this segment will require construction of new right-of-way through about three-and-one-half miles of forest land, one mile of agricultural land, and about one-fourth mile of urban land -- the communities of Brinnon and Quilcene. The pipeline will cut directly through the center of these small highway towns on U.S. 101. The existing transmission line right-of-way crosses three minor roads and two major highways -- U.S. 101 and the Olympic Highway -- in addition to five riparian corridors of which four are major streams (see Table VIII-10). The new right-of-way segment crosses three minor roads and one major riparian corridor, the Dosewallips River. The proposed route in this segment traverses an area of occasionally quite steep mountainous terrain. The overall average slope of the route alignment is nearly 9%.

- Segment 3 - Potlatch To Shelton

The third segment of the Peninsula link, nearly 40 miles in length, traverses the southern portion of the eastern edge of the Olympic Peninsula, running parallel to the Hood Canal. Roughly three-quarters of this segment is proposed to follow within an existing transmission line corridor. Of the 28-mile total, 95% is forested land and the remainder is agriculture with the exception of about one mile of line crossing an urban area -- the vicinity of the town of Shelton. One-quarter of the proposed route in Segment 3, roughly nine miles of forested lands and one mile of agricultural lands, will require clearing a new right-of-way. The existing transmission line right-of-way in Segment 3 crosses 11 transportation corridors, of which three are relatively major highways in this

FIGURE VIII-25 USGS TOPOGRAPHIC MAPS ALONG PENINSULA LINK & EAST WASHINGTON LINK



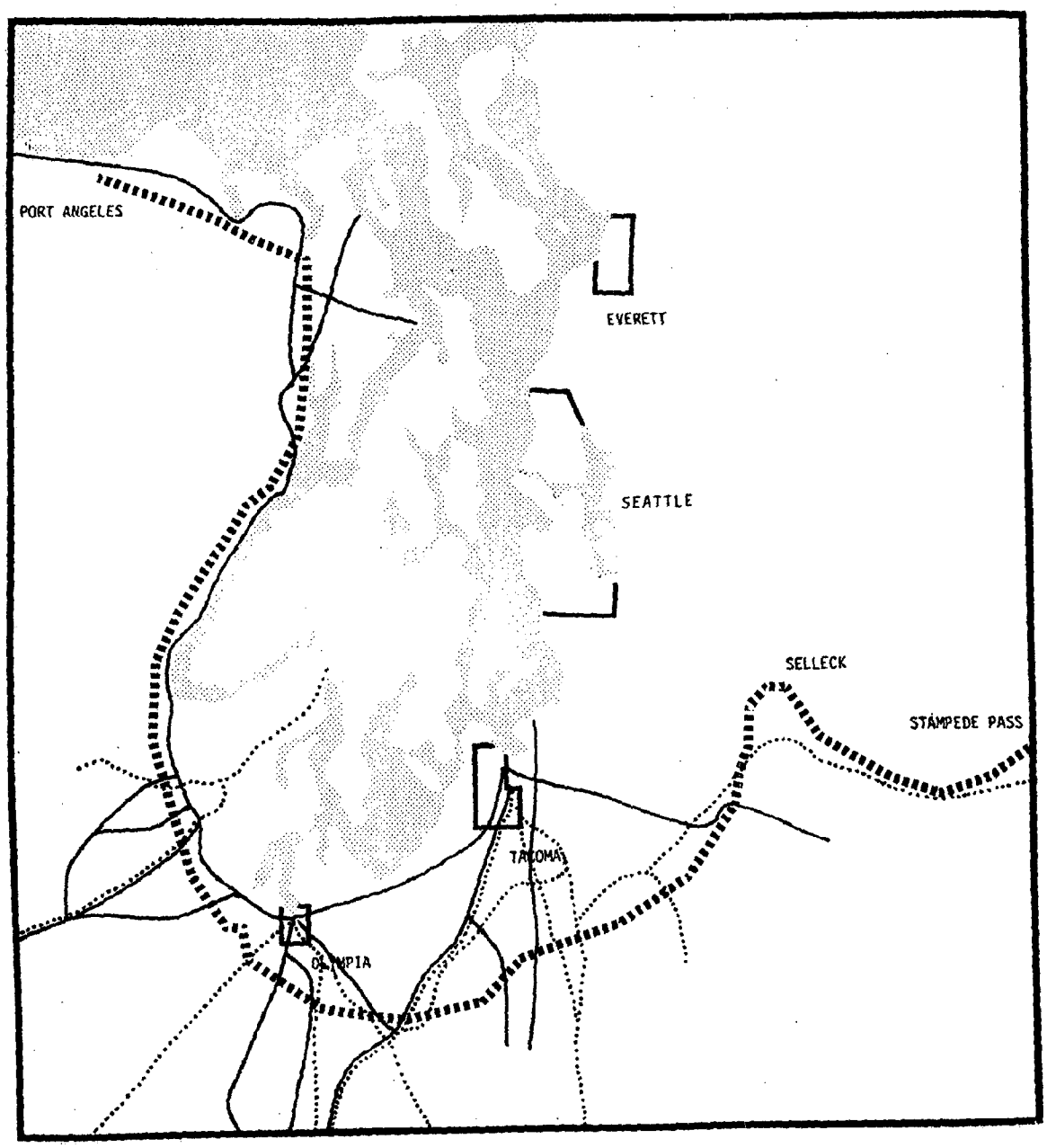
0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:

Northern Tier Pipeline Co., "Site Certification", July 6, 1976.

FIGURE VIII-26 MAJOR TRANSPORTATION CORRIDOR CROSSINGS: PENINSULA LINK & EAST WASHINGTON LINK



Transportation Corridors

Major roads

Railroads

0 10 20 mi

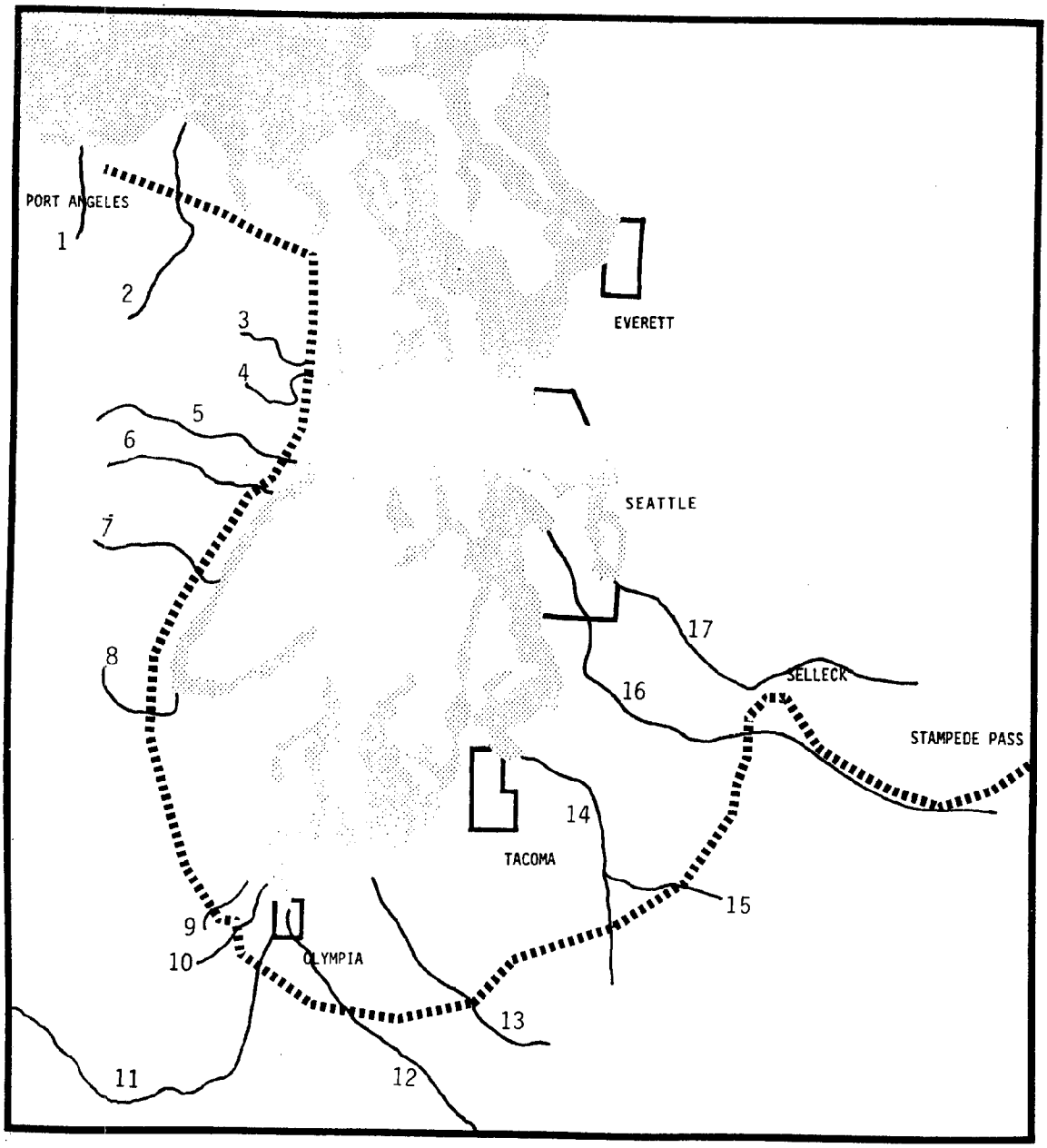
0 10 20 30 km

NORTH

SOURCES:

Arthur D. Little, Inc.

FIGURE VIII- 27 MAJOR STREAM CROSSINGS: PENINSULA LINK & EAST WASHINGTON LINK



Rivers

1 - Morse Cr.
2 - Dungeness R.
3 - Quilcene R.
4 - Little Quilcene R.
5 - Dosewallips R.
6 - Duckabush R.
7 - Hamma Hamma R.
8 - Skokomish R.
9 - Skookum Cr.
10 - Kennedy Cr.
11 - Black R.
12 - Deschutes R.
13 - Nisqually R.
14 - Puyallup R.
15 - Carbon R.
16 - Green R.
17 - Cedar R.

0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:
Arthur D. Little, Inc.

region, including State Highway 84 west and 108 (Figure VIII-26). It crosses seven riparian corridors, the most important of which is the Skokomish River (Figure VIII-27). The new right-of-way segment will cross five minor roads and three creeks. The proposed route in the segment is moderately steep, with an average line slope of 7.6%.

- Segment 4 - Tumwater to Fredrickson

The fourth segment of the Peninsula Link runs in largely an east-west direction across the flatlands and prairies of south Puget Sound. About four-tenths (17 miles) of the route is with an existing transmission line right-of-way, about 10 of the 16 miles run through forested lands and about five miles run through farmlands; the remaining miles cross the urban community of Lamberts Corner. The existing right-of-way portion crosses 13 transportation corridors, including State Highway 161 (Figure VIII-26). Four drainages are involved, the largest of which is the Deschutes River (Figure VIII-27).

Approximately 26 miles of Segment 4 requires the construction of a new corridor of which about 14 miles must pass through wooded lands, eight miles will pass through non-wooded lands, and about two miles will have to cross relatively urban areas. The non-wooded lands in this instance comprise both agriculture and five of the Puget prairies, including Weir and Yelm. The prairies are described in subsection 2-a(3), Terrestrial Biology. A total of 30,000 feet of pipeline will cut across one or another of these prairies. In all, 27 transportation corridors will be interrupted by pipeline construction, including Interstate 5, State Highway 507, and the Union Pacific Railroad (Figure VIII-26). The route will require construction across five riparian corridors, including both the Black River and the Nisqually River (Figure VIII-27). The terrain in Segment 4 is quite flat, with an average pipeline slope of only 2%.

- Segment 5 - Orting to Cumberland

Segment 5 runs northeast on the eastern side of Puget Sound from the Puget prairies toward Snoqualmie Pass. Four-tenths of the segment, about 20 miles, requires expansion of an existing transmission line right-of-way and the reamining 12.5 miles will require new right-of-way corridor. About 17 miles of the existing transmission line corridor runs through wooded lands, and all of the remaining three miles runs through agricultural lands with the exception of a small segment which crosses an urbanized area. The route intersects 13 transportation corridors, all roads, including State Highway 162 (Figure VIII-26). It also crosses six creeks and three rivers -- the Puyallup, Carbon, and Green (Figure VIII-27).

Where new right-of-way is required, about 7.5 miles of the corridor will have to be constructed through forested lands, about 2.5 through agricultural lands, and about 2.5 miles will affect the urban settlements in the vicinity of Buckley and Enumclaw. Construction of the new right-of-way

segment will require crossing 18 major roads, including State Highway 162 in two places and State Highway 410. Three riparian corridors are involved, the most important of which is the White River. The terrain in this segment is moderately flat but becomes steeper in the more northeastern portion. The overall average line slope is about 5%.

(3) Terrestrial Biology. The Northern Tier Pipeline route has been divided into several separate links based on district topography, vegetational components of the route, and degree of adjacent urbanization. Five segments, each composed over seveeral contiguous USGS quadrangle maps, have been designated between the western terminus at Port Angeles (Morse Creek) and the eastern terminus near North Bend to the east of Tacoma. (See Figure VIII-25 and discussion under subsection 2-a(2).)

Throughout much of the peninsula route the proposed pipeline is intended to follow the existing transmission line right-of-way, running first south to the south Sound-Olympia area and then east toward the Cascades. Portions of the route will have to traverse open country not yet included within a utility right-of-way. These will receive additional attention as they are likely to have even greater impact.

- Segment 1 - Morse Creek to Sequim

As can be seen from Table VIII-11, the Northern Tier Pipeline leading from the tank farm terminus in the Morse Creek area to Sequim is a segment roughly 20 miles long which traverses an area 75% wooded, of which 14% also represents riparian corridors. The corridors include two major drainiages -- Morse Creek and the Dungeness River. The latter has a floodplain 8200 feet wide, Although within the boundaries of the Puget Sound western hemlock zone, the forest composition of this link is at the drier end of the rain shadow zone of the Olympic mountains. In these forests, the typical successional forms of red cedar, Douglas fir, big leaf maple, and alder are also interspersed by drier habitat species, including the Oregon white oak and Pacific madrone. Other species characteristic of the drier sites include Rocky Mountain juniper, scouler willow, and cascara. The riparian zones are dominated by the characteristic species -- black cottonwood, Oregon ash, red alder, and Pacific willow. Characteristic wildlife associated with these woods are listed in Appendix B.

- Segment 2 - Gardiner to the Brothers

The next segment, approximately 40 miles long, traverses an area of steep terrain at the eastern edge of the Olympic mountains with an average slope of almost 9% and then parallels the northern Hood Canal for some distance. (See Table VIII-9.) Ninety-one percent of the area traversed by the pipeline right-of-way is forested. Of this, nearly 10% is riparian corridor including the drainages of five major streams and rivers and three minor creeks (Figure VIII-27). The forest composition of the wooded lands is similar to that of the more northern segment. The power line scar north

of Brinnon is very evident with much bare ground and some small Douglas fir, grand fir, and maple invading. The most successful recolonizer of the scar is alder, but all the species are doomed by right-of-way maintenance.

The area south of Brinnon-Pleasant Harbor comprises a large, relatively mature, dense forest with the western red cedar, Douglas fir, grand fir, big leaf maple, alder, and madrone as the dominant species. The area appears to have been subjected to logging activities at the turn of the century and has since recovered. Now it is an intermediate successional, mixed deciduous/coniferous forest, characteristic of much of the route along the eastern edge of the Olympic Peninsula.

- Segment 3 - Potlatch to Shelton

The third segment of the route is also roughly 40 miles long and also traverses mountainous country with an average slope of 7.6%. This segment parallels the southern portion of the Hood Canal and traverses an area which is 94% wooded, of which 8% is riparian corridor (Table VIII-10). Of the riparian portion, eight are minor streams and there is only one major river traversed, the Skokomish River (Figure VIII-15). A large portion of this segment does not follow the existing transmission line, but traverses open country including a Christmas tree farm north of Shelton and an area of dense seeded, even aged Douglas fir forest which grades into a mixed Douglas fir, grand fir, and lodge pole pine forest with an understory of salal and sword fern.

The pipeline would again be within the general alignment of the transmission line in the vicinity of the frontage road at Kennedy Creek. The scar representing the various phases of transmission line construction is continuously undergoing revegetation by weedy species, including a number of grasses, ferns, umbels, and composites, as well as some young trees -- red cedar and Douglas fir. There are stump sprouts of a few of the former large, old cedars which were cleared for the transmission line construction. The entire scar has the appearance of an old field pasture land which is slowly undergoing successional change to a mixed deciduous/coniferous forest resembling the adjoining woods. The dominant species in the woods in addition to those just mentioned include Pacific madrone, a dry site indicator, and a shrub layer composed of snowberry, vine maple, and baldhip rose.

- Segment 4 - Tumwater to Frederickson

The fourth segment of the Peninsula Link is also approximately 40 miles long and traverses an area which is markedly different from the previous portions in both its topography and vegetational composition (Table VIII-11). In contrast to the previous mountainous segments, this segment is largely flat, with an average line slope of only 2.1%. Only 60% is forested land, of which about 10% is riparian growth, including the

drainage of three major and six minor streams. Areas of typical mixed coniferous/deciduous successional woodland give way to a number of unique environments in Puget Sound.

The extensive long-standing prairies are thought to have developed as a result of the occurrence of droughty, gravelly soils derived from glacial outwash materials as well as low summer precipitation and historic frequent burning by natural causes including the native population and possibly also white settlers. Prairies traversed by the pipeline right-of-way in this forest segment include Bush, Rocky, Weir, and Yelm prairies. The vegetation literature indicates that the species composition of these prairies is unique, consisting of Idaho Fescue, a native bunch grass with the intermediate intervening spaces covered by a moss layer. The moss layer is penetrated by long stoloned sedge, broad leaf shooting star, common camas, northwestern saxifrage, Idaho blue-eyed grass, thrift, western long spur, and upland yellow violets, as well as meadow death camas and Puget balsam root. Many of the species present indicate very high soil mosture content during the winter and early spring. In recent times, many of these prairies have been subject to invasion by Douglas fir and Oregon white oak, and such invasion has been accelerated by improved fire protection on the prairies. This invasion indicates the prairies are not stable successionally, but the combination of soil type and precipitation profile indicate that the Puget lowland in this area may become recognized as a separate and special vegetated zone, more similar to the coastal Douglas fir zone in British Columbia than to the remainder of the western hemlock zone surrounding Puget Sound.

The pipeline route in this segment is also expected to traverse several low-lying marshy areas, possibly including the marsh south of Offutt Lake and another marsh in the vicinity of the intersection of Hawk Peterson and McKenna roads. This could have special significance because such marshes are important habitat for a large number of species of birds found in the general Puget Sound area (see Appendix B). Such marshes should be considered ecologic sensitive areas, deserving of special consideration in mitigating potential environmental impact.

- Segment 5 - Orting to Cumberland

The remaining segment south of the Puget Spur is approximately 30 miles long and traverses an area which is intermediate in a number of ways between Segments 1 through 3 and Segment 4 (Table VIII-12). Roughly 75% of the land traversed by the route is forest and the terrain is moderately flat with an average line slope of 4.8%. About 7% of the area designated woodland is also riparian, including the drainages of three major streams or rivers and nine minor streams (Figure VIII-27). This final segment has the greatest proportion of urban land traversed (8%) of the 32 miles. This segment is beyond the zone of the most significant south Puget prairie lands, but the route could cross two marshes -- the marsh of Forest Lake and another unnamed marsh in the Orting quadrangle. The total area of marsh which could be affected by the project is 300 acres. The woodland vegetation of this segment is in most places a well

developed late successional mixed deciduous/coniferous forest, having a shrub understory in some portion. Those segments of the proposed route most remote from urban settlement, largely the portion extending from Muskrat Lake across the Green River and the flatland west and north of Sugar Loaf Mountain, are in the less disturbed, late seral condition.

b. Northern Tier Pipeline - East Washington Link

(1) Location. From the Selleck-North Bend vicinity, the Northern Tier Pipeline route heads east into the Cascade range. From there a 40-inch pipeline will run approximately 32 miles up the steep Green River gorge to Stampede Pass at an elevation of 4460 feet. From Stampede Pass the pipeline runs through eastern Washington and across the states of Idaho, Montana and North Dakota to Bagley, Minnesota.

Since Stampede Pass lies at the crest of the Cascade Range, it marks the watershed boundary of the Puget Sound and eastern Washington areas and also marks the boundary between King County, a coastal county, and Kittitas County, an inland county. Since the concern of this study is with the coastal impacts as defined by the federal and state Coastal Zone Management legislation, the impact of the Northern Tier pipeline east of Stampede Pass will not be addressed. The East Washington Link discussed in this study refers to the portion of the Northern Tier Pipeline between Selleck and Stampede Pass (Figures VIII-23 and VIII-24).

(2) Land Use.

- Segment 1 - Selleck to Stampede Pass

The East Washington Link has only one segment; it runs approximately due east between the end points of Selleck and Stampede Pass. The great majority of this link (28 out of 31 miles) uses the existing rights-of-way of power transmission lines or of the Burlington-Northern railroad. Of the existing right-of-way portion, about 24 miles crosses heavily wooded timberland, much of which is in the Green River watershed.

The Green River provides the major water supply source for the City of Tacoma (Figure VIII-27). The line enters the Green River watershed as it parallels the Howard Hanson Reservoir in the vicinity of Bandera. About 2.5 miles of the existing right-of-way intersect riparian zones, including two crossings of the Green River itself and 17 creeks. No agricultural lands are crossed, but about a mile of Segment 1 passes through urban development areas -- the communities of Kangley and Stampede and the vicinity of Lester. The existing right-of-way portion crosses 16 minor roads and two railroad lines.

Nearly all (3.2 out of 3.4 miles) of the East Washington Link requiring new right-of-way will cut through wooded lands of the Snoqualmie National Forest. Three minor creeks are crossed within this segment, totaling one-tenth mile of riparian zone. No agricultural lands or urban areas are encountered in this short segment. One road crossing is involved (See Table VIII-14 and Figure VIII-26).

TABLE VIII-14

NORTHERN TIER PIPELINE: EAST WASHINGTON LINK

Pipeline Segment Summary

SEGMENT 1: Selleck (Kangley) to Stampede Pass

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	27.76	89.2	87.6	8.5	0	3.9
New Right-of-Way	3.36	10.8	96.4	3.6	0	0
Total	31.12	100				

TABLE VIII-14 (Continued)

NORTHERN TIER PIPELINE: EAST WASHINGTON LINK

Pipeline Segment Summary

Segment 1: Selleck (Kangley) to Stampede Pass

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT-OF-WAY						
3 Unnamed Cks.	200'	16 Unnamed Rds. Nort. Pac. RR (2x)	Kangley	reservoir	Howard Hanson (Tacoma Watershed)	1536 ac.
1 Unnamed Ck.	2900'		Lester vicinity			
1 Unnamed Ck.	200'		Stampede			
Sylvester Ck.	200'					
Cougan Ck.	200'					
Smay Ck.	200'					
McCain Ck.	200'					
4 Unnamed Cks.	200'					
Friday Ck.	200'					
Green Ck. (2x)	600'/400'					
2 Unnamed Cks.	200'					
2 Unnamed Cks.	500'					
NEW RIGHT-OF-WAY						
2 Unnamed Cks.	200'	Anacortes Rd.		reservoir	Howard Hanson	1536 ac.
Piling Ck.	200'			pond	Page Mill	nearby 5.5 ac.

Arthur D Little, Inc.

The one segment of the East Washington Link heads east from Selleck up the western slope of the Cascade range and then through Stampede Pass. The majority of this segment passes through heavily wooded lands of the Cedar River and Green River watersheds in Snoqualmie National Forest. (See subsection 2-b(2), Table VIII-14 for the linear distances of forest and riparian lands traversed.) A significant proportion of these watershed lands are expressly protected by watershed management policies and have been relatively undisturbed by logging activities for a long time. The exceptions are the relatively narrow corridors cut through the forest by different rights-of-way and the area between Stampede Pass and Snoqualmie Pass to the north, in the vicinity of Keechelus Lake. In this region, significant portions of both the Green and Cedar River watersheds have been logged as recently as 1960. Some areas are of relatively late successional age with the seral species such as Douglas fir represented by mature individuals which can begin to be replaced by climax species such as western hemlock. In the vicinity of Stampede Pass (elevation 3600 feet), the vegetation undergoes transition to subalpine forest where the dominant species of the climax community would be Pacific silver fir. Areas which have been disturbed within the last 500 years are largely represented by earlier successional species which include Douglas fir, western hemlock, and noble fir. This zone receives one-and-one-half to four times as much annual precipitation as the lowlands to the west. The earlier successional stages contain a higher overall proportion of coniferous trees among the overstory plants than the lowland seral communities.

In the area of Eagle Gorge, the route will either cross or closely skirt the northern arm of the recently enlarged Howard Hanson Reservoir. This is a major impoundment on the Green River which provides the water supply for the City of Tacoma. Five transmission lines currently cross this arm of the reservoir, but the pipeline would probably be built around the perimeter instead.

c. Puget Spur

(1) Location. The Puget Spur in this study is a hypothetical pipeline corridor. It does not correspond to any specific proposal on the part of government or industry. The concept of the Puget Spur was originally entertained by the Northern Tier Pipeline Company, which has contemplated a marine terminal at Cherry Point, and pipeline connection to Stampede Pass or Snoqualmie Pass. This line would have followed the approximate route of a Puget Spur. After the Northern Tier Pipeline Company altered its proposal by moving the marine terminal site to Port Angeles on the Olympic Peninsula, the Puget Spur route offered a potential means for the existing refineries along the northeast shore of Puget Sound to obtain a supply of crude oil that would substitute for curtailed Canadian shipments and would avoid the need for major tanker traffic on the inner waters of Puget Sound.

The route of the Puget Spur used in this study is derived from three sources. The first of these is the Trans Mountain Pipeline Company, Ltd., of Vancouver, which currently operates the Trans Mountain Pipeline from British Columbia to both Cherry Point and March Point. That pipeline could provide right-of-way for actual service to a portion of the Puget Spur running from the Burlington and Mt. Vernon vicinity to Cherry Point. From Burlington south to Everett, the Trans Mountain owns additional right-of-way not currently in use. Such contiguous right-of-way would offer the tremendous advantage over the construction of a new line even though many of the attendant land use and environmental impacts would remain undiminished. Furthermore, if a Puget Spur were to be operated independently of the Northern Tier Pipeline, it is quite likely that Trans Mountain would be the operator (Trans Mountain Pipeline Company, 1976, and Butler Engineering, 1976, pers. comm.).

From Everett south to Selleck the route studied is roughly that route contained in an early proposal by the Northern Tier Pipeline Company, which connected the Trans Mountain Pipeline right-of-way at Everett to an eastbound route through Snoqualmie Pass. Since Stampede Pass now appears more realistic, and since the latter route was not clearly identified on a small scale map, some consultant's judgment was used in estimating the route of the Puget Spur used in this study. That route does traverse some sensitive environmental and land use zones, and any engineering proposal would require detailed study before implementation. Such studies would facilitate identification of mitigation measures. The route discussed here is considered representative and appropriate for comparison with those routes more formally identified (Figures VIII-28 and VIII-29).

(2) Land Use. As was done for the Peninsula Link, the environmental setting for the Puget Spur is presented as a series of figures (Figure VIII-30 to Figure VIII-32) and tables (Table VIII-15 to Table VIII-21).

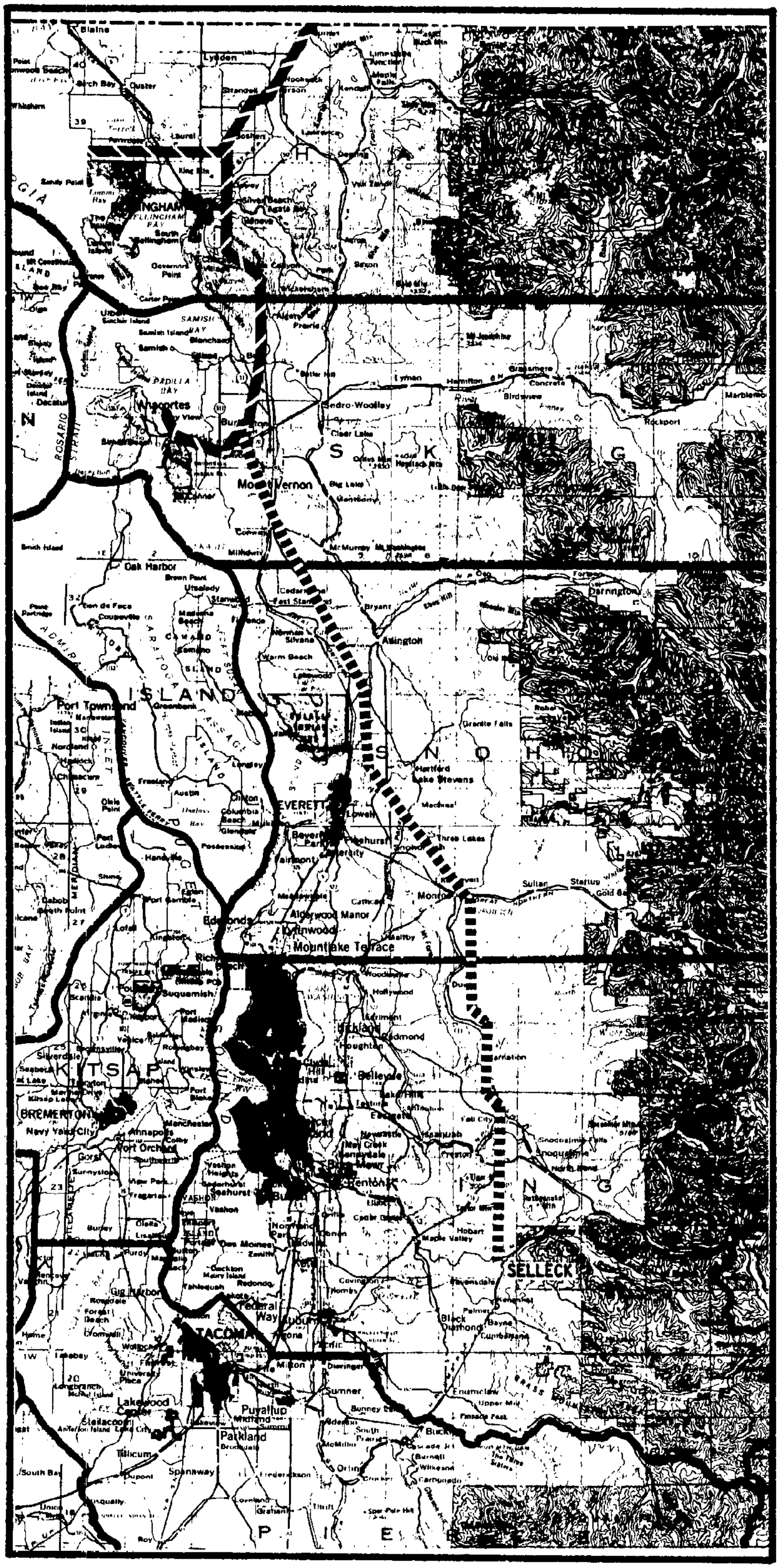
- Segment 1 - Cherry Point to Laurel Pump Station

Segment 1 is the connecting link between the refineries at Cherry Point and the main route corridor -- the junction is at Laurel. The entire segment lies in the right-of-way of the existing Trans Mountain Pipeline. About three of the 13 miles of this segment pass through wooded land, over half crosses intensively cultivated and pastureland, and about 1.5 miles are parallel to strip development along Smith Road, or intersect low-density suburbanization in the vicinity of Ferndale. Less than one mile crosses riparian zones, the Nooksack River and its floodplain, and two crossings of Silver Creek. The segment entails crossing 16 roads or highways, including Interstate 5, and one railroad (see Table VIII-15 and Figures VIII-30 to VIII-32).

- Segment 2 - Laurel to Burlington Pump Station

Segment 2 roughly parallels Interstate 5 for 27.5 miles running nearly due south from Laurel to the Burlington Pump Station, located about

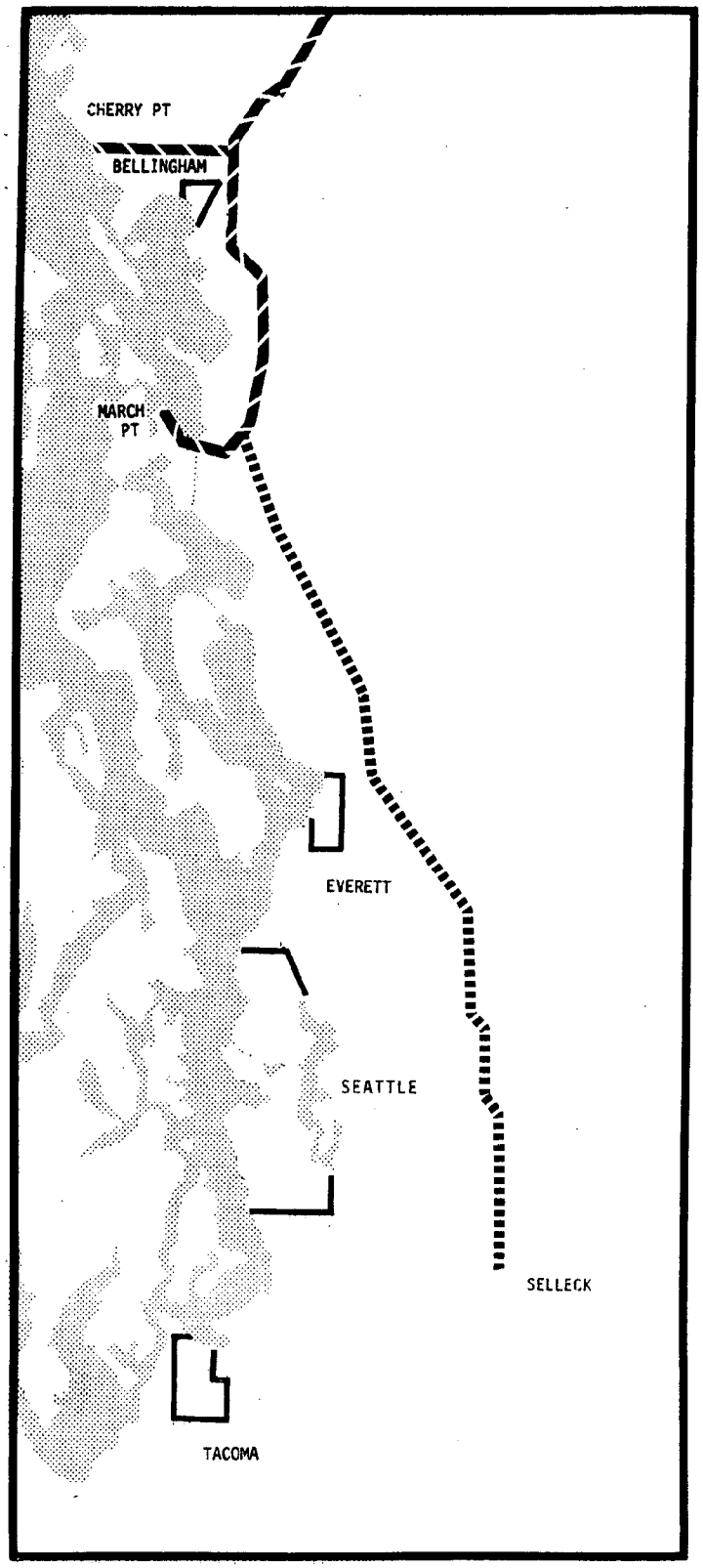
FIGURE VIII-28 LOCATION PUGET SPUR

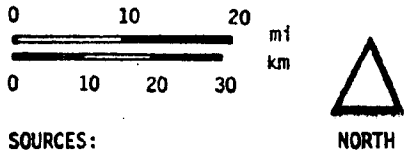


SOURCES:

Trans Mountain Pipe Line Co., "Right-of-Way Map", 1959; Arthur D. Little, Inc.

FIGURE VIII-29 ROUTE SCHEMATIC: PUGET SPUR

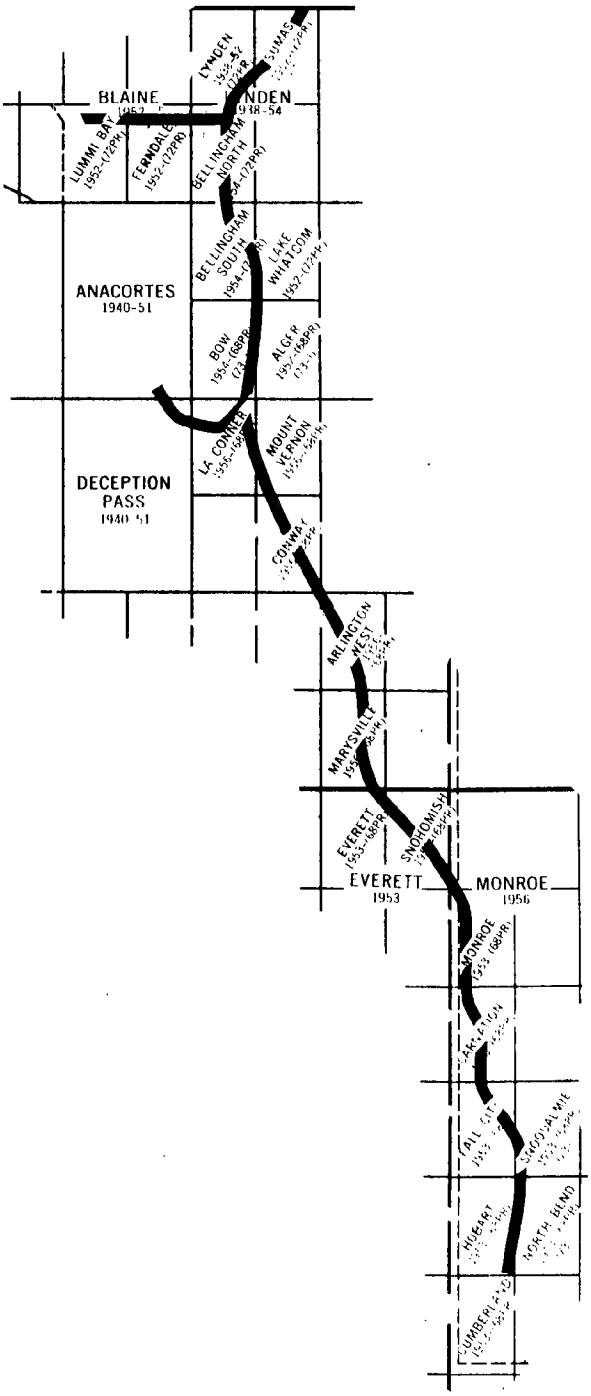




SOURCES:

Trans Mountain Pipe Line Co., "Right-of-Way Map", 1959; Arthur D. Little, Inc.

FIGURE VIII-30 USGS TOPOGRAPHIC MAPS ALONG PUGET SPUR



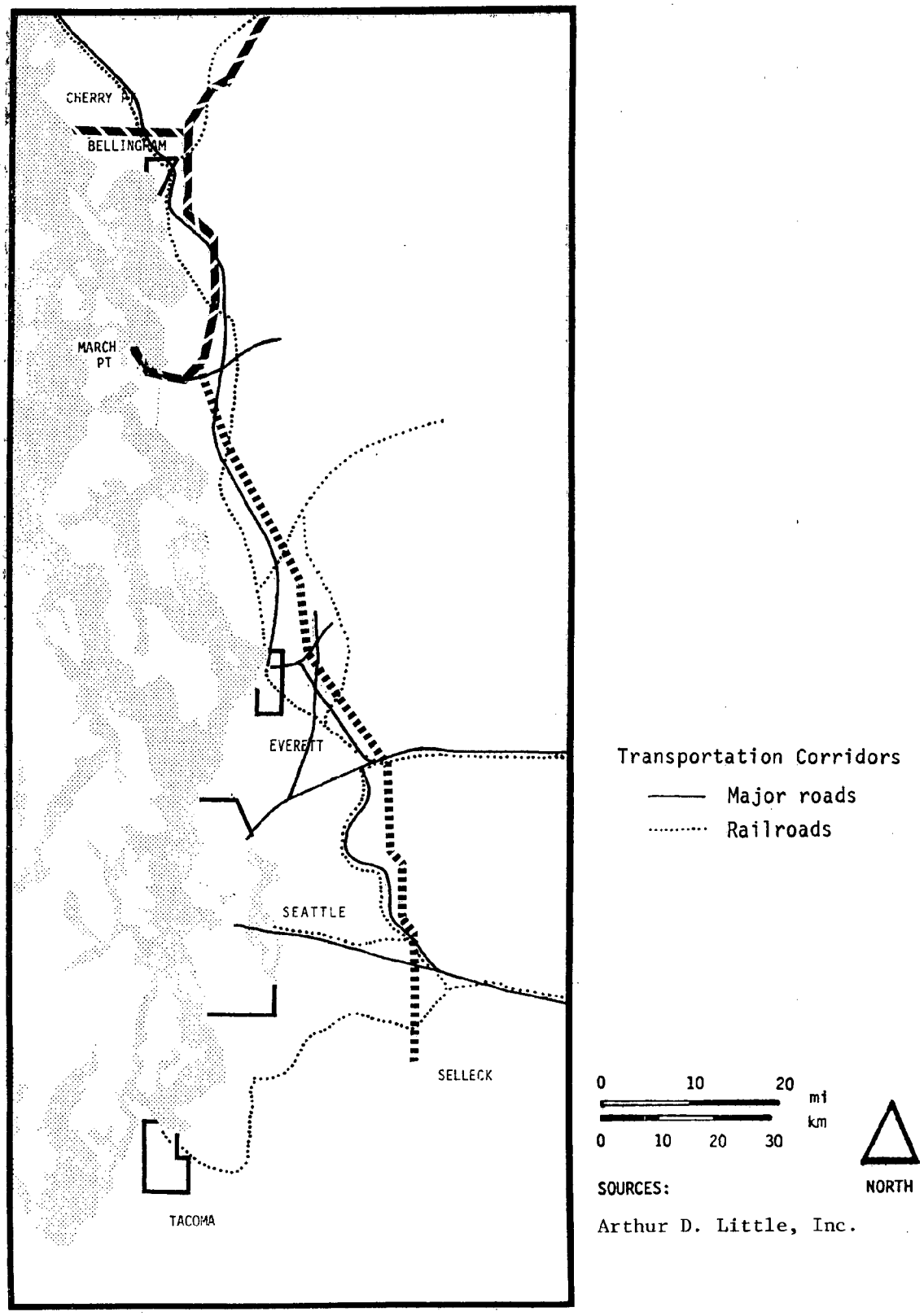
0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:

Trans Mountain Pipe Line Co., "Right-of-Way Map", 1959; Arthur D. Little, Inc.

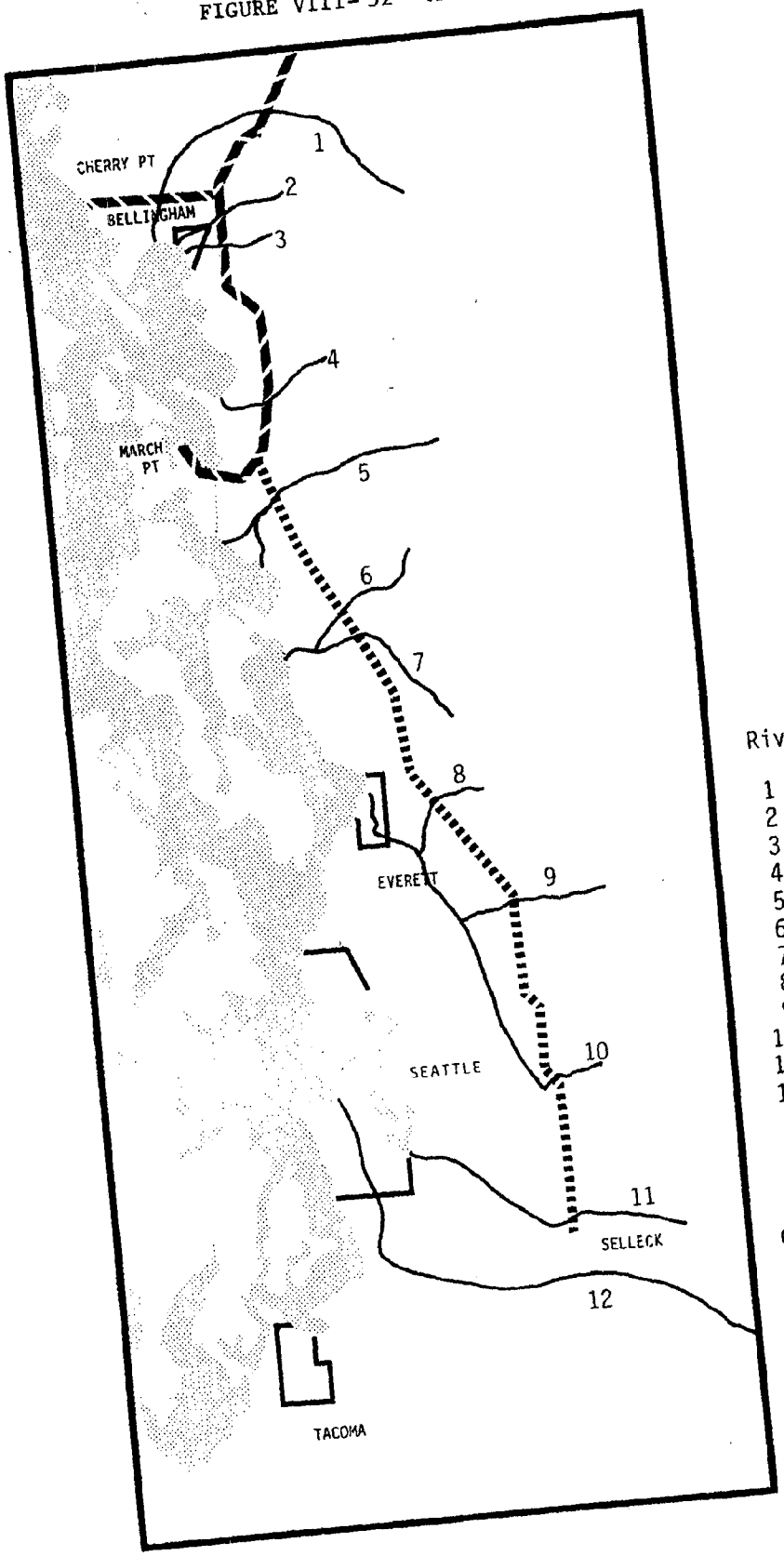
FIGURE VIII-31 MAJOR TRANSPORTATION CORRIDOR CROSSINGS: PUGET SPUR



SOURCES:

Arthur D. Little, Inc.

FIGURE VIII-32 MAJOR STREAM CROSSINGS: PUGET SPUR



Rivers

1 - Nooksack R.
2 - Squalicum Cr.
3 - Whatcom Cr.
4 - Samish R.
5 - Skagit R.
6 - N. Fk. Stillaguamish R.
7 - S. Fk. Stillaguamish R.
8 - Pilchuck R.
9 - Skykomish R.
10 - Snoqualmie R.
11 - Cedar R.
12 - Green R.

0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:
Arthur D. Little, Inc.

TABLE VIII-15

PUGET SPUR

Pipeline Segment Summary

Segment 1: Cherry Point to Laurel Pump Station

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	12.68	100	23.7	6.0	58.0	12.3
New Right-of-Way						
Total	12.68	100				

TABLE VIII-15 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment : Cherry Point to Laurel Pump Station

	Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
					Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY							
	2 Unnamed Cks.	200'			marsh	Tennant Lake	
	Nooksack R.	floodplain	Meridian Rd.				
	Silver Cr.	2000'	Hannegan Rd.				
			Red River Rd.				
			Elder Rd.				
			Olson Rd.				
			Johnston Rd.				
			Imhof Rd.				
			River Rd.				
			Hovander Rd.				
			Labounty Rd.				
			Aldrich Rd.				
			Northwest Rd.				
			Interstate 5				
			3 unnamed Rds.				
			Burlington Northern RR				
NEW RIGHT OF WAY		NONE					

TABLE VIII-16

PUGET SPUR

Pipeline Segment Summary

Segment 2: Laurel to Burlington Pump Station

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	27.52	100	64.4	8.6	8.3	18.7
New Right-of-Way	0					
Total	27.52	100				

TABLE VIII-16 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment Z: Laurel to Burlington Pump Station

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings: Type	Sensitive Area Crossings: Name	Sensitive Area Crossings: Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
1 Unnamed Ck.	1300'	Kelly Rd.	Bellingham	Slough	Edison	200'
Squalicum Ck.	200'	Van Wyck Rd.		Marsh	Unnamed	950'
Whatcom Ck.	400'	Bakerview Rd.		Animal Habitat (Nearby)	Upland State	11 ac.
Samish Lake	400'					
Bear Ck.	200'	Lakeway Drive				
Colony Ck.	950'	Galbraith St.		Marsh	Olympia	1.8 miles
		Burlington Northern Rr. (2x)				
Samish Rr.	100'	CMSP&P RR				
Unnamed Ck.	flood plain	Interstate 5				
		Tobacco Rd.				
		Colony Rd.				
		Bow Hill Rd.				
		Johnson Rd. (2x)				
		Chuckanut Drive (State 11)				
		16 Unnamed Rds.				
NEW RIGHT OF WAY	NONE					

TABLE VIII-17

PUGET SPUR

Pipeline Segment Summary

Segment 3: March Point to Burlington Pump Station

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	8.44	100	31.8	11.8	0	56.4
New Right-of-Way	0					
Total	8.44	100				

TABLE VIII-17 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment 3: March Point to Burlington Pump Station

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Swinomish Channel	1000'	Best Rd.	Whitmarsh Junction	Slough	Indian	200'*
				Slough	Telegraph	1000'
1 Unnamed Channel	500'	Memorial Highway		Slough	Blind	500'
		Burlington Northern Rr.				
Blind Slough	500'	2 Unnamed Rds.				
1 Unnamed Ck.	200'					

*All the sloughs are in a general marshy area south of Padilla Bay.

TABLE VIII-18

PUGET SPUR

Pipeline Segment Summary

Segment 4: Burlington Pump Station to East of Everett

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	37.16	100	27.2	7.1	28.1	37.6
New Right-of-Way	0					
Total	37.16	100				

TABLE VIII-18 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment 4: Burlington Pump Station to East of Everett

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings: Type	Sensitive Area Crossings: Name	Sensitive Area Crossings: Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
2 Unnamed Cks.	800',200'	Memorial Highway-(2x)	Marysville vicinity Avon Everett vicinity	None Significant		
Skagit R.	1900'					
Britt Slough	200'	Burlington Northern RR-(2x)				
Unnamed Stream,		Dunbar Rd.				
Holmes Levee	Flood Plain	Mclean Rd.				
Unnamed Ck.	600'	Penn Rd.				
Stillaguamish R.	600'	County Farm Rd.				
Portage Ck.	700'	Kimball Rd.				
Pilchuk Ck.	1500'	Britt Slough Rd.				
2 Unnamed Cks.	200'	Hickox Rd.				
Middle Fork Stream	200'	Stackpole Rd.				
Quilceda Ck.	200'	Interstate 5				
Allen Ck.	200'	Johnson Rd.				
Munson Ck.	200'	Fir Island Rd.				
6 Unnamed Cks.	200'	Mulltown Rd.				
1 Unnamed Ck.	200'	Freeborn Rd.				
		Stanwood Rd.				
		Jackson Gulch Rd.				
		State 530				
		Blacken Rd.				
		Cox Rd.				
		Shoultes Rd.				
		Otter Rd.				
		Zieball Rd.				

TABLE VIII-18 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment 4: Burlington P.S. to East of Everett

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY (con't)						
		Turk Rd. Anderson Rd. Hickok Rd. 13 Unnamed Rds.			None Significant	
NEW RIGHT OF WAY	NONE					

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TABLE VIII-19

PUGET SPUR

Pipeline Segment Summary

Segment 5: East of Everett to Monroe (Skykomish Rr.)

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	6.76	43.8	75.1	1.2	0	23.7
New Right-of-Way	8.68	56.2	35.5	4.6	16.6	43.3
Total	15.44	100				

TABLE VIII-19 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment 5: East of Everett to Monroe (Skykokish Rr.)

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Pilchuk R	4000'	Three Lakes Rd.	Snohomish vicinity		None Significant	
1 Unnamed Ck.	700'	Haines Rd.				
1 Unnamed Ck.	200'	Oilwell Rd.				
1 Unnamed Ck.	400'	Iverson Rd.				
French Ck.	200'	Spada Rd.				
		Meadowlake Rd.				
		4 Unnamed Rds.				
NEW RIGHT-OF-WAY						
1 Unnamed stream	1000'	State 204	Everett vicinity	marsh	out of Richardson Ck.	500'
Skykomish R., Haskel Slough	8000'	Hewitt Ave. East	Snohomish vicinity			
		State 9				
		83rd Ave.				
		52D St.				
		Brown Rd.				
		Yeager Rd.				
		Florence Acres Rd.				
		U.S. Route 2				
		Great Northern Rd.				
		4 Unnamed				

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TABLE VIII-20

PUGET SPUR

Pipeline Segment Summary

Segment 6: Monroe (Skykomish Rr.) to Selleck (Kangley)

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	23.39	77.6	79.4	5.0	6.4	9.2
New Right-of-Way	8.48	22.4	85.8	3.8	4.7	5.7
Total	31.87	100				

TABLE VIII-20 (Continued)

PUGET SPUR

Pipeline Segment Summary

Segment 6: Monroe (Skykomish Rr) to Selleck (Kangley)

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings: Type	Sensitive Area Crossings: Name	Sensitive Area Crossings: Size or Pipeline Length Traversing
EXISTING RIGHT-OF-WAY						
1 Unnamed (3x)	200'	Spicer Rd.	Carnation	Marsh	Unnamed	400'
Cherry Ck.	800'	North Rd.	Pleasant Hill	3 Marshes	Unnamed	3500'
Tolt Rr.	flood plain	Mountain View Rd.		slough	Rutherford	1900'
Griffin Ck.	400'	Langlois Rd.				
2 Unnamed Cks.	200'	Tolt Bunker Rd.				
1 small pond	800'	Tolt River Rd.				
French Ck.	200'					
North Fork of Cherry Ck. (2x)	200'	CMSP&P RR (2x)				
Griffin Ck.	400'					
2 Unnamed Cks.	200'					
7 Unnamed Cks.	200'	Brew Rd. (3x)				
1 Intermittent Ck.	200'	Kerriston Rd.				
Echo Lake	400'	Green Valley Rd.				
Raging R.	1000'	Rocky Rd.				
Rock Ck.	200'	North Pole Rd.				
Cedar R.	1000'	15 Unnamed Rds.				
NEW RIGHT-OF-WAY						
Skykomish R.	8200'	Ben Howard R.	Spring Glen	Marsh	Unnamed	500'
Harris Ck.	flood plain	Rock Rd. (3x)	Kangley			
Snoqualmie R.						
Mud Ck.	flood plain (3100')	State S22				
		Northern Pacific RR				
		4 Unnamed Rds.				

TABLE VIII-21

PUGET SPUR

Land Use Summary

Segment Name	Segment Length (Miles)	Miles on Right-of-Way	% of Segment	% Forest	% Riparian	% Agri.	% Urban	Urban Communities Crossed	Stream Crossings Major	Stream Crossings Other	Railroad Crossings	Road Crossings State or Federal	Road Crossings Other
1. Cherry Pt. to Laurel Pump Station	12.68	12.68	100	23.7	6.0	58.0	12.3	Vicinity	1	4	1	1	15
2. Laurel to Burlington Pump Station	27.52	27.52	100	64.4	8.6	8.3	18.7	1	2	6	3	2	26
3. March Pt. to Burlington Pump Station	8.44	8.44	100	31.8	11.85	0	56.4	1	1	3	1	1	3
4. Burlington P.S. to East of Everett	37.16*	*37.16*	*100*	*27.2*	*7.1*	*28.1*	*37.6*	*3*	*2*	*20*	*1*	*4*	*39*
5. East of Everett to Monroe	15.44	6.76 *8.68*	43.8 *56.2*	75.1 *33.5*	1.2 *4.6*	0 *16.6*	23.7 *43.3*	1 *3*	1 *2*	4 *1*	1 1	0 *2*	10 *10*
6. Monroe to Selleck		23.39 *8.48*	77.6 *22.4*	79.4 *85.8*	5.0 *3.8*	6.4 *4.7*	9.2 *5.7*	2 *2*	3 *2*	23 *2*	2 1	0 *1*	28 *8*
Total		78.79 *54.32* 133.11	59.19 40.81	55 *37.8*	6.8 *6.2*	14.2 *22.6*	19.3 *33.6*	5 *8* 13	8 *6* 14	40 *23* 63	8 3 11	4 *7* 11	82 *57* 139

TRANSMOUNTAIN LINK

Land Use Summary

Segment Name	Segment Length (Miles)	Miles on Right-of-Way	% of Segment	% Forest	% Riparian	% Agri.	% Urban	Urban Communities Crossed	Stream Crossings Major	Stream Crossings Other	Railroad Crossings	Road Crossings State or Federal	Road Crossings Other
1. Sumas to Laurel Pump Station	14.36	14.36	100	29.3	7.2	44.0	19.5	1	4	3	2	1	13

Bold Face Type - Existing right-of-way
Italic Type - New right-of-way

* Transmountain Pipeline Company owns right-of-way, but no pipe in place. Hence, this will be considered new right-of-way in the impact analysis.

five miles northwest of the town of Mt. Vernon in Skagit County. All of this segment lies in an existing pipeline right-of-way (the Trans Mountain Pipeline). Nearly 18 miles (65%) of the segment traverse forested lands, about two miles intersect agricultural lands, and about five miles cut through urban lands of the City of Bellingham. A total of about two miles cross riparian zones of six creeks, the Samish River and Samish Lake, as well as two marshes and Edison Slough (discussed in subsection 2-c(3). The segment has 28 road crossings, many associated with the long urban stretch, including one state highway and Interstate 5. Three railroad crossings also are involved (see Table VIII-16).

- Segment 3 - March Point to Burlington Pump Station

Segment 3 runs from the March Point refineries to the junction with the main north-south corridor at the Burlington Pump Station. About 2.5 of this 8.5-mile segment pass through wooded lands; more than 4.5 miles traverse urban lands in the vicinity of the March Point refineries and near Whitmarsh Junction. The segment crosses several riparian zones, including three sloughs and the Swinomish Channel, totaling about one mile. Four roads are crossed, including Memorial Highway which connects Fidalgo Island with the mainland, and one railroad (Table VIII-17 and Figures VIII-31 and VIII-32). All of the segment follows the existing right-of-way of the Trans Mountain Pipeline.

- Segment 4 - Burlington Pump Station to East of Everett

Segment 4 runs south and slightly east for about 37 miles, crossing the boundary between Skagit and Snohomish counties. All of it lies in the designated right-of-way of the Trans Mountain Pipeline, which roughly parallels Interstate 5, but there is no pipe in place. About 10 miles of this segment cut through forested lands, 10.5 miles cross lands under cultivation or in pasture, and 14 miles intersect urban areas. These include the community of Avon, the Smokey Pt. subdivision in the vicinity of Marysville, and the Cavalero Corner subdivision east of Everett proper. More than 2.5 miles of this segment will cross riparian zones. These comprise 19 creeks, one slough, and the Skagit and Stillaguamish rivers. Forty-three transportation corridor crossings are involved, including two intersections with Memorial Highway, one each with Interstate 5 and State Route 530, and two with the Burlington Northern Railroad (Table VIII-18).

- Segment 5 - East of Everett to Monroe

Segment 5 runs south and east for 15.5 miles from east of Everett to the Skykomish River near the Town of Monroe. Slightly less than half of this segment follows existing right-of-way; most is forested land, only about one-tenth mile crosses riparian zones, which comprise the corridors of the Pilchuck River, French Creek, and three minor creeks, and some of the existing right-of-way portion crosses urban lands in the vicinity of the Town of Snohomish. This portion requires 10 crossings of local roads and one railroad crossing.

The portion of Segment 5 requiring new right-of-way construction is about 9 miles long (56% of the segment). About three miles of the new right-of-way portion will require clearing through forested lands; about half a mile will cross riparian corridors which include the Skykomish River and Haskel Slough. About 1.5 miles of this portion will cut through agricultural lands in the vicinity of Monroe, and nearly four miles of this portion will traverse urban lands near Everett, Snohomish, and Monroe. The new right-of-way portion will require 12 road crossings, which include U.S. Route 2 and State Route 9, and one railroad crossing (Table VIII-19).

- Segment 6 - Monroe to Selleck

Segment 6 runs nearly due south from Monroe for about 32 miles to the junction with the Peninsula and East Washington Links of the Northern Tier Pipeline at Selleck. Slightly more than three-quarters of the segment follows the corridor of existing transmission lines -- nearly all of the southern half of the segment and half of the northern piece. Of the 24 miles of existing right-of-way, 19 miles cut across forested lands. Over half of these lands are part of the Snoqualmie National Forest which is also the Cedar River watershed. The latter provides the major source of domestic water supply for the City of Seattle. About 1.2 miles of the existing right-of-way portion of Segment 6 cross riparian zones, including three river crossings, 21 creek crossings, and one lake and one pond crossing. One and a half miles intersect agricultural lands in the flood-plains of the Skykomish and Snoqualmie rivers. About two miles of this portion cross the urban settlements of Carnation and Pleasant Hill. Twenty-eight local road crossings and two railroad crossings are involved.

Roughly 8.5 miles of Segment 6 require the creation of new right-of-way for the pipeline. Most of this is through forested lands in the northern half of the segment, and about one-half mile traverses agricultural lands in the Snoqualmie River valley. Less than half a mile of riparian zones is crossed, which includes both the Skykomish and Snoqualmie rivers and two creeks. The small towns of Spring Glen and Kangley are intersected by about half a mile of this new right-of-way segment. Nine road crossings and one railroad crossing are required in this portion, including the crossing of State Route 522.

(3) Terrestrial Biology. The woodland vegetation and wildlife of all six segments of the Puget Spur will be described together because the scale of analysis does not distinguish the small differences between the natural communities of these various segments. All of the segments run in a general north-south direction along the low western slopes and foothills of the Cascade Mountains. The total latitudinal difference between north and south is only $1\frac{1}{2}^{o}$, so that the differences in species composition attributable to latitudinal change are far less significant than differences due to degree and recency of prior disturbance by clearing. The terrestrial biology analysis was done using broad-scale field reconnaissance, supplemented by aerial photography and topographic map data at a scale of 1:24,000.

This scale of analysis does not distinguish natural early succession grassland communities from pastureland (extensive agriculture). All cleared areas were thus considered to be agricultural land, since in the absence of continued disturbance by grazing or mowing they would rapidly be replaced by successional forest species.

The natural communities other than grassland-grazing land largely comprise mixed broadleaf-coniferous forest riparian zones, and special sensitive areas -- usually wetlands in the vicinity of sloughs, lakes, or rivers. The extent of forest and riparian lands encountered in each segment is discussed in subsection 2-c(2). The individual sensitive areas crossed or closely paralleled by the segments of the Puget Spur are given in Tables VIII-15 through VIII-20.

The species composition of the broadleaf and coniferous forest areas is similar to that described for segments of the Peninsula Link, the dominant species being big leaf maple, Oregon ash, red alder, Douglas fir, Sitka spruce, and western red cedar. Some elements of the more northern British Columbia flora such as paper birch enter portions of the north Puget Sound segments (e.g., Segments 1-4). The complete species list of characteristic plants and animals is given in Appendix B.

Common plants of the riparian zones include black cottonwood, red alder, quaking aspen, several species of willow, creek dogwood, cattails, sedges, rushes, and stinging nettle. Riparian habitat is common in western Washington, but valuable in that it provides water, as well as food, nest sites, and cover for a large number of wildlife species, particularly birds. Riparian mammals such as beavers, raccoons, and river otters depend on freshwater fish as a source of food. Wetland vegetation associated with sloughs, lakes, ponds or rivers overlaps in species composition with riparian areas and wet meadow (see Appendix B). Rushes, sedges, cattails, and marsh grasses are the characteristic plants. Marshes are extremely valuable habitat for year-round resident birds which breed there, as well as for migratory species on the Pacific Flyway, which include numerous species of ducks, geese, and swans (see Appendix B).

d. Trans Mountain Link - Sumas to Laurel Pump Station Only

(1) Land Use. This segment extends 14 miles from Sumas near the Canadian border to the Laurel Pump Station northeast of Bellingham in Whatcom County. The entire segment follows the existing Trans Mountain right-of-way. About 30% (4.2 miles) traverses forested land, nearly half (6.3 miles) runs through cultivated lands, and almost three miles intersect parts of the urban community of Nooksack. The route requires five stream crossings, the most important of which is the Nooksack River. The total length of route within riparian zones is about one mile. The segment involves 14 road crossings, including one major arterial highway and two railroad crossings (see Table VIII-22, Figures VIII-30 through VIII-32).

TABLE VIII-22

TRANSMOUNTAIN LINK

Pipeline Segment Summary

Segment 1: Sumas to Laurel Pump Station

	Segment Length (miles)	% Total	% Forest	% Riparian	% Agriculture	% Urban
Existing Right-of-Way	14.36	100	29.3	7.2	44.0	19.5
New Right-of-Way	0	0	0	0	0	0
Total	14.36	100				

TABLE VIII-22 (Continued)

TRANSMOUNTAIN LINK

Pipeline Segment Summary

Segment 1: Sumas to Laurel Pump Station

Stream Crossings	Canyon Width (Feet)	Road and Railroad Crossings	Urban Area Crossings	Sensitive Area Crossings		
				Type	Name	Size or Pipeline Length Traversing
EXISTING RIGHT OF WAY						
Nooksack R.	4400'	Telegraph Rd. (2x)	Nooksack			
Breckenridge Ck.	200'	Alm St.				
Sumas R. (3x)	200'	Gillie St.				
Tenmile Ck.	1900'	Sumas Lawrence				
1 Unnamed Ck.	1300'	Highway				
		Emerson St.				
		Mission St.				
		Pole St.				
		Everson St.				
		Central St.				
		Hemmi St.				
		Noon St.				
		Axton St.				
		Smith St.				
		Burlington Northern RR				
		CMSP&P RR				
		1 Unnamed St.				
NEW RIGHT OF WAY	NONE					

(2) Terrestrial Biology. The existing vegetation communities of the Trans Mountain Link are similar to the Puget Spur. Roughly 30% of the segment is second growth forest. A relatively high proportion is riparian -- comprising portions of the broad floodplains of the Nooksack River and several creeks (see Table VIII-22 and Figure VIII-32).

B. ENVIRONMENTAL IMPACT

1. Tanker Transportation

a. Transportation Corridors

Five refineries in Puget Sound produce a full range of product. Atlantic Richfield Company, Mobil, Shell, and Texaco are located in the north Sound in the petroleum activity zones discussed in Chapter VII; the smallest, U.S. Oil and Refining, is at Tacoma. Although most of the product distribution from the north Sound refineries to local markets in Seattle, Tacoma, Olympia, and Everett is achieved through the Olympic Pipeline, there is nonetheless a substantial movement of petroleum through the shipping lanes directed toward Puget Sound proper for the southern part of the Sound, which is the center of the region's principal shipping activity. Much of the petroleum movement in this corridor is actually in the form of vessel bunker fuel. The majority of petroleum transfer operations in the south Sound is due to vessel fueling and handling of specialty cargoes, and this activity is responsible for the majority of spills over previous years; the total volume involved is fairly small.

The major use of the north Sound petroleum transportation corridors is by the four refineries, which have had to depend increasingly upon waterborne crude sources as the Canadian allotment received through the Trans Mountain Pipeline is curtailed. As discussed in Chapter II, crude oil receipts by water presently amount to roughly 250,000 barrels per day, and product exports by water amount to approximately 150,000 B/D. This does not include the movement of product by retailers such as Standard Oil of California, Union Oil, Gulf, etc., that do not have refining capacity in Puget Sound but who must import product directly to bulk loading terminals in population centers. The total volume of crude and product moved through the Strait of Juan de Fuca is the combination of traffic directed toward refineries in the north Sound and the fuel, incidental cargo, and product destined for the population and industry centers of the south Sound. The crude and product moved through the north Sound transportation corridors represent a significant proportion of the total volume, but the transportation occurs in relatively large units and thus the number of vessels and the number of operations on a time basis are smaller than that of the shipping industry activity in the Seattle-Tacoma-Everett area. This has resulted in a far smaller history of spills but, as may be expected, the volumes of crude involved represent a far greater potential for large spill size should an accident occur.

It has been the <u>potential</u> for major damage arising from a catastrophic oil transportation accident that has been the source of concern regarding continuing crude supply to north Sound refineries. In the impact scenarios discussed in this study, transportation corridors through the Strait of Juan de Fuca and into the northern Puget Sound are considered

(1) with regard to possible Alaskan Crude oil transshipment projects which require a marine terminal to serve a pipeline leading out of Washington, and (2) with regard to continuing crude oil supply to Puget Sound refineries. This study focuses only upon the transportation corridor leading through the Strait of Juan de Fuca and to the north Sound refinery centers. It should be borne in mind, however, that the shipping activity toward Seattle and Tacoma represents a major potential for oil spills which will persist independently of any change in the regional refinery supply transportation program.

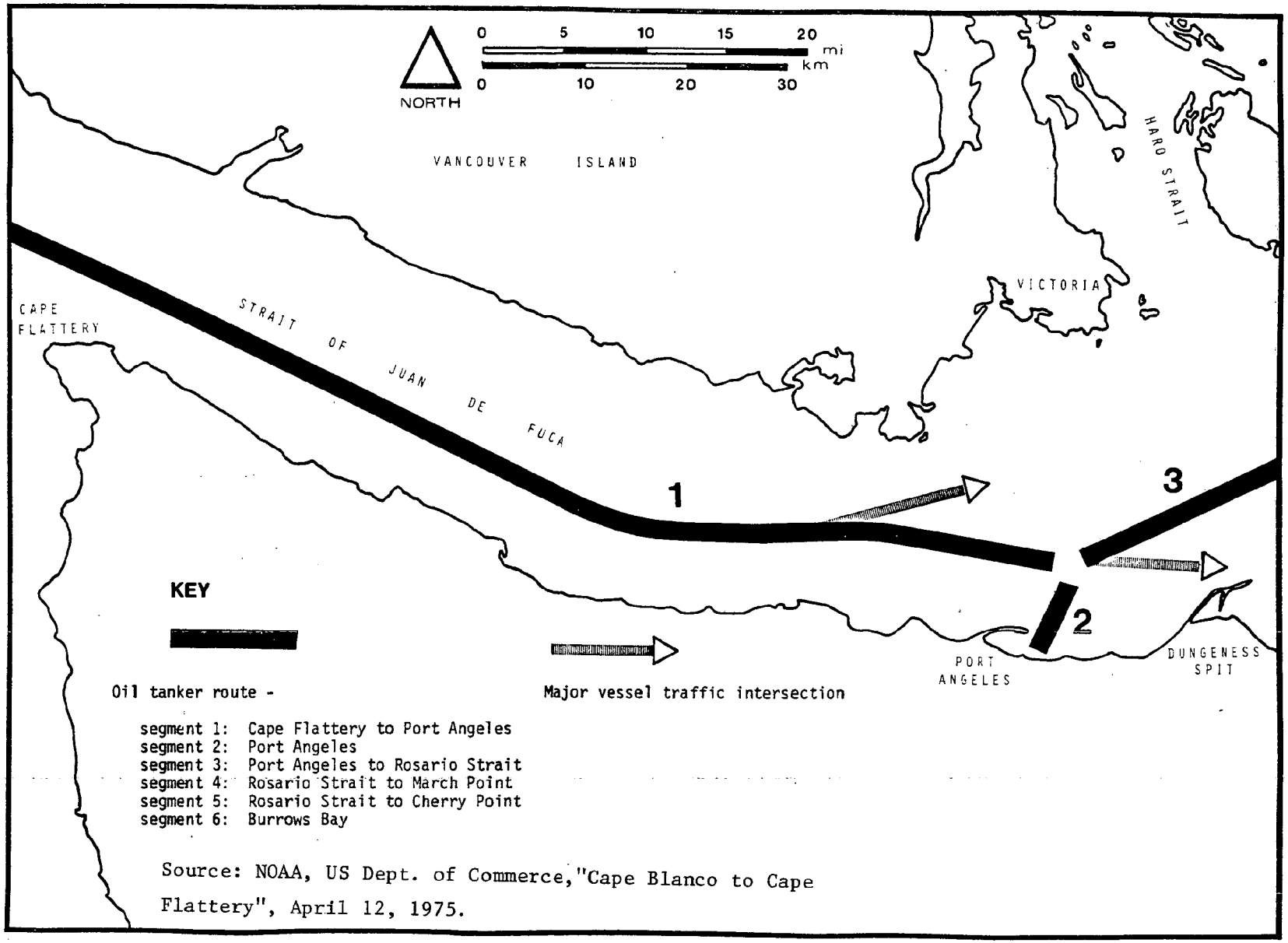
In order to discuss the petroleum transportation scenarios, the route from the Strait of Juan de Fuca to the northern Puget Sound industry activity zones has been subdivided into six separate segments. (See Figures VIII-33 and VIII-34.) The first segment is the Strait of Juan de Fuca from Cape Flattery to Port Angeles. This segment must be traversed by vessels under any of the petroleum transportation scenarios. For a Northern Tier type transshipment proposal requiring a marine terminal at Port Angeles, a short additional link (Segment 2) is required to bring vessels into the harbor behind Ediz Hook. Although several subsite alternatives are discussed under the Port Angeles sections, the scale of transportation impact zone analysis does not readily resolve between them; thus, for simplicity, Segment 2 is directed at the most likely Northern Tier terminal site.

Vessels destined for the existing refinery centers must transit Segment 3 from Port Angeles to Rosario Strait. From there vessels bound for March Point (Shell and Texaco refineries) must use Segment 4 through the Guemes Channel. Vessels bound for Cherry Point (Atlantic Richfield Company and Mobil refineries) must use Segment 5, which continues through the Rosario Strait into the Strait of Georgia. A transshipment scenario requiring a marine terminal at Cherry Point, whether to serve a Northern Tier type pipeline running along the east side of Puget Sound and out through eastern Washington, or whether serving a trans-mountain corridor proposal, would use the three major links from Cape Flattery to Port Angeles (Segment 1), from Port Angeles to Rosario Strait (Segment 3), and from Rosario Strait to Cherry Point (Segment 5).

Although Burrows Bay is not specifically discussed as a petroleum transshipment scenario, that site has been included in the oil spill impact zone definition for general information and for reference. That point source is identified as Segment 6 in Figure VIII-34.

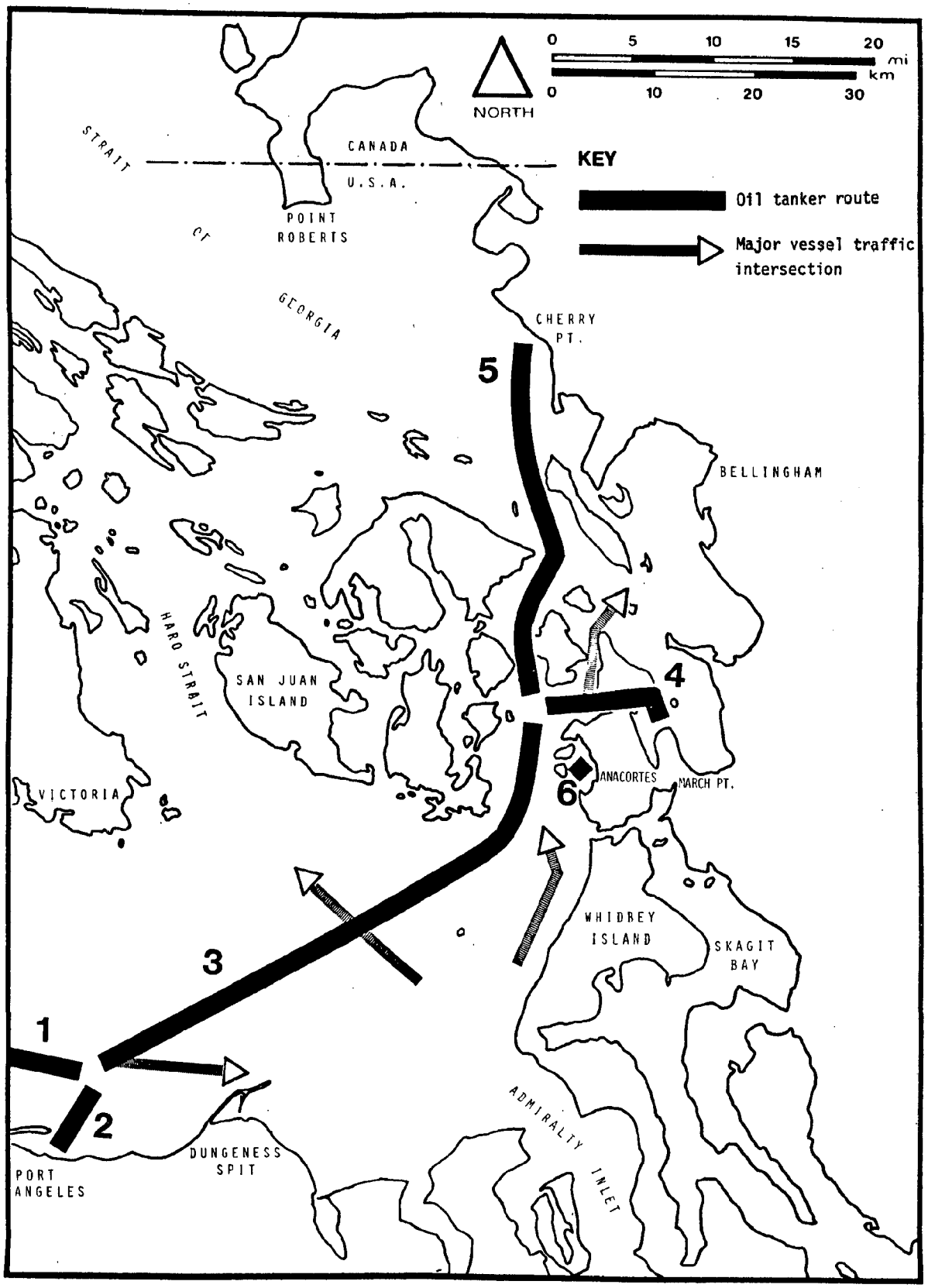
(1) Oil Spill Risk. The several petroleum transportation scenarios addressed by this study make different use of the tanker route segments just described (see Tables VIII-23 and VIII-24). The different levels of vessel activity combine with different degrees of risk exposure inherent in the route segments (as discussed in Chapter VI) to yield estimates of the frequency and average annual spill volume for each scenario according to route segment (see Tables VIII-25 and VIII-26).

FIGURE VIII-33 PETROLEUM TRANSPORTATION CORRIDORS: STRAIT OF JUAN DE FUCA



Source: NOAA, US Dept. of Commerce, "Cape Blanco to Cape Flattery", April 12, 1975.

FIGURE VIII-34 PETROLEUM TRANSPORTATION CORRIDORS: NORTHERN PUGET SOUND



Source: Washington, Department of Natural Resources, 1974.

The total risk is primarily determined by the crude oil throughput of each scenario. The greater vessel activity of a scenario using small vessels, such as Scenario I-B, results in greater (70%) risk per volume of crude transported according to this methodology. A scenario with heavy use of Rosario Strait (Segments 4 and 5), such as Scenario III, has a greater (30%) risk due to greater exposure to vessel casualty.

Risk exposure for each segment is far more sensitive to scenario. The heavy use of Rosario Strait in Scenario III, transshipment at Cherry Point, greatly increases risk in northern Puget Sound above the current level of exposure due to regional supply alone, and regional supply by tanker has more risk than regional supply via Port Angeles and the Puget Spur Pipeline (Scenario II-B). The increased throughput for the Northern Tier proposal increases risk in the Strait of Juan de Fuca such that the total spill risk is greater in Scenario II-B, but the risk has been shifted away from northern Puget Sound.

(2) Oil Spill Mobility and Impact Zone. Once crude oil is released, through operational failure or catastrophic accident, its impact on the environment depends largely upon its subsequent mobility. Although there are two phases to oil spill impacts -- a short-term acute phase characterized by mechanical and acute toxic disturbance, and a longer-term phase characterized by low level but lingering toxic effects -- the acute phase is that most commonly associated with the adverse environmental impacts of oil spill. It comprises the heavy oil slick on the surface of the water and the dense accumulation of oil along the shoreline that is responsible for the most obvious acute mortality of finfish, shellfish, birds, and mammals that is usually the source of the most immediate political concern regarding the oil spill. The effects of long-term exposure to oil in sediments or dispersed throughout the water column are far less understood and do not receive the same degree of public concern. Because of the different time frames for the two impact phases and because of the different transport mechanisms responsible for directing oil against sensitive species, the zone of impact will differ markedly. The discussion following concerns only short-term mobility; there is insufficient information presently available to model long-term mobility.

Assessment of environmental impact of tanker traffic through the transportation corridors is essentially a consideration of the impact zone of potential oil releases from those tanker corridors and a consideration of the marine resources within the impact zones. Since the tanker routes traverse the entire Strait of Juan de Fuca and northern Puget Sound, the potential for accidental oil release covers a wide area. Once oil is released, its fate in Puget Sound will be determined by a race between containment and cleanup efforts (see Chapter VI), and the tendency of wind and tidal current to disperse the oil even farther from its point of original release. The great number of variables involved, including the uncertainties regarding the actual point of release and weather conditions in effect at that time, prevent an exact estimate of the results of that race. However, one of the fundamental characteristics of the oil spill risk in Puget Sound is the intrinsic mobility of oil on the Sound's waters.

TABLE VIII-23

TANKER TRANSPORTATION CORRIDOR

YEARLY THROUGHPUT (1000 B/D) BY LINK AND SCENARIO

Scenario			1	2	3	4	5
I	A.	1980-1990	340	0	340	170	170
	B.	1980-1990	340	0	340	170	170
II	A.	1980	740	400	340	170	170
		1985	1140	800	340	170	170
		1990	1140	800	340	170	170
	B.	1980	740	690	50	30	20
		1985	1140	1090	50	30	20
		1990	1300	1250	50	30	20
III		1980	490	0	490	30	460
		1985	690	0	690	30	660
		1990	1140	0	1140	30	1110
IV		1980-1990	50	0	50	30	20

TABLE VIII-24

TANKER TRANSPORTATION CORRIDOR
VESSEL CALLS PER YEAR BY LINK AND SCENARIO

Scenario			Corridor Link 1	2	3	4	5
I	A.	1980-1990	129	0	129	64.5	64.5
	B.	1980-1990	222	0	222	111	111
II	A.	1980	281	152	129	64.5	64.5
		1985-1990	369	240	129	64.5	64.5
	B.	1980	240	207	33	20	13
		1985	360	327	33	20	13
		1990	408	375	33	20	13
III		1980	194	0	194	20	174
		1985	242	0	242	20	222
		1990	364	0	364	20	342
IV		1980-1990	19	0	19	11	8

TABLE VIII-25

CASUALTY SPILLS BY CORRIDOR SEGMENT

Corridor Segment (Spills/Year)

Scenario	Cape Flattery to Port Angeles	Port Angeles	Port Angeles To Rosario Strait	Rosario Strait To March Point	Rosario Strait To Cherry Point	Total
I. Regional Supply Only						
A. Unrestricted Fleet	.0215	0	.0094	.0014	.0035	.0358
B. Restricted Fleet	.0371	0	.0162	.0024	.0060	.0617
II. Northern Tier at Port Angeles						
A. Regional Supply by Tanker						
1980	.0469	.0029	.0094	.0014	.0035	.1073
1985-1990	.0616	.0046	.0094	.0014	.0035	.1487
B. Regional Supply by Puget Spur Pipeline						
1980	.0401	.0039	.0024	.0004	.0007	.1063
1985	.0601	.0062	.0024	.0004	.0007	.1627
1990	.0681	.0071	.0024	.0004	.0007	.1852
III. Transshipment at Cherry Point						
1980	.0324	0	.0142	.0004	.0094	.0564
1985	.0404	0	.0177	.0004	.0120	.0705
1990	.0608	0	.0266	.0004	.0185	.1063
IV. Regional Supply by Trans Mount Pipeline	.0032	0	.0014	.0002	.0004	.0052

TABLE VIII-26

CASUALTY SPILL VOLUME BY CORRIDOR SEGMENT

Gallons/Year

Scenario	Cape Flattery To Port Angeles	Port Angeles	Port Angeles To Rosario Strait	Rosario Strait To March Point	Rosario Strait To Cherry Point	Total
I. Regional Supply Only						
A. Unrestricted Fleet	8,950	0	2,410	160	400	11,920
B. Restricted Fleet	15,410	0	4,160	280	690	20,520
II. Northern Tier at Port Angeles						
A. Regional Supply by Tanker						
1980	19,500	330	2,410	160	400	22,800
1985-1990	25,610	520	2,410	160	400	29,100
B. Regional Supply by Puget Spur Pipeline						
1980	16,660	450	620	50	80	17,860
1985	24,980	710	620	50	80	26,440
1990	28,320	810	620	50	80	29,880
III. Transshipment at Cherry Point						
1980	13,460	0	3,630	50	1,080	18,220
1985	16,790	0	4,530	50	1,380	22,750
1990	25,260	0	6,810	50	2,120	34,240
IV. Regional Supply by Trans Mountain Pipeline	1,320	0	360	30	50	1,760

Using current and wind data, it is possible to make a rough estimate of the zone of probable location for oil spills released along the various segments of the transportation corridor. The accuracy of the method is only as good as the data. Unfortunately, the Puget Sound and Strait of Juan de Fuca are complex hydraulic bodies. There are current data acquisition programs and elaborate computer modeling efforts under way which will ultimately allow a far more exact characterization of the possible patterns of oil spill movement. The input data to this study unfortunately allow significant opportunity for error. Nonetheless, the results provide an indication of the potential mobility of oil spills and serve as a starting point for a discussion of the possible marine resource impacts of continuing major oil movements through various segments of the Strait of Juan de Fuca and northern Puget Sound.

The wind and current information presented in Chapter VIII-B indicate average conditions over several years of data accumulation. The variable estimates of tidal motion and wind motion derived from those data are also average figures in the sense that some variability is a predictable and average occurrence. There will be conditions, such as severe storms or anomalous patterns of persistent airflow, which can significantly alter the properties of net surface current over a portion of the year. At present the data base is inadequate for an explicit modeling of the possible effect of anomalous conditions. The following analysis relies on the average conditions described; they probably do not represent the worst case, but they represent the greatest statistical likelihood of occurrence.

In the discussion of oil spill impact zone that follows, no initial distinction is made regarding the density of crude movement through the transportation corridors. Similarly, no distinction is made between the accident potential for different segments, although intuitively one feels that the segment in Rosario Strait and Cherry Point, Segment 5, entails more difficult navigation than Segment 1. That problem of accident risk is discussed in Chapter VI-B and earlier in this section. Here the principal concern is the hydraulic potential for dissipation of spilled oil by surface current phenomena within the Strait of Juan de Fuca and northern Puget Sound. Each segment of the transportation route is treated as a potential line source with an implicit spill risk equal along every unit of length. In viewing initial oil spill impact zone diagram, it is important to remember that an actual event would occur at one place along the route, or at least over a very small portion of its total length. Thus, the actual impact zone of any individual incident would be far smaller than the impact zone defined by the entire length of the transportation segment. Since it is impossible to predict exactly where such incidents may occur, and since it is impossible to present every anticipated case, examination of the line source impact zone is a more succinct form of analysis.

Recall that the pattern of net surface current within the strait and north Sound is predominantly outward, away from the land and toward the Pacific Ocean. This represents a net flushing tendency for the area as

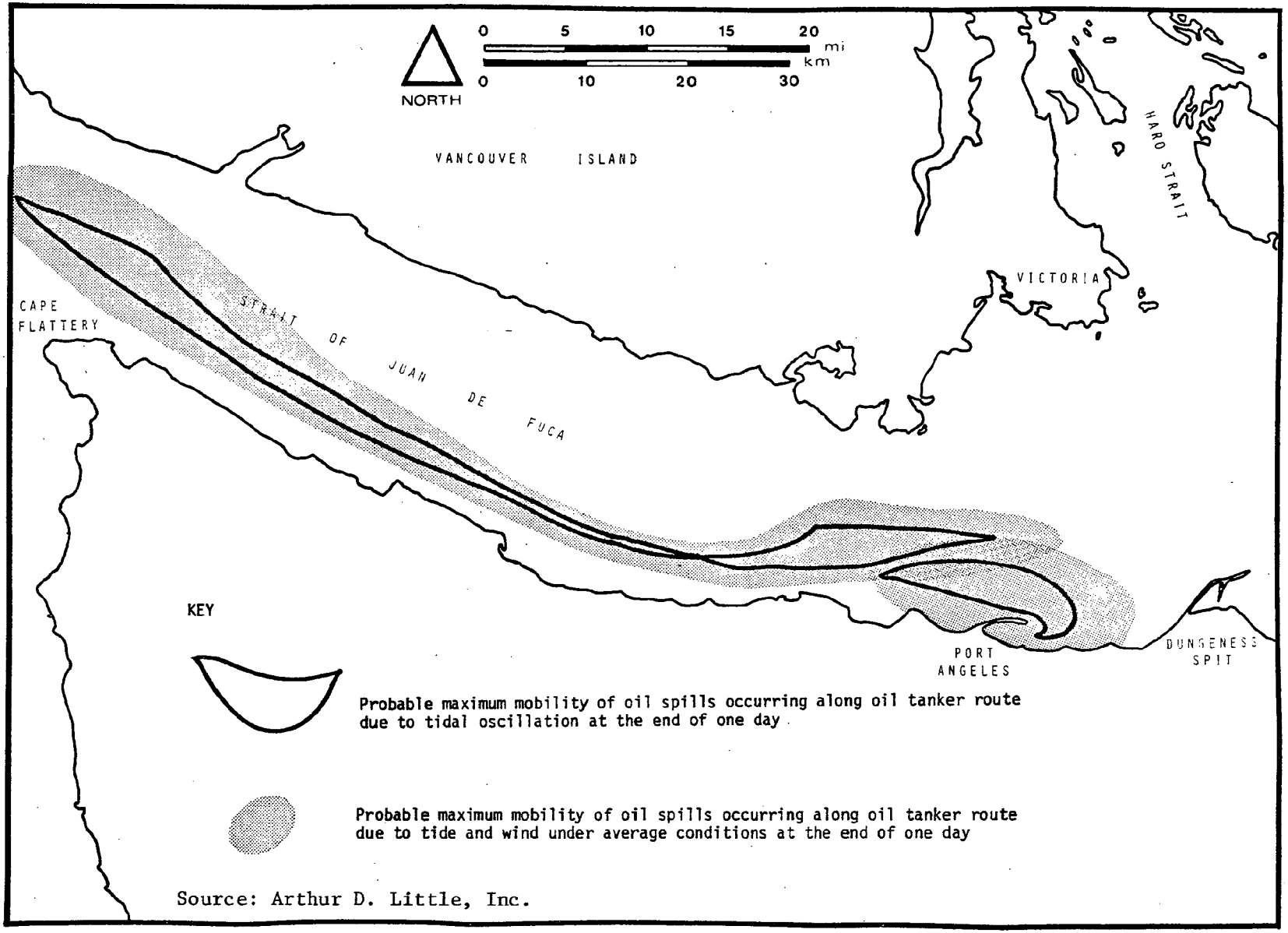
a whole. Within this zone there are small regions which have cyclical tidal movement or which may be positioned in relationship to the prevailing wind so as to experience poor flushing or possibly even some degree of concentration of surface-borne materials. For the Sound as a whole, however, the net motion appears to be outward; thus, oil spilled at any point along a transportation corridor will be gradually swept toward the Pacific Ocean. The variance of tidal and wind-induced motion around the predicted mean position increases the effective cross section of the oil spill impact zone that results.

The following series of figures illustrates the areas that are potentially affected within the first day after a spill occurring anywhere along the several tanker route segments. It is important to note that the displaced path depicted in fact represents the mean position of the floating body and that its actual path will have followed a highly active zig-zag caused by tidal fluctuations or oscillations. This distinction is critical for the understanding of oil spill impact zones. The net current allows prediction of the mean or average position of the spill at any time after its release from a known point. The instantaneous position will be found to vary around that mean due to the continual action of the tidal phenomenon. The envelope drawn around a trajectory of mean position indicates the range of possible wind and tidal displacement. The oil spill will then be expected to remain within that envelope except under exceptional conditions.

The area potentially affected by activity in the transportation segment from Cape Flattery to Port Angeles is depicted in Figure VIII-35, along with the impact zone from the small link connecting the main tank route with Port Angeles itself. The grey area of that figure depicts the impact zone. Within the grey area, an envelope defined by a heavy black line shows the range of variation and position around the mean that is due to tidal oscillation. The additional variation due to wind is responsible for extending the grey zone of impact beyond the dark line of tidal excursion. As stated before, the zone depicted is the estimate of the possible range of position that may be occupied by spills occurring anywhere along the tanker route under average conditions of wind and tide. To provide a picturesque interpretation of that zone, consider a vessel traveling between Cape Flattery and Port Angeles leaving a trail of dye in the water. That stripe of dye is initially located along the tanker transportation route depicted as Segment 1 in the earlier Figure VIII-33 and represented as the solid line in Figure VIII-36. After one day, the net influence of wind and tide will have caused the mean position of that stream of dye to have been displaced in the waters of the strait. According to the information presented in Chapter VIII-B, the mean position after 24 hours is expected to be that indicated by the broken line in Figure VIII-36.

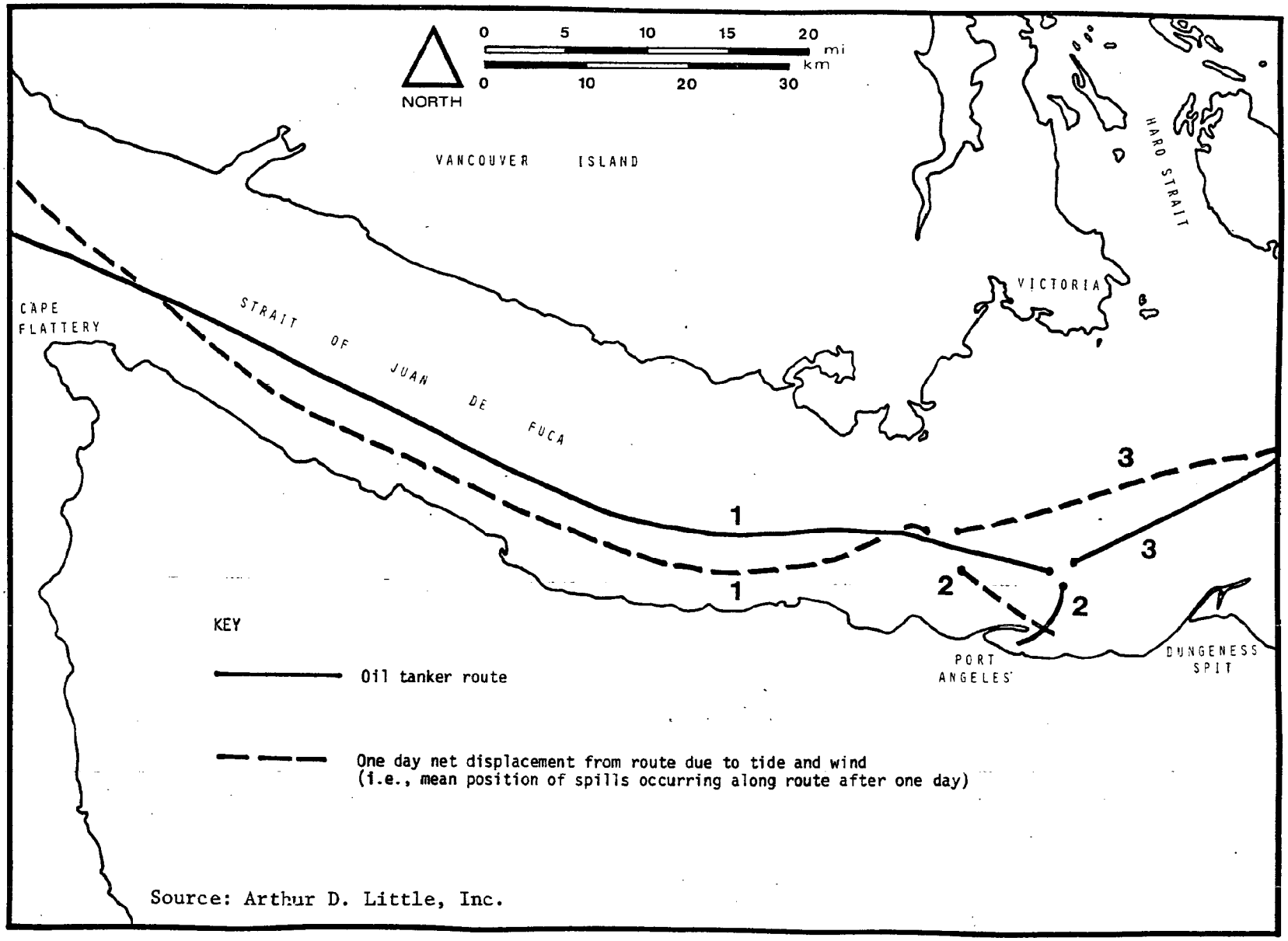
On a statistical basis, a spill may occur at any time -- either during flood or ebb; thus the range of tidal displacement from the mean position is obtained by considering the field of flood tide vectors (Figure VIII-1) and ebb tide vectors (Figure VIII-3). Those vector fields

FIGURE VIII- 35 ONE DAY IMPACT ZONE - SEGMENT 1: CAPE FLATTERY TO PORT ANGELES, AND SEGMENT 2: PORT ANGELES



Source: Arthur D. Little, Inc.

FIGURE VIII-36 SINGLE DAY MEAN DISPLACEMENT FROM LINE SOURCE(TANKER ROUTE): STRAIT OF JUAN DE FUCA



Source: Arthur D. Little, Inc.

indicate the maximum potential displacement due to tidal oscillation. This will move the actual position of the stream of dye away from its mean position in cyclical fashion, crossing through the mean position briefly four times during that 24-hour period. The maximum area covered by tidal fluctuation alone is that depicted in Figure VIII-35 by the solid line envelope. As may be seen, the vector field of flood and ebb is roughly parallel to the tanker route over much of the segment traversing the Strait of Juan de Fuca. For this reason a dye stream left by a vessel will be moved backwards and forwards, roughly parallel to itself.

The net motion of wind and tide, however, have displaced the mean position which is at the center of the tidal envelope toward the shore of the Olympic Peninsula, since the net current in this region apparently has an onshore or southerly component. The further variable action of wind has the potential to displace the floating dye in a random fashion within an ellipsoidal boundary defined by statistical considerations of wind conditions at Port Angeles, which is the most representative station available for this segment of the transportation corridor (refer back to Figure VIII-11). The orientation of the wind displacement curve or boundary is adjusted according to the vectors of prevailing wind direction given earlier in Figure VIII- 8-9. Superimposition of possible wind-induced variation in position extends the possible range of position for the dye stream to include the additional area of the gray zone depicted in Figure VIII-35 that lies outside of the boundary of tidal displacement.

Because of the nature of wind and tidal variation, the interpretation of the two areas depicted in Figure VIII-35 is slightly different. If the conditions which led to the displacement of the mean position of the dye stream persist, then it is almost certain that the stream at some time will occupy a majority of the area enclosed in the solid boundary which indicates tidal displacement. Because the extreme displacement of wind variation requires a special combination of wind persisting from roughly the same direction, there is a much smaller probability that the dye stream will actually occupy the entire area depicted by the outer grey envelope. Thus, that envelope is not the map of the actual position occupied by the dye stream within one day; rather, it is an approximate probability distribution that establishes an approximate outer limit for motion within 24 hours. As stated earlier, of course, anomalous weather patterns can result in displacement outside of the principal impact zone defined by Figure VIII-35, but the probability of such occurrence is smaller.

Also, it is important to note that the outer limit of the spill zone represents the maximum probable mobility of the centroid of the spill. Large spills (more than 250,000 gallons) will undergo further significant lateral spread due to the forces described in Chapter VI. In viewing the subsequent figures, the reader should bear in mind the approximate sizes of oil slicks resulting from various volumes of crude oil. Figure VIII-37 shows sizes for idealized circular slicks at the same scale as used for the series of impact zone maps. Actual impact from large spills is more likely to extend beyond the outer limit shown on those maps.

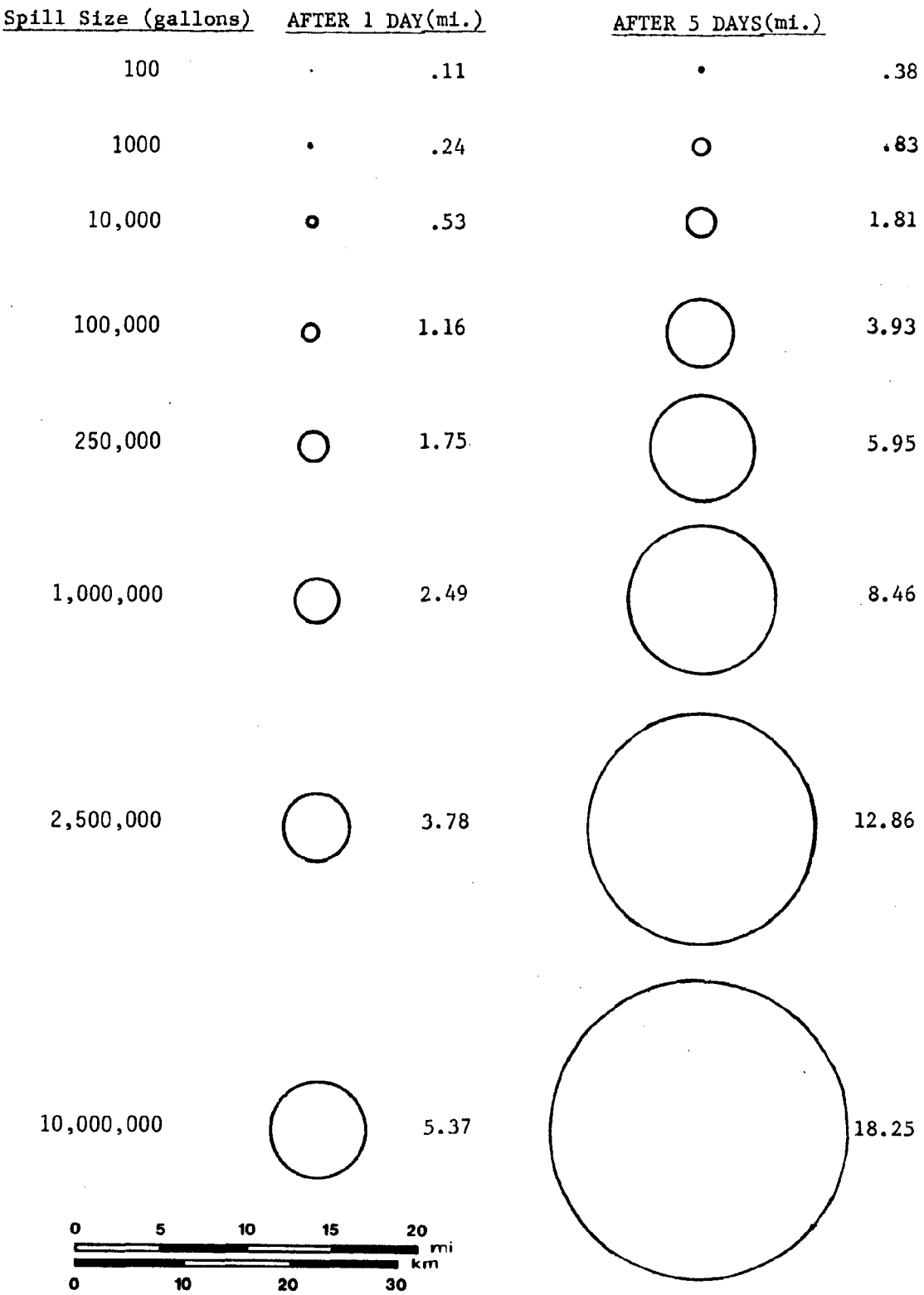
Interpreting the areas presented in Figure VIII-35, the zone from Segment 1, the route from Cape Flattery to Port Angeles is obviously larger than the zone of potential impact from the much smaller Segment 2, the link connecting with Port Angeles itself. The extent of the Segment 1 impact zone is narrow simply because the route lies parallel to the principal action of wind and tidal displacement. The Port Angeles segment, however, lies across the predominant tidal and wind direction and thus it is spread to a far greater east-west extent. Wind variation in position results in a significant probability that oil released along the link connecting Port Angeles will reach Angeles Point seven miles to the west of the tip of Ediz Hook to Green Point, approximately six miles to the east. An actual spill, of course, would not reach both locations within 24 hours but would be far more localized. That zone, however, must be considered at risk from releases occurring randomly along the Port Angeles connecting link. This analysis indicates that the wildlife refuge at Dungeness Spit is not within the 24-hour impact zone of the oil spill under average conditions.

Since the containment and cleanup effort for this portion of the Strait of Juan de Fuca and Port Angeles can be mobilized within a half day, the one-day spill impact zone indicates the approximate potential extent of damage from a small or moderate spill that could be controlled fairly quickly upon deployment of the proper equipment. According to a description of the statewide Oil Pollution Abatement Program (Department of Ecology, July 1976), the probable total 24-hour cleanup capacity in Puget Sound may exceed 250,000 gallons. Considering response time and allowing for difficulties in initial containment due to spreading that will occur during the response period, a crude oil spill would probably have to be significantly less than 100,000 gallons (2400 barrels) for impact to be limited to the one-day displacement zone. Although such a value is large compared to most operational spills, it is extremely small compared to the average volume spilled from the sort of incident expected to lead to a spill along a tanker transportation route.

The one-day potential impact zone for the transportation segment from Point Angeles to Rosario Strait (Segment 3) is depicted in Figure VIII-34. As seen in Figure VIII-38, the mean position of material spilled along the tanker route has been displaced to the south and west by net surface current motion. Tidal displacement indicated by the dark envelope in Figure VIII-39 spreads the potential range of spill impact which, when coupled with considerations of wind-induced variation position, defines a significant envelope of potential position which includes portions of the shorelines of several of the San Juan Islands and Burrows Bay and Fidalgo Head on Fidalgo Island. Those areas would be affected only if the spill were to occur at the extreme northeastern portion of the tanker route. If the spill were to occur along the western portion, its position after one day would be restricted to the zone of open water indicated in Figure VIII-39 and would not contact the shoreline.

The one-day potential oil spill impact zone from Segment 4, between Rosario Strait and March Point, includes portions of the San Juan Islands and portions of Cypress and Guemes Island to the north of Fidalgo Island

FIGURE VIII-37 OIL SLICK DIMENSIONS



Note: same scale as used for impact zone and marine resources elsewhere in this report.

Source: Arthur D. Little, Inc.

FIGURE VIII-38 SINGLE DAY MEAN DISPLACEMENT FROM LINE SOURCE(TANKER ROUTE): NORTHERN PUGET SOUND

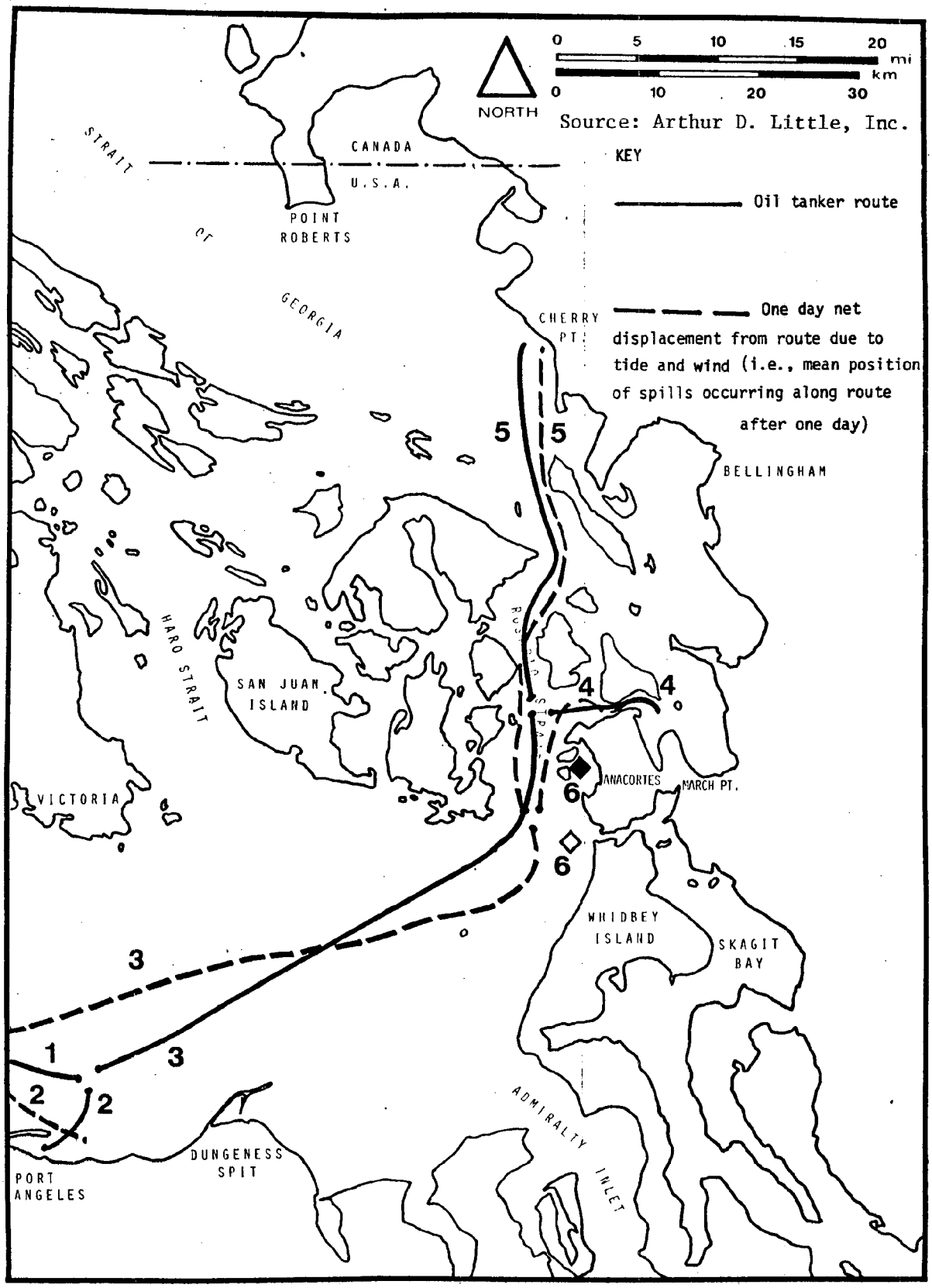
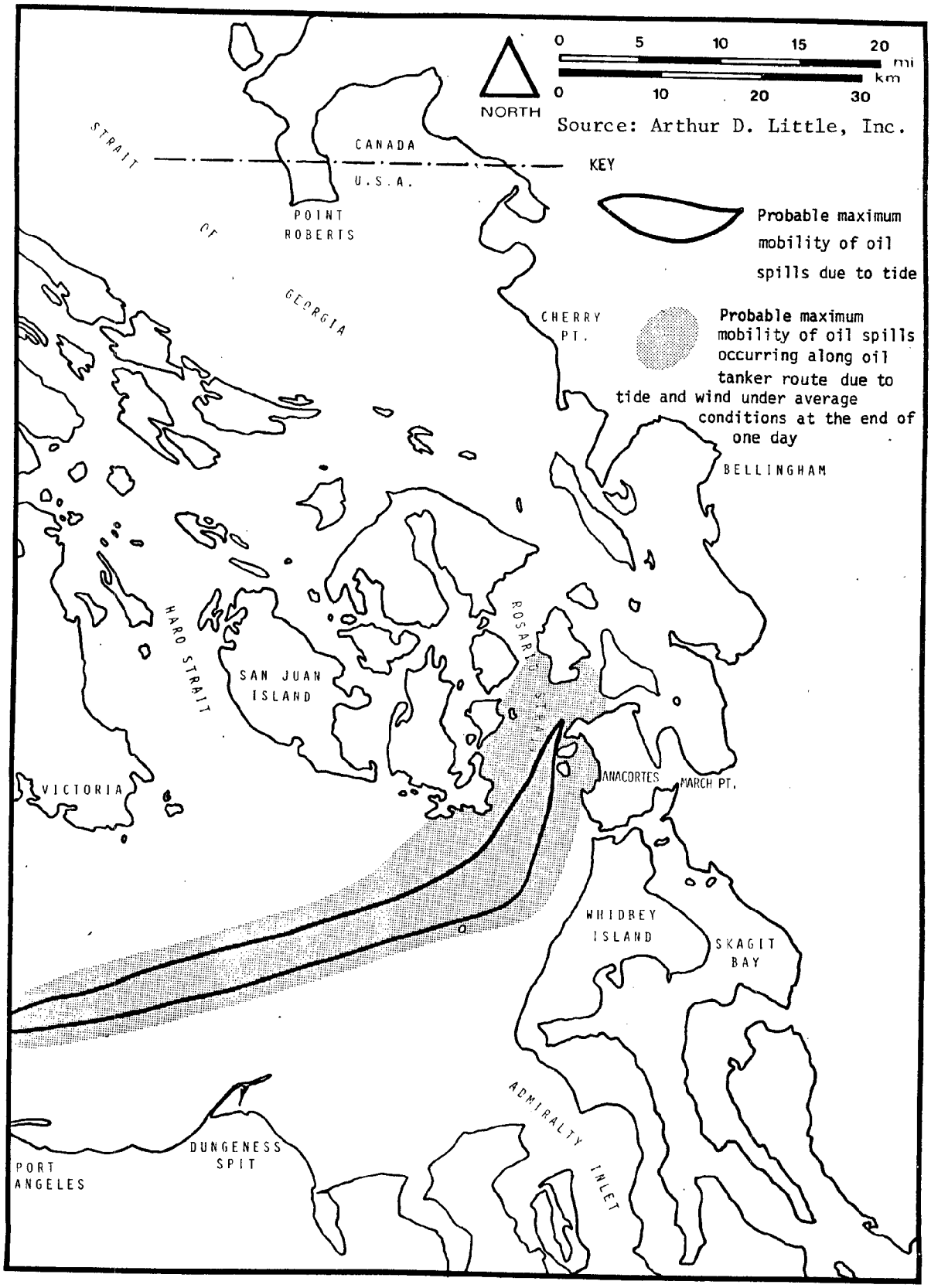


FIGURE VIII- 39 ONE DAY IMPACT ZONE - SEGMENT 3: PORT ANGELES TO ROSARIO STRAIT



opposite the City of Anacortes. Again, the exact location of the oil spill depends upon its point of initial release. Spills originating near March Point itself will reach into Fidalgo and Padilla Bay and possibly be driven northward by the strong prevailing winds toward Samish Bay. Similarly, spills occurring in Guemes Channel can be driven northward by flood tide and prevailing wind to reach Lummi Island. Spills occurring at the western end of the Rosario Strait link will drift southward with the prevailing current, resulting in the impact on the San Juan Islands and Burrows Bay (Figure VIII-40).

Tanker route segment 5, which extends from Rosario Strait to Cherry Point, will have its major impact on the shore adjoining Cherry Point, including the Lummi Peninsula on the west side of Lummi Island and on the islands adjoining Rosario Strait (see Figure VIII-41). Over the length of the segment between Rosario Strait and Cherry Point there is significant variation in tidal velocities and the mobility of spilled oil is quite variable. In the Cherry Point vicinity, currents are weaker and winds tend to induce surface currents blowing north and northwest, thus avoiding a major potential impact on Lummi Bay. Within Rosario Strait itself, strong tidal currents would give spilled oil a high mobility and incidentally interfere with potential containment and cleanup.

An oil spill occurring within Burrows Bay, east of Allen Island, would follow a net displacement indicated on Figure VIII-42. As may be seen, the location of the Burrows Bay displacement trajectory on the extreme east of Rosario Strait carries it along the shore of Fidalgo Island near to the mouth of Deception Pass. The trajectory is held in this position by the large volume of water which must leave Rosario Strait coming from the tidal prism to the north and east. Due to the strong tidal action through Deception Pass, it is probable that a portion of oil spilled within Burrows Bay will be drawn through Deception Pass into Skagit Bay. The likelihood is increased by the two-hour phase advance between the peak tidal current in Deception Pass and the tidal flow in Rosario Strait. Although such data are not presented for the remainder of the study area, there are a number of situations in which small channels between islands experience a peak current before the peak current is reached in the main channel. It is possible for the current to begin to flood into Deception Pass while a weak but still significant current ebbs from Rosario Strait, carrying material out of Burrows Bay and directly in through Deception Pass. If a Burrows Bay marine terminal were proposed, far more detailed studies would be required to estimate the frequency of Skagit Bay impacts.

As the mean position of the spilled material is gradually displaced from the tanker route by the effect of net surface current, it is subject to tidal and wind-induced variation at every point along the intermediate path. Over a longer period of time, the zone of possible oil spill position corresponding to the probable maximum mobility due to wind and tide can include a large area stretching from the vicinity of its original point of release to points quite distant. The following series of figures indicate the probable maximum extent of oil spill mobility for spills occurring under average conditions anywhere along a tanker route segment over the course of five days' time.

FIGURE VIII- 40 ONE DAY IMPACT ZONE - SEGMENT 4: ROSARIO STRAIT TO MARCH POINT

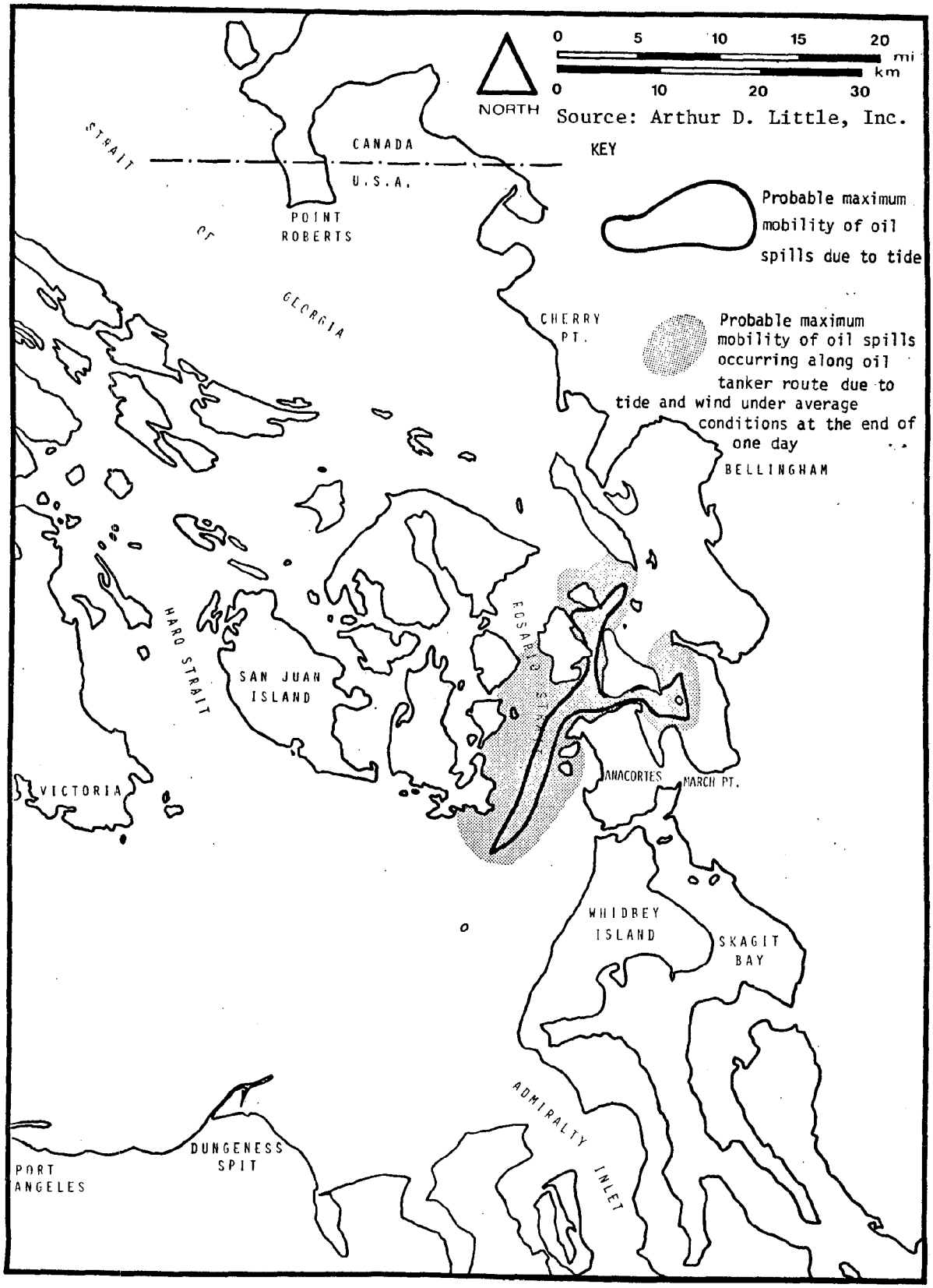


FIGURE VIII-41 ONE DAY IMPACT ZONE - SEGMENT 5: ROSARIO STRAIT TO CHERRY POINT

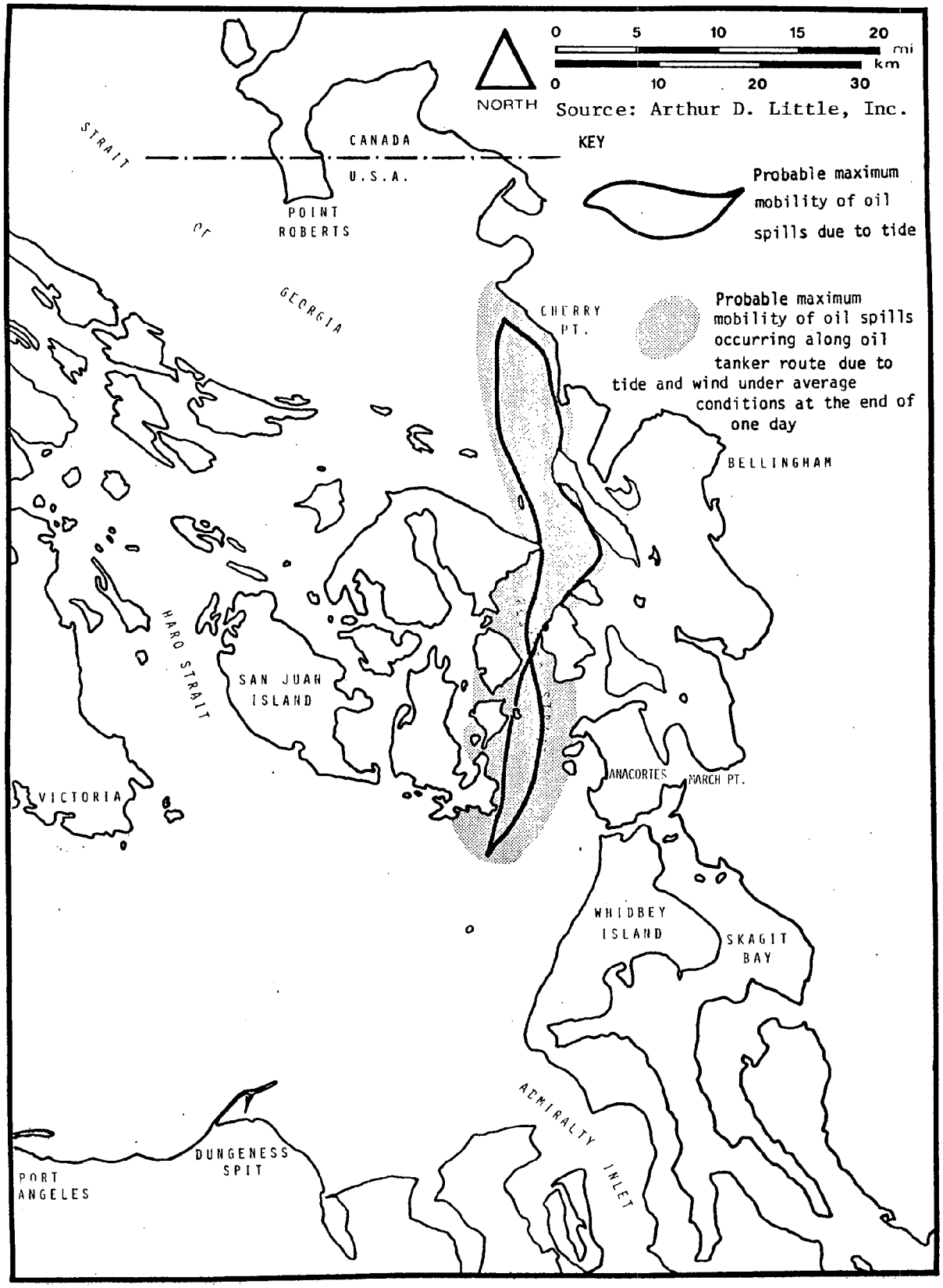
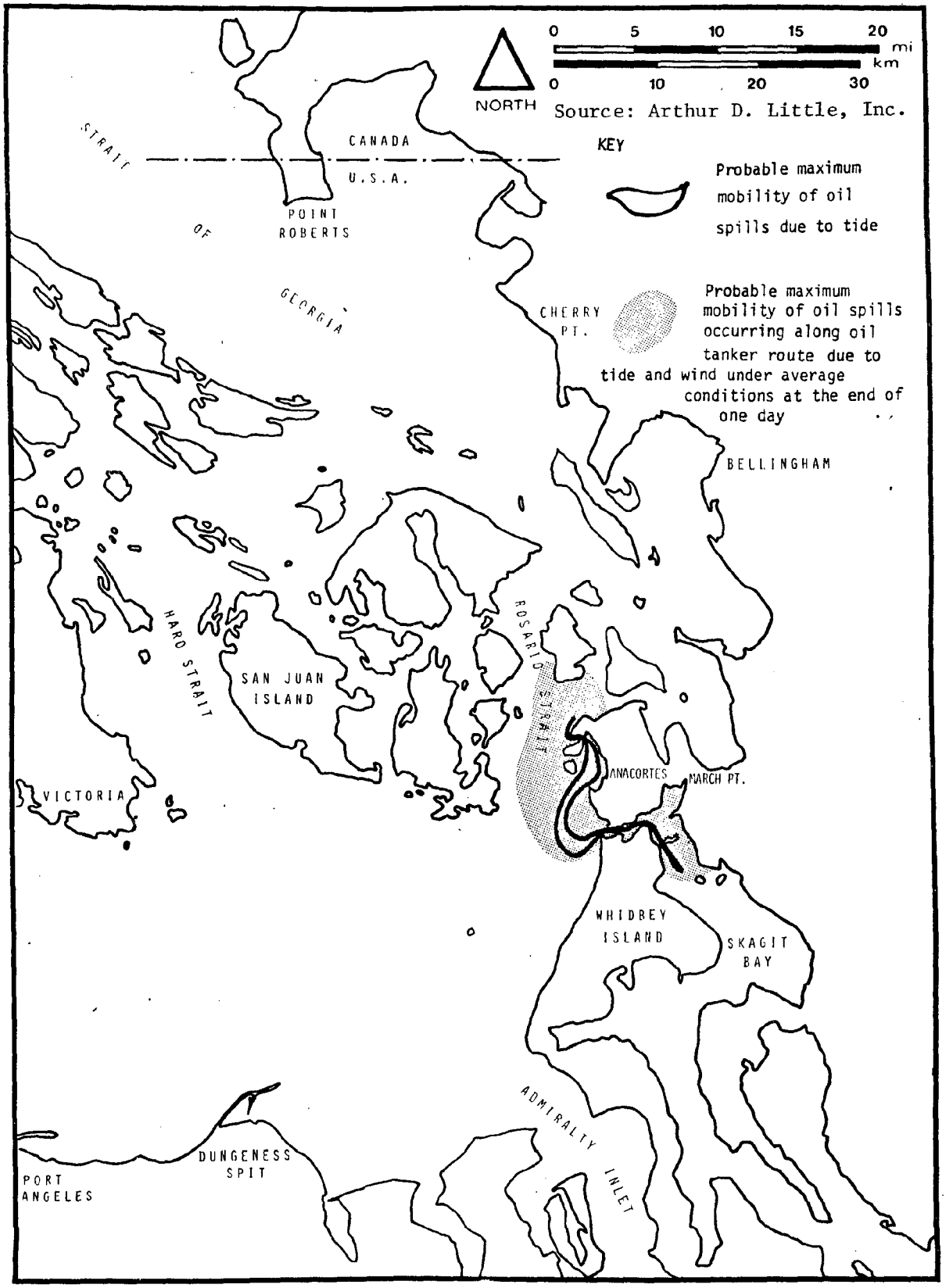


FIGURE VIII-42 ONE DAY IMPACT ZONE - SEGMENT 6: BURROWS BAY

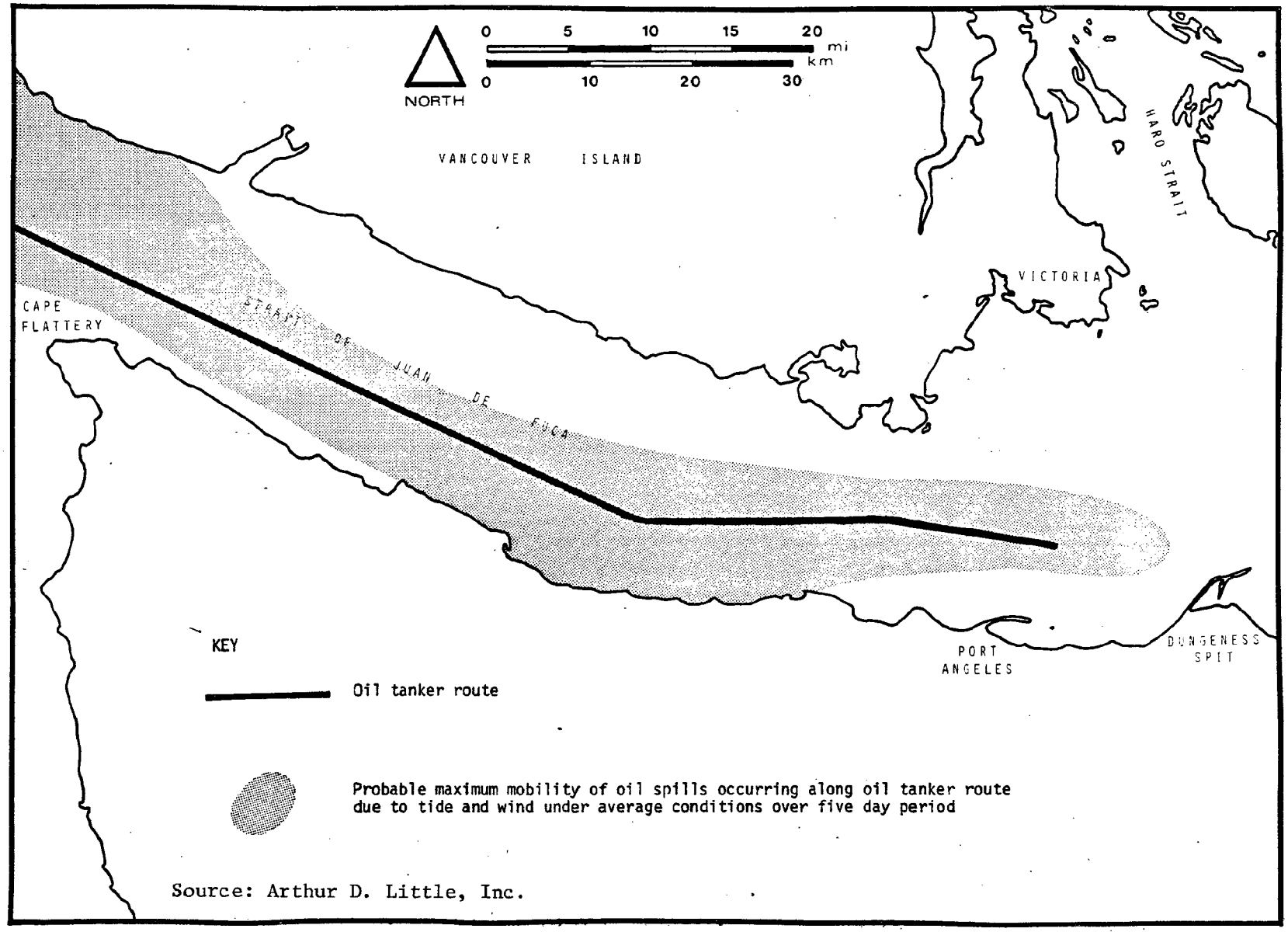


The five-day potential impact zone from the tanker route extending from Cape Flattery to Port Angeles is depicted in Figure VIII-43. The solid line depicts the tanker route segment that serves as a line source for possible oil spills. The gray area depicts the probable maximum displacement of oil spills from that line source over the course of five days. Since the tanker route is approximately parallel to wind and current throughout the Strait of Juan de Fuca, the probable impact zone is stretched along the axis of the tanker route and is expected to touch the shore only in those locations where significant radial net current is predicted. One of these is along the Olympic Peninsula and may extend from Slip Point near Clallam Bay on the west to Freshwater Bay on the east. The zone of possible shoreline impact from the Cape Flattery, segment also includes a portion of the southern shore of Vancouver Island. Over the course of five days the principal mobility from this route segment is from east to west, brought out of the Strait of Juan de Fuca by the prevailing net current.

The small segment connecting Port Angeles with the principal tanker route is situated closer to the shore of the Olympic Peninsula and therefore the five-day potential impact zone includes a far greater shoreline segment than does the zone from Segment 1 discussed earlier (see Figure VIII-44). A spill occurring within Ediz Hook or within a few miles could potentially affect the shoreline from Green Point to Clallam Bay if it were allowed to drift freely over a period of five days. According to the calculations used in this method, that five-day impact zone does not include Dungeness Spit. The method is conservative wherever possible, but its limited accuracy does not allow that important wildlife refuge to be excluded from the zone of concern.

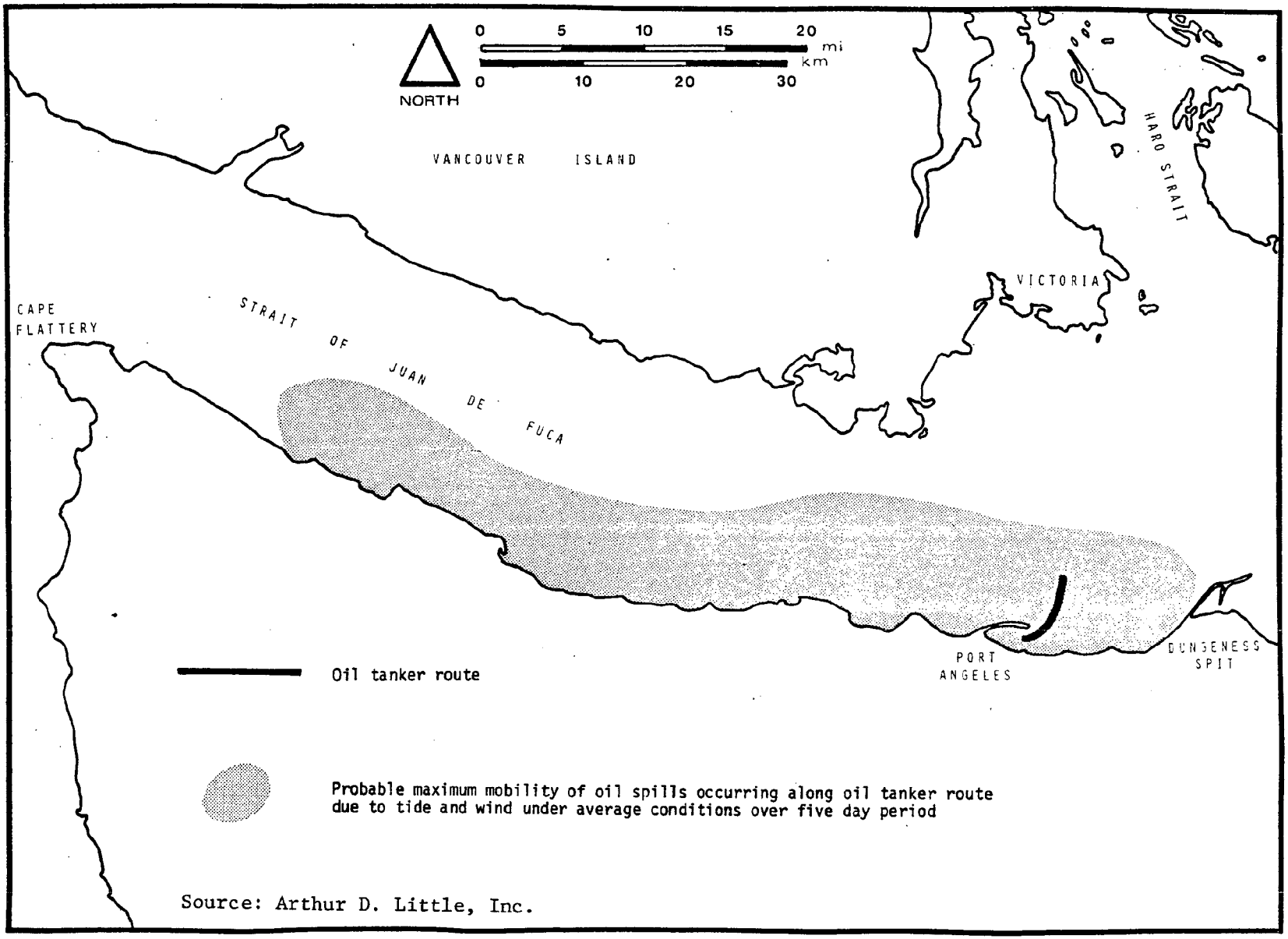
The tanker route segment from Port Angeles to Rosario Strait (Segment 3, Figure VIII-45) passes through areas of strong current with apparently strong and persistent gyres induced by the current contributions of many channels intersecting north of Dungeness Spit and west of Whidbey Island. This large-scale turbulence is responsible for broadening the zone of potential impact. Within the open area at the eastern end of the Strait of Juan de Fuca the impact zone does not intersect land near Dungeness Spit or Victoria, but as the net east to west current sweeps the mean spill position toward the Pacific Ocean the broadened zone of five-day impact intersects the coast of the Olympic Peninsula between Crescent Bay and Clallam Bay in much the same fashion as does the impact zone from the Cape Flattery to Port Angeles link. The impact zone from Segment 3 apparently intersects the shore of Vancouver Island near Cape Calver. Spills occurring at the Rosario Strait end of Segment 3 will potentially affect the San Juan Islands, Fidalgo Island, and the northwestern shore of Whidbey Island. Penetration within Deception Pass is predicted to be slight from spills occurring along this segment according to the model used. However, as with the case of Dungeness Spit, this extremely sensitive environment must be considered at risk given the probable error of the model.

FIGURE VIII-43 FIVE DAY IMPACT ZONE - SEGMENT 1: CAPE FLATTERY TO PORT ANGELES



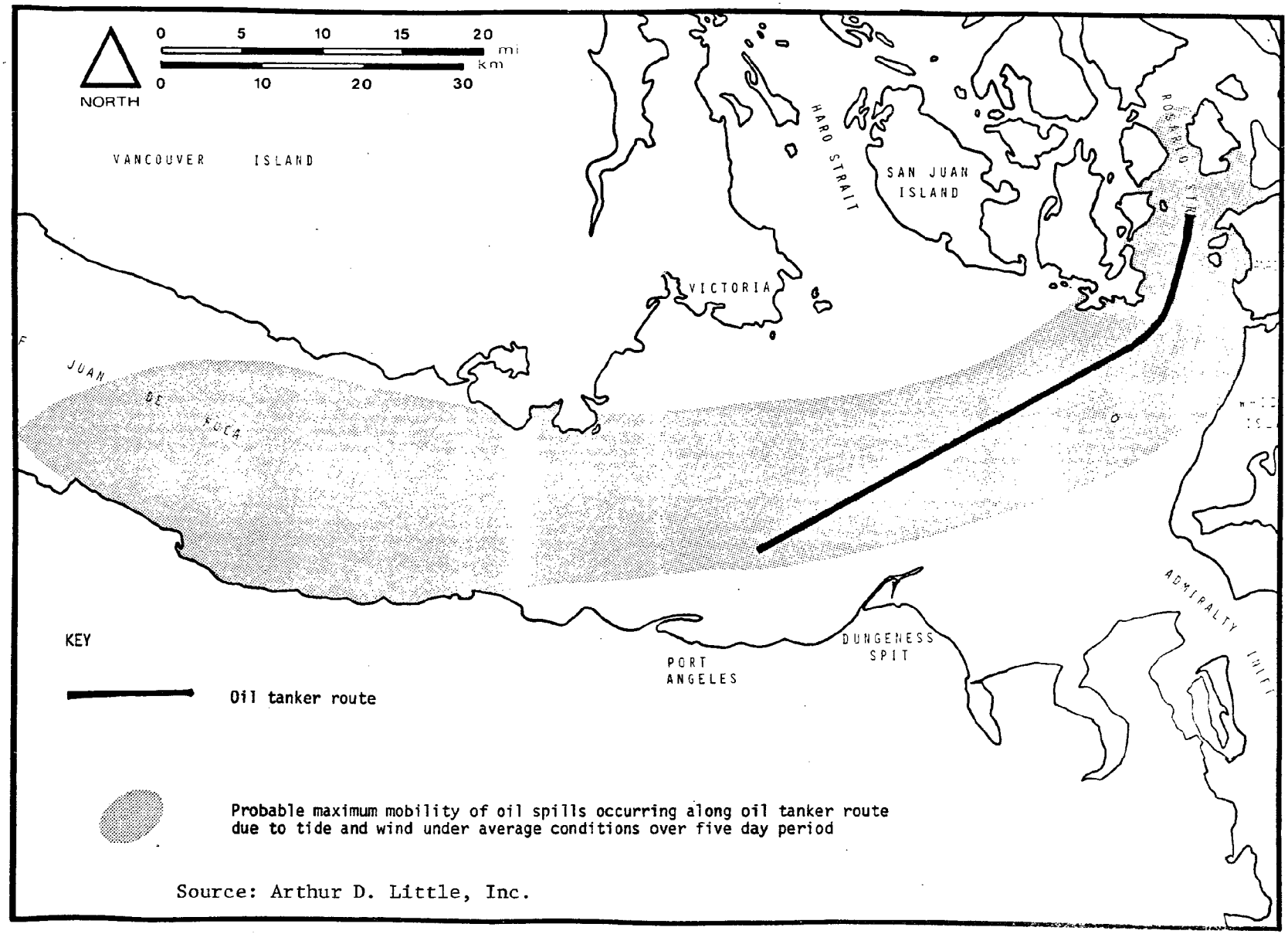
Source: Arthur D. Little, Inc.

FIGURE VIII- 44 FIVE DAY IMPACT ZONE - SEGMENT 2: PORT ANGELES



Source: Arthur D. Little, Inc.

FIGURE VIII-45 FIVE DAY IMPACT ZONE - SEGMENT 3: PORT ANGELES TO ROSARIO STRAIT



Source: Arthur D. Little, Inc.

The route connecting March Point to Rosario Strait (Segment 4) is situated in a zone of high mobility, which leads to a five-day potential impact zone depicted by Figure VIII-46. Spills occurring in the vicinity of March Point can be displaced into Fidalgo and Padilla Bay as described for the one-day impact zone. Net motion is likely to be outward, so that under normal conditions little oil is expected to be driven up into Samish and Bellingham bays. The islands around Rosario Strait including a portion of Deception Pass and the northern shore of Whidbey Island will be affected.

The route from Rosario Strait to Cherry Point (Segment 5, Figure VIII-47) lies in a region of apparently high net current which rapidly brings it through the strait and toward the Strait of Juan de Fuca. Spills along the northern portion of this segment in the vicinity of Cherry Point may move past Sandy Point into Lummi Bay and will significantly impact the shores of Lummi Island.

The five-day impact zone from spills occurring in Burrows Bay is given by Figure VIII-48. As discussed for the one-day impact zone, the location of Burrows Bay along the extreme eastern side of the Rosario Strait current complex will probably lead to significant injection of spilled material through Deception Pass into Skagit Bay. Because of the slight net clockwise circulation around Whidby Island, much of the material that actually enters Skagit Bay will be retained for long periods of time, drifting further south and east over periods longer than five days.

(3) Anomalous Weather Patterns - Oil Spill Movement. Since the method of definition of oil spill impact zone relies heavily upon observations of net tidal and wind-induced surface current, the principal deviation from the predicted potential impact zone would occur under conditions leading to significant changes in net surface current. The role of tide and wind in producing fluctuations around the mean position will be similar under a variety of actual weather patterns. The mean position of the spill, particularly after a day or more, may be quite different from that predicted by the displacement trajectories of Figures VIII-29 and VIII-30 and shown in Figures VIII-36 and VIII-37.

At present, not enough is known regarding tidal conditions within the strait and the north Sound to allow predictions of the character and duration of periods with net tidal flow different from that derived from NOAA data. It is possible to speculate as to what tidal current situations might arise; however, it is likely that the current pattern of the south Sound through Admiralty Inlet will not vary greatly from the net south to net north flow already described, since that segment of the sound is a dead end and has a significant freshwater inflow. The north Sound is somewhat different, however. The immense body of water of the Georgia Strait and the connection with the Pacific through the Seymore Narrows and Queen Charlotte Sound represent a far greater opportunity for variation in tidal phenomena. It is conceivable that some conditions might exist at some seasons, phases of the moon, or even for certain types of tidal extremes -- that the hydraulic boundary of the Strait of Juan de Fuca and Seymore Narrows would shift position from the lower portion of Queen Charlotte Sound into the San Juan Islands. If this were to occur on a

FIGURE VIII-46 FIVE DAY IMPACT ZONE - SEGMENT 4: ROSARIO STRAIT TO MARCH POINT

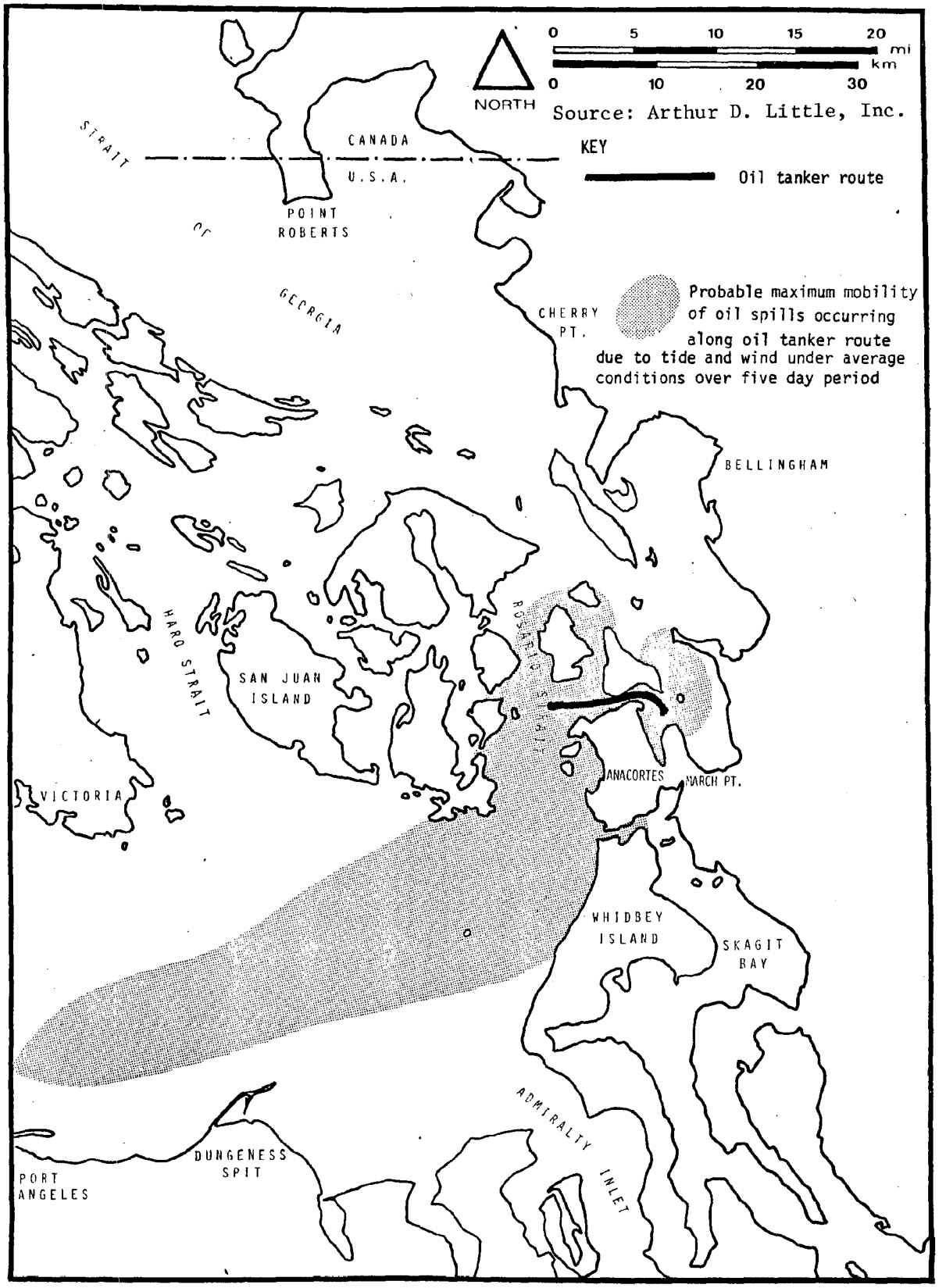


FIGURE VIII-47 FIVE DAY IMPACT ZONE - SEGMENT 5: ROSARIO STRAIT TO CHERRY POINT

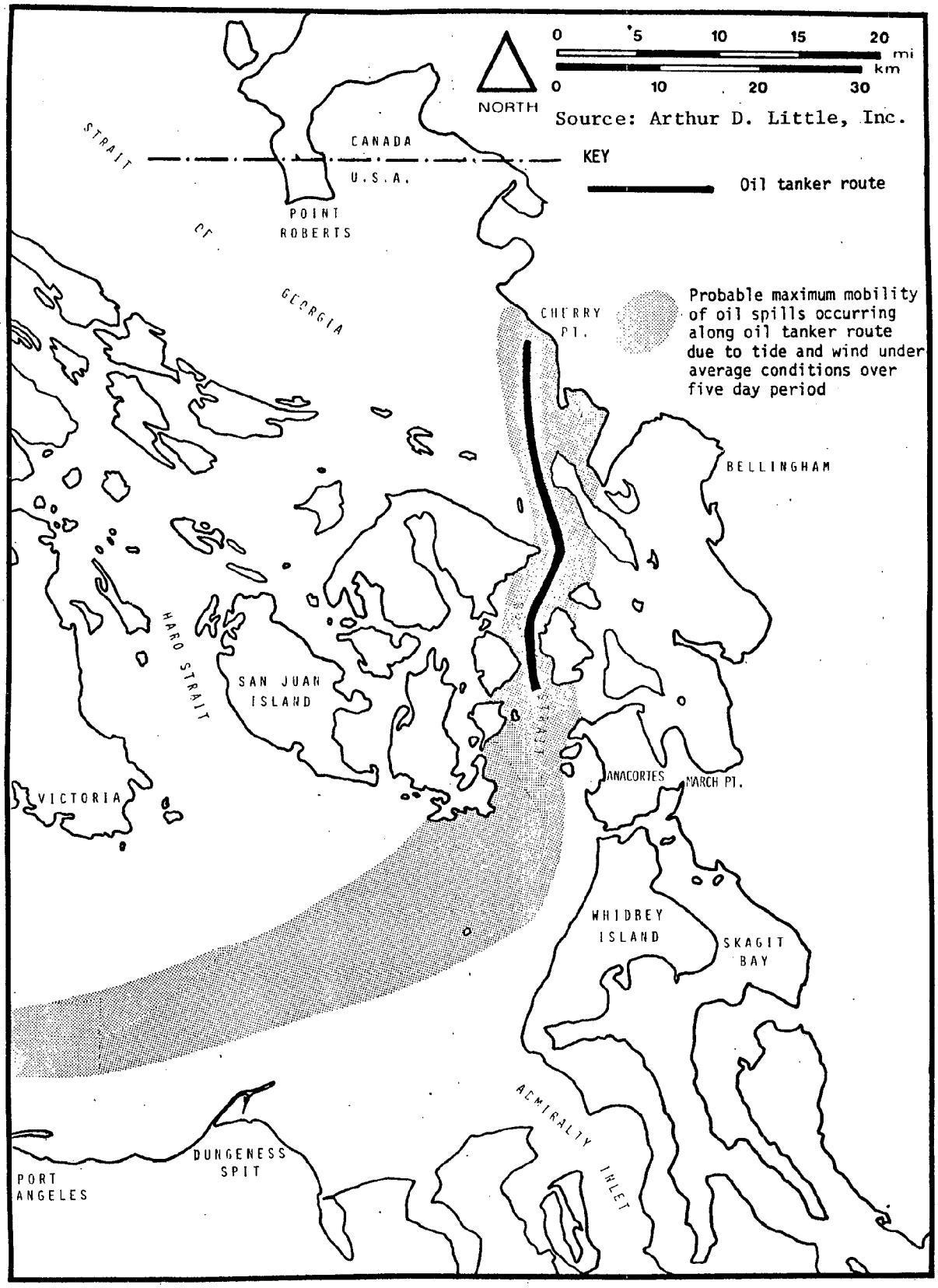
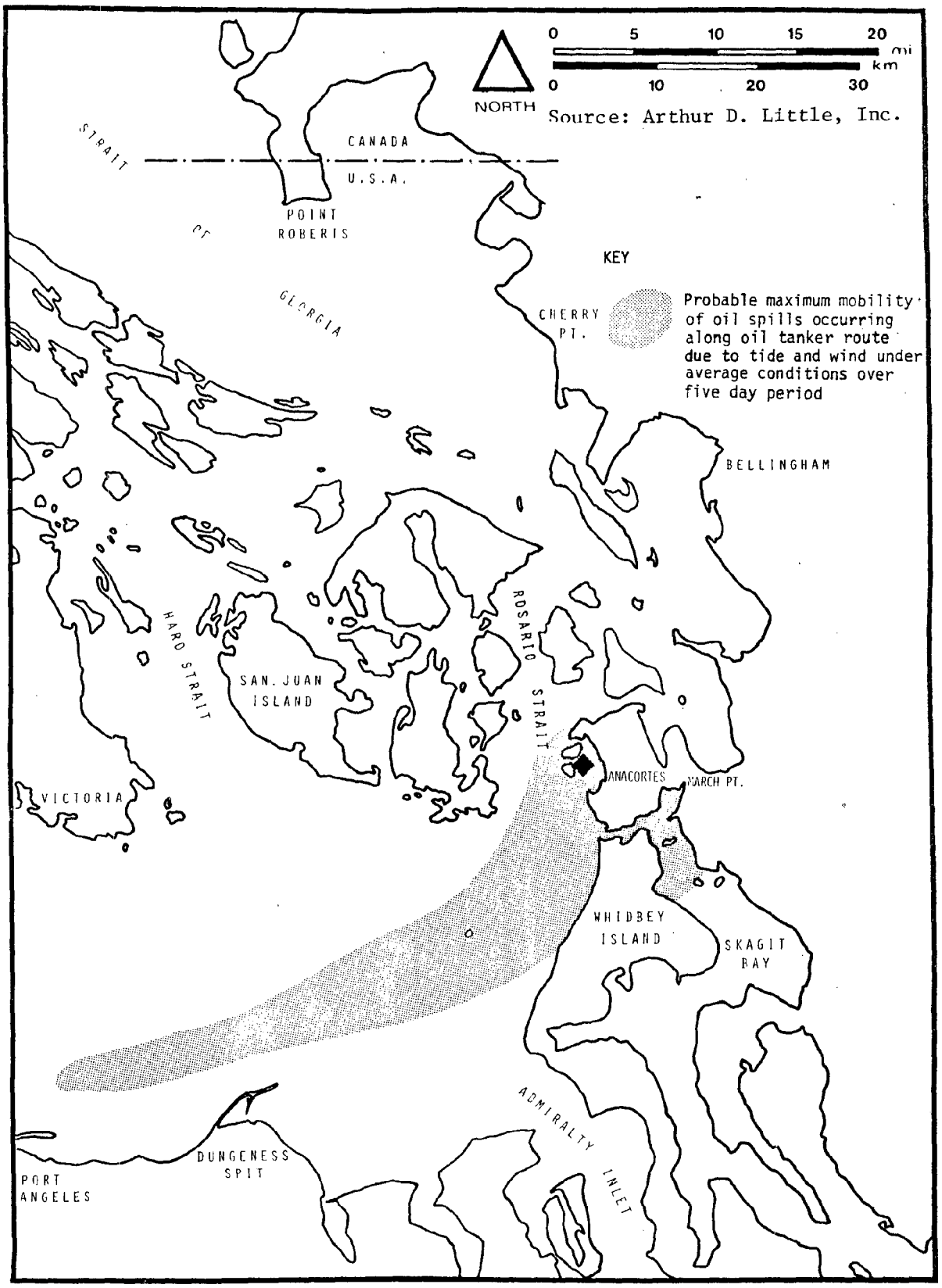


FIGURE VIII- 48 FIVE DAY IMPACT ZONE - SEGMENT 6: BURROWS BAY



significant basis, oil spilled in the Rosario Strait to Cherry Point segment would have a far greater tendency for net transport northward into the Strait of Georgia. Such flow would be augmented by the prevailing wind patterns in the area and would result in an extension of the impact zone to the north of Cherry Point past Blaine and across the international boundary. No data presently available to this study support such conjecture, however.

Within the Strait of Juan de Fuca, basic tidal hydraulics will persist under nearly every condition imaginable. It is possible, however, that net east to west flow may diminish occasionally or that storm conditions with strong winds from the west to northwest quadrant could arise which would briefly alter the pattern of net oil spill transport. Although weather records were not specifically searched to characterize such an incident, it is possible to conjecture that storm conditions could establish a predominant west to east surface current which would act over the course of a day or more. Winds averaging 20 miles per hour would induce surface currents of one-half mile per hour, given the 25% coupling factor between wind and surface oil slick movement. Under such conditions, with a weakening of the net tidal flow, the mean position of oil spill location would shift eastward for the Cape Flattery to Port Angeles segment and for the Port Angeles connecting link. The principal impact would still reamin along the north shore of the Olympic Peninsula but would now include the Dungeness Spit. For the segment from Port Angeles to Rosario Strait, the impact zone would be pressed against Whidbey Island and some oil may enter Admiralty Inlet, the entrance to Puget Sound proper. It is unlikely that conditions would persist long enough for oil to be brought deep within Puget Sound, however. For the route segments connecting Rosario Strait with March Point and Cherry Point, strong persistent storm conditions could bring spilled oil into the vicinity of Bellingham Bay. Casual examination of weather records indicates that the opportunity for such conditions is fairly rare and that, overall, an impact zone significantly different from that presented in the series of figures would only result from spills occurring during a few percent of the year.

b. Marine Resource Impacts

(1) Biological Resources - Location/Exposure. The biological resources of the marine transit impact zone are categorized according to vertical profile (intertidal, subtidal pelagic, and subtidal benthic) and according to geographic location (tanker route segment) within the total impact zone. The severity of impacts of potential oil spills on different types of marine life is strongly related to their occurrence along the vertical profile of the water column. The risk of oil spill, hence oil exposure, is related to scenario and tanker route segment, as discussed in detail in Section VIII-C-1a. The occurrence of many different types of marine life is also correlated with type of substrate -- rocky, sandy, muddy -- but since substrate type and resources are predictors of each other, substrate type is not explicitly discussed.

Owing to the properties of oil spills and their interaction with weather and landforms, intertidal organisms are likely to suffer the most severe immediate effects from oil spills. Subtidal benthic organisms will be exposed to some immediate, but more longer-term, effects; deepwater pelagic forms are exposed to perhaps less damage than species in the other habitats. Under many circumstances, an oil slick is moved by a combination of tides and winds to encounter the shore while still containing both the volatile, highly toxic fraction and the heavy, tarry, residual fractions. Once ashore, the oil becomes trapped on land by the receding tide and broken into a myriad of individual pockets or strands on rocks, sand beaches, mudflats, saltwater marsh, and tidepools. Oil effects on intertidal communities include coating and smothering plant and animal forms, as well as poisoning. Depending upon the type of substrate, cleanup may be rapid -- as on some sand beaches -- or may be difficult to impossible without even greater damage to the living resources in rocky intertidal areas and marshlands.

The residual, long-term toxic and carcinogenic fractions of the oil reach the sediments by sinking after the lightweight fractions have evaporated, or unmodified crude can reach deep benthic sediments by being initially deposited in the intertidal and rapidly retransported out to sea through the action of surf and tides on the shallow sediments. Owing to cold temperatures and oxygen as a limiting factor, biodegradation of the oil may be extremely slow in these sediments, and the oil can persist for periods of at least two years (Blumer and Sass, 1972).

Although crude oil has a lower density than seawater and tends to float on the surface, small droplets can be suspended throughout the water column by the turbulence induced by wind and wave action. Many of these droplets are in the same range as the food ingested by zooplankton -- once ingested, this oil can become concentrated in marine food chains. A study of the "ARROW" oil spill disaster off of Nova Scotia revealed that oil particles which had been suspended in the water column were recovered in plankton nets as far as 250 kilometers from the source, 30 days after their formation (Forrester, 1971). Pelagic organisms can also contact oil when it is entrapped in dense kelp beds, and thus accumulates faster than it is washed away. However, since many of the deepwater pelagic organisms are free-swimming adult fish, the streamlined shape and mucoid coating of these animals, and the fact that they are below the main mass of the oil, protects them from the degree of exposure experienced by surface (birds and mammals), benthic, and intertidal species.

(2) Sensitivity of Affected Zone - General Appraisal. North Puget Sound is a richer, more sensitive biological environment than the Strait of Juan de Fuca with respect to nearly all the biological resources identified in this study. The economic value summary table (Table VIII-1) shows the value of the commercial bottom fishery in the strait to be slightly greater than the north Sound, but nearly 90% of this is attributable to the fishery of the oceanic waters off Cape Flattery. Without the Cape Flattery component, the value of the north (inner) Sound bottom fishery is 10 times that of the strait (outer Sound). The resource area for bottom fish -- both commercial and sports resources -- is also far

greater in the north Sound (see Figures VIII-15 and VIII-16). Data for the sports fishery value are difficult to interpret because of overlap between the north Sound and the strait in the definition of one resource area (area 6 in Figure VIII-12), but the data generally indicate a larger catch and greater value for the north Sound.

With respect to salmon resources, the commercial productivity of the north Sound area is 11 times as great as the strait (1971-73 gross value averaged $22 million versus $2 million). The resource area of the strait for commercial fisheries is 20% greater. For sports salmon, the resource area of the strait is nearly twice as large as for the north Sound; the relative value is comparable to the resource area.

The resource area for clams (intertidal and subtidal) is roughly equal for the two areas (the north Sound is 29% greater if Skagit Bay is included). However, the clam harvest in the north Sound is 3.6 times as great, and the value of this catch is correspondingly larger. The area of crab resources in the strait is less than one-fourth the north Sound's, and the size of the harvest is nearly 18 times larger throughout the north Sound; its value is 16 times larger.

The area of oyster beds is six times greater in the north Sound than in the strait (5 versus 30 square miles). Oysters occur in the coastal waters south of Cape Flattery, but within the strait they are found only within the harbor of Dungeness Spit and in Sequim Bay. There are many more areas of natural occurrence as well as mariculture within the shallow bays of the inner Sound.

Herring spawning (Figures VIII-17 and VIII-18) is more prevalent in the north Sound, especially near the Canadian border. The herring spawning area of the north Sound is 10 times as large as in the strait (90 versus 9 square miles). Shrimp and scallops do not occur in the strait at all. While neither is abundantly distributed throughout the north Sound, there are about 30 square miles of shrimp beds in Burrows Bay and the San Juans (Lopez Sound and Passage). Scallops occur in a 20-square mile area of the waters off northern Whatcom County, including offshore Cherry Point.

The crab resource area is 4-5 times greater in the inner Sound. This difference correlates well with the difference in commercial crab catch and value. The sports crab catch is 18 times as large in the north Sound, and its value is 16 times as large (1973 harvest year).

The area of eelgrass beds is eight times larger in the north Sound (10 times larger if Skagit Bay is included as part of the north Sound). The area of waterfowl habitat is about 160 square miles in the north Sound and only 70 miles in the strait -- less than half.

Nearly all marine mammals which are known to occur within the waters of the north Sound must have entered either through the Strait of Juan de Fuca or the Strait of Georgia, so the former is thought to be important

as a migration route. However, the only species whose major period of residency is spent in the strait is the Dall porpoise. Within the north Sound, the majority of the other species are concentrated either within the San Juan Islands or between these and Vancouver Island.

A number of resources are concentrated in either the north Sound or the south Sound (Table VIII-27). Specifically, these resources have half or more of their total resource area in one of these two major subdivisions of the Sound. The Strait of Juan de Fuca does harbor moderate amounts of some resources but does not offer the secluded productive environments provided by the north or south Sound; hence none of the major marine resources is concentrated in the strait.

A corollary of the above resource distribution is that certain areas of the Sound are "richer" in marine resources than others; for the resources inventoried in the Marine Atlas series, Table VIII-2 indicates that the south Sound and the Skagit portion of the north Sound are the richest in marine resources. A subarea of the Sound is considered exceptionally rich if it has a greater proportion of a particular resource than would be expected on the basis of area alone. For example, by area Skagit Bay and vicinity is only 4% of Puget Sound, but it has 10% of the Sound's subtidal clam resource, 23% of the shrimp resource, 16% of the eelgrass beds, and is rich in other resources as well. The Skagit area and the south Sound, the richest areas, are exposed to the least amount of oil spill risk due to the tanker transportation routes shown in Figures VIII-32 and VIII-33.

(2) Methodology. To assess the impacts of oil tanker transport on Puget Sound's marine resources, the areal extent of each resource potentially affected was calculated as a proportion of the total areal extent of that resource within Puget Sound. Using the maps of 11 different marine resources published in the Washington Department of Natural Resources' Marine Atlas series, the total area shown for each resource was measured with a marked grid such that the number of marks occurring in a resource area could be converted to area in square miles. The area of each resource at risk due to oil movement through the Sound was similarly measured, using the unextended five-day impact zones associated with the various tanker route segments (see the discussion of impact zones in Chapter VI), as an intermediate approximation of the area of waters potentially affected under most wind and tide conditions. Thus, it was possible to calculate for each of 11 marine resources the proportion of the resource area at risk in each major geographic subdivision of the Sound, and in the Sound as a whole.

The unextended five-day impact zones resulting from the tanker route were selected to represent the most meaningful measure of area affected by tanker oil spills because (a) the one-day impact zones are too restricted to represent the regional mobility of spilled oil moved by tides and wind, and (b) the five-day extended impact zone, in which the largest spill's center at any point on the edge of the unextended five-day envelope generates a "worst case" impact zone, is so large as to fill the entire channel,

TABLE VIII-27

MARINE RESOURCES LOCATED DISPROPORTIONATELY
IN SUBAREAS AT PUGET SOUND

SOUND SUBAREA*	RESOURCE
Total SJF	sport salmon commercial salmon
Skagit area	intertidal clams shrimp waterfowl areas eelgrass beds commercial bottom-fishing (crab & herring spawning ground) - borderline
North PS	herring spawning ground scallops crab bottomfish, sport & commercial
South PS	intertidal clams subtidal clams oysters herring spawning grounds shrimp sport salmon waterfowl areas eelgrass beds

* SJF = Strait of Juan de Fuca
PS = Puget Sound

Source: Arthur D. Little, Inc.

implicating almost all of a resource's area in some locations. The unextended five-day impact zone represents a statistically intermediate or "most likely" impact zone (i.e., not assuming anomalous weather conditions) which does not grossly under- or overestimate the waters potentially affected.

The significance of potential oil spill impacts upon a given marine resource was determined in the following way: in each case where the area potentially affected by a five-day impact envelope equaled 30% or more of the resource area of the strait or north Sound, this proportion was then multiplied by the percent of the total Puget Sound resource contained in that subarea to yield the proportion of that resource in all of Puget Sound potentially affected by oil spilled in that portion of the tanker route. If oil spilled from a given tanker route segment affected 30% or more of a local subarea's resources, the impact was considered locally significant. If, in addition, 20% or more of Puget Sound's resource area would be affected, due to a concentration of that resource in the subarea, the impact was considered to be regionally significant as well.

As an example, Table VIII-28 shows that 64% of the subtidal clam resource area in west Strait of Juan de Fuca (from Cape Flattery through Port Angeles) would be at risk from spills in tanker route Segment 2. However, since the west strait's clam area is only 6% of the entire clam resource area of Puget Sound (see Table VIII-2), only 0.64 x 0.06 = 0.038 or about 4% of the Sound's clam resource would be at risk -- a locally, but not regionally, significant impact. On the other hand, spills from route Segment 5 would place 34% of the north Sound's scallop resource area at risk. Since 81% of the entire Sound's scallop resource area is in north Puget Sound, 0.34 x 0.81 = 0.275 or about 28% of Puget Sound's scallop resource would be at risk; this becomes a regionally significant impact (actually, risk of impact) as well as a locally significant one.

The main weakness in the areal extent method outlined above is that the areas covered by each resource in the Marine Atlas maps do not necessarily represent all of that resource in Puget Sound. These areas represent the most important or major concentrations of the resource and do not include, for example, private clam beaches or noncommercial oyster beds. Since these deficiencies would most likely result in a greater underestimation of the total existing resource area than of the area of potential impact, the affected proportions calculated may be slightly overestimated.

The resource areas calculated as "potentially affected" by oil spills are based on the five-day impact zones and thus represent the area of that resource that would be at risk from oil impacts, and not the area actually affected by any given spill. The actual resources affected by an oil spill along the tanker routes would occupy a much smaller area, depending upon the size and conditions of the particular spill, than the area at risk. The area of resources at risk, however, is amenable to estimation, whereas the area actually impacted from a given spill is not; in addition, impacts are better understood in terms of the extent of a given resource or of a given area's resources at risk for all spill sizes and weather conditions than to know the results of one particular spill.

TABLE VIII-28

PERCENT OF LOCAL MARINE RESOURCE AREAS
POTENTIALLY AFFECTED BY TANKER ROUTE SPILLS

RESOURCE	SEGMENT	WEST SJF*	EAST SJF*	ALL SJF*	SKAGIT AREA	NORTH PS*
Intertidal clams	1	31	-	12		
	2	75	-	28		
	3	28	-	10		-
	4	-	-	-	-	9
	5	-	-	-		13
Subtidal clams	1	-	-	-		
	2	64	26	40		
	3	-	-	-		-
	4	-	5	3	-	-
	5	-	-	-		-
Oysters	1	-	-	-		
	2	-	-	-		
	3	-	-	-		-
	4	-	-	-	-	5
	5	-	-	-		14
Herring spawning grounds	1	-	-	-		
	2	-	-	-		
	3	-	-	-		-
	4	-	-	-	-	-
	5	-	-	-		19
Shrimp	1	-	-	-		
	2	-	-	-		
	3	-	-	-		13
	4	-	-	-	-	13
	5	-	-	-		-
Scallops	1	-	-	-		
	2	-	-	-		
	3	-	-	-		-
	4	-	-	-	-	-
	5	-	-	-		34
Crabs	1	32	-	28		
	2	44	-	39		
	3	30	-	26		-
	4	-	-	-	-	5
	5	-	-	-		8

RESOURCE	SEGMENT	WEST SJF*	EAST SJF*	ALL SJF*	SKAGIT AREA	NORTH PS*
Salmon (sport)	1	57	-	43		
	2	55	7	44		
	3	47	25	43		13
	4	7	15	9	-	18
	5	15	12	15		14
Salmon (commercial)	1	64	1	41		
	2	31	7	22		
	3	46	62	49		32
	4	7	57	16	-	33
	5	16	51	22		32
Waterfowl areas	1	5	-	2		
	2	38	-	16		
	3	5	7	6		4
	4	-	-	-	-	19
	5	-	-	-		15
Eelgrass beds	1	-	-	-		10
	2	100	-	14		
	3	100	-	14		-
	4	-	17	14	4	10
	5	-	-	-		10
Bottomfish (sport)	1	10	-	8		
	2	16	13	15		
	3	2	9	3		17
	4	-	-	-	9	18
	5	-	-	-		27
Bottomfish (commercial)	1	40	-	11		
	2	51	-	14		
	3	53	30	43		22
	4	35	21	29	-	23
	5	40	-	22		24

* SJF = Strait of Juan de Fuca; PS = Puget Sound;
"West SJF" includes Cape Flattery through Port Angeles

("-" indicates trivial percentage; " " indicates area not affected)

Source: Arthur D. Little, Inc.

The geographic subareas of Puget Sound selected to facilitate meaningful analysis of marine resources were the Strait of Juan de Fuca and north Puget Sound, which includes the Strait of Georgia, the Skagit Bay vicinity, and a small triangle near Port Townsend (Figure VIII-12). Since the oil spill movement study indicated that no spilled oil would enter the Sound south of Port Townsend, Saratoga Passage, or Port Susan, the south Sound was not included in the impact analysis, although its resources were measured so that the affected proportion of the Puget Sound total resource area could be calculated. The Sound could have been divided other ways, such as into the more localized resource areas used in the economic value analysis of DOE's Baseline Study (see Tables VIII-1 and VIII-4). The two large subareas could also be further broken down by tanker route segment; however, these segments were simply constructed for use in the study of oil spill mobility and do not reflect any natural divisions of the Sound. The strait and north Sound do represent different oceanographic environments and, as discussed above, different levels of biological productivity in response to these environments.

Finally, the discussion of marine resource impacts will be according to oil development scenario, rather than by resource or by tanker route segment.

(4) Scenario Impacts. Oil exposure risk differs for each scenario and for the different years of phased oil development. A discussion of oil spill size and frequency appears in Chapter VI; these elements of oil spill exposure risk differ for the various scenarios because the factors upon which they are based -- throughput, vessel calls, and vessel size -- differ by scenario.

- Strait of Juan de Fuca

  - Sport and Commercial Resources. The potential impacts upon both the sport and commercial salmon fisheries of the strait would have regional significance especially upon the resources in the western portion, from Cape Flattery to Port Angeles. Oil spilled from tankers moving through the strait and up to Deception Pass (tanker route Segments 1 and 3) could potentially damage roughly 40-50% of the strait's sport and commercial salmon fisheries (Table VIII-28) and about 20% of the entire Sound's sport and commercial salmon fisheries (Table VIII-29).

Most of the potential impacts of oil spilled in the strait under Scenarios I, III, and IV would have strictly local significance. Large proportions of the strait's crab, commercial bottomfish, eelgrass beds, and the eastern strait's commercial salmon resource areas would be potentially affected by oil from tankers moving through the strait and, in the case of commercial salmon and bottomfish, moving through the north Sound (Segments 4 and 5) as well (see Table VIII-28). However, because crabs, commercial bottomfish and eelgrass beds are concentrated in the north or south Sound, the risk of serious impact is locally significant only.

TABLE VIII-29

PERCENT OF PUGET SOUND RESOURCE AREAS AT RISK

RESOURCE AT RISK	PORTION OF SOUND RECEIVING IMPACT*	PERCENT OF TOTAL PUGET SOUND RESOURCE AREA AT RISK
Intertidal clams	West SJF	1 - 5
Subtidal clams	West SJF	4
Oysters	North PS	2
Herring spawning grounds	North PS	9
Shrimp	North PS	2
Scallops	North PS	28
Crabs	West SJF	4 - 5
Salmon (sport)	West SJF	17 - 21
Salmon (commercial)	West SJF	11 - 22
Waterfowl areas	West SJF	3
Eelgrass beds	West SJF	1
Bottomfish (sport)	North PS	18
Bottomfish (commercial)	West SJF	4 - 5

* SJF = Strait of Juan de Fuca
PS = Puget Sound
"West SJF" includes Cape Flattery through Port Angeles

Source: Arthur D. Little, Inc.

Forty percent of the strait's 1973 commercial salmon catch equaled $962,391, or 3% of the dollar value of the entire Sound's commercial salmon catch for that year. Thus, although a significant portion of the Sound's commercial salmon resource area would be at risk in the strait, due to spills from strait tanker traffic, the greatest catch by dollar value is in north Puget Sound and would not be affected.

Because most of the 1973 commercial crab catch was taken in north Puget Sound, the locally significant 31% potentially affected would amount to only $2,189, less than 1% of the entire Sound's 1973 crab catch. On the other hand, because the bulk of the commercial bottomfish catch (dollar value) in 1973 was in the Strait of Juan de Fuca, 45% of the local strait fishery affected would amount of $734,464, or a regionally significant portion -- 41% -- of the Sound's commercial bottomfishery. Thus, a strictly local impact in terms of areal extent of commercial bottomfishery becomes a regionally significant impact in terms of dollar value of the catch.

The effect of adding tanker route Segment 2 to Port Angeles to the other segments is to increase somewhat the potential for risk to resources of the western Strait of Juan de Fuca; the risk to resources of the north Sound is not increased since the five-day impact zone of Segment 2 is confined to the strait. Of regional significance would be the added effect of spills near Port Angeles on the strait's sport salmon resource; between 17% and 20% of the Sound's sport salmon resource area would be at risk. However, as pointed out in the discussion of the impacts of route Segments 1 and 3, the great majority of the salmon, in terms of dollar value of catch, are taken in the north Sound, so the areal impact must be viewed as not truly regionally significant.

Spilled oil from the Port Angeles route segment could also affect both intertidal and subtidal clam resources west of Port Angeles on a strictly local level of significance: While some 75% of intertidal clams and 64% of subtidal clams would be at risk in the western strait, these resources are mainly concentrated in the south Sound and so would not suffer damage or tainting on a regional level if reached by spilled oil. This would also be true for the crab resource, which is concentrated in south and north Puget Sound but which could suffer locally significant damage due to oil spilled in Segment 2, since 44% of the western strait's crab area falls inside the segment's five-day impact zone.

The commercial salmon and bottomfish resources would also be at risk on a locally significant level: 31% of the western strait's commercial salmon fishery area and 51% of its commercial bottomfish area could be affected by oil.

- Waterfowl. None of the small and sparsely scattered waterfowl areas in the Strait of Juan de Fuca would be affected with even local significance by oil spilled from tankers moving through the strait or north Sound in Scenarios I, III, or IV, although all of one very small eelgrass bed (not a main waterfowl area) would be at risk due to Segment 3 spills.

Both of the western strait's two very small waterfowl areas would be at risk with the addition of the Port Angeles portion of the tanker route. While locally significant, on a regional level almost all the waterfowl areas are located in the larger, shallower, and more protected bays of the north and south Sound.

- Marine Mammals. Unlike finfish, which receive most of oil's toxic effects through internal poisoning or long-term sublethal disturbances, marine mammals are most immediately susceptible to the surface-coating effects of oil. Coating of the mammal integument with oil produces many of the physiological effects as in birds, since its effect is to remove the insulating properties of the fur and thus expose the animal to thermal shock. More susceptible mammals include seals, sea lions, and sea otters. The most sensitive members of the mammal populations are the young, due to their small weight and their greater surface-to-volume ratio. Whales and dolphins, however, are not subject to coating in the same way as marine mammals which regularly emerge on land or haul out at the surface. In addition, these animals have a smooth skin with isolated bristles for hydrodynamics and utilize a subcutaneous fat layer for insulation. Whales are also conjectured to avoid an oil mass if they detect it, but they may ingest oil with the zooplankton or suspended in the water. Fish-eating whales may be unable to avoid eating tainted fish.

Three species of whales and two species of sea lions migrate through the strait to and from their wintering grounds in the north or south Sound. Since the humpback, gray, and killer whales and the California and northern sea lions only traverse the strait and do not live there, and since the whales may be able to make diversions in their routes, these marine mammals would not be as likely to suffer adverse effects of oil spilled along the tanker route as resident or sedentary life. The other marine mammal of concern in the strait is the Dall porpoise, which is found between Cape Flattery and Port Angeles all year around and would probably not be as able to escape oil reaching the strait; the porpoise would also be somewhat sensitive to the spilled oil since it spends most of its time near the surface, where the oil would be concentrated following a spill.

- Anadromous Fish Streams. Table VIII-6 and Figure VIII-27 identify the names of the 13 anadromous fish streams (rivers or streams harboring winter and summer runs of migrating steelhead trout) emptying into the Strait of Juan de Fuca. These streams are all located on the Washington side of the strait and could, at least at their mouths, receive some oil from spills entering strait waters. The effects of oil in the

mouths of anadromous streams would be those of (a) chemical interference in the "homing" orientations of migrating adult trout or salmon, (b) toxicity or death to the extremely sensitive trout fry or yearling fish, or (c) tainting of the flesh of otherwise marketable adult fish. The Lyre and Elwha Rivers were ranked 15th and 23rd, respectively, in terms of numbers of steelhead caught in the winter runs of 1974. The Dungeness River is also a top trout-fishing stream in the strait in terms of both average annual catch and dollar value of catch.

- Threatened or Endangered Species. The gray and humpback whale, both threatened nationally, would be exposed to spilled oil in the strait at a rather low level of risk, as discussed above under "Marine Mammals." The humpback whale might possibly ingest tainted anchovies and sardines; however these are not the humpback's staple diet.

Two potentially threatened birds which could contact spilled oil in the strait are the black oystercatcher and osprey (see Table VIII-30). The actual exposure of members of these species to oil cannot be accurately assessed because of the combined uncertainty of tanker accident location and bird activity. Oil spill mortality has been documented to cause dramatic losses to bird populations and can be instrumental in reducing "potentially threatened" species to endangered.

- North Puget Sound

- Sport and Commercial Resources. While oil spilled from tankers moving through the strait and north Sound would cause only locally significant impacts to marine fisheries on an area basis, the scallop resource area of north Puget Sound would experience both a locally and regionally significant level of risk. Since about 81% of the scallop resource area is in north Puget Sound, the locally significant 34% area affected amounts to 28% of the whole sound's scallop resource area, a regionally significant impact in terms of both areal extent and dollar value. It should be remembered that this 28% would not be affected by spilled oil, but would be at risk chiefly due to movement of tankers through route Segment 5, from Deception Pass to Cherry Point.

- Waterfowl. Although north Puget Sound is rich in waterfowl areas compared to the Strait of Juan de Fuca, none of the five-day impact zones of the tanker route segments enters these areas enough to cause even locally significant risk to the waterfowl resource. It should be noted that the rich waterfowl areas of Samish and Skagit bays would not be approached by oil; a small portion of the outer edge of Padilla Bay's waterfowl area and the area off western Whidbey Island may be affected, but the magnitude of the effect would be neither locally or regionally significant.

- Marine Mammals. Three pinniped species found in the north Sound would be at risk from oil spilled from tanker route Segments 4 and 5, due to their inherent sensitivity to oil and, for two of the three,

TABLE VIII-30

POTENTIALLY THREATENED BIRDS: OCCURRENCE ALONG TANKER ROUTE SEGMENTS

Species	Segments
Northern Bald Eagle	5; 3,4 (possibly)
Osprey	1; 2 (possibly)
Black Oystercatcher	1, 2, 5
Western Snowy Plover	All (possibly)
Caspian Tern	All (possibly)

the fact that they reside in rather than migrate through the north Sound. Northern sea lions migrating in and out of the Strait of Georgia might not be able to avoid oil in Rosario Strait, if they do not tend to divert their routes as whales are thought to do. Harbor seals residing and breeding in Padilla Bay, Smith Island, and the eastern San Juan Islands would sustain serious damage should an oil slick or poisoned food reach them, since their young are the most sensitive members of the population. The sensitive river otter also inhabits the San Juans; eastern portions of this population would be at the highest level of risk due to oil spilled from tankers in Rosario Strait (Segment 5).

Two resident cetaceans would also risk contacting oil in Rosario Strait and the eastern San Juan Islands: the Minke whale and the harbor porpoise. However, these animals as well as the migrant gray whale, which travels to and from the Strait of Georgia, would probably be able to avoid oil in the water, although the possibility still remains of ill effects from eating tainted fish. These whales and porpoises are considered at minor risk compared to the seals, otters, and sea lions.

- Anadromous Fish Streams. As seen in Table VIII-6 and Figure VIII-32, six anadromous streams would empty into the five-day zone of impact from one or more of the tanker route segments. Of these, the Skagit River is the most important in terms of trout catch; it was ranked third in numbers of steelhead caught in 1973 and 1974. The Samish and Nooksack rivers are also important steelhead and salmon streams; the others potentially affected -- the Dakota, Squalicum, and Whatcom Creeks -- support minor trout resources. The mouths of these rivers could become filled with oil-bearing waters in the event of a spill as tankers near March Point or Cherry Point; adult fish could become poisoned or tainted, or could become disoriented and not migrate correctly, resulting in loss of spawning for the affected stream. Sensitive young could also receive the impacts of oil in the stream mouth if they are in the process of migrating downstream. Especially for the Skagit, Nooksack, and Samish, these impacts are considered to be major and of moderately high likelihood should a spill occur in tanker route Segments 4 or 5.

- Threatened or Endangered Species. The gray whale, which migrates through the San Juan Islands and Rosario Strait to and from the Strait of Georgia, would be at very minor risk, due to its relatively low sensitivity to oil and the fact that it is not resident but migratory and can possibly alter its route to avoid oil-bearing waters.

A few individuals of the black oystercatcher, western snowy plover, or caspian tern may happen to be along the beaches or in waters potentially affected by oil spilled in tanker route Segments 4 or 5 (see Table VIII-30). These birds, as all shorebirds, would suffer from surface-coating effects should oil contact them.

c. Summary

Combination of the resources at risk from each route segment with scenario utilization of the segments (Table VIII-31) leads to several conclusions: (1) Although generally less rich in marine resources than

TABLE VIII-31

SUMMARY MARINE RESOURCES IMPACT

Tanker Route Segment*

Impact Area	Cape Flattery To Port Angeles	Port Angeles	Port Angeles To Rosario Strait	Rosario Strait To March Point	Rosario Strait To Cherry Point
Strait of Juan de Fuca	SPORT SALMON COMMERCIAL SALMON DALL PORPOISE HUMPBACK WHALE (possibly) Intertidal clams Crabs Commercial bottomfish	SPORT SALMON COMMERCIAL SALMON DALL PORPOISE HUMPBACK WHALE (possibly) Intertidal clams Subtidal clams Commercial bottomfish Waterfowl areas Eelgrass beds Steelhead of Lyre, Elwha, & Dungeness Rivers	SPORT SALMON COMMERCIAL SALMON DALL PORPOISE HUMPBACK WHALE (possibly) Crabs Commercial bottomfish Eelgrass beds Steelhead of Lyre, Elwha, & Dungeness Rivers	commercial salmon commercial bottomfish	commercial salmon commercial bottomfish
North Puget Sound	none	none	none	HARBOR SEAL RIVER OTTER MINKE WHALE Steelhead of Skagit, Samish Rivers	SCALLOPS SPORT BOTTOMFISH HARBOR SEAL MINKE WHALE Steelhead of Nooksack River

* All capital letters indicates regional impact; lower case indicates local impact.

Source:

TABLE VIII-31 (Continued)

SUMMARY MARINE RESOURCES IMPACT

Scenario	Tanker Route Segments: Cape Flattery To Port Angeles	Port Angeles	Port Angeles To Rosario Strait	Rosario Strait To March Point	Rosario Strait To Cherry Point
I. Regional Supply Only	moderate	none	moderate	moderate	moderate
II. Northern Tier at Port Angeles					
A. Regional Supply by Tanker	high	moderate/high	moderate	moderate	moderate
B. Regional Supply by Puget Spur Pipeline	high	high	low	low	low
III. Transshipment at Cherry Point	high	none	high	low	high
IV. Regional supply by Trans Mountain Pipeline	low	none	low	low	low

the north Sound, many more impacts of regional significance occur in the Strait of Juan de Fuca, since all vessels entering the Sound must first pass through the strait; (2) Scenario III, transshipment at Cherry Point, will produce potentially most severe impacts on the strait's marine resources; (3) Scenario II-A will have slightly lower impacts on the strait, but greater effects on the north Sound; and (4) Scenario IV clearly presents the lowest risk of impacts to marine life.

2. Terrestrial Environment - Pipelines

a. Scenario Involvement of Pipeline Corridors

Table VIII-32 shows the involvement of each pipeline link in each scenario, and the level of activity in that link associated with that particular scenario. Thus, the Peninsula Link is involved in Scenarios II-A and II-B only. In both II-A and II-B, the Northern Tier Pipeline originates at Port Angeles; in II-A the line is used for out-of-state transshipment only; in II-B it also supplies the north Puget Sound refineries via the Puget Spur. The transshipment proposal of both Scenarios II-A and II-B also involves the East Washington Link of the Northern Tier line.

In Scenario III-A, transshipment originating at Cherry Point, the pipeline used is the Puget Spur in reverse with connection to a 40-foot line in the East Washington Link. In II-B above the Puget Spur requires a 20-inch line only; in III-A, the additional volume of crude to be moved necessitates a 40-inch line. The remaining scenarios -- I (A and B), III-B, and IV -- do not utilize either the Northern Tier Pipeline or the Puget Spur. Scenario I is regional crude supply by tanker only, coupled with existing product pipelines. Scenario III-A, Trans Mountain Reversal, will require new pump stations by 1980 to reverse the flow between Cherry Point and Sumas (i.e., Cherry Point to Laurel Pump Station, Laurel Pump Station to Sumas). The 1985 development of Scenario III-B with a Trans Mountain Loop to Canada would require the construction of a new 30-40-inch pipeline parallel and adjacent to the existing line in these two segments. In this case, some supply to the March Point refineries would probably continue to be by tanker, since the volume of specialty crude to be moved would not economically justify the construction of a heated line from Cherry Point to March Point (i.e., Cherry Point to Laurel Pump Station, Laurel to Burlington Pump Station, Burlington Pump Station to March Point) to carry some of the high-paraffin Indonesian and North African crudes used by the Shell and Texaco refineries.

Scenario IV is defined by reestablishing supply to the north Puget Sound refineries by non-Canadian crude via the existing Trans Mountain line, operating at full existing capacity with no new construction necessary. This scenario thus involves the Trans Mountain Line (Laurel Pump Station to Sumas), the segment between Laurel Pump Station and Cherry Point, between Laurel and Burlington pump stations, and the segment between the Burlington Pump Station and March Point.

TABLE VIII-32

SCENARIO INVOLVEMENT OF PIPELINE CORRIDORS

	Scenario	Activity by Pipeline Corridor: Peninsula Link	East Washington Link	Puget Spur	Trans Mountain
I	Regional Supply Only	None	None	None	Cessation of supply through existing pipeline
	A. Vessel Size Unrestricted				
	B. Vessel Size Restricted to 120,000 DWT or less				
II	Northern Tier Pipeline at Port Angeles				
	A. Regional Supply by Tanker	40-42 inch pipeline	40 inch pipeline	None	Cessation of supply through existing pipeline
	B. Regional Supply by Puget Spur Pipeline	42 inch pipeline	40 inch pipeline	20 inch pipeline	None
III	Transshipment at Cherry Point				
	A. Northern Tier Corridor Pipeline	None	40 inch pipeline	40 inch pipeline	None
	B. Trans Mountain Corridor Pipeline	None	None	None	1980 - new pump stations 1985 - new 30 inch pipeline
IV	Supply by Trans Mountain Pipeline	None	None	None	Full capacity operation of existing pipeline

NOTE: Scenario subcases A and B are distinct for Scenario I only with regard to tanker activity and for Scenario II only with regard to pipeline activity; thus they are not shown on every table in the report.

b. Introduction and Comparison

A comparative summary of the land use and terrestrial biology impacts of the three major pipeline links of this study: the Northern Tier Pipeline-Peninsula Link, Northern Tier Pipeline-East Washington Link, and Puget Spur are given in Tables VIII-33 and VIII-34. Much of the information presented earlier and in Tables VIII-8 to VIII-22 actually specifies the environmental impact and overlaps with the impact discussion. Owing to the linear nature of a pipeline route, it is more meaningful to characterize the existing environment of the route itself rather than of the general region. In other words, a better understanding of the pipeline route impacts is achieved by characterizing the immediate impact area, since a broader zone defined over such a distance would not be meaningful for understanding the impacts of the pipeline itself. The nature of oil pipeline land use and terrestrial biology impacts is given in Chapter VI; the discussion of the specific effects of the particular pipeline routes on particular geographic areas is given here.

c. Northern Tier Pipeline - Peninsula Link

(1) Land Use Impacts. The most important land use impacts of the Peninsula Link of the Northern Tier Pipeline are taking forested lands and possible spill damage to watercourses in the Olympic Peninsula. Impacts on watercourses are largely discussed under terrestrial biology impacts. Impacts on agricultural lands in the coastal terrace of Port Angeles and Sequim and in south Puget Sound, as well as the number of road and railroad crossings, are also significant.

The majority of the route (69%, or 117 out of its 170 miles) follows existing rights-of-way, largely of the power transmission lines which skirt the edge of the Olympic Mountains. As explained in the overall description of pipeline impacts given in Chapter VI under "Project Components," a pipeline which can follow a transmission line right-of-way through the mountains has reduced impact by comparison to one which follows a road, since the additional cleared and graded corridor required is narrower.

A minimum of about 96 miles (1170 acres) of forested land will be cleared on existing right-of-way and 33 miles (400 acres) on new right-of-way in this segment. Much of these lands do not have high present value as timber because, with the exception of a patch in the vicinity of Brinnon, they are not sustained-yield reforested lands. Most were last cut within the past 50 years or so and are now represented by numerous stands of moderately mature, successional mixed deciduous/coniferous forest. Most of the lands are in private ownership so that considerable conflicts with the owners of small holdings can arise over the taking of the productive use of their land and their future rights to manage it as they see fit.

A large number of watercourses are crossed by the Peninsula Link -- 51 on existing rights-of-way, of which 10 are major rivers, and 23 on new rights-of-way, of which five are major rivers. While these streams

TABLE VIII-33

PIPELINE LAND USE SUMMARY

All Links

Pipeline	Forest Miles	Forest %	Riparian Miles	Riparian %	Agric. Miles	Agric. %	Urban Miles	Urban %	Stream Crossings Major	Stream Crossings Minor	Transportation Corridor Crossings	Totals
Northern Tier												
Peninsula Link	96.2	82	3.26	2.8	16,9	14.4	.58	0.5	10	41	87	116.9
	32.6	*61.8*	*1.65*	*3.1*	*12.7*	*24.2*	*5.97*	*11.3*	*5*	*18*	*65*	*52.9*
												169.8 (Link total)
East Washington Link	24.3	87.6	2.36	8.5	0	0	1.08	3.9	2	17	18	27.8
	3.24	*96.4*	*0.12*	*3.6*	*0*	*0*	*0*	*0*	*0*	*3*	*1*	*3.4*
												31.2 (Link total)
Puget Spur	47.09	59.8	5.38	6.8	11.18	14.2	15.2	19.3	8	40	94	78.9
	20.5	*37.8*	*3.36*	*6.2*	*12.3*	*22.6*	*18.2*	*33.6*	*6*	*23*	*66*	*54.4*
												133.3 (Link total)
Transmountain Link (Laurel to Sumas only)												
	4.21	29.3	1.03	72	63	44.0	2.8	19.5	4	3	16	14.36

Source: Compiled from Segment Land Use Tables (VIII-A- to VIII-A)

Bold Face Type: Existing right-of-way.
Italic Type : New right-of-way

TABLE VIII-34

PIPELINE LAND USE IMPACT

Minimum Acreages Affected by 100' Corridor

Pipeline	LAND USE Forest	Riparian	Agriculture	Urban	Totals
Northern Tier					
Peninsula Link	1166 *395*	40 *20*	205 *154*	6 *72*	1417 *641* 2058 (Link total)
East Washington Link	295 *39*	29 *2*	0 *0*	13 *0*	337 *41* 378 (Link total)
Puget Spur	571 *248*	65 *41*	136 *149*	184 *221*	956 *659* 1615 (Link total)
Transmountain Link (Laurel to Sumas only)	51	12.5	77	34	174

Bold Face Type - Existing right-of-way

Italic Type - New right-of-way

Source: Table VIII-B-

do not provide the main domestic water supply for any major cities, they are important surface drainages with many beneficial uses (discussed under Terrestrial Biology). The forested watershed lands of these streams are sensitive to removal of the vegetation and have high erosion and landslide potential because of their steep angle of repose and the saturated soil conditions which exist during at least half of the year. Thus, in the Olympic portion of the Peninsula Link there is a relatively high probability of siltation of surface streams due to pipeline corridor construction and a chance of oil contamination of individual streams in the infrequent event of pipeline rupture caused by landsliding, or structural or accidental failure. A number of these streams are used for recreational fishing or swimming, but these uses are mostly higher in the watershed than the point where oil would enter. The streams north of the Little Quilcene River drain to the north into either Port Discovery, Sequim Bay, or the Strait of Juan de Fuca. Big and Little Quilcene rivers drain to Quilcene Bay, and the more southern streams of the Olympic Peninsula empty into the Hood Canal. The remaining streams of the Peninsula Link drain into the many narrow inlets, passages, and bays of south Puget Sound. The numerous beneficial uses of these bodies of water could be adversely affected, on a very infrequent basis, by oil pollution in stream runoff. (Marine resources and beneficial uses of anadromous streams are discussed under Tanker Transport.)

Urban lands are relatively unimportant by comparison to other land uses in that they comprise only 11% of the Peninsula Link (0.6 miles on new right-of-way and 6 miles on new right-of-way). Nevertheless, the new right-of-way portion will disturb 6 miles (a minimum of 72 acres) in a number of small communities along the western edge of the Hood Canal in south Puget Sound. Numerous individual small holdings are in the corridor area, and the pipeline right-of-way will amount to both a visual and nuisance impact as well as a restriction on future land use which could affect the development potential of adjoining land.

Ownership and right-of-way acquisition will probably be a significant problem on the Peninsula Link because the vast majority of the lands are in private ownership. Individual opposition to the sale of the right-of-way corridor may be encountered by owners of both new and existing right-of-way portions of the link. During field reconnaissance, the consultant was exposed to extremely negative sentiment toward an additional oil pipeline by several owners of hundred-acre woodlot parcels where public utility corridors had already cut several wide, overlapping swathes through their lands.

The Peninsula Link crosses public lands in several places. Its corridor makes several brief excursions through the edge of the Olympic National Forest -- one between Sequim and Center, one south of Quilcene, one near Lake Cushman, and one northwest of Shelton. The route also crosses forest board county trust lands in several places, and forest board fee lands in Thurston County. Right-of-way through these lands is probably relatively easily obtained from the public agencies with jurisdiction over them, or from the timber companies holding timber rights to them.

Pipeline construction will have a fairly high nuisance impact on travelers, since the route encounters an average of 1.1 roads per mile, and a major state or interstate highway once every 20 miles -- 8 in all, 152 transportation corridors in all. The impact of road crossings is not appreciably different for roads crossed on existing versus new rights-of-way since in either case the normal function of the road must be temporarily disrupted by pipeline construction. During the course of pipeline construction over several months, several thousand motorists could be minimally to significantly inconvenienced. This may have a minor impact on the extensive tourism industry of the Peninsula. To the degree to which lane closures, detours, and the presence of an obstruction and work crew affect highway safety, pipeline construction can also increase the accident potential on the affected roads. Restrictions on normal traffic flow can also delay the flow of goods along the Olympic Peninsula to and from the urban communities along the Strait of Juan de Fuca and the Hood Canal.

Agriculture is a relatively important land use along the Peninsula Link, comprising a total of 17 miles on existing and about 13 miles on new right-of-way. Creation of a 100-foot corridor could thus temporarily affect the productivity of about 350 acres of these lands (150 of which will be on new right-of-way). The extent of actual crop loss involved will depend on the seasonal occurrence of the disturbance. The impacts on the new right-of-way cultivated lands will be the greatest because of the problem of access. There will be little long-term impact.

(2) Terrestrial Biology Impacts. The Peninsula Link of the Northern Tier Pipeline, which runs 170 miles from Morse Creek in Clallam County to Selleck in King County, will have significant impacts on forested lands, surface waters, riparian zones, and sensitive areas, and could impact several threatened or endangered species.

In all, the link traverses 129 miles of forested lands, of which 33 require creation of new right-of-way and the remainder largely follow power line rights-of-way. Most of these forest lands are mixed coniferous/deciduous woods of varying maturity and successional stage. The existing transmission line right-of-way forms a highly visible cleared scar, one hundred to several hundred feet wide at some points. Further impacts of corridor widening for the pipeline will be significant -- an increase in corridor width by a factor of 25-100%; however, the main impacts on terrestrial wildlife will have already occurred as a result of clearing the original corridor. Herbicides and other vegetation removal techniques are used within a transmission line corridor to keep the strip free of tall, obstructing vegetation. The impacts of these will be moderately increased by right-of-way widening, but will be considerably less than the impact of clearing and maintaining a new right-of-way. (See the discussing given under Impact Characteristics of Project Components in Chapter VI.)

The 33 miles of new right-of-way through forest lands will constitute significant disturbance and permanent habitat removal for wildlife utilizing the affected second-growth forest. One of the areas which will be cut with the new right-of-way is the dense, pure stand of Douglas fir north of Shelton in Segment 3 (Potlatch to Shelton).

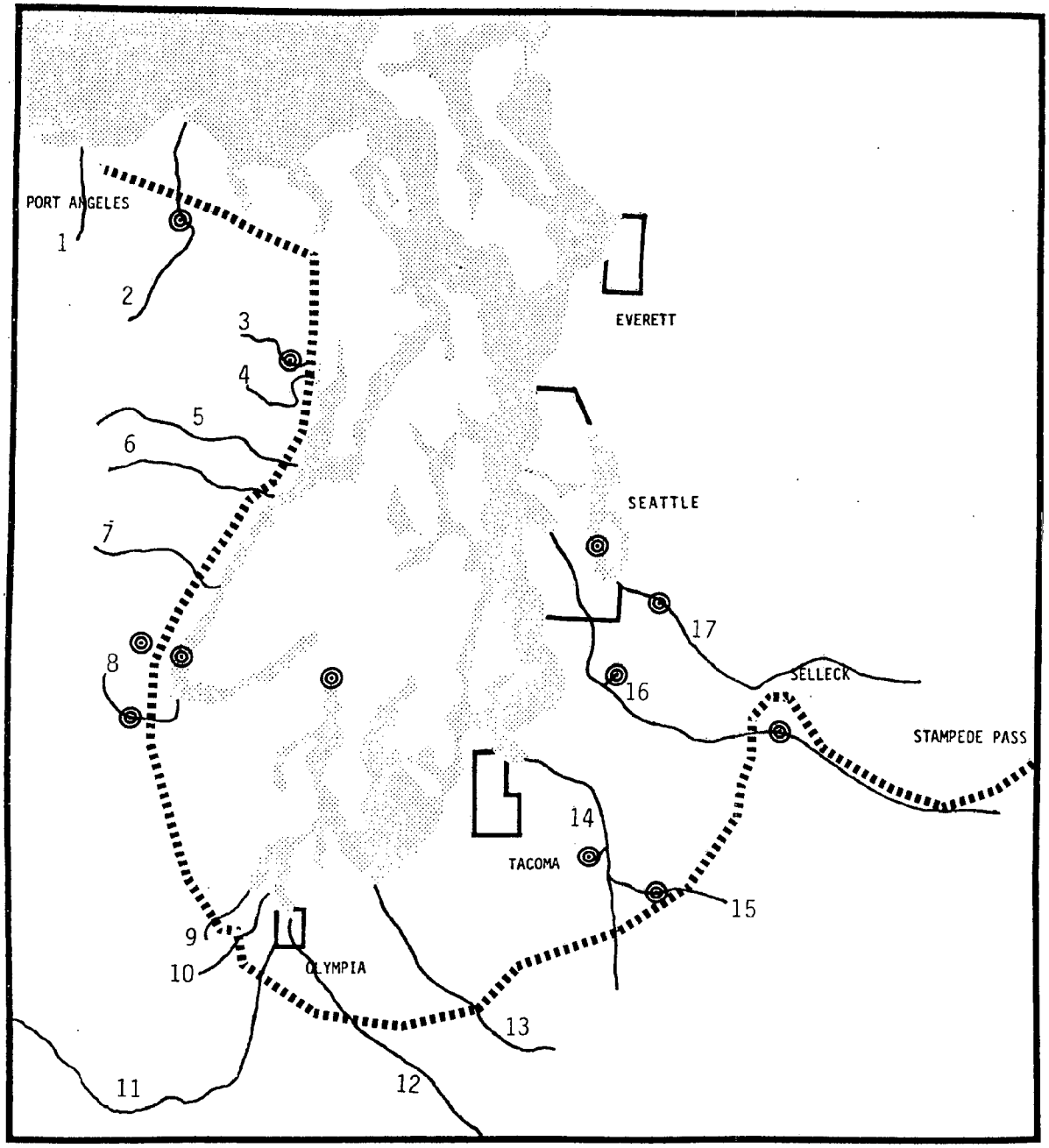
All of the areas cleared during pipeline construction, including the corridor, its periphery, and access roads cut through adjoining parts of the forest to allow storage of equipment or aid movement of construction vehicles, will revegetate first with weedy species -- grasses and composites -- and then rapidly with the seedlings of fast-growing species -- alder and big leaf maple -- as well as a scattering of the longer-lived coniferous trees -- Douglas fir and red cedar. Cut areas other than the maintained corridor which are allowed to completely revegetate should take several years to develop a dense ground cover, and anywhere from 30 to more than 100 years to attain their previous appearance. A high proportion of the forest lands which will be traversed by new right-of-way are in the flat lands of south Puget Sound interspersed with agricultural lands, rather than on the slopes of the Olympic Mountains. Deliberate revegetation of cut areas peripheral to the corridor or adjoining access roads could be done as a mitigating measure to minimize erosion and aid recovery from disturbance. This should be accomplished by planting some of the later-arriving tree species.

A large number of watercourses are impacted by the Peninsula Link. As described in Chapter VI, the impact of a stream crossing is roughly equivalent for new and existing right-of-way portions of the route because the same construction techniques are usually required, except in those rare instances where the pipeline may cross the stream on the trestle of an existing bridge. In all, 74 creek and river crossings are required in the Peninsula Link. Some of these may be at two different points on the same stream (see Tables VIII-8 to VIII-14). Fifteen of the 74 crossings are of major rivers, including the Dungeness, Big and Little Quilcene, Duckabush, Dosewallips, Skokomish, Deschutes, Nisqually, Black, and Carbon. The total riparian zone crossings add to 4.9 miles of the link, or about 60 acres, including the width of the watercourses themselves.

These numerous riparian corridors contain a nearly complete representation of all of the freshwater aquatic species found in the coastal area of Washington, including anadromous and freshwater fish and invertebrates. As summarized in Chapter VI, impacts of the stream crossings and the presence of the completed oil pipeline on these resources include increased siltation of the streams from the crossing and from the corridor higher in the watersheds, and the risk of infrequent but catastrophic oil releases from pipeline rupture. The latter risk is highest in the mountainous portions of the route. All of the watercourses would be affected by the construction impacts since these are certain to occur. Only one or at most a few of the drainages are likely to ever be exposed to oil spill effects, since these occurrences are both localized and have a very low probability. For the affected streams, there could be major kills, loss of recruitment, severe reduction of anadromous runs, or tainting of many of the resources which would lead to the temporary loss of recreational fisheries.

Figure VIII-49 shows the location of Washington Department of Fisheries and Department of Game hatcheries in relation to the streams crossed by the Peninsula Link. Five hatcheries are located directly on

FIGURE VIII-49



Rivers

1 - Morse Cr.
2 - Dungeness R.
3 - Quilcene R.
4 - Little Quilcene R.
5 - Dosewallips R.
6 - Duckabush R.
7 - Hamma Hamma R.
8 - Skokomish R.
9 - Skookum Cr.
10 - Kennedy Cr.
11 - Black R.
12 - Deschutes R.
13 - Nisqually R.
14 - Puyallup R.
15 - Carbon R.
16 - Green R.
17 - Cedar R.

◎ Fish hatchery

0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:
Bob Foster, Salmon Culturing Division, Washington Department of Fisheries; Office of Program Planning & Fiscal Management, State of Washington Pocket Data Book 1976, Dec. 1976.

streams crossed by the route. Of these, only one, the Carbon River hatchery, is located downstream of the pipeline crossing. In the event of a pipeline break and spill affecting the Carbon River, the water diverted from the river for the hatching and rearing tanks could be polluted with oil. Since eggs, larvae, and newly hatched young fish are extremely sensitive to oil at even very low concentrations, the river water could be unusable for several weeks or longer after a major spill.

Hatchery production is dependent on a continuously available supply of high-quality water at the correct temperature, which is cycled through the rearing tanks and returned to the river. If this water became unusable as a result of oil contamination, it is unlikely that an alternate source could be devised; the hatchery would probably have to close temporarily, with the loss of an entire seasonal salmon release. After the acute phase of the spill, the river water would have to be monitored for several months to guard against the loss of the next season's production.

Where hatcheries are located upstream of the pipeline crossings, or on small upstream tributaries (e.g., the Puyallup hatchery), accidental oil release will not affect hatchery water withdrawal, but could still result in a kill of young fish if a release had been made just prior to the spill.

The Peninsula Link passes through a number of sensitive areas, as defined in Chapter VI. In Segment 4 (Tumwater to Frederickson) the pipeline will cross three marshes totaling 885 acres, and some six miles of Puget prairies, all on new right-of-way. In Segment 5 (Orting to Cumberland quadrangles) the line will cross one marsh on existing right-of-way. The nature of oil pipeline impacts on these types of sensitive areas is also described in Chapter VI. The extent of disruption of wildlife activities through both physical disturbance and removal of vegetation is a function of the cross section of the marsh at the point where the pipeline traverses it, but not directly a function of the size of the marsh. The larger the marsh, the more wildlife will utilize it, but in a marsh as large as 250 or more acres, many animals could leave the area of immediate disturbance and still find suitable habitat. In a 250-acre marsh, a bird could move one-half mile from the construction site and still be within the wetland area. If the marsh is elongated in shape, the distance a bird could move in one dimension would be even greater and the instances where marshes are elongated are those where engineering cost dictates that the pipeline cross the marsh rather than skirt the perimeter. Wetland vegetation has extremely high productivity, so that the disturbed cut for the corridor should quickly revegetate. In any event, the most serious impacts would result in the rare event the wetland was contaminated by spilled oil after accidental release.

A number of endangered, threatened, or potentially threatened wildlife species could occur along the Peninsula Link or its vicinity (see Table VIII-7). These include the endangered peregrine falcon which nests in both the Olympic and Cascade Mountains, and several potentially

threatened species whose populations are declining in numbers owing to habitat losses, pesticide effects, and killings. These are the pileated woodpecker which resides and breeds in forested areas east and west of the Cascades, the mountain quail which is known to reside in lower Puget Sound around Olympia, and the Northern bald eagle which breeds west of the Cascades and is known to winter on the Olympic Peninsula. Potentially threatened species could suffer increased population depletion from additional projects which expose them to disturbance or take more of their habitat, including pipelines or other utility corridors. If past trends continue, these species may be reduced to the status of threatened species. Further encroachments on their habitat in the absence of deliberate management schemes to protect them will most likely result in a continuing decline in their chance for survival. Endangered species such as the peregrine falcon are already so depleted that their entire existence is critically sensitive to even minor disturbance or further habitat destruction.

d. Northern Tier Pipeline - East Washington Link

(1) Land Use Impacts. The East Washington Link (within the coastal counties) is a short 30-mile segment running between Selleck and Stampede Pass, at the crest of the Cascades. The area traversed is little urbanized and none of it is in agricultural use. Consequently, this pipeline link would have only minor urban impacts -- four miles cross three small towns or vicinities, for a total of 13 acres, and only 18 transportation corridors are crossed, none of which is a major highway.

The most significant impacts of the East Washington Link are on the forested watershed lands of Snoqualmie National Forest. A large portion of the link passes through the Green River watershed which supplies the City of Tacoma. The route crosses the Green River itself twice and cuts across the north arm of the Howard Hansen Reservoir, a major impoundment in this water supply system. Land in the Green River watershed is extremely steep. Of the 21 miles of the East Washington Link within this watershed, all of the surrounding lands have an average area slope of over 10%, and all but four miles have an average area slope of 30% or greater. An additional two miles of the link pass through an area of the Cedar River watershed for the City of Seattle, where the average area slope is between 10% and 20%.

The impact of this pipeline link in these watersheds is potentially high because of the combination of pipeline rupture hazards and environmental sensitivity. The extremely steep slopes dictate that an exceptionally wide corridor must be created to allow maneuverability of the construction crew, which simultaneously increases the risk of erosion from the corridor. Vegetation removal and erosion reduces the water-holding capacity of the watershed, and produces excess siltation in the streams. Landslide risk is extremely high, mediated by very steep terrain and high precipitation. The risk is intensified by vegetation removal in and around the pipeline corridor. Pipeline rupture caused by such ground slippage would almost certainly contaminate the Green River and render the water

unsuitable for domestic use for a period of several days to weeks, until the system was both mechanically cleaned and flushed out by river flow. Oil-contaminated water allowed to run out to sea would pollute the waters of Elliott Bay, south of Seattle.

The pipeline link is also likely to impact a large number of private landowners because of the established "checkerboard" pattern of public and private lands in this region, with a grid size of about one square mile. Opposition to an additional right-of-way corridor is likely to run high because of the existence of a corridor already 600 feet wide throughout most of this link, which houses five or six power transmission lines. The present corridor width in no way insures that no further widening is necessary for the pipeline because the present arrangement of transmission line towers gives a clear space of at most 50 feet between centers and does not provide a sufficient margin for construction. For every linear mile of corridor, a right-of-way 600 feet wide constitutes a taking of 73 acres. The taking of an additional 100 feet (17% more land) represents a significant incremental loss to the owners of this land.

(2) Terrestrial Biology Impacts. Forested lands comprise 27.5 out of the total of 31 miles traversed by the East Washington Link of the Northern Tier Pipeline. Of these, 24 follow existing rights-of-way, primarily of the multiple transmission lines which generally parallel the Green River, and also of the Burlington Northern Railroad through the Cascades. The power line transmission corridor has been expanded over the years to include more lines, so that a large portion which runs through the Green River watershed contains six lines and is about 600 feet wide.

The power line corridor through both private and public lands of the Snoqualmie National Forest has already had major impact. The pipeline will increase the corridor width by only about 15-20%; habitat loss impacts should be roughly proportional to this, and thus small in comparison to the existing corridor. Construction impacts will create additional physical disturbance.

For its length, the East Washington Link has significant impacts on riparian corridors. In all, 2.5 of its 31 miles cross riparian zones, which include 20 minor and two major stream crossings; the two major crossings are of the Green River in the Tacoma watershed. The nature of stream crossing impacts on the beneficial uses of the streams and biotic resources are discussed in Chapter VI. Since the Green River crossings occur relatively high in the watershed, siltation and oil contamination impacts can affect the majority of the river. In addition to crossings, the pipeline closely parallels the Green River for about one mile near the intersection of McCain Creek with the major channel. In this section, more riparian vegetation will be destroyed during construction than for a crossing, and the risk of impacts on the stream due to failure of the pipe is slightly increased. There is one other mile-long segment where the pipeline closely parallels a stream in the East Washington Link-Sunday Creek in the Lester Quadrangle.

Sensitive areas intersected by the pipeline are largely confined to the Howard Hansen Reservoir, and the very small (five-acre) Page Mill Pond. The major impacts on the reservoir relate to its beneficial uses (land use impacts) which are discussed under Pipeline Impacts - Land Use. The pond is so small that it is doubtful that the pipeline would ever cross it in preference to detouring around it.

A number of endangered or potentially threatened species occur in the area crossed by the pipeline. These include the endangered peregrine falcon which resides both east and west of the Cascades and is thought to nest within these mountains, and several potentially threatened species -- the spotted owl, pileated woodpecker, and osprey. The spotted owl is known to breed in wet coniferous forests within the Cascade range; the pileated woodpecker is found in coniferous forests east and west of the Cascades. The osprey is known to breed, among other locations, in the Snoqualmie National Forest and in Snoqualmie Pass. Protection procedures for these species recommended by the Washington Department of Ecology include the protection of known nesting areas by the prohibition of logging in the vicinity of nesting trees. Protection for the pileated woodpecker includes the provision of adequate virgin timber stands.

In order for these measures to mitigate impacts of pipeline construction, particularly through new right-of-way areas, pipeline construction must be preceded by a search of the area during nesting season to identify possible nest sites within a range that could be affected by the pipeline route. The area would probably have to be avoided completely or the pipelaying would conflict directly with identified protection policies for these species, which involve habitat preservation. At the very least, construction would have to be scheduled out of the breeding season, and as much as possible when the birds were thought not to be in the area at all.

e. Puget Spur

(1) Land Use Impacts. The Puget Spur will have significant impacts on forested, agricultural, and urban lands. Nearly two-thirds is on existing right-of-way, which reduces the overall impacts somewhat, although this mitigation is more pronounced for terrestrial biology than for land use impacts (see Table VIII-32). The largest proportion of the Puget Spur traverses forested lands (68 out of its 133 miles -- 47 miles on existing and 21 on new right-of-way). A small portion of this (about four miles) is Cedar River watershed lands, which provide the water supply for the City of Seattle. Once again, similar to the situation for the East Washington Link in the Green River watershed, the potential for pipeline rupture and contamination of the Cedar River exists, but the risk for the Puget Spur is considerably smaller because a far smaller length of pipe is involved, and because the lands traversed lie in much gentler slopes of 0-20%, with only one mile of slopes of 30-40%. The Cedar River flows west and then north to empty into Lake Washington between Seattle and Bellevue, so that in the rare event that a pipeline rupture in the watershed released a large quantity of oil into the river, the entire downstream area, including Lake Washington, could suffer the effects (biotic effects are discussed under Terrestrial Biology).

The route traverses private lands almost exclusively; the only public lands crossed are scattered forest board county trust lands in Whatcom and Snohomish counties. Similar to the other pipeline links, problems of right-of-way acquisition could be encountered from the numerous private landowners, particularly when the pipeline right-of-way is proposed to be parallel and immediately adjacent to an already wide transmission line corridor.

Urban lands comprise 33 miles or 25% of the route, 18 of which will lie on new right-of-way. In all, about 400 acres in 17 different urban or suburban areas will be affected by the construction and maintenance of the 100-foot corridor. In Scenario II-B the acreage affected would be reduced by about 30% since the 20-inch line in this scenario would require a corridor only 70 feet wide. The construction of the pipeline can have nuisance effects on several hundred to several thousand persons over a short period of time (several weeks). (See discussion of nuisance effects given under Impact Character of Project Components.) The maintenance of the finished corridor without permanent structures or mature woody vegetation can affect the potential to subdivide and sell the parcels of which the corridor forms a part, as well as the value or salability of adjoining parcels because of the visual impact of the linear pipeline "scar" and the psychological implication of industrial use in a primarily residential area.

Since a high proportion of the Puget Spur traverses urban lands, the route crosses many transportation corridors. In all, 160 transportation corridors must be crossed -- 94 on existing right-of-way, 66 on new right-of-way. Of these, 12 are major state or interstate highways (five on existing, seven on new right-of-way). The total extent of inconvenience to motorists, increase in highway accident risk, and temporary restriction of normal traffic flow is highest for the Puget Spur in comparison with the other pipeline links. A conservative estimate of about one million vehicle-trips will be affected during the pipeline construction phase, on all routes crossed; the effects will range from minor delay to complete rerouting.

In addition to the Cedar River discussed above, a large number of watercourses are affected by Puget Spur construction. These include 14 large rivers -- eight on existing and six on new right-of-way -- and 64 other creeks, streams, and other channels, of which 40 are on existing rights-of-way. A total of 77 surface drainages are crossed by this pipeline link. All of these surface streams are subject to some degree of siltation and erosion during pipeline construction and from the poorly vegetated scar, and to the varying risk of oil contamination due to future pipeline breakage. These risks are proportional to the slope and soil stability of the surrounding lands, and the impacts on beneficial uses are a function of the combination of risk and the importance of the stream. Impacts on aquatic life are discussed under Terrestrial Biology.

About 18% of the Puget Spur traverses agricultural lands. The majority of contiguous agricultural lands crossed are in the northern segments of this link, in Whatcom and Skagit counties. In all, the route crosses about

23 miles of cultivated lands, of which 11 are on existing rights-of-way. At the least, corridor construction will affect 75 acres of farmed land on existing and 150 acres on new rights-of-way. The 70-foot corridor of Scenario II would take correspondingly less. The productivity of these lands will be temporarily affected in the manner described in Chapter VI.

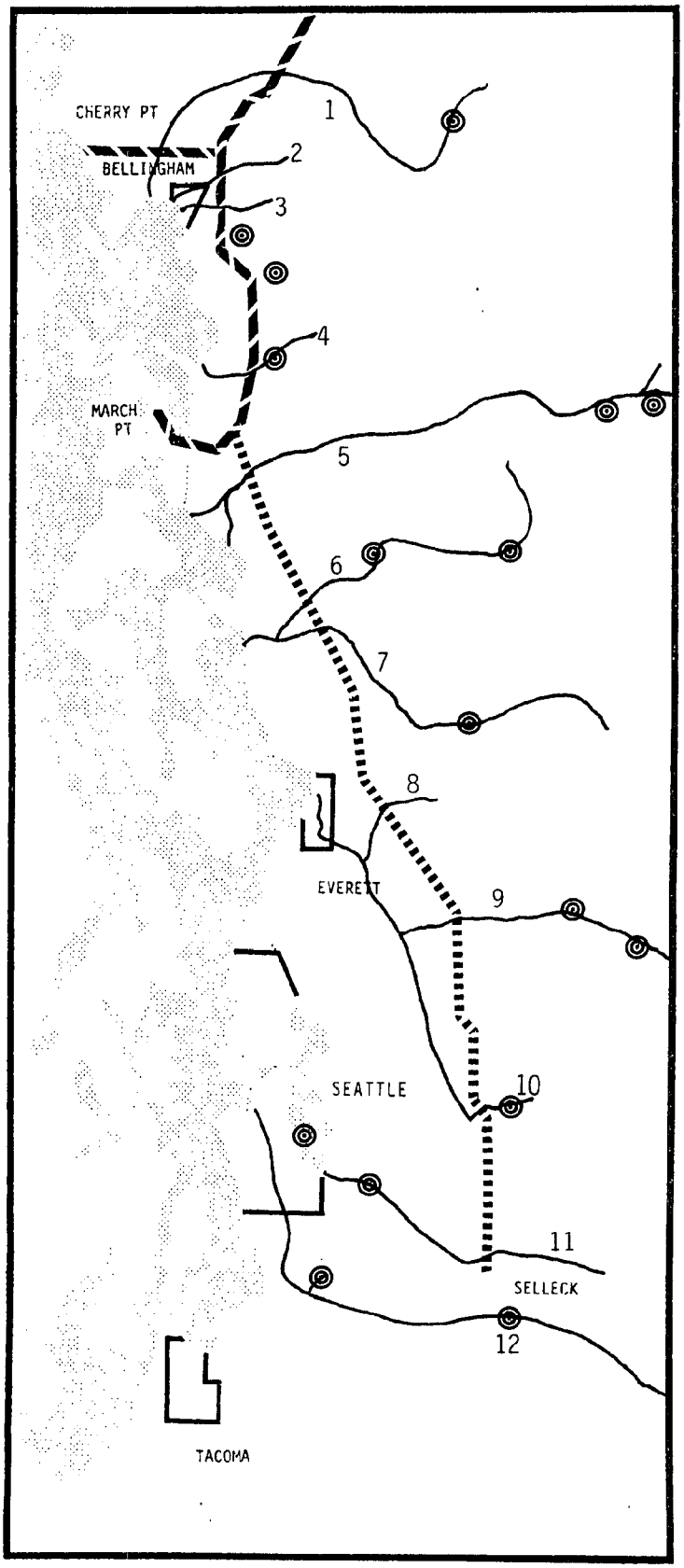
(2) Terrestrial Biology Impacts. The Puget Spur traverses 68 miles of forest land, of which 47 are on existing rights-of-way, mostly adjacent to the corridor of the existing Trans Mountain Pipeline. Although there is pipe in place for the existing line, the corridor would have to be widened by 50-100 feet for the new 42-inch line (about double its present width). The remaining 21 miles, which run through forest lands, require new right-of-way. A portion of this, Segment 5 between the Burlington Pump Station and east of Everett, is within the right-of-way corridor owned by the Trans Mountain Pipeline Company, but no pipe has ever been installed in the corridor, so the impact is the same as all new disturbance. The total acreage disturbed by 100-foot corridor widening on existing right-of-way is 571, and on new right-of-way it is 248. These are minimum figures for the corridor itself and do not include access to the corridor where this does not now exist.

The Puget Spur will have highly significant impacts upon streams and riparian zones since it intersects 14 major rivers and 63 other creeks and streams, which comprise most of the watercourses draining to the west from the Cascades north of the latitude of Stampede Pass. Some of the most important bodies of water intersected include the Nooksack, Samish, Skagit, Stillaguamish, Pilchuk, Cedar, Skykomish, and Snoqualmie rivers and Samish Lake. In all, the link crosses about nine miles of riparian zones and will thus disturb roughly 100 acres. Many of the streams which will be subject to definite construction impacts and to possible oil spillage are important anadromous fish runs and contain an abundance of freshwater biota as well.

The location of state salmon and trout hatcheries in relation to the streams crossed by the Puget Spur is given in Figure VIII-50. In all, 11 hatcheries are located directly on rivers crossed by the pipeline route. Of these, only the Cedar River hatchery is downstream of the crossing. The impacts of oil release on fish hatchery production and releases is discussed above under Terrestrial Biology Impacts on the Peninsula Link. In the event of oil contamination of one of these streams, a season's run of both hatchery and natural production of stream could be destroyed.

A number of the larger rivers, such as the Nooksack and Skagit, are also the source of freshwater feeding the intensely productive estuaries of the north Sound, and the source of sediments for their tidelands. While the risks of oil damage to these areas from spillage associated with pipeline rupture are small in comparison to the risks of damage from oil spillage within Puget Sound from marine transport, the potential for adverse effects to aquatic life is still high.

FIGURE VIII-50



Fish hatchery

Rivers

1 - Nooksack R.
2 - Squalicum Cr.
3 - Whatcom Cr.
4 - Samish R.
5 - Skagit R.
6 - N. Fk. Stillaguamish R.
7 - S. Fk. Stillaguamish R.
8 - Pilchuck R.
9 - Skykomish R.
10 - Snoqualmie R.
11 - Cedar R.
12 - Green R.

0 10 20 mi
0 10 20 30 km

NORTH

SOURCES:

Bob Foster, Salmon Culturing Division, Washington Department of Fisheries; Office of Program Planning & Fiscal Management, State of Washington Pocket Data Book 1976, Dec. 1976.

The Puget Spur crosses a number of sensitive areas as described in Tables VIII-15 to VIII-19. Segment 2 (Laurel to Burlington Pump Station) crosses Edison Slough, an estuary open to Puget Sound, and two freshwater marshes. Nearly two miles of the route runs through Olympia Marsh, and the small (11-acre) Upland State Animal Habitat is also intersected by the proposed corridor. Segment 3 crosses three sloughs on Padilla Bay (totaling 700 feet of pipe) and the Swinomish Channel. Segment 5 (east of Everett to Monroe) intersects the marsh of Richardson Creek for a length of 500 feet. Segment 6 (Monroe to Selleck) is proposed to cross five different wetlands for a total length of 4400 feet, as well as 1900 feet of Rutherford Slough, a freshwater slough off the Snoqualmie River. Construction through wetlands is difficult, so that only about one-tenth mile of pipe may be completed in a day, and the direct construction disturbance of vegetation and wildlife will persist for as long as about three weeks where extensive crossing lengths are involved (e.g., Olympia Marsh). Construction through brackish water sloughs will temporarily destroy an area of the bottom which contains the eggs, larvae, and juvenile forms of shellfish and finfish, and provides a feeding area for the young of salmon and other anadromous forms. Depending upon the season of disturbance, the preexisting bottom conditions which can be reestablished by backfilling, as well as by natural sediment transport in the channel, may not occur for at least a year. Likewise, the bottom fauna will not repopulate for this length of time.

The western slopes of the Cascades and the lowlands to the west which adjoin Puget Sound are rich in wildlife, including a relatively large number of forms which are either endangered, threatened, or potentially threatened. The golden eagle is known to winter in the upper Skagit River area. This species, recognized as threatened in Washington, prefers arid plateaus with canyons and breeds in the eastern portion of the state only. The endangered peregrine falcon is found in the lowlands west of the Cascades. The nationally endangered trumpeter swan is potentially threatened within Washington, and is known to winter in the Skagit area. The endangered California condor, which formerly occurred on the east and west slopes of the Cascade Range, may still occur there but is so rare that it may already be totally extinct in Washington.

Two potentially threatened birds known from the area of the Puget Spur are the osprey and the spotted owl. The former occurs in the vicinity of rivers, lakes, and reservoirs in the Snoqualmie National Forest, in Skagit County, and along the Snohomish River, among other locations in the state. This species is facing increasing depletion from the pesticide contamination of its fish food resources but still breeds in the state where it can establish nest sites inaccessible to man or predators. The latter species is declining mostly by virtue of habitat losses -- removal of old growth timber and physical disturbance due to recreation and construction activities in its coniferous forest habitat.

The type of activities contemplated for the pipeline are in the same class as those which have contributed to the presently observed depleted state of these species. While the construction and presence of the pipeline

corridor per se could never be blamed for extinction of any of these species in Washington, it would definitely affect their further decline, contrary to stated management policies designed to aid recovery of these populations. Since the habitat-removal aspects of the corridor are intrinsic to the project, they are not easily mitigated.

f. Trans Mountain Link

(1) Land Use Impacts. New construction would be required on the Trans Mountain Link only in Scenario III, transshipment at Cherry Point, with some form of Trans Mountain reversal. This would comprise either the Atlantic Richfield Company "yo-yo", which would require construction of several new pump stations along this link, or a Trans Mountain loop which would require construction of a new 30-inch pipeline parallel to the existing line (1985).

New construction along the right-of-way of the existing Trans Mountain Pipeline will widen the present corridor, which will disturb several miles of forest, riparian, agricultural and urban lands, as given in Table VIII-33. Only one town, Nooksack, is intersected by this link. The most significant land use affected by construction is agriculture, where 70-80 acres will be cleared, but these lands may be returned to cultivation at least by the following year. Forty to fifty acres of forest lands will be permanently removed (see Table VIII-34). The figures given in the table overestimate the acreages affected by a 30-inch line slightly, since the table gives the prototypical acreage cleared by the 100-foot corridor required for a 40-42-inch pipe. Sixteen transportation corridors will require temporary closure or rerouting as a result of pipeline construction, but none of the roads affected on this link is a major state or interstate highway.

The new pump station facilities would have minor land use impacts since the new facilities could possibly be constructed within the compound of the existing pump stations at Sumas and Laurel, or might require an additional acre or two of land immediately adjacent to these stations. The one entirely new station required would be the initial one at Cherry Point; the impacts of this are considered as part of the Land Use impacts at Cherry Point discussed in Chapter VII.

The existing Trans Mountain Pipeline crosses the Nooksack River, and the additional crossing of the river by a second, parallel pipeline would increase the risk of possible future breakage due to accident or mechanical failure and subsequent oil escape. The Nooksack River provides a major source of the public water supply for the cities of Bellingham and Ferndale. The Bellingham supply is withdrawn at Lake Whatcom, where the Nooksack River water enters through a diversion tunnel. If oil released upstream entered Lake Whatcom before it could be contained, the water supply could be contaminated for several days to several weeks, although supplementary sand filtration and chlorination at the filtration plant would remove much of the oil. After such an episode of heavy oil pollution, the water supply source would probably require special monitoring for at least a year.

(2) Terrestrial Biology Impacts. As described under Land Use, the only scenario significantly affecting the Trans Mountain Link is III-B. The loop reversal in this scenario, scheduled for 1985, would require construction of a new 30-inch line in the existing Trans Mountain Pipeline right-of-way. Several miles of forest land and about a mile of riparian zones would be permanently affected by the corridor widening under this scenario, totaling about 50 and 10 acres, respectively. The nature of the impacts on these natural communities is discussed in detail in Chapter VI.

Seven stream crossings are involved, the most important of which is the Nooksack River. An additional crossing of this river by a second pipeline increases the risk of a possible future breakage and oil release to these waters. The Nooksack River supports a salmon hatchery in its upper reaches. Although the pipeline crosses downstream of the hatcheries, there is the small chance that a particular age class of young fish could be destroyed if a spill occurred when these were migrating through the lower reaches of the river.

Endangered, threatened, or potentially threatened species known to occur in the general vicinity of the Trans Mountain Link include the spotted owl, pileated woodpecker, northern bald eagle, and peregrine falcon. Very little forest and riparian land is affected by this link, but such is one more small increment of habitat reduction which is in part responsible for the present depleted state of these species.

IX. LOGISTIC SUPPORT ACTIVITY ZONES ENVIRONMENTAL SETTING AND IMPACT

Continuing development of Alaskan petroleum reserves will result in a continuing reliance on the State of Washington as a source of logistic support. Three basic activities raise a potential concern for environmental impact. These are:

1. The fabrication of large pieces of equipment for the Alaskan development,

2. Transportation of large volumes of bulk materials and supplies by water, and

3. Transportation of supplies and personnel by air.

The three activities are identified with three independent zones of logistic support -- air supply will depend entirely on the Seattle-Tacoma Airport, the predominant barge traffic will flow from there and out of the Port of Tacoma, and a recent proposal for offshore drilling platform fabrication has been made for Everett. Equipment fabrication is also possible at other locations, but those are not included within the scope of this study.

The storage, repair, and disposal of the equipment used in the construction of the Trans Alaska Pipeline system will not be conducted within Washington's coastal zone. The equipment, however, will move by barge through Seattle and by rail across the Cascades to eastern Washington, where it will be stored at an abandoned Air Force base at Moses Lake. The effects of that storage will not be considered in this study; the movement of those goods is included under the consideration of total tonnage transported. Similarly, the provision of manpower to the State of Alaska will not be considered to have a direct environmental impact other than its requirements for transportation.

A. PORT OF SEATTLE AND SEA-TAC AIRPORT - TRANSPORTATION

In terms of both air and ocean movement, Seattle comprises the most attractive port of the region. The activity of the Trans Alaska Pipeline system and the development of several Alaskan petroleum regions has been largely supported by the movement of goods and personnel through the Seattle area. The forecast for equipment transshipment anticipated as part of a natural gas pipeline or continuing Outer Continental Shelf petroleum development are given in Chapter IV. Considered together, several of these projects may significantly overlap and result in a demand for transportation through the Seattle area than is greater than anything experienced due to the Trans Alaska Pipeline system itself. Although a level of activity cannot be considered minor, the physical capacity of the Port of Seattle and the Sea-Tac Airport to handle a volume of goods and personnel appropriate to that port's share of the total transportation

requirement is probably adequate. No major proposals to provide new facilities or significant expansions of existing facilities have been identified that can be related exactly to the portent of continuing or increasing Alaskan logistic support.

Such facilities as may be required would be relatively inexpensive, such as semi-temporary structures that could be used to protect equipment and supplies from inclement weather. There is sufficient space in the airport vicinity for a modest amount of such new construction. There is limited space only at the Port of Seattle itself. New berth construction at the port is probably netierh necessary nor easily accomplished. The Port of Seattle is a major West Coast port. It has undergone substantial development in the past in order to serve general commodity movement and particularly to serve such speciality markets as forest products and earlier phases of Alaskan logistic support. The inner waterfront area at Seattle, the Duwamish River area, is probably fixed over the near and intermediate term without major capital expenditure.

The activity for logistic support will entail continued large movements of freight and continued air movements of freight and passengers. Such activities generate a proportion of the urban pollution load that affects both water and air. The magnitude of the impact cannot be readily calculated since the exact proportionality cannot be determined. It appears that the principal level of logistic support in the future will serve to replace a level of activity established over the past decade which has declined due to changes in the foreign market for forest products and the completion of the Trans Alaska Pipeline system. The analysis of continuing Alaskan development indicates a significant phase shift between peaks of hypothetical construction demand. Displacement of the peaks by two to four years will have a major beneficial effect on both the economy and the environment of the State of Washington. It is likely that most of the logistic support efforts that would be directed through the Port of Seattle can be sustained, if the Alaskan development follows a course as described in Chapter IV, without a significant increase in either new construction or in operation. In this sense, the environmental impact of logistic support is essentially the environmental impact of continuing a sector of the state's economy that has already become established.

B. PORT OF EVERETT - DRILLING PLATFORM FABRICATION

To date the only concrete proposal for major Alaskan petroleum development equipment fabrication is the proposal by Kaiser Engineers to fabricate offshore drilling rigs at a site to be created within the Port of Everett. The site requires approximately 2,150,000 cubic yards of sand and silt to be dredged from the channel adjoining the presently little used portion of the harbor, and deposited as hydraulic fill over approximately 53 acres of tidal flats which lie along the east side of the river. The dredging and filling proposal was originally initiated in 1971 in order to provide space for a wood chip handling facility at a time when the forest products industry exports to Japan were at their

peak. An environmental impact statement was prepared according to state law, but a permit for dredging and filling filed with the U.S. Army Corps of Engineers was delayed to opposition by the U.S. Fish and Wildlife Service to filling the tidal mud flats on the Snohomish River. Subsequent to an involved process of permit application and modification the interest in development a wood chip handling facility on that site dwindled. At present, the Port of Everett has a series of permits which essentially allow the originally proposed use. They have been approached by Kaiser Engineers and a proposal to modify the original intended use was prepared. A draft environmental impact statement (January 1977) and a final environmental impact statement (February 1977) have been prepared providing some documentation of the Kaiser proposal. The following discussion is largely based on those two documents.

The existing conditions at the Port of Everett in the vicinity of the proposed drilling rig fabrication site are characterized by a long history of fairly intensive water-oriented industrial use. A ship channel with maneuvering basins has been maintained in that area for many years. The principal industry has been forest products which, with associated log handling wastes, has resulted in an apparently significant impact on the water quality of the harbor area and on its marine life.

Platform fabrication entails transportation of large quantitites of steel and other materials, extensive electric arc welding, launching, and floating the completed tower in the adjoining waterway and towing to its site of erection. The site is adequate for simultaneous construction of two towers. Net production may amount to some two to six towers per year, but at present no contracts have been used by Kaiser engineers to estimate the actual level of activity. One major project component is the relatively large amount of labor required depending on the rate of construction. The platform fabrication site could draw between 250 and 600 workers.

1. Terrestrial Biology

The area immediate intended for disturbance in order to accommodate the Kaiser platform fabrication project has long been subject to industrial use. The flora and fauna associated with the site are unlikely to be rare or unusually valuable in a regional setting. Indeed, the land area affected is relatively small.

Whatever incidental flora and fauna are on the site at present will be destroyed in the course of project construction. Because existing plant and wildlife are not particularly rare or valuable in this region, the habitat destruction is probably insignificant.

2. Air Quality

Air quality at Everett reflects its moderately large urban character and its location along the developed corridor, east of Puget Sound. Particulates are moderate with no violations of the state standard for

annual geometric mean. Sulfur dioxide is moderate on the whole with an annual average of one part per hundred million (pphm) and a 24-hour maximum of 8 pphm, below the state standard of 10 pphm. In 1975, however, there were five one-hour averages in excess of the state standard of 40 pphm. This is the greatest number of violations occurring in that year for any location monitored by the state. Neither ozone nor carbon monoxide are monitored at Everett.

Extensive arc welding will generate some smoke, fumes, nitrogen oxide, and ozone emissions. No method is available to directly calculate the pollution potential, although it is expected that impact would be small by comparison with the majority of the surrounding industrial activities. Indeed, the principal emission source would be transportation of raw materials to the site and particularly transportation associated with the labor force commuting to the site from remote residences. Since many of the employees will be local, the project does not represent a major impact which could have associated with it a significant net increase in vehicular emissions.

3. Water Quality/Marine Biology

The Port of Everett, located at the mouth of the Snohomish River on an innerchannel of Puget Sound, has been the site of port-related industrial development which has had a significant impact on water quality. Several major dischargers, particularly sulfite pulp mills operated by Scott Paper and Weyerhaeuser, contribute to degradation that has led to a designation of "fair to good" for the immediate vicinity of the port and the mouth of the Snohomish River. The adjoining waters of Puget Sound are classified as excellent, but that classification must be compared against the rating "extraordinary" which characterizes the vast majority of the waters in Puget Sound.

Despite the poorer than average water quality, the waters immediately adjoining the Port of Everett are valuable waterfowl areas with eelgrass beds in the sandy substrate at the mouth of the Snohomish River. There is also significant commercial bottom fishing and sports salmon fishing near the port. Crab are found in the waters of the Sound nearby. The diversity and value of the marine resource, however, cannot escape damage from the large degree of industrial activity here.

The phenomenon of rapid degeneration of benthic habitat from a thick blanket of waterlogged bark and wood debris has been a significant environmental issue at many locations. Even after cessation of log rafting in the area, the heavy organic content of the bottom sediments represents a biochemical and chemical oxygen demand which will render the sediments anaerobic for many years to come. The prolonged oxygen deprivation leads many marine sediments to become highly toxic due to the presence of sulfide formed by microbial action on organic material, particularly in the presence of ferrous minerals. In the light of the history of prior disturbance, the claim in the Port of Everett draft environmental impact statement that the tidelands affected by the dredging project have little biological value is probably valid. Similarly, the potential for reclamation of those tidelands is small over the short term without a deliberate effort to remove the persistent load of wood waste.

Very little wastewater will be generated by the platform fabrication process. Domestic waste will be contained within a sanitary sewer system, and the only discharge to surrounding waters will comprise storm water runoff which will become contaminated with oil, miscellaneous chemicals, and the industrial litter that will be found on such a site. A minimal amount of barge traffic will be required for supply and the actual departure of a platform will require tow vessels and some substantial maneuvering in the narrow channel between the bulkhead line and the breakwater to the west. Overall, however, the anticipated water quality impacts are likely to be minimal compared with the impact of adjoining forest product industries.

As no significant water quality impact can be identified, it is unlikely that there will be any further adverse effects on the marine resources of the area from toxic discharge. One factor is the dredging and fill of 53 acres of tidal flats. As noted earlier, the subtidal area is degraded below expected quality due to the large quantity of bark waste and miscellaneous industrial sediments that have accumulated there over the years. The filling then will probably have little direct adverse impact on existing conditions. It will, however, represent a distinct foreclosure of the option or opportunity for that tidal flat to regain its earlier role in the regional ecology of the Snohomish estuary. Such foreclosure would be a part of any project requiring subtidal fill and is not necessarily a direct effect of logistic support activities in general. The principal reason why the Kaiser project is located at Everett on landfill is that the Port of Everett has planned such an expansion in the past and received permits which it desires to implement. Intensification of use in an already industrialized zone minimizes disturbance elsewhere and in some degree offsets any foreclosure of the subtidal filling.

C. PORT OF TACOMA - TRANSPORTATION

Tacoma will share the volume of water shipment for logistic support with the Port of Seattle. Tacoma has developed a series of major waterfront industries which have made heavy use of the deepwater channels leading to this southern portion of Puget Sound. Although the early role of port was directed toward Puget Sound. Although the early role of the port was directed toward Puget Sound and northwest trade, recent years have seen the development of major barge marshaling activities that support major cargo movement to Alaska. It is expected that a large proportion of continuing logistic support will flow through the Port of Tacoma.

No specific information regarding contracts or quantity of freight shipped are available. Neither is there any concrete indication of plans for the expansion specifically oriented toward continuing or increasing Alaskan trade. It is felt, however, that the Port of Tacoma offers a somewhat greater opportunity for expansion than does the Port of Seattle and that such growth of large facilities as may occur in Puget Sound due to peak demands for Alaskan trade will occur in this vicinity.

In order to obtain an indication of the environmental effects, the Port of Tacoma was queried regarding expansion projects that would serve barge trade. Although no projects are specifically associated with those major tug and barge companies, the port supplied a draft environmental impact statement for an industrial yard landfill that the consultant feels is typical of the degree of activity or new construction that may be encountered in future years.

The Port of Tacoma is located at the estuary of the Puyallup River. The broad plain of alluvial deposits has been dissected with channels dredged and diked that increase the waterfront area of the port. This activity continues and the past decade has seen extension inland of the Blair Waterway by nearly one mile and enlargement of the Hylebos Waterway at its base near the heights of northeast Tacoma. There is still area into which waterway extension can proceed in order to create further water frontage, but this can occur only at the expense of flat back-up land which is always at a premium in a freight transshipment operation.

Extension of the spits of flat land into Commencement Bay is limited by the abrupt bottom contour transition formed by the boundary between the edge of the alluvial plain and the deep water of the glaciated fjord. There are several areas, however, which can be increased by amounts of a rew acres. One of these is an area adjoining the Blair Waterway at the site of some abandoned ship ways. It is this location that the Port of Tacoma has proposed to fill.

The fill technique entails clamshell dredging and rock placement to form a dike around a six-acre portion of tital and subtitle lands. The area within will be filled with material of a terrestrial origin imported to the site.

1. Terrestrial Biology

The history of industrial activity and the major changes in the estuary land form of the Puyallup River have already eroded its original value as a habitat for terrestrial and water-oriented wildlife. Pockets of original flatland vegetation are rare and reflect their recent history of disturbance. Considering the small amount of land that would be affected, terrestrial biological impacts are probably minor.

2. Air Quality

The existing air quality at Tacoma is moderately good, and similar to that of the other urban locations along Puget Sound. Its position at the southern portion of the Sound has lent the only significant ozone problem for this region of the state. Sulfur oxides are high at certain locations, indicating the principal contributors are stationary point sources. Particulates have fluctuated below the standard of 60 micrograms per cubic meter annual geometric mean.

Construction of new sites for barge traffic will entail primarily only short-term impacts on air quality due to the fugitive dust from such land fill operations. Operating impacts are expected to be relatively

minor since the number of vessels required to tow a string of barges is only on the order of a few per week. Apart from land transportation emissions, such as truck and rail, the freight marshaling activity will have few air emissions.

3. Water Quality/Marine Biology

Present water quality of Commencement Bay is rated as "good" -- the third lowest of the categories established by the State Department of Natural Resources and the Department of Ecology. Much of the degradation is due to the long history of log rafting along the northern shore of Commencement Bay. Bark wastes and miscellaneous industrial wastes have contaminated the blind sloughs created by the industrial waterways such that bottom conditions in most have become anaerobic and the species present no longer represent the full range of marine organisms which could be found in this portion of Puget Sound. Needless to say, the intensive use of the Puyallup Estuary has destroyed most of its original value as a habitat for marine organisms. Despite this, however, some commercial and much sports fishing is practiced in the vicinity. The species sought are those that may be found at many other locations in Puget Sound.

The freight marshaling and barge transportation activities themselves represent a continuation of a form of disturbance which has been common for decades at this location. Few discharges, if any, are expected from that activity. If construction of new waterfrontage is required to handle an increased barge traffic, the effects on water quality will be primarily brief periods of high turbidity from the resuspension of bottom sediments. Some may contain quantities of toxic industrial materials, but the primary expected impact would be from temporary oxygen depletion in a small portion of Commencement Bay. The turbidity resulting is probably minor compared to the turbidity due to seasonally river-borne sediments.

The area of land fill possibly remaining in the Port of Tacoma is a few tens of acres at most without entailing large engineering costs. Since the quality of that habitat has already been affected by industrial use, it cannot be considered a prime marine resource. The orginal area of tidal and shallow subtidal lands that was originally present in this area has been reduced already to a fraction of its original extent. The conversion of any of the remaining shallow subtidal lands represents a significant impact upon the remaining fraction thereby foreclosing its potential for reestablishment of a more healthy community of marine organisms. Practically speaking, as long as port activity continues, such reestablishment is foreclosed. Considering sustenance of a major segment of the region's economy, this represents an advantageous trade off between concentration of environmental impact at one location with a diffused impact of development of various smaller pockets of flat shoreline that dot the shore of Puget Sound.

X. THE EXISTING ECONOMIC SETTING

A. INTRODUCTION

The impacts of petroleum-related activities in Alaska on the State of Washington will not be evenly distributed across all areas. Rather, they will concentrate in two groups of coastal counties: those which provide logistic support services to the oil and gas industries, and those which are impacted by petroleum flows from Alaska. In the first group are the counties of King, Pierce, and Snohomish, and the three major cities of Seattle, Tacoma, and Everett. In the second group lie the counties of Clallam, Skagit, and Whatcom, and the major municipalities of Port Angeles, Anacortes and Bellingham; these cities are significantly smaller than the major cities in the three counties which will provide logistic support.

The purpose of this chapter is to provide the following background economic data: the current population of each county, distribution of employment, tax receipts, and historical levels of waterborne and airborne trade between Washington and Alaska. All of the information will be used as a reference point for discussion, in Chapter XI, of the economic impacts of continued oil-related trade between Alaska and Washington.

B. POPULATION

The population of the six-county region is shown in Table III-C. By far the largest county of the six is King, with a 1976 population of approximately 1,155,000. King County, however, was the only county of the six to actually lose population between 1970 and 1976, incurring a decline of roughly 3700. The greatest population increase in absolute numbers was in Pierce County, from 412,000 in 1970 to approximately 421,000 in 1976. In Whatcom County the population increased by about 8000 to 90,000 in 1976. In percentage terms, the fastest growing county has been Clallam, whose 1976 population of 39,800 represented a 14.5% increase from the 1970 figure.

The three central Puget Sound counties -- King, Pierce, and Snohomish -- all experienced net out-migration during the six-year period; in King County the total was approximately 34,700. Whatcom County experienced the greatest in-migration -- 5277. In all of the counties there was a natural increase in population, ranging from 1226 in Clallam County to 31,022 in King County.

C. EMPLOYMENT AND WAGES

Table X-1 shows covered employment by major activity for each of the six counties in 1975. King County had almost 70% of the total employment in the six-county region.

TABLE X-1

COVERED EMPLOYMENT - 1975 AVERAGE

	Clallam	King	Pierce	Skagit	Snohomish	Whatcom
Construction	607	20,482	5,605	940	3,508	1,813
Manufacturing	3,498	103,272	20,431	4,212	20,589	6,421
Transportation and Public Utilities	558	33,064	4,377	796	3,116	1,677
Wholesale Trade	237	39,330	5,683	677	2,031	1,043
Retail Trade	2,384	80,984	21,547	3,332	11,852	5,937
Financial, Insurance, and Real Estate	387	36,664	5,471	515	2,075	1,058
Services	1,763	86,015	19,590	1,909	8,701	4,540
Other	1,640	43,934	14,522	1,300	4,489	2,829
Total	11,074	443,745	97,226	13,681	56,361	25,318

Source: Washington Pocket Data Book - 1976.

Almost 25% of total employment in King County is in manufacturing. In Snohomish County, roughly two of every five covered employees work in manufacturing firms. King County is clearly the center of finance and insurance activities in Washington: one out of every 12 employees in the county is employed in finance, insurance, and real estate. In the other five counties, only one employee of every 21 is employed in similar activities. King County is also the center for wholesaling activities: while only 68% of all employees work in King County, more than 80% of those engaged in wholesale trade are employed there. Similarly, more than 75% of all persons employed in transportation and utility activities work in King County. Therefore, most of the efforts in logistic support of oil and gas development in Washington will logically be located in King County.

Wage levels for covered employees are also significantly higher in King County than in the other five counties (see Table X-2). The average wage in King County was $11,577 in 1975, compared with $10,796 for Snohomish and $9,507 for Clallam County. Employees in King County are paid higher wages for every type of employment, with the greatest differentials achieved in the transportation and public utilities services, and finance, insurance, and real estate sectors. Clallam County generally has the lowest wages of the six counties. Service employees in Clallam receive an annual wage of only $5,337; the comparable wage in King County is $8,800. Table X-2 makes clear the wide income disparities among the counties. However, these disparities are in part compensated for by different costs of living: for example, housing prices in the less-developed counties are significantly lower than those in the three central Puget Sound counties.

D. TAX REVENUES

A significant percentage of the revenues to local governments -- including cities, towns, and counties -- comes from state-distributed taxes. Receipts from the three tax services, as shown in Table X-3, represent the majority of state-distributed tax revenues. Other sources of state-distributed revenue, including forest excise taxes, motor vehicle excise taxes, liquor profits, and overload fines, are insignificant in comparison.

By far the largest recipient of these tax revenues is King County, which received approximately $43 million in 1975. Clallam County, with the smallest population of the six counties, received approximately $1.7 million during the same year. The largest single producer of revenue is the local sales and use tax; this generated 65% of total revenues from the three sources.

Until 1970 all sales and use tax proceeds had gone to the state's general fund. In that year, the legislature allowed local governments to levy a 0.5% tax to be collected by the state and redistributed to local governments. The state charges an administration fee of 1.5% of all revenues received. Of the remainder, counties receive 100% of the amount collected in unincorporated areas and 15% of the amount collected within incorporated areas, while cities and towns receive 85% of the amount collected within

TABLE X-2

AVERAGE WAGES FOR COVERED EMPLOYEES - 1975

	Clallam	King	Pierce	Skagit	Snohomish	Whatcom
Construction	$11,690	$15,270	$13,479	$14,245	$12,956	$13,002
Manufacturing	12,858	14,512	13,111	12,655	13,716	13,281
Transportation and Public Utilities	11,461	15,053	12,564	11,481	11,664	12,394
Wholesale Trade	11,726	13,774	12,787	10,736	12,084	9,995
Retail Trade	6,426	7,464	6,908	6,045	7,006	6,080
Finance, Insurance, and Real Estate	7,904	10,097	9,075	8,357	8,489	8,510
Services	5,337	8,799	7,453	6,300	7,636	6,544
Other	9,909	12,631	11,264	10,752	11,735	12,304
Average	9,507	11,577	10,071	9,762	10,796	9,859

Source: Washington Pocket Data Book - 1976.

TABLE X-3

DISTRIBUTED STATE TAXES - 1975*
(thousands of 1975 dollars)

	Clallam	King	Pierce	Skagit	Snohomish	Whatcom
Motor Vehicle Fuel Tax**	$669.2	$12,699.7	$4,943.5	$1,017.9	$3,443.0	$1,261.6
Local Sales and Use Tax	950.5	27,853.8	7,595.5	1,197.7	4,447.8	2,030.2
Liquor Sales	67.9	2,286.5	719.6	94.9	480.3	162.8

*Taxes collected by state and returned to cities, towns, and counties.
**Includes both ½¢ motor fuel tax and 6-7/8¢ motor fuel tax.

Source: Washington Pocket Data Book - 1976.

their boundaries. The use of the funds is unrestricted. In 1971 the legislature authorized King County to levy an additional 0.3% tax, upon approval of the electorate, to be used for supporting public mass transit. In 1974 the legislature extended this tax to any county where the voters approved the tax, but only Grays Harbor County has adopted the tax.

The state motor vehicle fuels tax of $0.09 per gallon; approximately $0.04125 is shared with local governments through the Urban Arterial Trust account and the general highway funds of local governments. The remaining monies are used by the state for highway purposes, although some funds are used to defray the expenses of the Puget Sound Ferry System.

Liquor tax receipts are distributed between the state and local govenments. Monies allocated for local governments are distributed on the basis of population. In addition, some funds are reserved for University medical research and for alcoholic rehabilitation programs.

Our impact model (described in Appendix C) estimates motor vehicle fuel taxes, sales and use taxes, and liquor taxes. The results of the model can be compared to the existing levels of revenue in each of the counties to determine the importance of marginal oil-related revenues.

The other major source of revenue for local governments in Washington is the property tax. Table X-4 shows expected 1976 property tax collections and tax receipts per capita for the six counties. Whatcom County had the highest per capita tax receipts -- $284; the lowest per capita payments -- $188 -- were in Clallam County. King County generates almost a quarter of a billion dollars of revenue annually in property tax collection, compared with only $7.5 million for Clallam County. The three central Puget Sound counties generally have lower per capita tax burdens than the three outlying counties, even though personal incomes in the central Puget Sound counties are significantly higher. This is largely accounted for by the greater per-person land ownership in the outlying counties.

In all of the counties, property tax receipts are significantly greater than the receipts from distributed revenues. For instance, in Pierce County, revenues from distributed state taxes equal $13.3 million, whereas property tax receipts exceed $80 million. More than one-fifth of this latter amount is required by the state school tax levy.

E. TRADE BETWEEN ALASKA AND WASHINGTON

The economic impact of oil development activities in Alaska on the State of Washington will be felt in the form of trade through logistical supports and through petroleum flows. These activities will stimulate Washington's economy and create jobs and tax revenues and increase the demand for land, infrastructure, and other scarce resources. Historical petroleum flows into Washington were discussed in Chapters I-IV. The following discussion deals with historical flows of equipment and supplies from Washington to Alaska.

1. Waterborne Commerce

The Port of Seattle's maritime trade with Alaska has increased dramatically in recent years (see Table X-5). In 1967 almost one million short tons of trade with Alaska moved through the Port of Seattle; by 1976 this figure had increased to slightly more than two million short tons.

TABLE X-4

PROPERTY TAX COLLECTIONS - 1976
(thousands of dollars)

County	Property Tax Revenues	Tax Receipts Per Capita
Clallam	$ 7,496.2	$188
King	247,278.3	214
Pierce	80,033.9	190
Skagit	14,742.4	273
Snohomish	47,222.8	175
Whatcom	25,529.8	284
The State	727,430.1	204

Source: Washington Pocket Data Book - 1976.

TABLE X-5

SEATTLE WATERBORNE TRADE WITH ALASKA

Year	Receipts (thousand short tons)	Shipments (thousand short tons)	Total (thousand short tons)	Receipts (as % of total)	Shipments (as % of total)
1950	124.5	468.2	592.7	21	79
1951	121.0	531.5	652.5	19	81
1952	131.8	432.3	564.1	23	77
1953	126.3	449.3	575.6	22	78
1954	86.8	491.9	578.7	15	85
1955	85.1	501.8	586.9	14	86
1956	87.7	575.4	663.1	13	87
1957	69.5	512.4	581.9	12	88
1958	72.7	549.2	621.9	12	88
1959	74.6	583.7	658.3	11	89
1960	71.0	618.3	689.3	10	90
1961	73.8	532.1	605.9	12	88
1962	69.5	528.5	598.0	12	88
1963	92.5	575.0	667.5	14	86
1964	109.7	715.9	825.6	13	87
1965	144.1	801.6	945.7	15	85
1966	162.7	775.0	937.7	17	83
1967	163.2	801.5	964.7	17	83
1968	164.1	810.0	974.1	17	83
1969	166.6	964.4	1,131.0	15	85
1970	162.6	715.7	878.3	19	81
1971	224.7	832.2	1,056.9	21	79
1972	168.7	1,054.8	1,223.5	14	86
1973	406.4	964.3	1,370.7	30	70
1974	312.9	1,495.9	1,808.8	17	83
1975	291.1	1,728.0	2,019.1	14	86

Source: U.S. Department of Army Corps of Engineers.

The vast majority of this growth occurred in shipments to Alaska. Between 1967 and 1975 receipts from Alaska increased by only 128,000 short tons, while outbound shipments increased by more than 900,000 short tons. Of this total trade, the allocation between receipts and shipments has remained roughly steady, with shipments equaling between 80% and 85% of the total, and receipts at between 15% and 20% of the total. Prior to the discovery of oil in Alaska and the resulting increase in exploration and population growth, total trade between Seattle and Alaska had remained steady between 1950 and 1962 at approximately 600,000 tons annually. However, in that year trade began to increase and reached the one million ton mark in 1969.

The impact of the construction of the Aleyska pipeline on trade between the two states is clearly demonstrated in Table X-6. In 1975, seven of the ten most heavily shipped commodities between Seattle and Alaska were classifications in which the percentage of shipments related to pipeline and other oil development activities can be expected to be large. The fact that the Aleyska pipeline accounted for much of these shipments can be seen in the dramatic increase in the total volume of shipments. For instance, the most heavily shipped product -- miscellaneous food products -- increased from 127,000 short tons in 1973 to almost 178,000 short tons in 1975, or by approximately 39%. However, during that same period, shipments of non-electrical machinery increased from approximately 22,000 short tons to almost 107,000 short tons, an increase of more than 400%. Similar increases can be seen in building cement, which increased from about 29,000 short tons to 117,000 short tons. Rapid increases were experienced in other commodities, such as iron and steel pipe, fabricated metal products, and miscellaneous manufactured products.

In addition, the "commodities not elsewhere classified" category is also heavily composed of pipeline-oriented shipments. Many of the commodities in this category were rail boxcars shipped on the Hydro-Train. The operator was required only to give the total weight in the boxcars, not to indicate the commodities within. In addition, the sudden explosion in volume of these commodities in 1974 indicates that they were heavily oriented to the pipeline.

Alaska also has been increasing in both relative and absolute importance as a trading partner for the Port of Seattle. In 1974 more than 50% of all westbound cargo from the Port of Seattle was destined for Alaska. The volume of more than 1.8 million short tons shipped between the Port and Alaska in 1974* compares favorably with the Port's commerce with its largest overseas trading partner, Japan, which amounted to 1.5 million short tons in that year. Of the tonnage carried between Seattle harbor and Alaska, approximately 450,000 tons were carried to southeast Alaska, 650,000 tons to Anchorage, an additional 550,000 tons to other ports, such as Seward, Whittier, Valdez, and Kodiak in central Alaska, and 150,000 short tons to other ports in the state.

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* Port of Seattle, Department of Planning and Research.

TABLE X-6

TEN MOST HEAVILY SHIPPED COMMODITIES - SEATTLE TO ALASKA*
(short tons)

Commodity	1973	1974	1975
Miscellaneous Food Products	127,287	149,001	177,762
Building Cement	28,996	93,113	117,006
Lumber	56,346	75,710	116,605
Machinery, except Electrical	21,775	84,674	106,908
Iron and Steel Pipe and Tube	28,259	34,121	88,770
Miscellaneous Non-metallic Mineral Products	28,226	47,662	87,651
Fabricated Metal Products	41,250	55,316	70,123
Miscellaneous Manufactured Products	39,404	50,775	69,616
Alcoholic Beverages	51,382	58,664	68,907
Motor Vehicles, Parts, Equipment	33,239	46,637	51,634
Total of 10 Commodities	456,164	695,673	954,982
Total Trade	964,318	1,495,922	1,728,088

*Commodities, not elsewhere classified, not included: 1973 volume, 152,596; 1974 volume, 339,727; 1975 volume, 218,993.

Source: Research and Planning Department, Port of Seattle.

As indicated previously, cargo movements from Alaska to Seattle are only about one-fifth of those in the reverse direction. Pulp is the cargo most heavily shipped to Seattle from Alaska, accounting for approximately 50% of the total tonnage volume of the top ten commodities and 40% of all shipments from Alaska to Seattle. The other major commodity shipped is fish and shellfish, both fresh and prepared. In recent years miscellaneous manufactured products have shown a dramatic increase, from approximately 2400 short tons in 1973 to approximately 18,800 tons in 1975. Petroleum movements are not shown in Table X-7 because no petroleum enters the Port of Seattle from Alaska.

Compared to the Port of Seattle, the Ports of Tacoma and Everett have relatively little trade with Alaska. The Port of Everett estimates that to date virtually no Alaskan related trade has flowed through Port facilities. The Port of Everett serves largely as a bulk shipper of pulp and paper products to its principal trading partner, Japan. However, as is discussed in Chapter XI the Port may serve as a fabrication yard for drilling platforms to be used in Alaskan oil development.

The Port of Tacoma has had some trade with Alaska. During the construction of the Aleyska pipeline, equipment modules such as pumping stations were constructed at Tacoma facilities. It is estimated that in 1975 employment at the Port for module construction was approximately 2800; however, this dropped to 1800 in 1976 and is currently at only 900 persons. If additional work from Alaska is not forthcoming in the near future, it is likely that the facility will be shut down. In recent months the Totem Ocean Trailer Express Company has moved its operations from the Port of Seattle to the Port of Tacoma. In any future Alaskan development T.O.T.E. can be expected to carry a large percentage of total waterborne cargos - meaning that the Port of Tacoma will grow in significance in terms of trade with Alaska. Table X-8 shows historical volume of trade between the Port of Tacoma and Alaskan ports. The majority of the tonnages listed were oil-related movements. Fifty-nine thousand short tons of the cargo moved in 1970 was pipe for the Aleyska pipeline which was brought to the Port of Tacoma from Japan and transferred to ocean going barges for subsequent transit to Alaska. The rapid increases in 1975 and 1976 were largely due to both the introduction of Crowley Tug and Barge and T.O.T.E. operations to the Port and also to the shipment of the equipment modules being constructed on Port land. It is likely that the Port will handle an increasing share of any future oil-related shipments to Alaska.

2. Airborne Cargo

The Port of Seattle began to maintain records of airfreight movements between Seattle and Alaska only in 1975. However, the information shown in Table X-9 is indicative of the levels of airfreight movements that have occurred between Sea-Tac International Airport and Alaska. As is the case with waterborne shipments, shipments outbound from Seattle to Alaska account for the vast majority of total air shipments. Only during the fishing season, when operators desire to have fresh fish flown to Washington in the shortest possible time, do freight movements from Alaska to Seattle achieve any significance.

TABLE X-7

TEN MOST HEAVILY SHIPPED COMMODITIES - ALASKA TO SEATTLE*
(short tons)

Commodity	1973	1974	1975
Pulp	224,455	161,821	120,176
Fish and Shellfish, Prepared	63,287	55,898	66,793
Miscellaneous Manufactured Products	2,393	15,970	18,753
Fresh Fish, except Shellfish	22,335	16,069	17,769
Shellfish, except Prepared	3,782	4,668	8,036
Non-metallic Minerals, Not Elsewhere Classified	0	3,885	5,405
Lumber	3,481	3,850	5,306
Machinery, except Electrical	4,424	4,045	4,904
Coal and Lignite	1,783	2,687	3,274
Motor Vehicles, Parts, Equipment	2,896	1,252	2,993
Total of 10 Commodities	328,836	270,145	253,409
Total Trade	406,365	312,979	291,112

*Commodities, not elsewhere classified, not included: 1974 volume, 26,721; 1975 volume, 24,830.

Source: Research and Planning Department, Port of Seattle.

TABLE X-8

OIL AND CONSTRUCTION RELATED CARGOS
FROM THE PORT OF TACOMA TO ALASKA
(short tons)

Year	Amount
1967	3,372
1968	2,065
1969	1,043
1970	59,597*
1971	1,009
1972	1,673
1973	623
1974	3,544
1975	34,234
1976	36,030**

*Includes 59,000 short tons of pipe which was shipped from Japan and transferred to barges.
**First eight months of 1976.

Source: Port of Tacoma.

TABLE X-9

AIRFREIGHT MOVEMENTS TO ALASKA
(short tons)

Year	Quarter	Total Freight Moved	Inbound	Outbound
1975	1	8,708	628	8,080
	2	10,731	1,077	9.654
	3	13,375	2,672	10,703
	4	10,231	923	9,308
1976	1	8,779	648	8,131
	2	11,246	1,535	9.711
	3	12,040	2,621	9,419
Total		75,110	10,104	65,006

Source: Planning and Research Department, Port of Seattle.

During the seven quarters shown in Table X-9, slightly more than 75,000 short tons of airfreight moved between Seattle and Alaska, with more than 65,000 tons outbound from Seattle. The Port of Seattle does not keep records of the types of cargo moving by airfreight, but our interviews with the major airfreight operators at the Sea-Tac International Airport indicate that the vast majority of items moving in this way are perishable foodstuffs. Most of the remaining commodities tend to be of high value and are also relatively dense. Specific examples were given by airfreight operators of the commodities carried which were destined for the Aleyska pipeline. These included a planeload of ladders, welding rods, truck transmissions, pipe valves, and other equipment whose absence could seriously slow construction of the pipeline.

According to the Port's Planning and Research Department, airfreight movements to Alaska account for approximately 40% of total airfreight movement to and from Sea-Tac International Airport. Air passenger movements to Alaska have also shown a dramatic increase paralleling the development of the Aleyska pipeline. As shown in Table X-10, approximately 400,000 persons flew between Sea-Tac International Airport and Alaska in 1967. By 1975 this traffic had increased to approximately 775,000 and, as a percentage of Sea-Tac's total traffic, had increased from 10.1% to approximately 12.7%. This traffic is generally allocated between four airlines: Western, Northwest, and Alaskan Airlines, which fly between Sea-Tac and Anchorage, and Pan American which, with Alaskan Airlines, flies between Sea-Tac and Fairbanks. In addition, other airlines service other locations in Alaska, including Juneau and Sitka.

The regional breakdown of the 775,000 enplaned and deplaned passengers traveling between Sea-Tac and Alaska in 1975 indicates that approximately 432,000 traveled between Anchorage and Sea-Tac, 173,000 between Fairbanks and Sea-Tac, and the remaining 170,000 between southeastern Alaskan airports and Sea-Tac.

TABLE X-10

SEA-TAC INTERNATIONAL AIRPORT
AIR PASSENGER TRAFFIC BETWEEN SEA-TAC AND ALASKA

	Number of Enplaned and Deplaned Passengers	
Year	Total	Percent of Total Sea-Tac Traffic
1957	171,470	12.17%
1958	168,230	11.72
1959	189,949	11.86
1960	196,343	12.00
1961	202,826	12.52
1962	219,430	10.96
1963	215,388	12.09
1964	255,037	12.72
1965	285,655	12.21
1966	319,174	11.31
1967	390,049	10.12
1968	401,849	9.06
1969	430,600	8.96
1970	457,573	9.83
1971	468,944	9.86
1972	514,323	10.73
1973	524,366	10.07
1974	604,467	10.47
1975	775,544	12.68

Source: Planning and Research Department, Port of Seattle; Airport Management records.

XI. ECONOMIC IMPACT ASSESSMENT

This chapter describes the economic impacts that can be expected in the State of Washington from the forecast levels of petroleum flow and logistic support activity. It first summarizes the findings and resulting conclusions of the economic analysis. The major finding is that all of the proposed transportation flow scenarios and the probable logistical support impacts will have only a minimal effect on the state's economy, although there will be relatively larger impacts on specific areas.

The remainder of the chapter presents the detailed results of the analysis that led to the conclusions. First, for readers who may be unfamiliar with the theory of regional economic multiplier analysis, several reference sources are suggested which can explain the topic. Washington's special trading ties with Alaska, and the reason why any major development in Alaska will affect Washington, are next discussed, followed by a description of the types of economic impacts that will result from petroleum development and transshipment of crude through Washington. Here, drawing on the scenario definitions developed in previous chapters, we detail the final demand impacts, including specific estimates of their magnitude and timing. Finally, the total multiplier impacts are presented, along with tax revenues, population increases, and resultant land requirements.

The specific methodology utilized in this impact assessment is discussed in this chapter and detailed in Appendix C. Each scenario is analyzed in terms of its size and importance as compared with the surrounding local and regional economy.

A. SUMMARY OF ECONOMIC IMPACTS

Before estimates of the impacts are presented, it is useful to develop an understanding of which of the impacts will be new impacts on Washington and which will only replace activities which have already been occurring. In this report we will use the terms "net impacts" and "gross impacts" to differentiate between new and replacement impacts. "Net impacts" will be used to refer to impacts projected to occur which have no counterpart in today's Washington economy. An example of such an impact would be the construction and operation of the proposed Northern Tier Pipeline project. "Gross impacts" will be used to refer to the combined total of both net impacts and replacement impacts. An example of a replacement impact is the cost of refining Alaskan crude oil in the four Puget Sound refineries. These refineries are currently using crude from Canada and other foreign sources. With the introduction of Alaskan crude, these refineries will not change their output nor will their impact on the local community alter significantly. Hence, no new or additional impacts will result from Alaskan crude. However, the use of Alaskan crude must be counted as part of a gross impact because the impact of the refineries at any point in time must be distributed among the crude sources in use at that time.

As noted in Appendix C, logistical support impacts related to the development of the petroleum industry have already occurred in Washington during the construction of the Alyeska pipeline. However, we believe that the project logistical impacts must be considered as net impacts because they will be related to different projects and have not developed directly from previous activities.

In Appendix C we have indicated which of the components of final demand are net impacts and which are replacement impacts. The tables presented in this chapter will present the gross impact of the transportation scenarios and the difference in impacts between the net and gross scenarios will be discussed in the text. The indirect and induced impacts which flow from a new impact are considered to be net impacts while the indirect and induced impacts which flow from a replacement impact are considered to be gross impacts.

Our analysis assessed five different petroleum transshipment scenarios and two logistical support scenarios. The petroleum transshipment scenarios differed in both the amount of oil to be delivered to Washington, the type and location of facilities used to handle the oil, and the size of the tanker fleet used to bring the oil to Washington. The logistical support scenarios differed in their assumptions as to the number of Washington residents who would find employment in Alaska on oil-related jobs and the amount of their income that they would return to Washington.

Table XI-1 lists both the high and low estimates of both gross employment and tax impacts of the two logistical support scenarios, while Table XI-2 lists the highest and lowest estimate of gross employment and tax impacts of any oil transshipment scenario. From these two tables the following conclusions can be drawn:

- The logistical support net impacts will be larger than the gross impacts of any of the possible oil transshipment scenarios except during the period when the Northern Tier Pipeline is being constructed.

- Both the logistical and transshipment impacts will have only a small influence on the total Washington economy and will not have a large impact even on the region in which they are located.

- Because there is a high volume of business sales involved in the impacts in comparison to the amount of employment created or supported, the tax revenues flowing from the impacts will be sufficient to support the probable level of public costs associated with the impacts.

- The impacts of the oil transportation scenarios will peak early in the forecast period, during the time of facilities construction. After construction is completed, the impacts will remain stable for a long time.

TABLE XI-1

RANGE OF IMPACTS FOR LOGISTICAL SUPPORT ACTIVITIES*

	Logistical Support Activities (high estimate)		Logistical Support Activities (low estimate)	
	Employment (person years)	Taxes ($000s)	Employment (person years)	Taxes ($000s)
1978	81	$ 139	81	$ 139
1979	1,663	1,866	1,663	1,866
1980	3,953	4,381	3,642	4,177
1981	5,474	5,564	4,551	4,962
1982	6,937	6,578	5,249	5,460
1983	8,148	7,440	5,787	5,873
1984	8,684	7,803	5,885	5,943
1985	9,106	8,109	5,990	6,038
1986**	5,734	3,841	3,600	2,422
1987**	2,880	1,929	1,798	1,210
1988**	1,366	915	846	569

*Net impacts.
**Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-2

RANGE OF IMPACTS FOR PETROLEUM TRANSSHIPMENT SCENARIOS*

	Scenario I Status Quo		Scenario II-A Northern Tier Pipeline without Puget Sound Spur	
	Employment (person years)	Taxes ($000s)	Employment (person years)	Taxes ($000s)
1978	896	$1,144	3,732	$2,648
1979	1,133	1,300	5,024	3,546
1980	957	1,159	1,991	3,096
1981	971	1,180	2,750	2,985
1982	844	1,095	2,229	2,645
1983	777	1,049	1,816	2,376
1984	777	1,050	1,816	2,378
1985	777	1,050	1,816	2,379
1986**	427	328	1,045	848
1987**	213	163	521	422
1988**	99	76	243	196

*Gross impacts.
**Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

- The logistical impacts will grow over time as there is an increase of oil development activity in Alaska and as the construction of a proposed natural gas pipeline occurs.

In Table XI-1 all of the impacts are net impacts. However, in Table XI-2 some of the impacts are related to the activities of the existing Puget Sound oil refineries. As a result, they are gross impacts and the net impacts of the petroleum scenarios are smaller than those shown in Table XI-2. In fact, net employment in Table XI-2 is about 680 person-years less than shown in Table XI-1. This makes the relative importance of the logistical impacts even larger than is evident solely from reviewing the two tables.

The smallest oil transshipment impacts would occur if the status quo were maintained with the minimum number of changes. The only changes that would be necessary would be the construction of some improved tanker berthing facilities at refinery locations in Puget Sound and the use of tankers to bring oil to Washington from Alaska, rather than the existing pipeline system which has been bringing oil from Canada. Under this assumption, gross employment impacts would reach their peak in 1981 with only 971 people employed. Since many of these persons would owe their employment to the operation of the existing refineries, the number of net jobs created would be significantly less, about 305. Similarly, of the $1,180,000 in tax revenues generated during that year, only about $354,000 would be new revenues obtained from the tanker traffic and the construction of the improved landing sites.[1] By comparison construction of the proposed Northern Tier Pipeline and associated impacts could create more than 5000 jobs during 1979. These jobs would be new since the Northern Tier Pipeline represents a new project. However, since there is a constant level of construction activity in the state and a high rate of unemployment among construction workers, it is probable only a small percentage of the construction work force would be in-migrants to Washington.

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1. Taxes included in the estimate include the state sales tax, the business and occupation tax, the statewide property tax levied for school financing, the alcoholic beverage tax, the cigarette tax, and the motor vehicle fuel tax. The sales and business and occupation tax rates used were those actually paid by businesses as a percentage of total sales during the period October 1975 through March 1976.

B. METHOD OF ANALYSIS

In assessing the impact of Alaskan oil-related development on Washington we have employed traditional multi-regional input-output analysis. We suggest that the reader unfamiliar with this form of analysis consult some of the outstanding texts available on the topic.[1]

We have chosen to use multi-regional analysis rather than the simpler single-region analysis because it provides far more useful information as multi-regional analysis allows one to pinpoint more accurately exactly where the impacts of any project will occur. We have been fortunate in being able to locate two multi-regional input-output tables for the State of Washington which provided regional definitions almost exactly equal to those we would have constructed had the resources been available to construct such tables especially for this study.[2]

A detailed description of the methodology we have employed is provided in Appendix C, along with a brief description of the data sources used and the manner in which the components of the final demand estimates were derived. The reader interested in that level of detail should refer to the appendix.

C. THE SPECIAL TIES BETWEEN WASHINGTON AND ALASKA

One might ask why Washington will be significantly affected by any oil-related development in Alaska. The answer is relatively simple. For an analogy, one need only to review history -- the Alaskan gold rush of the 1800s. At that time Seattle grew very rapidly as it was the stepping stone from the lower 48 states to the Alaskan gold fields. Because Seattle was the westernmost port, it was the point at which traffic to Alaska changed from land-based transportation to water-based transportation. In other words, it was the point at which the mode of transportation changed.

Washington, specifically Puget Sound, will play a similar role in the development of "black gold" in Alaska. First, Washington is the closest state to Alaska. Second, the mode of transportation of most goods bound for Alaska changes in Washington: goods that enter Washington on rail leave for Alaska on either truck, ship, or plane;

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1. The following two texts provide excellent descriptions of multi-regional input-output analysis: Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science, M.I.T. Press, Cambridge, 1960; and William Miernyk, Regional Input-Output Analysis.
2. We wish to thank the Oceanographic Institute of Washington and Professor William Beyers of the University of Washington for providing the input-output tables that were used in this study.

many goods that enter by truck leave by ship. In short, Washington is a marshaling point for goods movement to Alaska and a point at which the mode of transportation changes.

Washington's position works well for it with respect to products shipped from Alaska to the continental states. Oil entering Washington via tanker is transferred to pipelines. Pulp products entering by ship are placed on railroads. Bulk shipments from Alaska bound for individual consumers in the continental states are routed to their ultimate destination in Washington.

Because of its small size and geographic and climatic constraints, Alaska produces few of the goods and services desired by its residents. Therefore, relative to the total size of the Alaskan economy, there is a large demand for imported goods and services. Even in the case of local manufacture, the production process has large leakages and must import services and materials. Again, Washington is in a position to serve as the collection and transshipment point in the continental United States.

Because Washington's own manufacturing base is relatively small and highly specialized, it is likely that a great percentage of the goods currently moving through Washington to Alaska is in fact manufactured elsewhere. For instance, Washington has no facilities to manufacture oil pipeline, nor has it all of the facilities required to manufacture oil drilling equipment. Domestically, most of this manufacturing activity is in the southern states where heretofore the majority of U.S. oil development has occurred. Because Alaska's total demand for manufactured goods is still very small in comparison to the volume used elsewhere in the nation, it is unlikely that major manufacturers will locate in Washington solely to serve the Alaskan market.

The cost of living in Alaska is higher than almost anywhere else in the nation. This is caused largely by Alaska's isolation from the rest of the United States and the high transportation charges associated with moving goods to the state. In addition, compared to many of the continental states, the climate in Alaska is bleak during the long winter. Businesses therefore offer salary premiums to attract people to Alaska. A higher standard of living can be achieved by working in Alaska and earning Alaskan wages, but living in Washington and enjoying lower prices. Washington provides a more pleasant climate, is closer to other parts of the nation, and provides more of the amenities found in urbanized areas. Therefore, many people whose Alaskan jobs require long periods of working time and long periods of time off prefer to live in Washington. This arrangement is particularly well suited to many oil industry employees, who commonly work a seven-day week for a number of weeks followed by an equally long off-work period during which the employee can return home. As he returns, he brings back much of the income he has earned while in Alaska and thereby contributes, in the present case, to the economy of Washington.

Thus, Washington's future is interwoven to some degree with Alaska's future. The continuing development of the Alaskan economy will serve as a stimulus to the development of the Washington economy. The particular sectors in Washington's economy which will be most heavily impacted are those involved in the transshipment and receipt of goods and materials to and from Alaska. Because of the small size of the economies of both states, it is unlikely that any major shift of manufacturing will occur in the near future. But because of Washington's unique position, it can be expected to remain one of the prime beneficiaries in the continental United States of future development in Alaska.

D. DIRECT IMPACTS ON WASHINGTON OF ALASKAN PETROLEUM DEVELOPMENT AND PRODUCTION

1. General Description of Impacts

In this analysis we have been asked to focus on only one segment of Alaskan development -- that related to petroleum resources. The connections which have evolved and will continue to evolve between Washington and Alaska in this regard are similar to those described above. That is, Washington serves as a transshipment point for goods and services required by the developing petroleum industry in Alaska and will also serve as a receptacle for Alaskan crude oil. Our analysis concentrates on several specific impacts which this connection between Washington and Alaska will have on Washington. These impacts are:

- Sales of firms in Washington
- Employment created in Washington
- Income to Washington
- Taxes received by Washington
- Population increase
- Land consumption

As indicated above, the primary source of impact of Alaskan development on Washington will be in the transportation sector. Therefore, we will consider sales of shipping lines to Alaska and airfreight movements to that state. Another primary impact will be the shipment of Alaskan crude oil to Washington for use both in Washington and for transshipment to other states. We will therefore discuss the economic impact of Alaskan related tanker travel in Washington waters and the induced sales in various sectors of the Washington economy.

Transshipment of Alaskan oil eastward will also require the construction of new pipeline systems. The construction impacts could be among the major impacts of oil development on Washington. Finally, a new era

of offshore oil drilling has arrived in Alaska, requiring numerous offshore drilling rigs. Because of Washington's proximity to Alaska and to the sources of the necessary materials and labor, some of the drilling platforms probably will be manufactured in Washington.

Sales of firms in Washington are only important in that they create jobs for Washington residents. Therefore, our analysis estimates both the jobs created in the firms which will have direct relationships with petroleum activities in Alaska, and the jobs created in support industries in Washington. Washington currently has a high unemployment rate. The development of Alaskan trade serves to broaden the base of Washington economy and to provide another growth sector which can create more jobs. Therefore, employment is one of the primary impacts with which this study is concerned.

Coupled with such employment is wage and salary income. Traditionally, wages in the petroleum industry have been higher than the average wage for all employees. Therefore, a growth in oil-related jobs resulting from development of petroleum resources in Alaska can be expected to have a greater impact on Washington than would an increase in number of jobs in other economic sectors.

Many of the other jobs will be involved with waterborne freight transportation, where wages are also higher than average. Finally, wages of Washington residents employed in Alaska will be much higher than the Washington average because of the above-noted differential.

One of the impacts on state government will be the tax revenues which are generated. Washington's state tax system relies primarily on taxes on business sales in the form of both a sales tax and a business and occupation tax. The state has neither a personal nor corporate income tax. Combined state and local taxes per $1,000 of income in Washington are approximately equal to the U.S. average. The transaction volumes associated with Alaskan development will generate significant amounts of revenue for Washington. In this report, tax revenues are estimated by applying the appropriate tax rates to these sales. (A thorough description of the methodology is provided in Appendix C.)

Impacts on Washington will be concentrated on specific industries and geographical areas. Any additional employment will be distributed unevenly throughout the state, but concentrated in specific locations. As a result, people may migrate to those specific areas from locations within or outside the state. In any case, some redistribution of Washington's population is likely to occur and some regions will be required to provide services to an increased population.

These population increases result in additional demands for government services -- police protection, schools, fire services, and recreation. These impacts were estimated in Chapter IX. In this chapter, population increases are projected on the basis of increases in economic activity. In addition, residential and commercial land use needs resulting from these population increases are estimated.

2. Final Demands on Washington's Economy

This section transforms the anticipated commodity impacts described in Chapters I-IV into economic impacts for use with developed input-output models, in order to estimate their total effect on the Washington economy. The derivation of the economic impacts and sources and assumptions used to generate these impacts is reviewed in Appendix C.

The logistical support final demands are far larger than those related to any oil transshipment scenario and they are presented first. Because the level of logistical activity will probably not be significantly altered by the choice of oil transshipment scenario, they may be considered to be part of every transshipment scenario.

Most of the oil-related impacts will fall into several economic categories. All of the impacts will entail increased employment, wages and salaries, and resulting multiplier activities in the retail and service sectors. However, the five scenarios to be presented have very different levels of direct economic impact and hence will have very different levels of total economic impact.

Logistic Support Activities

The logistic support activities which Washington will provide to oil-related development in Alaska will have a far greater impact than the petroleum flow activities. Regardless of which petroleum flow scenario is realized, the following logistic support activities will occur:

- Transshipment of materials by water;
- Transshipment of materials by air;
- Construction or manufacture of equipment in Washington to be used for oil-related development in Alaska; and
- The employment of Washington residents in oil-related occupations.

Our analysis covers two categories of water transportation flows to Alaska: those required for the development of crude oil resources and those required for the construction of the proposed El Paso natural gas pipeline. The total tonnages of materials that will be shipped, and their descriptions, are provided in Tables IV-7 and IV-8.

Washington offers the potential shipper several methods of transporting goods to Alaska by water. There are four major Washington-Alaska carriers: Crowley Maritime, which operates both the Sealift and the Hydro-Train; Foss-Lawson; Sealand; and Totem Ocean Trailer Express (TOTE). Crowley Maritime and Sealand both carried substantial amounts of cargo to Alaska during the construction of the Trans-Alaska oil pipeline. TOTE began its operations in June 1976 and utilizes a large

ship capable of handling approximately 390 truck trailers. The Hydro-Train can carry 100 railroad boxcars per trip. The Sealift operation which occurs once a year and varies in size from year to year, utilizes large oceangoing barges to carry building modules to the Alaskan North Slope. Because no other operator has the ships required for this cargo, the Sealift has a monopoly on such trade. The Sealift also carries general cargo, but primarily to fill the barges.

Currently TOTE provides weekend service with its one ship leaving Tacoma every Friday night and delivering its cargo to Anchorage on Monday. However, the size of the cargos is limited to those which can fit on a semi-trailer. In addition, because of its higher speed and shorter loading and unloading time, freight rates are higher on TOTE than on the Hydro-Train. However, Hydro-Train requires about eight days for a one-way trip, making it a less desirable carrier for perishable goods. Foss-Lawson also provides barge service to Alaska but, unlike Crowley Maritime, does not provide service to the Prudhoe Bay area. Sealand strikes a medium position between TOTE and the barge operators; it can carry cargo faster than Crowley Maritime and Foss-Lawson but at a higher freight rate, and it is slower and less expensive than TOTE. The majority of the equipment for the Alyeska pipeline was carried by Crowley Maritime; however, because of the proprietary nature of the operations, specifics of the amounts carried by each operator are unavailable.

Because of the different capabilities of each carrier and because of their differing freight rates, total cargos to be shipped to Alaska were divided among the carriers based on our estimate of the peculiar requirements and characteristics of different cargos including size, weight, ability to stockpile in Alaska, and freight rates. Once cargos were allocated to specific vessels, the freight rate for that cargo on that vessel was applied to estimate shipping charges. These shipping costs are the estimate of final demand to the water transportation sector.[1]

Airfreight was used extensively during development of the Alyeska Pipeline primarily because of the speed with which it can deliver vitally necessary cargos. Airfreight was used primarily for perishable goods, those of comparatively light weight, and those critical goods whose absence could cause postponement of other operations. Airfreight was also generally used for goods with a high value-to-weight ratio.

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1. Because of possible proprietary conflicts, these working papers cannot be presented. Tables C-16 and C-18 show total shipping charges for all carriers.

Because the forecast of the exact equipment requirements for crude oil development and for the El Paso natural gas pipeline is not available, it has been necessary to make a general allocation of percentages of those cargo classifications within which airfreighted goods can be expected to concentrate. Specifically we assumed that airfreighted cargo would be concentrated in welding materials, oil completion equipment, and other miscellaneous equipment. A brief list of the types of commodities sent by airfreight during the Alyeska Pipeline construction would include ladders, welding rods, engines, gears, equipment transmissions, specialized valves, connectors, rubber hosing, and a wide variety of other equipment upon whose arrival much of the work depended. General airfreight was used heavily during the Alyeska operations because much of the necessary equipment and parts were warehoused outside of Alaska. It was considered cheaper to fly this equipment to Alaska on short notice than to maintain local stockpiles which might eventually have to be shipped back to the mainland if they proved unnecessary. The estimated charges for airfreighted cargos are shown in Tables C-17 and C-19. The average charge for equipment airfreighted to Alaska from Washington for the Alyeska pipeline was $500. Because similar materials will be shipped by air in the future, this standardized charge has been applied to all items.

Chapter IV provides our best estimates of the number of Washington residents who will find oil-related jobs in Alaska until 1985. However, there is a possibility that a far smaller percentage of the work force will be from Alaska than is assumed in Chapter IV. Therefore, the economic analysis considers two different sizes for the Washington labor force working in Alaska. Table C-20 shows the payroll that would flow to Washington from those Washington residents who work in Alaska. Table C-20 is derived from both the number of people expected to be of Washington origin, as shown in Tables IV-10 through IV-18, and from information providing the probable payroll levels for this personnel. This payroll is applied directly as final demand to the personal consumption expenditures vector of the input/output model. It has been assumed that most workers will be residents of the Central Puget Sound region.

Kaiser Engineering has taken out options on waterfront land at both the Port of Everett and at Grays Harbor to construct offshore drilling platforms. For the purpose of our analysis we have assumed that the Everett site will be selected, although the impacts will be similar regardless of the site finally chosen. It is Kaiser's intention to construct offshore drilling platforms at the site at the rate of four per year. Kaiser plans to develop orders for these platforms during 1977 and to ask the port to develop the land in that year. Port officials indicate that the first portion of the land can be made available to Kaiser Engineering in 1978, allowing the production of one platform by the end of that year. Production during 1979 can increase to three platforms and will achieve a stable level of four platforms annually starting in 1980. Kaiser Engineering estimates that the selling price of each platform will be between $50 million and $100 million, depending on its size, which is determined by the specific location in which it will be used. Using an average price of $75 million, the annual output of the facility after 1980 will be $300 million. In addition, the Port

of Everett anticipates that approximately $15 million will be required to prepare the site, including costs for dredging and diking and extending the necessary rail lines. The port will supply approximately $10 million of the cost while Kaiser will commit an additional $5 million to the development of the facility. These final demands are summarized in Table XI-3.

One of the sectors that will receive significant impacts from the logistics activities will be the services and finance, insurance, and real estate sectors. However, we do not believe that these impacts will be caused by direct final demands for the services of these sectors but will rather arise through indirect and induced demands. The way in which direct final demands would be placed on these sectors in Washington would be through oil-related development companies based in Alaska. Demands from companies in Washington working on oil-related activities would be indirect and the direct final demands would be for the industry itself. Similarly, the use of these services by Washington residents working in Alaska is an indirect demand stemming from the salaries they are paid. While Washington does have a much larger services and FIRE sector than Alaska, most of the oil-related development firms are national and international in character. We believe that these agencies will locate most of their demands for services and FIRE in their base office or at the place of operations. Therefore, if one of these firms cannot find the service it requires in Alaska, it is more likely to seek the service through its home office rather than set up separate accounts with a firm in Washington. Therefore, we have not included any direct final demands for services of FIRE.

All of the logistic support final demands are summarized in Table XI-3. The total impact of logistic support activities will be between $2,171 million and $2,561 million. Almost 75% of this will be generated by the construction of oil production platforms at the Port of Everett. However, this is an activity in which large leakages are anticipated. Discussions with Kaiser Engineering have indicated that only a very small portion of the total materials requirements for the platforms will be purchased in Washington, the majority coming from both the Midwest and California. As a result, the impact of this activity on Alaska will be far less than would be implied by the total volume of sales of the facility alone.

Because it is expected that timing will be a more important consideration with the construction of the El Paso natural gas line than with the continuing program of crude oil development, we have assumed that a greater percentage of total material needs will be shipped to Alaska via airfreight. As a result airfreight charges are estimated at $32.5 million for the pipeline over a three-year construction period but at only $9.2 million over a six-year period for crude oil development.

TABLE XI-3

DIRECT ECONOMIC IMPACT OF LOGISTIC SUPPORT ACTIVITIES
(high estimate; thousands of 1976 dollars)

Year	Scenario Component: Waterborne Commerce for Crude Oil Development[a]	Airborne Commerce for Crude Oil Development[b]	Waterborne Commerce for El Paso Gas Line[c]	Airborne Commerce for El Paso Natural Gas Line[d]	Washington Residents Working in Alaska[e] High	Washington Residents Working in Alaska[e] Low	Manufacturing of Oil Platforms in Washington[f]	Total High	Total Low
1977	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 6,000	$ 6,000	$ 6,000
1978	0	0	0	0	0	0	9,000	9,000	9,000
1979	0	0	40,248	12,773	0	0	75,000	128,021	128,021
1980	15,196	893	40,583	13,865	28,414	4,011	225,000	323,951	299,548
1981	21,430	960	3,259	5,840	55,723	7,867	300,000	387,212	339,356
1982	27,246	1,523	0	0	83,031	11,722	300,000	411,800	340,491
1983	33,064	1,837	0	0	89,429	12,625	300,000	424,330	347,526
1984	33,246	1,953	0	0	95,828	13,529	300,000	431,027	348,728
1985	35,693	2,067	0	0	102,228	14,432	300,000	439,988	352,192
Total	$165,875	$9,233	$84,090	$32,478	$454,653	$64,186	$1,815,000	$2,561,329	$2,170,862

a. From Table C-18. New impact.
b. From Table C-19. New impact.
c. From Table C-16. New impact.
d. From Table C-17. New impact.
e. From Table C-20. New impact.
f. From Table C-21. New impact.

Scenario I-A: Status Quo

In this scenario the only Alaskan oil flowing into the state of Washington will be destined for the four existing Puget Sound refineries -- Atlantic Richfield, Mobil, Shell, and Texaco. With the exception of the Atlantic Richfield installation, each refinery is limited as to the percentage of its total capacity which can be filled by Alaskan crude. This limitation is caused by the specific gravity count and sulfur content of Alaskan crude as compared with the crude for which the refineries were designed. Using the information in Table IV-7, it has been assumed that total flow into the four Washington refineries will equal 133.4 million barrels per day (million B/D). This flow can be expected to begin in 1978 with the Trans Alaska Pipeline operation.

Some of the final demands will be new activities for Washington, while others will simply replace activities which had been previously operating in the state. An example of a new impact is the construction of new berths and oil storage tanks, while an example of a replacement impact is the refinery operations that will be conducted using Alaskan crude in the future compared to Canadian crude in the past. The impacts generated by the new final demands will be called the "net impacts" of oil-related development on Alaska. Addition of the replacement impacts will estimate the "gross impacts" of oil-related development on Alaska. It is useful to estimate gross impacts because it provides an indication at any one time of the total amount of an activity on the state. Net impact estimates are useful in that they show for what new activities planning must take place and facilities provided. In this chapter we will clearly delineate between those parts of the gross impacts that derive from both new and replacement final demands.

The impacts of this scenario on Washington fall into three major categories: tanker movements, petroleum refinery operations, and expansion of petroleum berth facilities. The costs of tanker operations required to supply 133.4 million B/D of oil to Puget Sound refineries are presented in Table C-13, refinery operating costs in Table C-12, and petroleum berth expansion facility costs in Table C-11. It should be noted that the petroleum berth expansion costs are the total costs required for all necessary expansion anticipated by each of the major refineries before 1985. These costs are summarized in Table IV-6. Since only the Atlantic Richfield refinery will be receiving 100% of its crude oil requirements from Alaska, the percentage of these berth expansion costs that could be allocated to Alaskan operations is less than that indicated in the table. However, even if foreign sources of oil were not being used in the three other refineries, expansions of this size would be required simply to handle the Jones Act fleet tankers arriving from Alaska. Therefore, we have included the total berth expansion costs in our estimate.

In contrast to the above, only those tanker transportation and oil refinery costs related to Alaskan crude are included in the scenario definition. Transportation costs of crude originating outside Alaska and refinery costs of that crude are excluded.

The direct level impact of this scenario is shown in Table XI-4. Impacts begin in 1978 with the expansion and construction of the dock facilities, the transportation of Alaskan crude oil to Washington, and the refining of Alaskan crude. During this first year, the total expected impact on Washington will approximate $121 million. After the terminal facilities are completed in 1979, the impact of this scenario in constant 1976 dollars is expected to decline to $92 million in gross final demands and $22 million in net final demands. Because none of the refineries is expected to make the changes which would allow them to handle a higher percentage of Alaskan crude, this figure is assumed to remain constant thorugh 1985. The total gross impact of this scenario from 1978 through 1985 is approximately $600 million.

Scenario II-A: Northern Tier: Port Angeles Terminal Without Puget Sound Spur

The only difference between Scenarios I-A and II-A is the addition of the Northern Tier Pipeline beginning in Port Angeles and running to Clearbrook, Minnesota. In this scenario it is assumed that no connection is made between the Northern Tier Pipeline and the four existing Puget Sound refineries. Therefore, the Puget Sound refineries will continue to receive oil from their own berth facilities. They will use the same amount of oil as calculated in Scenario I and the subsequent costs of the operation will be the same as those in Scenario I.

Because this analysis addresses only the impacts of oil-related development in Alaska on the State of Washington, we have not included the total construction and operation costs of the Northern Tier Pipeline. Instead, only those costs which will occur in Washington have been included. (The methodology for this computation is explained in the text of Appendix C and in Table C-15.)

Two throughput levels for the Northern Tier Pipeline have been proposed -- 600 million B/D and 800 million B/D. Table C-15 shows the marginal increase required in both capital and operating expenses for an additional 200 million B/D.

Tanker costs associated with transporting oil to the Northern Tier Pipeline are reviewed in Table C-14. We have assumed for this scenario a Port Angeles terminal and a 600 million B/D throughput. Tanker transportation costs are based on work conducted by Arthur D. Little for the Port of Long Beach in a Draft Environmental Impact Report on the Standard Oil of Ohio proposal to ship Alaskan crude oil to Long Beach and then send it to Midland, Texas, via a series of reversed natural gas pipelines.

TABLE XI-4

DIRECT ECONOMIC IMPACT OF SCENARIO I
(thousands of 1976 dollars)

	Scenario Component			
	Marine Terminal Expansion Costs[a]	Refining Costs for Puget Sound Refineries[b]	Crude Oil Delivery to Puget Sound Refineries[c]	Total
1977	$ 0	$ 0	$ 0	$ 0
1978	29,484	69.755	22,073	121,312
1979	17,064	69,755	22,073	108,892
1980	0	69,755	22,073	91,828
1981	0	69,755	22,073	91,828
1982	0	69,755	22,073	91,828
1983	0	69,755	22,073	91,828
1984	0	69,755	22,073	91,828
1985	0	69,755	22,073	91,828
Total	$46,548	$558,040	$176,584	$781,172

a. From Table C-11. New impact.
b. From Table C-12. Replacement impact.
c. From Table C-13; Cherry Point destination. New impact.

As part of that study, we assessed the costs of alternative oil shipment proposals including the Northern Tier Pipeline. Tanker costs were estimated for two scenarios. The scenario resulting in the highest transportation costs assumed that all Jones Act fleet ships were allocated so that the largest capacity vessels were sent on the longest runs and the smaller capacity ships were used for shorter runs such as Valdez to Puget Sound. The rationale is that large ships achieve their greatest savings on the longest runs.

In the second scenario it was assumed that the largest ship which could safely dock at each landing site was used. In the case of the Northern Tier Pipeline, it was assumed that the maximum tanker size was 265,000 deadweight tons (DWT). Transportation costs per barrel were then calculated for each scenario; the results have been used in the present study to estimate tanker transportation costs. As can be seen from Table C-14, the difference between the high and low cost estimate is approximately $14 million annually.

Table XI-5 summarizes the direct impacts on Washington of Scenario II-A. All of the impacts that were not part of Scenario I-A are new impacts adding to the net impact of this scenario. The only replacement impact in the scenario is the refining of Alaskan crude oil in the four Puget Sound refineries. As noted above, the difference in size of the impacts in Scenarios I-A and II-A is due solely to the introduction of the Northern Tier Pipeline. Annual operating costs of the pipeline, including shipment of Alaskan crude to Port Angeles and operating expenses of the pipeline, range between $94 million and $108 million depending on the size of the tanker uses. Construction costs for the pipeline within Washington State alone are estimated at slightly more than $288 million in 1976 dollars. Both figures refer to a pipeline with a throughput of 600 million B/D. Total operating costs for an 800 million B/D throughput, including tanker transportation, are between $126 million and $145 million annually; construction costs for the pipeline increase the total by $18 million.

Scenario II-B: Northern Tier: Port Angeles Terminal with Puget Sound Spur

This scenario differs from Scenario II-A in that oil bound for the four Puget Sound refineries would be off-loaded at the Port Angeles terminal and piped to the refineries via the Northern Tier Pipeline and an additional pipeline spur from lower Puget Sound. The following differences in economic impact would result:

- No expansion of berth facilities at the refineries necessary.
- Increased size for the initial part of the Northern Tier Pipeline, resulting in increased construction and operating costs.

TABLE XI-5

DIRECT ECONOMIC IMPACT OF SCENARIO II-A
(high estimate; thousands of 1976 dollars)

Year	Scenario Component: All Scenario I Components[a]	Crude Oil Delivery to Northern Tier Pipeline[b]	Northern Tier Pipeline Construction and Operation Cost[c]	Total
1977	$ 0	$ 0	$ 0	$ 0
1978	121,312	0	144,184	265,496
1979	108,892	0	144,184	253,076
1980	91,828	76,427	31,736	199,991
1981	91,828	76,427	31,736	199,991
1982	91,828	76,427	31,736	199,991
1983	91,828	76,427	31,736	199,991
1984	91,828	76,427	31,736	199,991
1985	91,828	76,427	31,736	199,991
Total	$781,172	$458,562	$478,784	$1,718,518

a. From Table XI-4. Replacement impact during each year is $69.755 million.
b. From Table C-14; Port Angeles destination. Assumes 600 MBPD. New impact.
c. From Table C-15. Assumes 600 MBPD. New impact.

- Addition of construction and operating costs of the spur pipeline.

- Reduction of tanker transportation cost to Puget Sound refineries because of Port Angeles, not Cherry Point, destination.

The direct impacts of this scenario are shown in Table XI-6. The cost of crude oil transportation to Puget Sound refineries drops from $22 million in Scenario I to between $14 million and $17 million. The cost of tanker transport of crude to Port Angeles for eventual use in Puget Sound refineries is the same as the cost for eventual shipment through the Northern Tier Pipeline. Refinery costs, which are the only replacement impact in this scenario, are the same as those of Scenario I-A. There is a net difference of $14-$16 million between the construction and operating costs of the pipeline spur and of the alternative improved berth facilities at Cherry Point.

This scenario assumes the Puget Sound refineries would not construct the berth expansions and improvements of Scenario I-A. However, this would require the pipeline spur to be completed by 1978 since the refineries would otherwise be hampered in their ability to receive Alaskan oil.

Scenario III: Northern Tier Pipeline: Cherry Point Terminal

This scenario is similar to Scenario II expect that it is assumed that the Northern Tier Pipeline begins at Cherry Point. Total costs are similar to those of Scenario II-A. (See Table XI-7.) As a result tanker costs would increase because of the additional time tankers would be required to spend at Puget Sound and because different size tankers would be used. These differences, between $22 million and $36 million annually, are shown in Table C-14. There would be a savings in berth construction and operating costs for the pipeline because of the shorter length. For the purposes of this analysis it has been assumed that the costs of a pipeline from a Northern Tier Cherry Point terminal to the Puget Sound refineries would equal the costs of the proposed refinery berth expansions shown in Table C-11. Therefore, total costs of local refinery operations including oil transportation, refining, and berth expansion are assumed to equal those of Scenario I-A. Refining operations, which comprise 32% of total final demand after construction of the Northern Tier Pipeline is completed, are the only replacement impact in this scenario.

Scenario IV: Kitimat Trans Mountain Pipeline

This proposal would utilize a deepwater port at Kitimat, British Columbia, for oil off-loading and ship the oil through a combination of new and existing pipelines to the four Puget Sound refineries and to the Midwest. Because of the paucity of facilities at Kitimat, it is assumed that all tankers would still use Puget Sound as their home port and that

TABLE XI-6

DIRECT ECONOMIC IMPACT OF SCENARIO II-B
(high estimate; thousands of 1976 dollars)

Year	Scenario Component: Refinery Operating Costs[a]	Pipeline Construction and Operation Costs[b]	Tanker Transport Costs[c]	Total
1978	$ 69,755	$174,184	$ 22,073	$ 266,012
1979	69,755	174,184	22,073	266,012
1980	69,755	35,000	71,472	176,227
1981	69,755	35,000	71,472	176,227
1982	69,755	35,000	71,472	176,227
1983	69,755	35,000	71,472	176,227
1984	69,755	35,000	71,472	176,227
1985	69,755	35,000	71,472	176,227
Total	$558,040	$558,368	$472,978	$1,589,386

a. From Table C-12. Replacement impact.
b. From Table C-15. Assumes a capacity of 730 MBPD from Port Angeles to the origin of the pipeline spur, a capacity of 130 MBPD for the pipeline spur, and a capacity of 600 MBPD for the remainder of the Northern Tier Pipeline. New impact.
c. From Table C-14. Assumes 730 MBPD. New impact.

TABLE XI-7

DIRECT ECONOMIC IMPACT OF SCENARIO III
(high estimate; thousands of 1976 dollars)

Year	Scenario Component: All Scenario I Components[a]	Crude Oil Delivery to Northern Tier Pipeline[b]	Northern Tier Pipeline Construction and Operation Costs[c]	Total
1977	$ 0	$ 0	$ 0	$ 0
1978	121,312	0	139,668	260,980
1979	108,892	0	144,248	253,140
1980	91,828	98,550	31,000	221,378
1981	91,828	98,550	31,000	221,378
1982	91,828	98,550	31,000	221,378
1983	91,828	98,550	31,000	221,378
1984	91,828	98,550	31,000	221,378
1985	91,828	98,550	31,000	221,378
Total	$781,172	$591,300	$469,916	$1,842,388

a. From Table XI-4. Replacement impact during each year of $69.755 million.
b. From Table C-14. Assumes 600 MBPD and Cherry Point destination. New impact.
c. From Table C-15. New impact.

the costs of tanker operation would accrue to Washington. Because the Canadian government prefers to see Canadian rather than U.S. labor used whenever possible, and because there are existing rail lines into the Kitimat region, it has been assumed that no construction materials would flow through the ports of Seattle or Tacoma in support of any construction work required by this scenario. Impacts on Washington would be limited to petroleum refinery operations at the Puget Sound refineries and tanker transportation expenses. Refinery operations are a replacement impact while tanker transportation is a new impact.

Refinery operating costs will be the same as they are in all other scenarios. However, oil transportation costs will be between only $62 million and $89 million. It has been assumed that the economic impacts of all pipeline transportation costs under this scenario will accrue to the Province of British Columbia.

The impacts of this scenario on Washington are shown in Table XI-8. This scenario will have the smallest net impact of the five because of both the lower tanker costs and the comparative lack of construction of oil-handling facilities within Washington. Nevertheless, total net impacts are estimated at approximately $570,000 by the end of 1985, assuming 600 million B/D through the Kitimat pipeline to the Midwest and the utilization of the comparatively smaller ships of the Jones Act Fleet.

E. TOTAL IMPACTS ON WASHINGTON OF ALASKAN PETROLEUM DEVELOPMENT AND PRODUCTION

As has been indicated previously, our assessment measures both the gross and net impacts of petroleum flow and logistic support activities on the State of Washington. Net impacts are those generated by the net final demands while gross impacts also include those related to the gross impacts.[1] We have utilized two different input/output models of the state. Both models disaggregate the state into two regions: Region 1 is that area in which the direct final demand impacts will occur, while region 2 is the rest of the state. In the case of logistical impacts, region 1 consists of the counties of King, Pierce, and Snohomish; for petroleum flow impacts, region 1 includes the counties of Clallam, Whatcom, and Skagit.

Tables XI-9-XI-20 describe the gross impacts of each scenario on both regions. The following impact measurements are provided for each scenario:

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1. The only gross impacts are those related to the existing refining activities.

TABLE XI-8

DIRECT ECONOMIC IMPACT OF SCENARIO IV
(high estimate; thousands of 1976 dollars)

Year	Scenario Component: Crude Oil for Local Refineries Delivered to Kitimat[a]	Crude Oil for Midwest Delivered to Kitimat[b]	Refining Cost for Puget Sound Refineries[c]	Total
1977	$ 0	$ 0	$ 0	$ 0
1978	22,073	0	69,755	91,828
1979	14,415	64,360	69,755	148,530
1980	14,415	64,360	69,755	148,530
1981	14,415	64,360	69,755	148,530
1982	14,415	64,360	69,755	148,530
1983	14,415	64,360	69,755	148,530
1984	14,415	64,360	69,755	148,530
1985	14,415	64,360	69,755	148,530
Total	$122,978	$450,520	$558,040	$1,131,538

a. From Table C-14. New impact.
b. From Table C-14. Assumes Kitimat as destination and throughput of 600 MBPD. New impact.
c. From Table C-12. Replacement impact.

TABLE XI-9

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS*
LOGISTIC SUPPORT ACTIVITIES
(high estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978	$ 15,000	$ 18,951	$ 397	$ 757	$ 56	74	7
1979	128,021	178,842	5,441	19,619	800	1,560	103
1980	323,951	473,075	24,861	38,091	2,891	3,576	377
1981	387,212	625,081	45,461	41,791	5,230	4,781	693
1982	411,800	713,955	64,885	48,158	7,434	5,942	995
1983	424,330	771,458	76,906	55,090	9,137	6,916	1,232
1984	431,027	793,885	83,867	57,680	10,056	7,322	1,362
1985	439,988	814,312	89,315	60,074	10,743	7,648	1,458
1986**	-0-	266,852	46,861	30,836	7,261	4,742	992
1987**	-0-	133,718	23,602	15,480	3,659	2,380	500
1988**	-0-	63,189	11,234	7,336	1,743	1,128	238

*All impacts are net impacts; i.e., there are no replacement impacts.
**Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-10

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS*
LOGISTIC SUPPORT ACTIVITIES
(high estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978	173	18	58	6	23	2	$ 44	$ 1	$ 70	$ 1	$ 21	$ 2	$ 135	$ 4
1979	3,674	248	1,225	83	490	33	633	21	701	115	470	26	1,804	62
1980	8,417	914	2,806	305	1,122	122	1,510	80	1,613	53	1,027	98	4,150	231
1981	11,245	1,674	3,748	558	1,499	223	1,970	152	1,869	94	1,308	181	5,147	427
1982	13,972	2,399	4,657	800	1,863	320	2,380	224	1,987	131	1,597	259	5,964	614
1983	16,264	2,965	5,421	988	2,169	395	2,710	281	2,112	159	1,857	321	6,679	761
1984	17,221	3,273	5,740	1,091	2,296	436	2,843	314	2,152	174	1,966	354	6,961	842
1985	17,987	3,503	5,996	1,168	2,398	467	2,953	338	2,196	185	2,058	379	7,207	902
1986**	11,159	2,373	3,720	791	1,488	316	1,537	230	469	126	1,224	255	3,230	611
1987**	5,602	1,196	1,867	399	747	159	772	116	235	63	614	129	1,621	308
1988**	2,655	570	885	190	354	76	366	55	112	30	290	62	768	147

*All impacts are net impacts; i.e., there are no replacement impacts.
**Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-11

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO I - STATUS QUO
(thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$121,312	$129,187.0	$19,821.6	$11,864	$2,286	671	225
1979[b]	108,912	123,168.2	35,379.9	1,053	4,094	731	402
1980[c]	91,828	106,677.1	35,504.4	6,269	4,142	553	404
1981[d]	91,828	107,432.5	36,345.3	6,355	4,266	556	415
1982[e]	91,828	105,604.8	31,081.0	5,747	3,676	488	356
1983[f]	91,828	104,627.8	28,266.9	5,422	3,361	452	325
1984[f]	91,828	104,627.8	28,266.9	5,422	3,361	452	325
1985[f]	91,828	104,627.8	28,266.9	5,422	3,361	452	325
1986[g]	-0-	8,542.2	18,864.5	2,133	2,243	210	217
1987[g]	-0-	9,402.4	9,402.4	1,063	1,118	105	108
1988[g]	-0-	1,986.9	4,387.8	496	522	49	50

a. Net impacts will be approximately 65% of gross impacts in all categories.
b. Net impacts will be approximately 60% of gross impacts in all categories.
c. Net impacts will be approximately 40% of gross impacts in all categories.
d. Net impacts will be approximately 35% of gross impacts in all categories.
e. Net impacts will be approximately 25% of gross impacts in all categories.
f. Net impacts will be approximately 15% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-12

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO I - STATUS QUO
(thousands of 1976 dollars)

Year	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	1,583	530	528	177	211	71	$182	$ 65	$569	$35	$230	$ 63	$ 982	$162
1979[b]	1,724	948	575	316	230	126	234	117	541	63	232	113	1,007	293
1980[c]	1,305	954	435	318	174	127	235	119	464	66	162	114	860	299
1981[d]	1,312	979	437	326	175	131	237	123	468	69	165	119	870	310
1982[e]	1,151	840	384	280	154	112	219	106	460	61	147	102	826	269
1983[f]	1,066	766	355	255	142	102	210	97	456	56	137	94	802	247
1984[f]	1,066	766	355	255	142	102	210	97	456	56	137	94	803	247
1985[f]	1,066	766	355	255	142	102	210	97	456	56	137	94	803	247
1986[g]	495	511	165	170	66	68	62	65	40	38	60	63	163	165
1987[g]	247	255	82	85	33	34	31	32	20	19	30	31	81	82
1988[g]	115	119	38	40	15	16	14	15	9	9	14	15	38	38

a. Net impacts will be approximately 65% of gross impacts in all categories.
b. Net impacts will be approximately 60% of gross impacts in all categories.
c. Net impacts will be approximately 40% of gross impacts in all categories.
d. Net impacts will be approximately 35% of gross impacts in all categories.
e. Net impacts will be approximately 25% of gross impacts in all categories.
f. Net impacts will be approximately 15% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-13

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO II-A - NORTHERN TIER PIPELINE WITHOUT PUGET SOUND SPUR
(high estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$265,496	$286,056	$ 66,973	$59,265	$ 7,860	2,953	779
1979[b]	253,076	292,804	129,982	62,355	15,279	3,510	1,514
1980[c]	199,991	241,228	126,120	16,668	14,850	1,531	1,460
1981[d]	199,991	242,037	119,646	15,462	14,103	1,375	1,375
1982[e]	199,991	237,100	98,844	13,083	11,673	1,101	1,128
1983[f]	199,991	233,402	82,435	11,209	9,748	884	932
1984[f]	199,991	233,402	82,435	11,209	9,748	884	932
1985[f]	199,991	233,402	82,435	11,209	9,748	884	932
1986[g]	-0-	22,298	55,015	4,284	6,505	423	622
1987[g]	-0-	11,114	27,420	2,135	3,242	211	310
1988[g]	-0-	5,186	12,796	996	1,513	98	145

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-14

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO II-A - NORTHERN TIER PIPELINE WITHOUT PUGET SOUND SPUR
(high estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	6,970	1,838	2,323	612	929	245	$332	$226	$ 687	$109	$1,074	$214	$2,096	$ 552
1979[b]	8,282	3,573	2,760	1,191	1,104	476	535	441	717	212	1,216	423	2,469	1,077
1980[c]	3,614	3,446	1,204	1,148	481	459	498	432	1,089	221	441	412	2,030	1,066
1981[d]	3,245	3,245	1,081	1,081	432	432	453	413	1,092	226	405	393	1,951	1,034
1982[e]	2,598	2,662	866	887	346	354	373	345	1,069	201	330	323	1,774	871
1983[f]	2,086	2,199	695	733	278	293	309	291	1,052	181	272	269	1,634	742
1984[f]	2,086	2,199	695	733	278	293	309	291	1,052	181	272	270	1,635	743
1985[f]	2,086	2,199	695	733	278	293	309	291	1,052	181	273	270	1,636	743
1986[g]	998	1,468	332	489	133	195	128	194	101	121	121	180	352	496
1987[g]	497	731	165	243	66	97	64	96	50	60	60	90	175	247
1988[g]	232	341	77	113	30	45	29	45	23	28	28	42	81	115

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-15

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO II-B - NORTHERN TIER PIPELINE WITH PUGET SOUND SPUR
(high estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$251,012	$269,275	$ 61,459	$55,622	$ 7,273	2,762	720
1979[b]	251,012	287,653	123,308	61,572	14,591	3,415	1,445
1980[c]	198,300	237,141	121,336	15,992	14,372	1,456	1,412
1981[d]	198,300	238,075	115,046	14,893	13,641	1,313	1,329
1982[e]	198,300	234,053	96,513	12,843	11,455	1,076	1,107
1983[f]	198,300	230,534	80,297	11,059	9,542	869	912
1984[f]	198,300	230,534	80,297	11,059	9,542	869	912
1985[f]	198,300	230,534	80,297	11,059	9,542	869	912
1986[g]	-0-	21,512	53,588	4,171	6,368	412	609
1987[g]	-0-	10,722	26,709	2,079	3,174	205	303
1988[g]	-0-	5,004	12,464	970	1,481	96	142

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-16

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO II-B - NORTHERN TIER PIPELINE WITH PUGET SOUND SPUR
(high estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	6,518	1,699	2,172	566	869	226	$313	$210	$ 546	$100	$1,007	$199	$1,867	$ 511
1979[b]	8,060	3,410	2,686	1,136	1,074	454	511	422	630	202	1,190	404	2,333	1,030
1980[c]	3,436	3,333	1,145	1,111	458	444	482	419	1,071	214	421	399	1,975	1,033
1981[d]	3,097	3,136	1,032	1,045	413	418	438	400	1,074	219	387	379	1,901	1,001
1982[e]	2,538	2,611	846	870	338	348	366	339	1,056	197	323	317	1,747	854
1983[f]	2,050	2,152	683	717	273	287	303	285	1,039	177	268	263	1,611	726
1984[f]	2,050	2,152	683	717	273	287	303	285	1,039	177	268	264	1,612	727
1985[f]	2,050	2,152	683	717	273	287	303	285	1,039	177	269	264	1,613	727
1986[g]	972	1,436	324	478	129	191	124	190	98	118	118	177	341	485
1987[g]	484	716	161	238	64	95	62	94	48	59	58	87	170	242
1988[g]	226	334	75	111	30	44	29	44	22	27	27	40	79	113

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-17

GROSS SALES, EMPLOYMENT, AND INCOME IMAPCTS
SCENARIO III - NORTHERN TIER PIPELINE WITH CHERRY POINT TERMINAL
(high estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$231,496	$253,024	$ 56,575	$50,712	$ 6,695	2,526	663
1979[b]	236,076	270,081	113,508	56,204	13,433	3,128	1,330
1980[c]	221,378	260,473	118,890	16,009	14,037	1,427	1,377
1981[d]	221,378	264,408	120,344	15,500	14,175	1,345	1,378
1982[e]	221,378	262,302	107,122	13,880	12,593	1,153	1,215
1983[f]	221,378	260,459	95,553	12,463	11,208	986	1,072
1984[f]	221,378	260,459	95,553	12,463	11,208	986	1,072
1985[f]	221,378	260,459	95,553	12,463	11,208	986	1,072
1986[g]	-0-	26,081	63,769	4,857	7,480	480	715
1987[g]	-0-	12,999	31,784	2,421	3,728	239	356
1988[g]	-0-	6,066	14,832	1,130	1,740	112	166

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 75% of gross impacts in all categories.
f. Net impacts will be approximately 75% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-18

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO III - NORTHERN TIER PIPELINE WITH CHERRY POINT TERMINAL
(high estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	5,960	1,564	1,986	521	794	208	$297	$193	$ 534	$ 93	$ 919	$183	$1,752	$ 471
1979[b]	7,380	3,138	2,460	1,046	984	418	480	388	612	187	1,088	372	2,182	948
1980[c]	3,366	3,249	1,122	1,083	448	433	468	409	1,179	213	416	389	2,064	1,013
1981[d]	3,173	3,252	1,057	1,084	423	433	444	417	1,196	233	398	394	2,041	1,046
1982[e]	2,721	2,866	907	955	362	382	386	373	1,186	221	347	349	1,922	944
1983[f]	2,326	2,529	775	843	310	337	336	335	1,177	210	303	309	1,818	856
1984[f]	2,326	2,529	775	843	310	337	336	335	1,177	210	304	310	1,818	856
1985[f]	2,326	2,529	775	843	310	337	336	335	1,177	210	304	310	1,819	857
1986[g]	1,132	1,688	377	562	151	225	146	223	118	140	137	207	403	572
1987[g]	564	841	188	280	75	112	73	111	59	70	67	103	200	285
1988[g]	263	392	87	130	35	52	34	52	27	32	31	48	93	133

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 75% of gross impacts in all categories.
f. Net impacts will be approximately 70% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-19

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO IV - KITIMAT-TRANS MOUNTAIN PIPELINE
(high estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$ 91,828	$ 96,086	$ 9,402	$3,289	$1,118	242	108
1979[b]	148,510	161,924	30,210	6,175	3,512	466	338
1980[c]	148,510	169,078	46,643	7,484	5,386	595	518
1981[d]	148,510	173,653	57,081	8,373	6,585	683	633
1982[e]	148,510	175,917	62,376	8,717	7,178	717	689
1983[e]	148,510	175,917	62,376	8,717	7,178	717	689
1984[e]	148,510	175,917	62,376	8,717	7,178	717	689
1985[e]	148,510	175,917	62,376	8,717	7,178	717	689
1986[f]	-0-	18,278	41,628	3,612	4,790	356	460
1987[f]	-0-	9,110	20,748	1,800	2,387	178	229
1988[f]	-0-	4,251	9,682	840	1,114	83	107

a. Net impacts will be approximately 35% of gross impacts in all categories.
b. Net impacts will be approximately 40% of gross impacts in all categories.
c. Net impacts will be approximately 50% of gross impacts in all categories.
d. Net impacts will be approximately 50% of gross impacts in all categories.
e. Net impacts will be approximately 55% of gross impacts in all categories.
f. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE XI-20

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO IV - KITIMAT-TRANS MOUNTAIN PIPELINE
(high estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	571	254	190	84	76	33	$147	$ 32	$415	$ 18	$ 74	$ 29	$ 637	$ 81
1979[b]	1,099	797	366	265	146	106	201	102	721	62	142	95	1,067	261
1980[c]	1,404	1,221	468	407	187	162	241	158	754	98	180	146	1,176	404
1981[d]	1,611	1,493	537	497	214	199	268	194	775	120	207	181	1,251	496
1982[e]	1,691	1,626	563	542	225	216	279	211	785	132	217	197	1,282	542
1983[e]	1,691	1,626	563	542	225	216	279	211	785	132	217	198	1,282	543
1984[e]	1,691	1,626	563	542	225	216	279	211	785	132	218	198	1,283	543
1985[e]	1,691	1,626	563	542	225	216	279	211	785	132	218	199	1,283	544
1986[f]	840	1,085	280	361	112	144	108	141	83	88	102	133	294	363
1987[f]	419	541	139	180	55	72	54	70	41	43	50	65	146	181
1988[f]	195	252	65	84	26	33	25	32	19	20	23	30	68	84

a. Net impacts will be approximately 15% of gross impacts in all categories.
b. Net impacts will be approximately 40% of gross impacts in all categories.
c. Net impacts will be approximately 50% of gross impacts in all categories.
d. Net impacts will be approximately 50% of gross impacts in all categories.
e. Net impacts will be approximately 55% of gross impacts in all categories.
f. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

- Final demand sales
- Total sales
- Wage and salary income
- Person years of employment
- Population supported
- Household supported
- Residential land consumption of supported population
- Property and per capita tax revenues
- Total tax revenues

Other economic and infrastructure impacts are discussed in Chapter VII.

Two result tables have been prepared for each scenario. The first table in each pair provides information concerning the first four impacts above, while the second table shows the impacts of the remaining categories. In Tables XI-9 and XI-10, which describe the impacts of the logistical support activities, all of the impacts are net impacts, since there were no replacement final demands. However, in the case of the petroleum flow scenarios, the impact of the existing refining activities is a replacement impact. The level of this activity is constant in all the petroleum flow scenarios. In footnotes to each table we indicate the impacts that are related to the replacement impacts.

Each table shows the level of total impacts for each year in the forecast period -- 1978-85. Because multiplier impacts are expected to lag final demands by up to three years, the tables show impacts through 1988. The impacts from 1986-88 are only multiplier impacts and are therefore far smaller than the impacts shown for previous years. However, while no forecasts have been made of final demand impacts occurring from 1986-88, there will be some such impacts; therefore the tables underestimate impacts for those three years.

The timing of final demand impacts is shown clearly in Tables XI-3-XI-8. While these forecasts represent our best estimates of when these impacts will occur, environmental constraints, legal decisions, and capital formation problems might delay them. However, as long as they eventually occur, their long-term impact on the economy will not vary significantly. Because the exact magnitude of the final demands is unknown, we have provided a range for those where forecasting is likely to be most inaccurate. Tables XI-3-XI-8 have shown the high estimates of impact while Tables D-1-D-5 in Appendix D have shown the low estimates. Similarly, the impacts projected using these low estimates of final demand are shown by scenario in Appendix D, Tables D-6-D-15.

1. Logistic Support Activities

In spite of the fact that most people think of the impact of Alaskan development on Washington as consisting of the impacts of the oil flowing from Alaska through Washington, our analysis of the impacts of the logistic support Washington will provide Alaska demonstrates conclusively that logistic support activities will far outweigh the impact of any petroleum flow scenario.

The total impact on sales of logistic support activities will be over $810 million during 1985 alone. During this year almost 9000 jobs will be dependent upon these activities and more than $70 million in wage and salary income will be generated. Statewide tax receipts during 1985 for those tax sources we have estimated will total $2.4 million. (See Tables XI-9 and XI-10.[1])

By way of comparison, Scenario III, which has the greatest long-term impact of any of the petroleum flow scenarios, has peak year sales of $288 million and 1985 sales of only $231 million. Only during the years 1978 and 1979 of the forecast period are sales for logistic support less than those amounts.

The high volume of sales is caused in part by the $300 million in projected sales by Kaiser Engineering of drilling platforms at the Port of Everett. However, the impact of these sales on the economy is minimal. Most of the steel will be shipped to Everett from California and the operation will need to make few other purchases from local suppliers. Employment at the site has been estimated at between 250 and 600 but will probably be about 300 persons as forecasted by the model. Since the linkages between the project and the rest of the regional and state economy will be so small, the indirect impact is limited. Because of the small amount of employment at the site compared to the total volume of sales, even the induced impacts emanating from the project will not be very large.

While the impacts of the logistic activities are larger than those of the petroleum flow activities, their concentration in the Central Puget Sound region means that they will not have a larger percentage impact on their surrounding region than the petroleum flow activities had on Clallam, Whatcom, and Skagit counties. The estimated 1976 population of the three Central Puget Sound counties was over 1.8 million. The maximum supported population of 18,000 represents less than 1% of this total population. Since it will be dispersed from Tacoma to Everett, its impact on any single area will be minimal. In addition, the estimate of population supported in Table XI-10 would be the maximum amount of in-migration that would occur. Many of the jobs supported by logistic activities will be held by present residents of the Central Puget Sound area and will not cause any in-migration.

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1. All logistical impacts are net impacts.

The residential land requirements are significantly greater than those of the petroleum flow scenarios but are still insignificant compared to the vast area in which they will be located. Since only a fraction of the supported population will be in-migrants, only a fraction of the residential land required to house the population will be changed from its present undeveloped state.

The tax revenues from logistic activities will be substantial. During 1985 alone, more than $8.1 million in tax revenue will be generated, or more than $375 for every person supported by these activities. Since this estimate of tax revenues does not include local tax revenues, the total amount generated will be even higher. Because of the high proportion of final demand that is made up of wages of Washington residents working in Alaska that are sent back to Alaska, a very high proportion of the total revenue will consist of sales taxes -- 40% of all revenue in 1985. Business and occupation taxes contribute an additional 30%, with the remaining 30% generated by a combination of the state property tax levy, alcoholic beverage, motor vehicle fuel, and cigarette taxes.

Tables XI-9 and XI-10 present our best estimates of net logistic impacts. Corresponding to a lower level of final demands, particularly caused by fewer Washington residents holding jobs in Alaska, a lower level of impacts is shown in Tables D-6 and D-7. The difference in statewide sales grows to a maximum of $214 million in 1985, or 24% of total statewide sales in the best estimate. Differences in the other impact measures are similar.

With the exception of some of the wage and salary income earned in Alaska, it has been assumed that all the logistic final demands accrue to the three Central Puget Sound counties. For the wage and salary income it has been assumed that 80% of the amount accrued to the Central Puget Sound counties and 20% to the rest of the state, probably other parts of Puget Sound. The multipliers from this activity in the rest of the state appear to be approximately equal. It is impossible to estimate the multipliers in each region for this activity, but based on population they are probably similar. However, in the case of persons living outside the Central Puget Sound region, the leakage rate of the multiplier out of their local community is higher than for those people who reside in the Central Puget Sound area.

2. Scenario I - Status Quo

Scenario I will have the smallest economic impacts of all the petroleum flow scenarios. In addition, the only net impacts of Scenario I are the transshipment of Alaskan crude oil to the Puget Sound refineries and the construction of the necessary dockage and storage facilities. In this scenario, there is no transshipment of oil through Washington for other parts of the nation, so tanker traffic is the minimum required to serve Washington refineries. Capital construction is limited to the necessary berth and dock expansion at the existing refineries. Gross

sales impacts in region 1 -- Clallam, Whatcom, and Skagit counties, but particularly the latter two -- will reach their peak during the first year of this program. During that year, berth and dock expansion expenditures will be at their maximum level of $29 million.

However, employment will not reach its peak until the second year. The construction, oil shipping, and refining activities have relatively low employment-to-sales ratios, whereas the multiplier activity, including retail sales and business services, has a much higher employment-to-sales ratio. Therefore, if the impact of this stimulus filters through the economy and secondary jobs are created, the number of jobs relative to the amount of sales can be expected to increase. In fact, in region 2, where the impacts are totally those of the multiplier, employment does not peak until 1981. Gross wage and salary income in region 1 begins at its highest value of about $11.9 million in 1978 and dips to $5.4 million in 1983. In comparison, gross income in region 2 rises from about $2.3 million in 1978 to a peak of $4.3 million in 1981 and drops to $3.4 million in 1983. (See Tables XI-11 and XI-12.)

Much of the gross impact of this scenario is related to the impact of the existing oil refineries. As a result net impacts are less than half of total gross impacts. We estimate that net employment in region 1 peaks at 680 during the second year of the scenario and declines to only 100 by 1983. This represents only 60% of total employment during the peak year and 13% during 1983. Therefore, the net impact of this scenario would be almost negligible on the area.

The population supported by this scenario is small compared with the population of the region.[1] In region 1, the supported population reaches its peak in 1979 at 1724, or slightly more than 1% of the 1976 population of Whatcom and Skagit Counties. In region 2, the peak is reached in 1981 with a supported population of 979. Assuming a population-per-household ratio of 2.5 for both regions, the number of households supported varies between 355 and 575 in region 1, and between 177 and 326 in region 2.

The maximum amount of tax receipts in one year is $1.3 million generated in 1979. The biggest producer of taxes is the business and occupation tax, which consistently generates approximately half of all tax revenues. The sales tax generates approximately one-third of all revenues

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1. Population supported means the number of people whose income is dependent upon oil-related activities. It does not mean the number of new in-migrants to the region, since many of the people who will be supported by the oil-related development are already residents of the region. In addition, because these impacts will be spread among many businesses throughout the region, only a few people will be totally dependent upon oil-related activities. Population supported equals the people fully supported by oil-related activities.

while other revenues are created by both the statewide property tax and taxes on alcohol, cigarettes, and gasoline. Tax receipts in comparison to the tax receipts of the entire region as shown in Chapter X are quite small, and it appears unlikely that the tax generation impacts of this scenario would significantly affect the fiscal picture of local and state government.

Several interesting facts about how Washington's economy operates can be seen in an analysis of Tables XI-11 and XI-12. First, even though final demands accrue to region 1, only 23% of the indirect and induced multiplier accrues to region 1 while the other 77% accrues to region 2. That multiplier impacts are larger in region 2 than in region 1 can be seen by comparing the total impacts for both regions for 1986-88.

The total multiplier effect is relatively small for petroleum-related activities. This is because they employ relatively little labor and make many of their purchases from out-of-state suppliers.

There is relatively little employment in region 1 compared to the volume of sales. For instance, during 1980 approximately $192,000 of sales is required per employee, while in region 2 $88,000 is needed per employee. In terms of employment, region 2 benefits almost as much as region 1. However, the average wage level for the jobs created in region 2 is lower -- $10,300 -- than for those supported in region 1 -- $11,400. This disparity is caused by the comparatively high wage rates in petroleum-related activities.

Because the sales impact in most businesses will be very small, we do not forecast any increase in commercial and industrial land as a result of this scenario. The gross amount of residential land required by the supported population will peak at 230 acres in region 1 and 131 acres in region 2. Net demand for land will be only 215 acres in both regions. Given the vast size of these regions, the land requirements are minimal, particularly when they will be spread in residential zones throughout the region.

In summary, the impacts of Scenario I on the State of Washington will be minimal. Because the existing refineries are already operating, the only new impacts of this scenario will be an increase in tanker traffic to meet the refineries' crude oil needs previously met by oil transported from Canada, and the construction of new berth and dock facilities to accommodate the increase in tanker traffic. We are not incorporating any forecasts of refinery modification costs since it is unlikely that the refineries will undertake such activities before 1985.

3. Scenario II-A - Northern Tier Pipeline without Puget Sound Spur

This scenario has a much greater impact on Washington than does Scenario I. The additional impact is caused by the construction and operation of the Northern Tier Pipeline. Construction is projected for 1978 and 1979. Beginning in 1980 increased tanker traffic will enter the Strait of Juan de Fuca to bring Alaskan crude to the Northern Tier terminal at Port Angeles.

Total gross sales in region 1 will be $286 million during 1978, compared to only $129 million for the same year in Scenario I. Gross sales in Scenario II-A are consistently at least twice as great in Scenario I throughout the forecast period. Gross sales in region 2 reach a peak of almost $130 million compared to a peak of $36 million in that region in Scenario I.

The difference in impact is reflected in all the impact measures. Gross employment in the two regions reaches more than 5000 full-time equivelent jobs, while net employment peaks at 4350 jobs. At its highest level, the net population supported by the scenario exceeds 11,800 in 1979.

Despite the size of the impacts, the amount of additional land required is still relatively quite small. Only 994 acres of net residential land would be needed in region 1 during the year of peak impact -- 1979. Less than 500 acres would be required during any given year in region 2. In addition, since many of the people who would be supported by this activity already live in the impact zones, the amount of undeveloped land required would be far less than even these numbers would indicate. Due to the diversity of the location of the impacts, it is unlikely that there would be any permanent need for any additional industrial or commercial land development.

Gross tax revenues in Scenario II-A will equal approximately $15.9 million in region 1 and an additional $7.6 million in region 2. The peak year for tax collections will be 1979 in both regions with approximately $2.5 million collected in region 1 and $1.1 million collected in region 2. The biggest component of tax revenues is the business and occupation tax, amounting to almost $1.1 million in region 1 in 1981 alone. However, in comparison with the total tax revenues of the state and of the counties in which the impacts will occur, the magnitude of the impacts is not so significant as to cause major changes in the financial picture of either the local or state government.

The information provided in Tables XI-13 and XI-14 is for the high estimates of final demand to the state. In Appendix D, Tables D-8 and D-9, the impacts of alternative final demand levels are shown. However, the total difference in sales between the two sets of figures is minimal. For instance, in 1981 total gross sales in region 1 under the high assumption concerning final demand are $242 million whereas under the low assumption sales are $225 million. The difference between the two scenarios is only 17%. The other impacts, including employment, wage and salary income, population demand requirements, and tax revenues, also show differences between the high and low estimates of approximately similar proportion.

Because of the size of the Northern Tier Pipeline project, net impacts comprise most of the total impacts of this scenario. For instance, during the peak impact year $3.07 million of the total of $3.6 million in taxes collected from both regions will be net impacts. A similar percentage of the other impacts will be net impacts.

4. Scenario II-B - Northern Tier Pipeline with Puget Spur

The final demand estimates for this alternative are shown in Table XI-3 while the total impacts are depicted in Tables XI-15 and XI-16. The impacts shown in these tables are for the high estimate of final demands; the impacts corresponding to the low estimate of final demand are shown in Appendix B, Tables B-10 and B-9.

The total impacts of this scenario on sales, employment and other measures are very similar to those of Scenario II-A. In fact, total sales in region 1 over the forecast period differ by only 4%. The peak level of impacts in Scenario II-B is reached in 1979, which would be the second year of construction on the Northern Tier Pipeline. As with Scenarios I and II-A, a greater percentage of the multiplier impacts accrues to region 2 than to region 1. This is easily seen in the listing of impacts for 1986-88 when all of the impacts are generated by the multiplier linkages.

Approximately the same population will be supported by Scenario II-B as will be supported by Scenario II-A -- a peak of 8060 in region 1 in Scenario II-B, as compared with a peak of almost 8300 in Scenario II-A. The largest population supported in region 2 will be 3400 and the average population supported will be approximately 2500.

Tax revenues and land requirements will be approximately the same as those in Scenario 2. Because of the small size of the impact of this scenario compared to the size of the regional economy, we have assumed that there will be no need for additional commercial or industrial land to serve the increased population.

Within region 1, pipeline construction activities will be concentrated around Port Angeles in Clallam County. Construction of the pipeline spur will occur in Skagit and Whatcom counties and the counties of Central Puget Sound. Some construction impacts will be spread throughout the pipeline route, but the economic impact of these activities on any county is expected to be minimal. Tanker traffic impacts will accrue solely to Clallam County since the introduction of the Northern Tier Pipeline will make it unnecessary for tankers to travel on Puget Sound to Cherry Point refinery locations. Therefore, the only ongoing activities in Whatcom and Skagit counties will be the refining of Alaskan crude oil at the existing refineries.

The net impacts of Scenario II-B will also be very similar to those of Scenario II-A. In both scenarios the only non-net impact will be existing refinery operations and their impacts will be the same in both scenarios. The peak net population supported will be approximately 7,580, compared to a maximum gross supported population of 8,060.

5. Scenario III - Northern Tier Pipeline Originating at Cherry Point

The major economic difference between this scenario and Scenarios II-A and II-B is not in the total size of the economic impact but in its location. In Scenarios II-A and II-B, much of the construction activity related to the Northern Tier Pipeline would have occurred in Clallam

County. However, under Scenario III the starting point of the Northern Tier Pipeline will be at Cherry Point, meaning that Clallam County will not be impacted at all by petroleum flows from Alaska. Rather, the impact of construction activities will accrue largely to the Cherry Point area. Associated with these construction activities will be the ongoing activities of pipeline operation and also of tanker trips since all tankers carrying oil bound for the Northern Tier Pipeline will now call at Cherry Point instead of Port Angeles. Therefore, while the total impacts of this scenario do not differ significantly from those already presented, there would be a major difference in the location of the impacts.

Tables XI-17 and XI-18 show the gross impacts of Scenario III for the high estimates of final demand. The gross impacts calculated using the low estimates of final demand are found in Appendix D, Tables D-12 and D-13.

Because of the shorter distances required for the pipeline, the costs of pipeline construction and operation are lower in Scenario III than in either Scenario II-A or II-B. However, the extra distance required for tanker travel, and also the probable smaller tanker size used in Puget Sound than would be used in Port Angeles, generate a significant increase in the cost of oil transportation to the Cherry Point off-loading site. Therefore, the total gross and net impacts of Scenario III are smaller than those of Scenario II-A for the initial years 1978 and 1979 but are larger for all succeeding years. For example, the gross sales impact of Scenario III on region 1 in 1984 is $260 million, whereas for Scenario II-A the impact for that same year is $233 million.

Peak gross employment in Scenario III occurs during 1979, the second year of construction of the Northern Tier Pipeline, in which more than 4458 persons are employed throughout the state. This is similar to the employment of 5020 persons estimated for Scenario II. Net employment during this year will be approximately 4122. This and other impact measures are similar for Scenarios II-A, II-B, and III.

6. Scenario IV - Kitimat-Trans Mountain Pipeline

This alternative has the second smallest impact on Washington of all the scenarios. Impacts are limited to petroleum and refining impacts and tanker operations. Tanker operations are allocated to Puget Sound port because it is assumed that insufficient docking and ship storage facilities would exist at Kitimat. Because no construction would be required in Washington for this scenario, no construction impacts are included in the analysis. Similarly, since only a small link of pipeline in Washington would be used as part of this scenario, we have not included the pipeline operation costs for the Kitimat-Trans Mountain Pipeline. It is anticipated that these would accrue to Canada.

The impacts of Scenario IV are shown in Tables XI-19 and XI-20. Total gross sales in region 1 from 1978-88 are $1,190 million; in region 2 they are an additional $438 million. In 1978, gross sales in region 1 are $96 million compared with $286 million in Scenario II-A. However, by 1985 the

gap is much narrower: gross sales in region 1 are $176 million for Scenario IV and $233 million for Scenario II-A. The much smaller size of the impacts during the initial year is explained by the fact that in these years in Scenario II-A, the construction of the Northern Tier Pipeline is occurring and oil transportation by tanker does not begin until 1980; in Scenario IV, there are no construction projects in 1978 and 1979, but tanker traffic begins in 1980.

The employment, population, land use, and tax revenue implications of this scenario are much lower than some of the other scenarios. For instance, in 1985 employment in region 1 is 717 persons and 689 persons in region 2. The population supported by this employment base is 1691 in region 1 and 1626 in region 2. Residential land requirements are 225 acres in region 1 and an additional 216 in region 2. Because of the small size of the economic impact, it is not anticipated that any additional commercial and industrial land would be required in either region. Therefore, no additional land requirements have been forecast.

Since the only impacts of Scenario IV are tanker movements and crude refining, a much smaller percentage of the total impact of this scenario is net impact. During 1978 net sales in region 1 are only 15% of gross sales. Net employment and tax impacts are a similar percentage of total gross impacts.

Within region 1, activities will concentrate in Skagit and Whatcom counties. The tankers might be supplied from the ports of Seattle or Tacoma, and it is therefore possible that a greater percentage of the total impacts of this scenario would accrue to region 2 than is indicated in these tables. However, because the point of supply is not known, the forecast of impacts assumes a region 1 supply point. It is unlikely that the tankers would be supplied from Port Angeles since that would require the construction of major facilities unlike any which already exist in that area.

APPENDIX A

APPENDIX A

PETROLEUM: AVAILABILITY AND DEVELOPMENT

A. ORIGINS OF PETROLEUM

Petroleum is either a gas or a colorless to black liquid which consists of several types of hydrocarbons usually mixed with small quantities of other materials. The origin of petroleum begins with the deposition of organic debris in an oxygen-deficient, underwater (typically marine) environment. Over long periods of time the organic debris is converted by heat and pressure to the waxy, fatty, and resinous organic compounds which form petroleum.

The organic debris which is converted to petroleum can consist of either marine organisms which fall to the sea bottom or material which is washed by rivers into topographic depressions, such as lake bottoms or shallow seas. Sediment which is eroded from subareal areas and is washed into the lake beds or seas will serve to bury the organic debris; and given favorable geologic processes, the sediment cover will thicken as movements of the earth's crest create a deepening depression containing the shallow sea or lake. As the sediment thickens, increased pressure, temperature, and geological and chemical processes will compact and convert the sediments to sedimentary rock. The rock contains the water and petroleum originally buried with the sediment in small pore spaces between the grains of compacted sediment.

B. EVOLUTION OF PETROLEUM ACCUMULATIONS

There are two criteria for the development of petroleum accumulations, a source rock (marine sediments) and a trapping mechanism which will prevent the upward movement of petroleum to the earth's surface. The source rock is typically a marine sedimentary rock such as shale or siltstone which has been buried containing organic debris. The trapping mechanisms are of four general types (see Figure A-1), although only the fault, anticlinal, and stratagraphic traps will occur in Alaskan areas.

Anticlines and fault traps result from geological processes which warp and fracture near-surface portions of the earth's crust. Stratagraphic traps results from a lateral change in the permeability of a rock formation. Salt dome traps do not occur in Alaskan areas but are prolific in and surrounding the Gulf of Mexico oil and gas producing areas. An essential characteristic present in all traps is the presence of a "cap rock" or a rock which is impermeable and will prevent the upward migration of petroleum.

C. PETROLEUM EXPLORATION

There are two phases to the exploration of potential petroleum resources. The first phase of an exploration program consists of an indirect probing of the earth's cruse through geophysical surveying techniques.

FIGURE A-1

SCHEMATIC OF HYDROCARBON TRAP TYPES

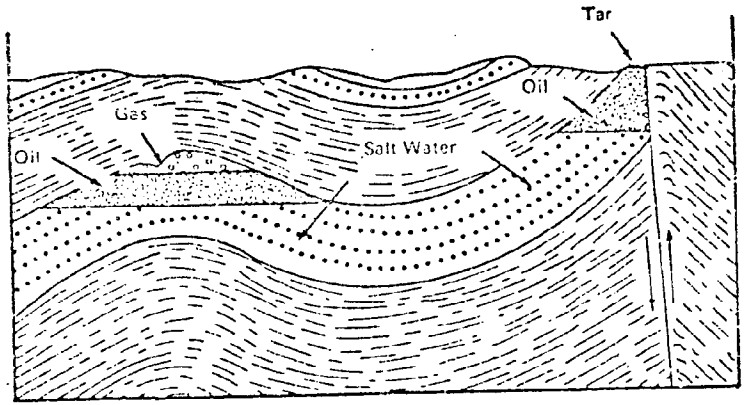


Figure a Anticlinal Trap

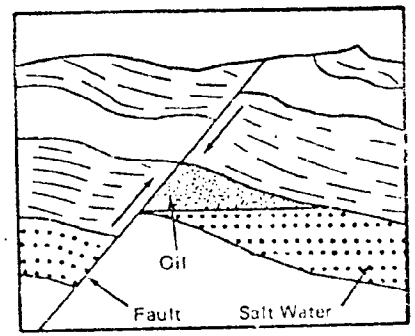


Figure b Fault Trap

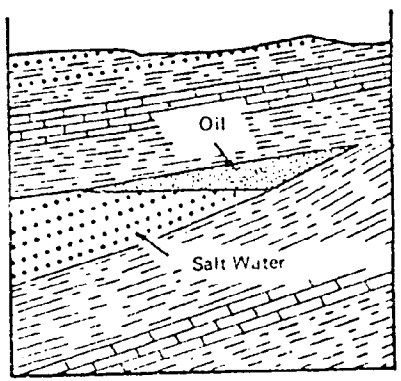


Figure c Stratigraphic Trap

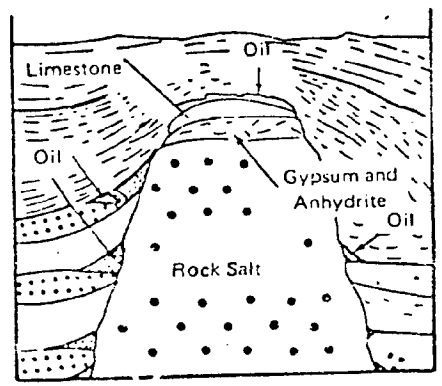


Figure d Salt Dome Trap

Source: Arthur D. Little, Inc.

After geophysical methods have identified potential structural and/or fault traps as specific targets for exploration drilling, mobile drilling rigs begin an exploratory drilling program.

1. Geophysical Exploration

The primary geophysical exploration methods involve the gathering and interpretation of seismic, gravity, and magnetic geophysical data which will identify the dimensions of a sedimentary basin and the location and size of geologic structures, such as anticlines or faults, which are potential petroleum trapping mechanisms. The primary geophysical tool is the seismic survey.

Offshore seismic surveys are carried out by research ships as is shown in Figure A-2. Periodic sound waves are generated by explosives or electronic devices towed by the ship. As the sound waves penetrate the sea floor, each successively deeper rock layer partially reflects the sound impulses, and the echoes off of the rock layers are heard and recorded by the hydrophones which are attached to long cables towed behind the research ship. The recorded noise data is computer processed to print out the profiles of sediment layers indicating the geometry of buried rock formations.

Onshore geophysical exploration is conducted by land crews who operate out of field trucks. There are no significant differences in principal between on- and offshore geophysical surveying.

2. Exploration Drilling

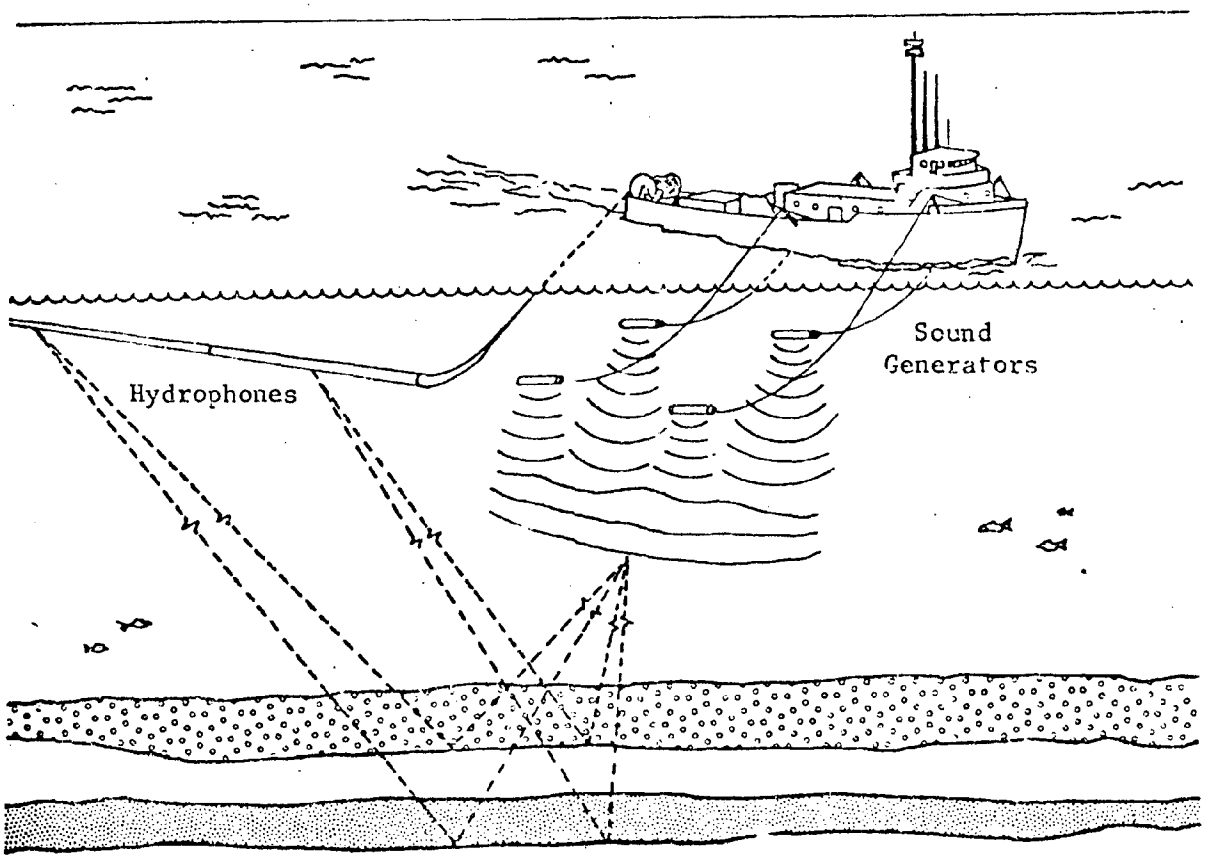
Exploration drilling programs are conducted subsequent to the purchase of lease rights which have been bid for based on the type and size of geological structures identified using geophysical surveys. In offshore areas companies buy leases through a cash bonus bidding system and obtain the rights to explore for and develop oil and gas found on tracts which are generally have a size of three square miles, or 5760 acres.

Onshore exploration is carried out by drilling rigs which can be disassembled and transported by trucks to each well location. Figure A-3 provides a view of the principal drilling rig components.

Offshore drilling is similar to drilling on land except that marine drilling requires some special adaptive equipment between the drilling rig and the well head on the ocean floor. Also, exploration drilling in offshore areas requires a mobile platform which can provide reasonable stability in spite of wind and wave action on the structure of the platform. Offshore exploration drilling is performed from four types of mobile equipment (see Figure A-4) depending primarily on water depth. Submersibles and jack-ups are limited to shallow waters and are platforms with legs which are adjustable in height. Floating platforms, or semi-submersibles, and specially-equipped drill ships are generally used in water depths exceeding 200 feet.

FIGURE A-2

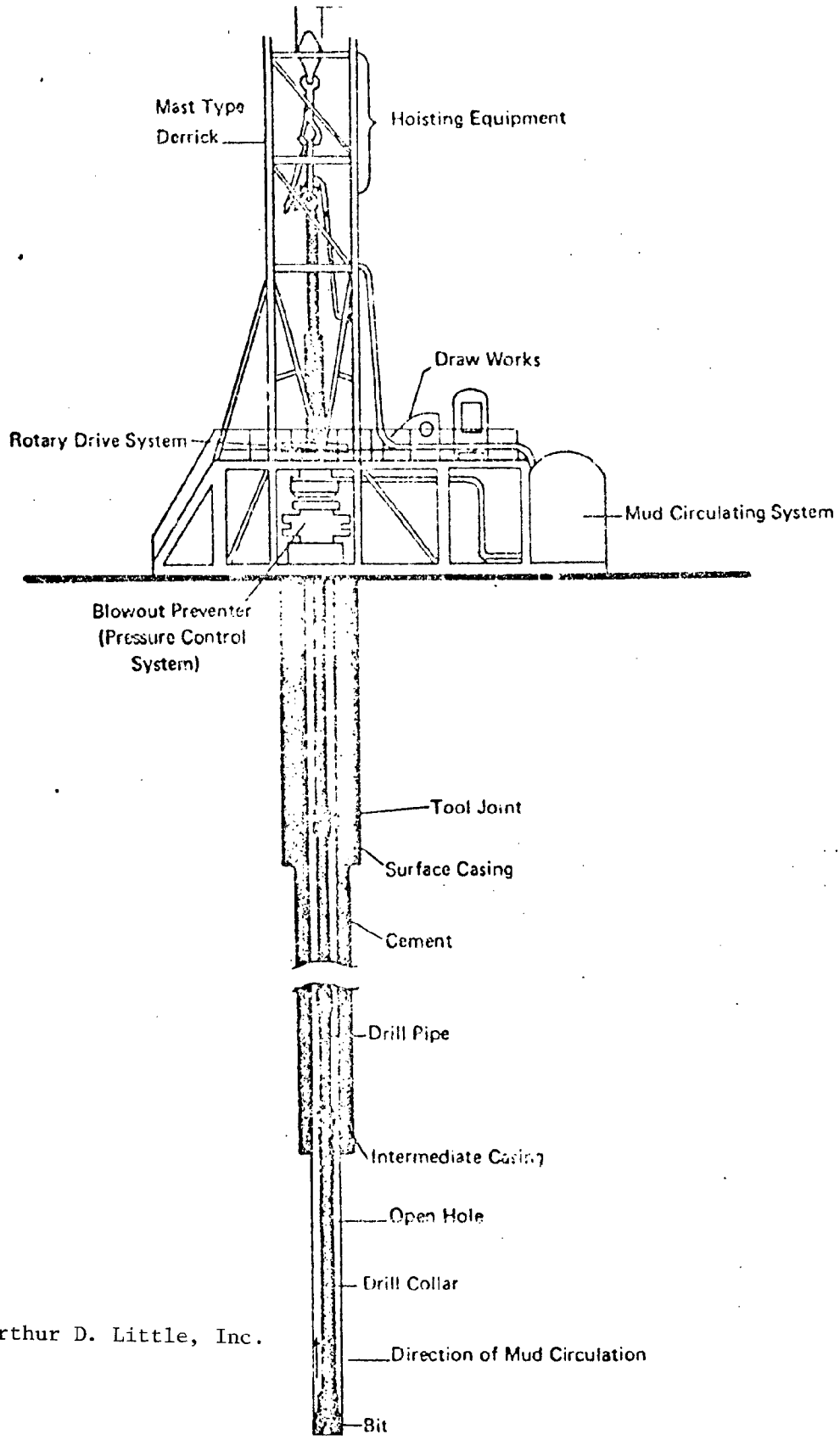
SEISMIC SURVEYING



Source: Offshore Technology Conference, 1969 Offshore Technology Conference, May 18-21, 1969, Houston, Texas.

FIGURE A-3

PRINCIPAL DRILLING RIG COMPONENTS

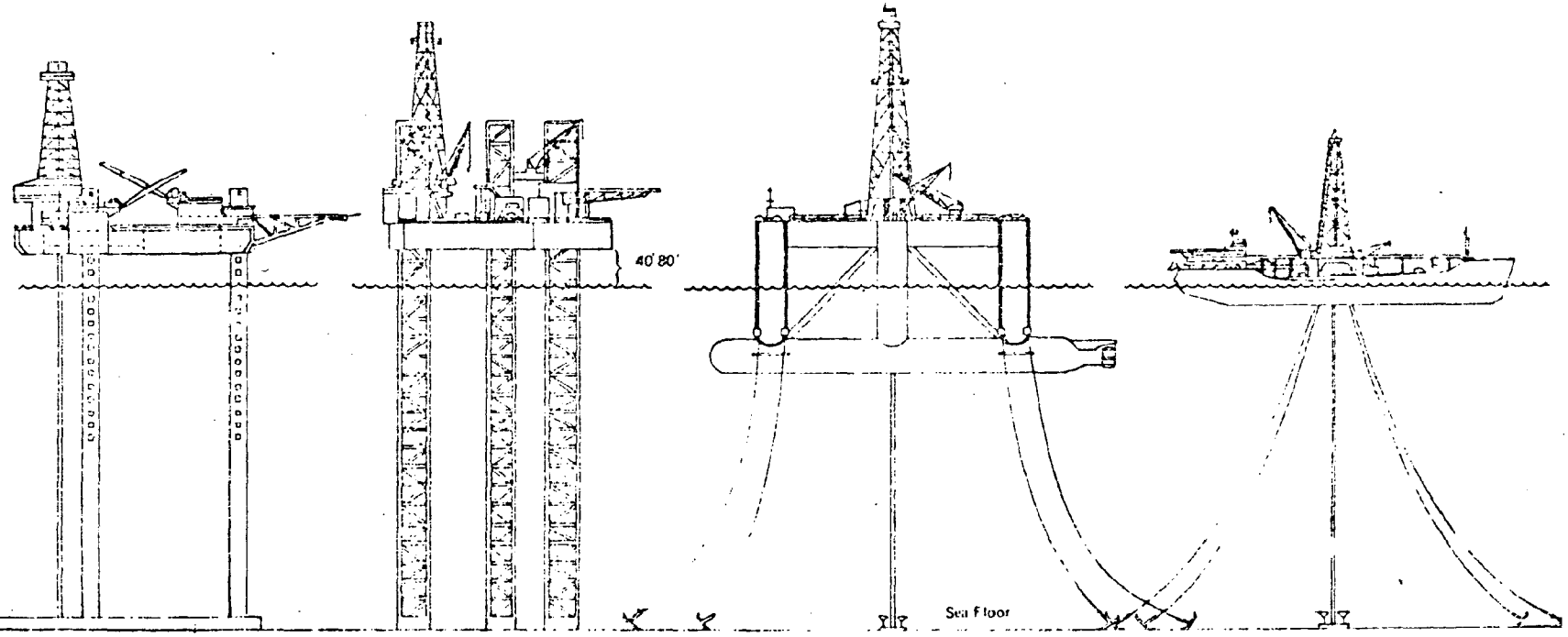


Source: Arthur D. Little, Inc.

FIGURE A-4

MOBILE OFFSHORE DRILLING RIG TYPES

Type	Submersible	Jack-Up	Semi-submersible	Drill Ship
Typical Water Depth (ft)	less than 100	100 400+	200 1000+ (theoretically unlimited)	200 1000++ (theoretically unlimited)
Initial Cost (MM 1974 $)	5-10	15 20	25 50	20 40
Operating Cost (M 1974 $/day)	10-15	15-20	25 45+	20-40+
Principal Advantages, Disadvantages, and Outlook	Forerunner of mobile offshore rigs; stable; relatively inexpensive, restricted to shallow, calm waters; least mobility, bottom conditions important; limited out look.	Proven mid-water depth capability; stable; relatively mobile, but may be unstable under tow; can drill several wells in single set-up; continuing demand, good for severe service (e.g., N. Sea).	Good water depth capability; good mobility, requires anchoring or dynamic positioning, less stable than jack up when operating, but designed for severe service, continuing demand despite high cost	Best mobility, best cargo support capacity; best stability under way; needs 2 crews, less stable than semi when drilling; therefore, more vulnerable to severe conditions.



1 Excludes support, other services, mobilization, demobilization, intangibles, etc

Source: Arthur D. Little, Inc.

Construction costs of jack-up rigs range between $20-35 million depending on the operating conditions in which the rig will be used. When contracted by an oil company, the costs of the rig will range from $20,000-30,000 per day. Construction costs of the larger semi-submersible drilling rigs are $40-50 million, and these rigs will be contracted for by oil companies for as much as $60,000 per day.

The costs of a single exploration well in the North Sea/Gulf of Alaska areas can be as high as $9 million, in addition to the costs of the mobile drilling rig, $20,000-30,000 per day plus supporting services such as supply boats which cost up to $4,000 per day. The number of days required to drill an exploration well is not only dependent on the depth of the well and the hardness of the rock formations, but also on prevailing weather conditions and can take as long as 120 days.

There are several categories of exploration drilling. Exploration wells drilled in areas where there has been no previous drilling are termed "new field wildcats" and have a success ratio ranging between 7-15%. Exploration wells which are drilled in previously drilled areas are categorized according to objectives, such as discovery of shallower or deeper oil or gas pay zones, etc. The success ratios of all of the categories of exploratory drilling ranges between 15-25%. However, the success ratio used in this report for estimating successful new field wildcat wells in Alaskan offshore areas is 7%. This percentage is based on the fact that the largest and most promising drilling targets identified by geophysical surveys will be drilled first. But because of the paucity of regional geological information in the previously unexplored area, a conservative drilling success ratio is used in the estimate of future petroleum production.

If a successful exploration well is drilled and oil and/or gas is found in commercial quantities, further drilling is required by the mobile drilling rig in order to delineate the size and shape of the oil or gas accumulation. Appraisal, or delineation, of the discovery can require an additional three to six exploratory wells, depending on the complexity of the geology of the area in which the field has been found.

D. PETROLEUM RESOURCE DEVELOPMENT AND PRODUCTION

The development of an offshore oil or gas field requires the design, construction, and installation of a large platform usually fixed to the sea bed, the drilling of development wells, and the installation of facilities which enable transportation of the oil or gas to an onshore terminal. All equipment required to drill and maintain producing wells, separate and meter oil and production, as well as other equipment such as cranes, compressors, a power plant, a helicopter landing deck, and crew's quarters for up to 90 men are all located on the deck sections of a platform which is either anchored to the sea bottom or floating and held in place directly over the oil or gas field. The weight of the required equipment on production platforms in the North Sea may range between 10,000 to 30,000 tons. The deck loads of platforms will vary

based on the maximum number of production wells and the maximum size platform which can be constructed. Several of the largest steel platforms have been designed for the North Sea and are capable of accommodating production equipment for up to 40 wells. The world's two tallest steel latforms are now under construction for offshore locations in the Santa Barbara Channel and the Gulf of Mexico. The platform to be installed off of California will be 945 feet high, stand in 850 feet of water, and require 19,000 tons of steel for construction. A 1220 foot high platform is being designed for 1000 feet of water in the Gulf of Mexico, and the structure will require 45,000 tons of steel for construction.

The majority of offshore production wells are drilled from steel platforms which have been anchored to the sea bottom. The platform provides a stable base from which 20 to 40 development wells can be drilled. Deviated drilling techniques can allow development well penetration of petroleum reservoirs located up to three lateral miles from the platform, depending on the depth below surface of the oil or gas accumulations (see Figure A-5).

Figure A-6 shows several alternative production platform designs currently being used or tested by the industry. The steel platform is the typical design, although large concrete platforms also have been constructed for the North Sea.

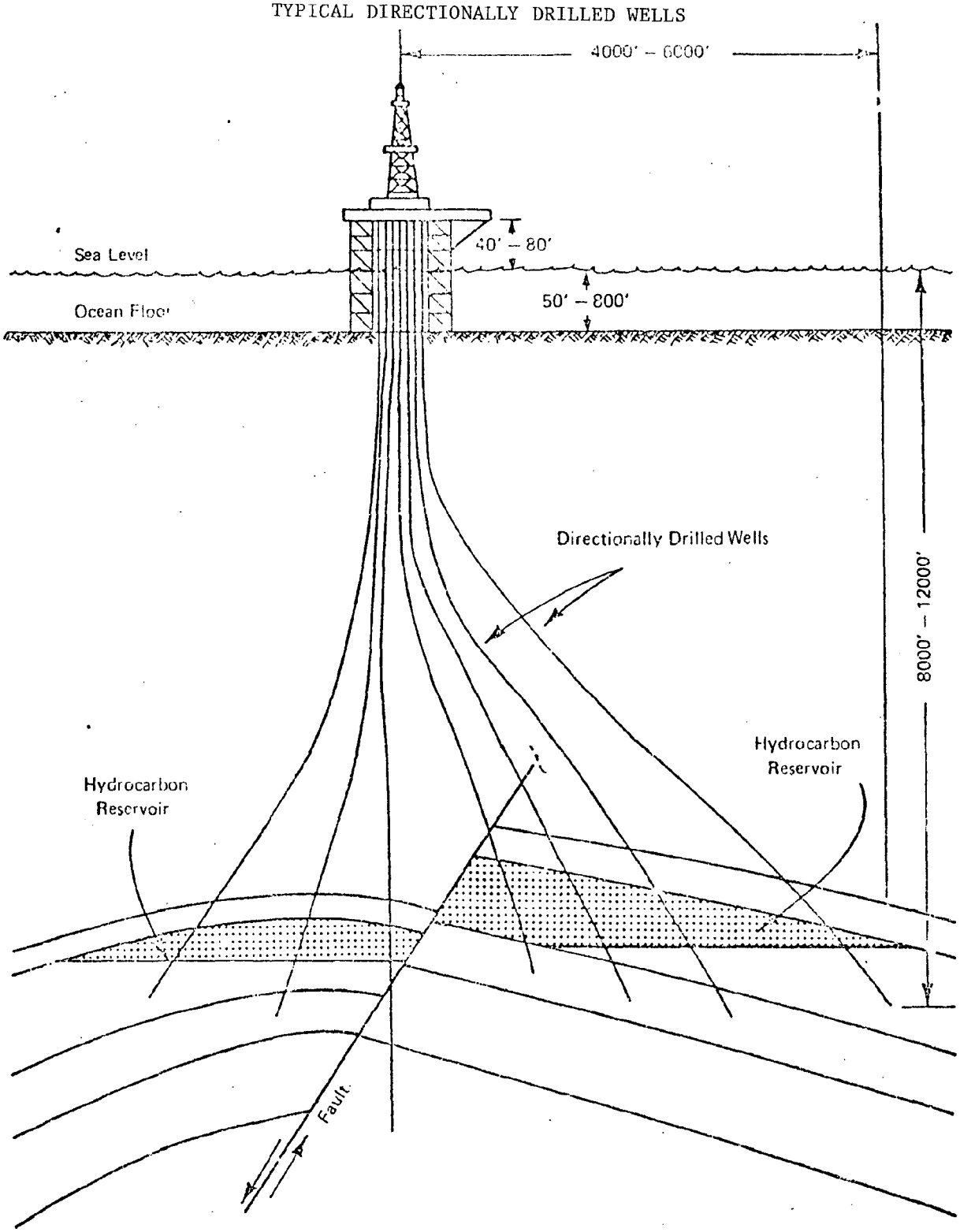
Floating production platforms are used in conjunction with subsea well completions. However, there has been limited experience with floating platforms which have been used only for the development of small North Sea fields.

Costs of fixed offshore platforms depend on required deck loads and water depths, and platform costs in the North Sea range from less than $100 million to more than $200 million. Platform construction costs for the Gulf of Alaska would be comparable to the North Sea if well productivities are of the same magnitude and the discoveries are located in similar water depths. The equipment on a production platform is listed in Table A-1 with the approximate cost figures for a large North Sea platform. Higher well productivities increase the size of the production treating and processing equipment required for a platform and, therefore, increase the size and cost of the offshore installation. However, the higher well productivities result in lower investment costs on a unit basis for the total number of barrels of petroleum produced.

Prefabrication and installation of an offshore production platform occurs in several phases and locations. Each platform is engineered for the specific well productivities, water depth, etc., of a particular oil or gas field and a steel jacket is designed to support the weight of deck sections large enough to accommodate the equipment listed in Table A-1. Then, the steel jacket is prefabricated at a waterfront construction site which has unobstructed access to open water. During assembly of the steel jacket, the required production and other equipment is constructed in as many as 10 to 15 modules which weight up to 1000 tons each.

FIGURE A-5

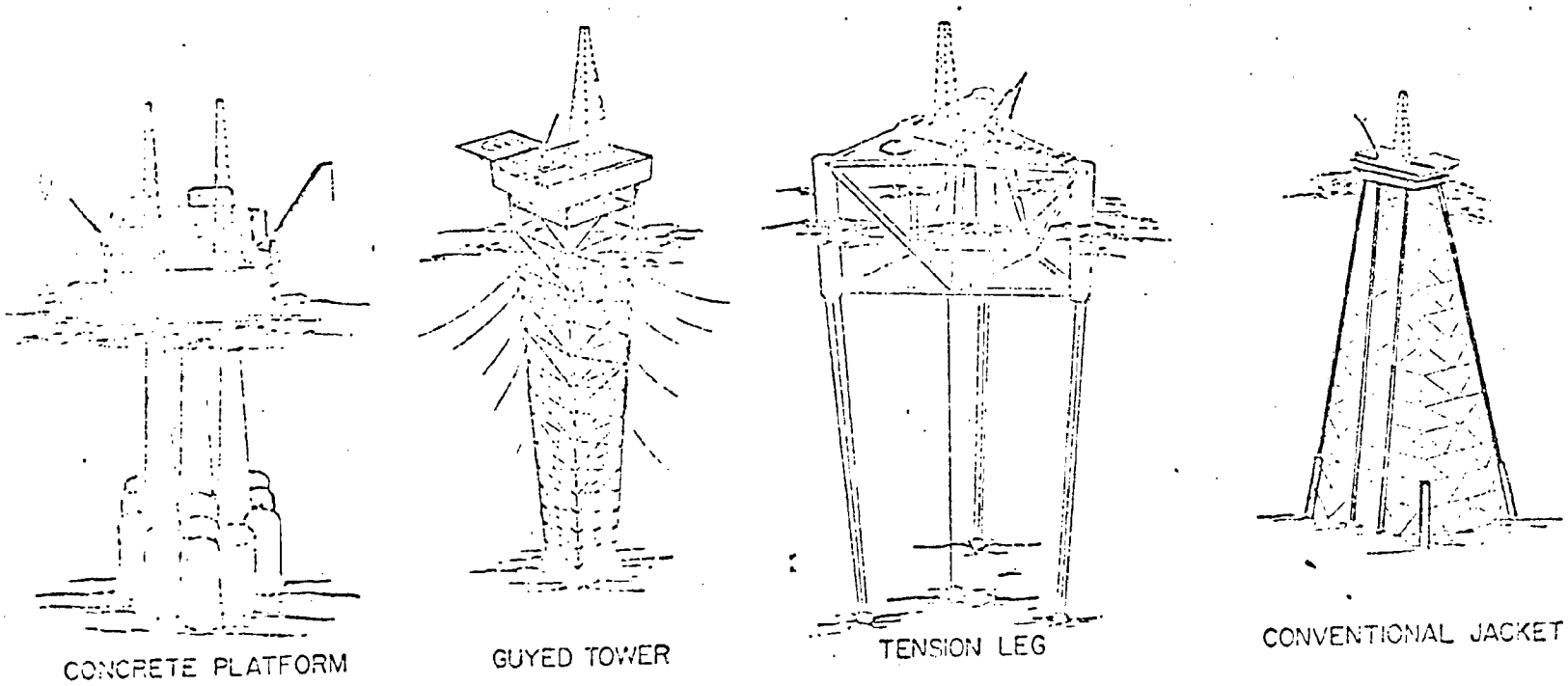
TYPICAL DIRECTIONALLY DRILLED WELLS



Source: Paper by C.C. Taylor, Exxon Company, U.S.A., "Status of Completion/ Proudction Technology for the Gulf of Alaska and the Atlantic Coast Offshore Petroleum Operations," presented at the Resources for the Future, Inc., seminar, Washington, D.C., December 5-6, 1973, conducted for the Council on Envrionmental Quality under Contract No. EQ4AC003.

FIGURE A-6

ALTERNATIVE FIXED PLATFORM CONSTRUCTION
FOR OFFSHORE PRODUCTION OF OIL AND GAS



Source: Oil & Gas Journal.

TABLE A-1

PRODUCTION PLATFORM COSTS

Equipment	Estimated Costs (thousands of dollars)	Percent of Total Costs
Steel Jacket	$100,000	68
Oil and Condensate Production and Treatment Plant	22,500	15
Power Plant and Communications	11,250	8
Living Quarters and Helicopter Deck	2,250	1.5
Drilling Equipment	2,250	1.5
Firefighting and Safety	2,250	1.5
Cranes	2,250	1.5
Other	5,000	3
Totals	$147,750	100.00

Source: Arthur D. Little, Inc., estimates based on industry contacts.

When completed, the 1900 to 45,000 ton steel jacket will be either winched onto a barge or floated by flotation tanks and then towed by up to six tug boats onto the location of the underwater oil or gas field. Once on location, the steel jacket will be partially sunk and tilted into an upright position before being placed on the sea bottom in the desired location. The steel jacket then will be fixed to the ocean floor by steel piles which are driven through each jacket leg as mush as 250 feet into the sea bottom and cemented in.

With the steel jacket in place, the deck sections and equipment modules will be bsrged to the installation site. The platform deck sections, equipment modules, living quarters, and drilling gear will be lifted sequentially into place. The mechanical and electrical hookup of the installed modules will complete the construction of the platform, and oil and gas development drilling will begin.

The prefabrication of a large steel production platform requires approximately nine months to a year following completion of engineering and design work. Installation can take from two to five months depending on weather conditions which are of primary importance during heavy lifting by the derrick barge.

At least one derrick barge will be required on-site during the installation of the platform jacket, deck section, and equipment modules. The derrick barge supports a heavy crane with a short radius lifting capacity of 250 to 1000 tons. Operations of a derrick barge are supported by one to three tug boats which handle the barge anchoring lines and smaller supply barges.

During platform installation, the derrick barge serves first to assist in positioning the steel jacket as it is placed on the bottom. Next, the heavy capacity derrick crane supports a multi-ton steam pile driver, rated up to one million foot-pounds, which drives the steel piling to anchor the platform jacket. After the platform jacket has been fixed to the sea bed, the derrick is used to lift the deck sections and modules into position on top of the jacket. The derrick barge also functions as a base for the habitat housing underwater diving teams which participate in saturation diving during underwater construction and inspection activities. Table A-2 provides an estimate of North Sea platform installation costs.

Following complete installation and hookup of the fixed production platform, development drilling will begin with one or two drilling rigs in operation on the drillin deck with drill pipe channeled through well conductors in lower decks. Development drilling will continue for at least two years depending on the number of wells to be drilled and the total depth of each well. Average drilling progress should range between 150 to 250 feet per day, and development drilling should achieve a success ratio of approximately 75%. The number of development wells which will be completed as producers will be a function of platform design based on expected well productivities and petroleum reservoir depth.

TABLE A-2

PLATFORM INSTALLATION COSTS
FOR JACKET AND DECK SECTIONS

Item	Costs (thousands of dollars)	Percent of Total Costs
Derrick Barge	$18,000	60
Mechanical and Electrical Hookup	4,500	15
Tugs and Supply Vessels	3,900	13
Diving	2,100	7
Miscellaneous	1,500	5
Totals	$30,000	100

Source: Arthur D. Little, Inc., estimates based on industry contacts.

Once production has begun, there will be two methods of transporting oil to shore. A pipeline can be laid from the oil or gas field to shore, or tankers can be loaded from oil storage facilities located at the oil field. Transportation of natural gas by tankers directly from producing fields is neither technically nor economically feasible at this point due to difficulties with locating gas liquifaction facilities on production platforms and with the design requirements of low temperature, flexible loading hoses to be used in even mild sea states.

For oil, shipment by tanker is economically competitive with pipelines in circumstances when large diameter pipelines cannot link several oil fields with a shore terminal. However, it is likely that if substantial discoveries are made in the Gulf of Alaska that pipelines will be constructed to shore terminals from which the crude oil will be moved to markets by tanker.

Construction of a marine pipeline is carried out by two types of heavy construction equipment, a pipelay, and a pipe bury barge. The most modern offshore construction barges are combination derrick/pipelay barges capable of laying up to two miles per day of large diameter pipe in water depths of up to 600 feet. Down-time factors for pipelay barges are high due to the weather sensitivity of pipelaying operations and will be of particular importance in the Gulf of Alaska. Pipelaying operations are conducted by welding together sections of pipe and then pulling the pipelay barge forward on its anchor by deck winches. The pipeline, which is coated with protective layers of tar and cement, lies on the surface of the sea floor until a pipe bury barge makes a pass over the line pulling a jetting sled.

The pipe bury barge houses high compression pumps that force water through jets on a sled which is dragged down the underwater pipeline. The jet sled forces bottom sediment from underneath the pipe creating a ditch into which the pipe settles. Several passes of the bury barge and its jet sled may be required to bury a pipeline in unusual bottom sediment conditions.

Mobilization and demobilization costs of a pipelay barge can range up to $1.5 million, and day rates can range from $75,000-200,000, depending on pipelaying performance. Pipe bury barges have a day rate contract cost ranging from $60,000-80,000.

Several types of support and supply vessels service the larger offshore equipment. Offshore work boats, or supply vessels, fulfill the primary functions of towing, anchor handling, and cargo carrying. In the North Sea, supply boats of the 4000 horsepower anchor handling class are typically equipped with a heavy duty winch, stern roller, and towing and anchoring gear, and therefore have limited deck cargo capacity. The newer North Sea cargo carrying work boats are over 200 feet long and have a deck cargo capacity of 2000 tons and can carry up to 9000 cubic feet of bulk chemicals. Under deck tankage is in the range of 1400 tons of fuel oil and treated water required for drilling. Costs for the large North Sea boats are approximately $4,000 per day.

APPENDIX B

SPECIES CHARACTERISTIC OF MAJOR PUGET SOUND UPLAND HABITAT

Habitat (upland)

Grassland (dry, parkland, fields)
Wet meadow (lowland bogs)
Riparian (along watercourses)
Shrubland (early succession, shrubs and young trees)
Broadleaf (deciduous) forest
Coniferous forest
Mixed broadlead-coniferous forest

GRASSLAND

Characteristic plant species

Name	Comment
western fescue	
white hawkweed	
common beargrass	
woodland groundsel	
fireweed	
brome grass (species)	
autumn willowweed	
rattlesnake plantain	
Idaho fescue	
northwestern saxifrage	
Idaho blue-eyed grass	
upland yellow violet	
wild radish	introduced
American vetch	
perennial pea	introduced
red clover	introduced
white clover	introduced
Queen Anne's lace	introduced
self heal	introduced
Canada thistle	introduced
dog fennel	introduced
cow parsnip	introduced

Characteristic animal species (vertebrates)

Amphibians (non-dry habitat)

Reptiles

Northwestern Garter Snake
Northern alligator lizard

Birds

Legend: R= resident WR= winter resident SR= summer resident
M= migrant C= common U= uncommon R= rare x= breeds in that habitat

	Seasonality	Breeding Status	Relative Abundance
rough-legged hawk	WR		U
red-tailed hawk	R	breeds	C
marsh hawk	R		U
gyrafalcon	WR		R
peragrine falcon	R		R
pigeon hawk	R		U
sparrow hawk	R		C
ring-necked pheasant	R	x	C
black-bellied plover	M		U
killdear	R	x	C
American golden plover	M		R
band-tailed pigeon	R		U
rock dove	R	x	C
mourning dove	SR	x	C
barn owl	R	x	C
great horned owl	R	x	U
snowy owl	WR		R
short-eared owl	R	x	C
nighthawk	SR	x	C
eastern kingbird	SR	x	C
western kingbird	M	x	C
horned lark	R	x	C
violet green swallow	SR	x	C
tree swallow	SR	x	C
barn swallow	SR	x	C
cliff swallow	SR	x	C
black-billed magpie	M	x	C
raven	R	x	U
common crow	R	x	C
western bluebird	SR		U
mountain bluebird	WR	x	C
water pipit	WR		C
northern shrike	WR		U
starling	R	x	C
house sparrow	R	x	C
western meadowlark	R	x	C
red-winged blackbird	R		C
yellow-headed blackbird	M		U
Brewer's blackbird	R	x	C
brown-headed cowbird	SR	x	C
common redpoll	WR		U
American goldfinch	R	x	C
Savannah sparrow	R	x	C
tree sparrow	WR		U
lapland longspur	WR		U
snow bunting	WR		R

Mammals

Legend: A= abundant C= common

	Abundance
opossum	C
dusky shrew	C
eastern cottontail	introduced species
deer mouse	A
Oregon vole	A
house mouse	A
coyote	C
long-tailed weasel	A
striped skunk	A
spotted skunk	A
bobcat	C
black-tailed deer	A

WET MEADOW

Characteristic plants	
long-stoloned sedge	
common camas	
broad-leaved shooting star	
thrift	
meadow death camas	
Puget balsamroot	
valley violet	
water sedge	
slough sedge	
common rush	
broad-leaved cattail	
bulrush	
yellow skunk cabbage	
spring-bank clover	
Sierra rush	
sickle-leaved rush	
golden blue-eyed grass	
Douglas aster	
lady fern	
leathing grape fern	occasional
American brookline	
cow parsnip	
common horsetail	
giant horsetail	
hedge nettle	
monkey flower	

Amphibians

long toed salamander
northwestern salamander
Pacific Northwest newt
western toad
Pacific treefrog
sullfrog

Reptiles

Northwestern garter snake
western garter snake
common garter snake
painted turtle
Northwestern pond turtle

Birds

Legend: R= resident WR= winter resident SR= summer resident
M= migrant C= common U= Uncommon R= rare x= breeds in that habitat

	Seasonality	Breeding Status	Relative Abundance
red tailed hawk	R	x	C
rough-legged hawk	WR		C
golden eagle	R	x	U
marsh hawk	R	x	C
gyrafalcon	WR		R
sparrow hawk	R	x	C
ring-pecked pheasant	R	x	U
kill deer	R	x	C
common snipe	R	x	C
snowy owl	WR		R
short-eared owl	R	x	C
barn swallow	SR	x	C
cliff swallow	SR	x	C
water pipit	WR	x	C
northern shrike	WR		U
starling	R		C
Nashville warbler	M		C
MacGillivwray's warbler	SR	x	C
western meadowlark	R	x	C
Brewer's blackbird	R	x	C
Savannah sparrow	R	x	C
vesper sparrow	SR	x	C

(Fresh water marsh birds)

Mammals

Legend: A= abundant C= common R= rare

dusky shrew		C	
vagrant shrew	A		
northern water shrew	(bogs)		
Pacific water shrew	A (marsh)		
masked shrew			R
Townsend mole	A		
Pacific mole	A		
shrew mole	A		
deer mouse	A		
long-tailed vole		R	
montain beaver	A		
muskrat	A (marsh)		
beaver	A (ponds)		
Townsend vole	A		
Raccoon	A		
mink		C (marsh)	
long-tailed weasel	A		
spotted skunk	A		
river otter		C (marsh)	
Bobcat		?	
black-tailed deer	A		

RIPARIAN

Characteristic plants

Red alder			
Pacific willow			
black cottonwood			
Piper willow			
quaking aspen			R
Oregon ash			
paper birch	east Sound, north of Seattle		
salmon berry			
hardhack			
red elderbem			
creek dogwood			
bush honeysuckle			
soft-leaved willow			
Sitka willow			
rigid willow			
broad-leaved cattail			
water sedge			
slough sedge			
long-stoloned sedge			
bur reed			

common rush
Sierra rush
wapato
American false hellebore
valley violet
stinging nettle
creek dogwood

Characteristic animals

Amphibians

Pacific giant salamander
long-toed salamander
western toad
Pacific treefrog
western spotted frog

Reptiles

Northwestern garter snake
western garter snake
common garter snake
painted turtle

Birds

Legend: R= resident WR= winter resident SR= summer resident
M= migrant C= common U= Uncommon R= rare x= breeds in that habitat

	Seasonality	Breeding Status	Relative Abundance
Turkey vulture	SR	x	U
sharp-shirred hawk	R		U
cooper's hawk	R	x	U
red-tailed hawk	R	x	C
sparrow hawk	R	x	U
ruffed grouse	R	x	C
mourning dove	SR	x	C
barn owl	R	x	U
screech owl	R	x	C
great horned owl	R	x	C
long-eared owl	WR	x	U
saw-whet owl	WR		U
black swift	SR		
Rufous hummingbird	SR	x	C
red-shafted flicker	R	x	C
Lewis woodpecker	R	x	C
yellow-bellied sapsucker	R	x	C
dawny woodpecker	R	x	C
eastern kingbird	SR	x	C
western kingbird	M	x	C

Traill's flycatcher	SR	x	C
western flycatcher	SR	x	U
western wood pewe	SR	x	C
violet green-swallow	SR	x	C
tree swallow	SR	x	C
bank swallow	M(sand banks)		
rough-winged swallow	SR	x	C (sand banks)
barn swallow	SR	x	C
cliff swallow	SR	x	C
black-billed magpie	M	x	C
common crow	R	x	C
black-capped chickadee	R	x	C
white-breasted nuthatch	R	x	C
red-breasted nuthatch	R		U
dipper	R (streams)		
house wren	SR	x	C
Bewick's wren	R	x	C
robin	R	x	C
Townsend's solitaire	WR		U
Swainons thrush	SR	x	C
western bluebird	SR	x	U
Golden=crowned kinglet	R		C
ruby-crowned kinglet	WR		C
bohemian waxwing	WR		U
cedar waxwing	SR	x	C
northern shrike	WR		U
starling	R	x	C
red-cyed vireo	SR	x	C
wardling vireo	SR	x	C
yellow warbler	SR	x	C
black and white warbler	M		R
bullock's oriole	SR	x	C
brown-headed cowbird	SR	x	C
black-headed grosbeak	SR	x	C
house finch	R	x	C
Lazuli bunting	SR	c	C
Gray-crowned rosy finch	WR	x	C
pine Siskin	R		C
American goldfinch	R	x	C
Rufus-sided towbee	R	x	C
Slate colored junco	WR		U
Oregon junco	R		C
tree sparrow	WR		U
white-crowned sparrow	R		C
golden-crowned sparrow	WR		C
box sparrow	R		C
song sparrow	R	x	C

Mammals

Legend: A= abundant C= common

Pacific water shrew	A
mountain beaver	A
beaver	A
deer mouse	A
raccoon	A
mink	C
long-tailed weasel	A
river otter	C

SHRUBLAND (thickets) (shrub successional communities)

Characteristic plants

sword fern
bracken fern
salal
Oregon oxalis
Pacific rhododendron
Oregon grape
creambush oceanspray
creeping snowberry
baldhip rose
common snowberry
salmonberry
thimbleberry
red alder
vine maple
red huckleberry
ovalleaf huckleberry
snowbrush ceanothus
California hazel
Scowler beltflower
trailing blackberry
big leaf maple (shrub form, immature)
western yew
red elderberry
Pacific willow
silk tassel
ninebark
western crabapple
twinflower
lady fern

Characteristic animals

Amphibians

western toad (near water)

Reptiles

northwestern garter snake
northwestern rubber boa

Birds

Legend: R= risident WR= winter resident SR= summer resident
M= migrant C= cmmon U= uncommon R= rare x+ breeds
in that habitat

	Seasonality	Breeding Status	Relative Abundance
blue grouse	R		U
California quail	R	x	C
ring-necked pheasant	R	x	C
downy woodpecker	R		U
black-capped chickadee	R	c	C
mountain chickadee	WR		R
common bushtit	R	x	C
barn swallow	SR	x	C
cliff swallow	SR	x	C
house wren	SR	x	C
Bewick's wren	R	x	C
golden crowned kinglet	R		U
ruby-crowned kinglet	WR		U
orange-crowned warbler	SR	x	C
Wilson's warbler	SR	x	C
brown-headed cowbird	SR	x	C
Lazuli bunting	SR	x	C
Rufus-sided townee	R	x	C
Harris sparrow	WR		R
slate-colored junco	WR		U
Oregon junco	R	x	C
tree sparrow	WR		U
White crowned sparrow	R	x	C
golden-crowned sparrow	WR		C
fox sparrow	R	x	U
Lincoln sparrows	M	x	C

Mammals

Legend: A= abundant C= common

dusky shrew	C
snowshoe hare	A
eatern cottontail	(introduced)
Townsend chipmunk	A
Deer mouse	A
long-tailed weasel	A
Striped skunk	A
spotted shunk	A

BROADLEAF FOREST

Characteristic plants

big leaf maple	dominant
Oregon ash	

golden chinkapin	
red alder	dominant
Oregon white oak	dry sites around Puget Sound
paperbirch	North Puget Sound
salal	understory species
Pacific madrone	dry sites (especially east side of Olympic peninsula)
swordfern	understory species
thimbleberry	understory species
creeping snowberry	understory
creambush oceanspray	understory
vine maple	understory dominant
Pacific dogwood quaking as per	
black cottonwood	wet areas
baldhip rose	understory
bush honeysuckle	
creeping buttercup	
red huckleberry	understory
red current	understory

Characteristic animals

Amphibians

western red-backed salamander	
Oregon red salamander	
king-toed salamander	(near water)

Reptiles

northern alligator lizard	
northwestern rubber boa	
northwestern garter snake	most common
western garter snake	(near water)
common garter snake	(near water)

Birds

	Seasonality	Breeding Status	Relative Abundance
Turkey vulture	C	X	U
sharp skinned hawk	R		U
Cooper's hawk	R	x	U
red-tailed hawk	R	x	C
pigeon hawk	R	x	U
sparrow hawk	R	x	U
ruffed grouse	R	x	C
band-tailed pigeon	R	x	U
screech owl	R	x	C
great horned owl	R	x	C
vaux's swift	SR	x	C
Rufano hummingbird	SR	x	C

red-shafted flicker	R	x	C
yellow-bellied sapsacker	R	x	C
downy woodpecker	R	x	C
eastern kingbird	SR	x	C
Traill's flycatcher	SR	x	C
western wood pewee	SR	x	C
violet green swallow	SR	x	C
tree swallow	SR	x	C
rough-winged swallow	SR	x	C
common crow	R	x	C
black-capped chickadee	R	x	C
chestnut-backed chickadee	R		U
common bushtit	R	x	C
white-breasted nuthatch	R	x	C
red-breasted nuthatch	R	x	U
house wren	SR	x	C
Bewick's wren	R	x	C
robin	R	x	C
Swanson's thrush	SR	x	C
golden-crowned knight	R		C
ruby-crowned knight	WR		C
bohemian waxwing	WR		U
cedar waxwing	SR	x	C
starling	R	x	C
Solitary Vireo	SR	X	U
Hutton's vireo	R	x	U
red-eyed vireo	SR	x	C
warbling vireo	SR	x	C
orange-crowned warbler	SR	x	C
Nashville warbler	M		U
yellow warbler	SR	x	C
myrtle warbler	WR		U
Max Gillivray's warbler	SR	x	C
white-and-black warbler	M		R
bullock's oriole	SR	x	C
brown-headed cowbird	SR	x	C
black-headed gorsbeak	SR	x	C
common redpoll	WR		U
pine Siskin	R		C
American goldfinch	R	x	C
Rufus-sided townee	R	x	C
Slate-colored junco	WR		U
Oregon junco	R		C
chipping sparrow	SR	x	C
tree sparrow	WR		U
white-crowned sparrow	R		C
golden-crowned sparrow	WR		C
fox sparrow	R		C
song sparrow	R		C

Mammals

Legend: A+ abundant C= common

dusky shrew		C
vagrant shrew	A (wet areas)	
Masked shrew		R (moist areas)
Townsend more	A (moist areas)	
Pacific mole	A	
shrew mole	A (moist areas)	
long-legged myotis		C (open forest)
long-eared myotis		R
yuma myotis	A (open woods)	
silvery-haired bat	A	
big brown bat	A	
snowshoe hare	A	
mountain beaver	A	
Oregon vole	A	
coyote		C
red fox		C (semi-open country)
black bear	A	
raccoon	A (near water)	
long-tailed weasel	A	
short-tailed weasel	R	
spotted skunk	A	
bobcat		C
black-tailed deer	A	

CONIFEROUS FOREST

Characteristic plants

Douglas fir	(dominant in seral stands)
Sitka spruce	
wester. redcedar	C
western hemlock	(rare, except in old-growth areas)
grand fir	
western white pine	(special zones around Puget Sound)
lodgepole pine	(special zones around Puget Sound)
Pacific yew	(minor element)
cascara	(understory)
salal	(understory)
swordfern	(moist sites)
ladyfern	(moist sites)
licorice fern	
creambush oceanspray	(dry sites)
salal	(dry sites)
skunk cabbage	(wettest sites)
Pacific rhododendron	(intermediate moisture sites)
Oregon grape	(intermediate moisture sites)
whipplevine	
starflower	
waterleaf	(moist sites only)
snowqueen	
twinflower	
bedstraw	ground cover

Characteristic animals (vertebrates)

Amphibians.

long toed salamander	near water
western red-backed salamander	
Oregon red salamander	
western toad	near water
Pacific treefrog	near water
western wooding	near ponds

Reptiles

northern alligator lizard	
northwestern garter snake	
western garter snake	near water
common garter snake	near water

Birds

	Seasonality	Breeding Status	Relative Abundance
turkey vulture	SR	x	U
goshawk	R	x	U
sharp-skinned hawk	R	x	U
coopers hawk	R		U
red-tailed hawk	R	x	C
bald eagle	R	x	C
peregrine falcon	R	x	R
pigeon hawk	R	x	U
sparrow hawk	R	x	U
blue grouse	R	x	C
ruffed grouse	R	x	C
band-tailed pigeon	R	x	C
great horned owl	R	x	C
hawk owl	WR		R
pigmy owl	R	x	U
spotted owl	R	x	R
great gray owl	R	x	R (status uncertain)
saw whet owl	WR	x	C
boreal owl	WR		R
Vaux's swift	SR	x	C
rufous humming bird	SR	x	C
red-shafted flicker	R	x	C
pileated woodpecker	R	x	U
yellow-bellied sapsucker	R	x	C
hairy woodpecker	R	x	C
Hammond's fly catcher	SR	x	C
western flycatcher	SR	x	C
western wood pewee	SR	x	U
olive-sided flycatcher	SR	x	C
dusky flycatcher	M		C
violet-green swallow	SR	x	C
tree swallow	Sr	x	C
rough-winged swallow	SR	x	C
Steller's jay	R	x	C
gray jay	R	x	C
raven	R	x	C

	Seasonality	Breeding Status	Relative Abundance
common crow	R	x	C
black-capped chickadee	R		C
chestnut black chickadee	R	x	C
mountain chickadee	WR	x	C
common bushtit	R	x	C
red-breasted nuthatch	R	x	C
brown creeper	R	x	C
winter wren	R	x	C
robin	R	x	C
varied thrush	R	x	C
Townsend's solitaire	WR	x	C
hermit thrush	M	x	C
Swainson's thrush	SR	x	C
mountain bluebird	WR	x	U
golden crowned kinglet	R	x	C
ruby crowned kinglet	WR		C
Bohemian waxwing	WR		U
cedar waxwing	SR		C
northern shrik	WR		U
starling	R	x	U
solitary vireo	SR	x	C
Hutton's vireo	R	x	U
warbling vireo	SR	x	U
myrtle warbler	WR		U
MacGillivray's warbler	SR	x	C
Wilson's warbler	SR	x	C
black and white warbler	M		R
brown-headed cowbird	SR	x	C
evening grosbeak	R		C
purple [illegible]	R	x	C
pine [illegible]	R	x	C
red crossbill	R	x	C
white-winged crossbill	WR	x	R
rufous-sided towhee	R	x	C
slate-colored junco	WR		U
Oregon junco	R	x	C
white-downed sparrow	R	x	C
golden-crowned sparrow	WR		C
song sparrow	R	x	C

Mammals

Legend: A= abundant C= common R= rare

dusky shrew	C	
vagrant shrew	A	- wet areas
masked shrew	R	- moist areas
Trowbridge shrew	A	- coniferous forest only)
townsend mole	A	- moist areas
Pacific mole	A	
shrew mole	A	moist areas
long-eased myotis	R	
silvery-haired bat	A	
big brown bat	A	
shonshoe hare	A	

mountain beaver	A (moist areas)
townsend chipmonk	A
Douglas squirrel	A (coniferous forests only)
northern flying squirrel	C (coniferous and mixed forests)
deer mouse	A
Oregon vole	A
California red-backed vole	A (coniferous forest only
black rat	A (coniferous and mixed woods)
raccoon	A (near water)
Fisher	R (mixed forest)
long-tailed weasel	A
short-tailed weasel	R
mountain lion	R (coniferous forest only)
bobcat	C ?
black-tailed deer	A

MIXED CONIFEROUS/DECIDUOUS FOREST

Mixed coniferous/deciduous forest contains a mixture of the elements listed separately under coniferous and deciduous forest and hence will not be given separate, detailed enumeration. Most of the second growth assemblages commonly sited in the study area activity zones are mixed coniferous/deciduous forest communities.

It appears that the earlier or younger stands the tallest vegetation a larger component of deciduous forms, paricularly red alder, vine maple, and big leaf maple. Many of the coniferous (particularly Douglas fir and western red cedar, if present, are young specimens not mergent above the shrubs layer. In slightly older stands, the coniferous appear to be a more dominant element, as they are now mature enough to compare in height to the alders and maples.

FRESH WATER MARSH BIRDS

Legend: R= resident WR= winter resident SR=summer resident M= migrant
C= common U=uncommon R= rare x= breeds in that habitat

	Seasonality	Breeding Status	Relative Abundance
common loon	M	x	U
Arctic loon	WR		R
western grebe	M		C
red-necked grebe	W		U
horned grebe	M		U
hared grebe	M		C
pied-billed grebe	R	x	C
double-crested Cormorant	SR	x	U
great blue heron	R	x	C
black-crowned night Heron	M	x	C
green heron	R	x	U
American bittern	SR	x	C
whistling swan	M		U
trumpeter swan	WR		U
Canada goose	R	x	C
white-fronted goose	M		R
snow goose	WR		R
mallard	R	x	C
gadwall	WR		C
pintail	WR		C
American widgeon	WR		C
shoveler	WR		C
blue-winged teal	SR	x	C
Cimmamon teal	SR	x	C
European widgeon	WR		R
Green-winged teal	WR		C
wood duck	R	x	U
redhead	WR		C
canvasback	WR		C
ring-nected duck	WR		C
greater scaup	M		U
lesser scaup	WR		C
American goldeneye	WR		C
Barrow's goldeneye	WR	x	C
bufflehead	WR		C
oldsquaw	WR		R
harlequin duck	WR	x	R
white-winged scoter	M		R
ruddy duck	WR		C
hooded merganser	R	x	U
common merganser	R	x	U
red-breated merganser	M		R
surf scoter	M		R

	Seasonality	Breeding Status	Relative Abundance
marsh hawk	R	x	C
osprey	SR	x	U
sandhill crane	M		U
Virginia rail	R	x	C
sora rail	SR	x	C
American coot	WR	x	C
black-bellied Plover	M		U
semipalmated plover	M		R
killdeer	R	x	C
whimbrel	M		R
solitary sandpiper	M		U
spotted sandpiper	SR	x	C
greater yellowlegs	M		C
lesser yellowlegs	M		C
American golden Plover	M		R
short-billed dowitcher	M		R
long-billed dowitcher	M		C
ruddy turnstone	M		R
long-billed curlew	M		R
pectoral sandpiper	M		C
willet	M		R
knot	M		R
dunlin	WR		R
Baird's sandpiper	M		C
sanderling	M		U
least sandpiper	M		C
marbled godwit	M		R
common snipe	R	x	C
western sandpiper	M		C
Wilson's phalarope	M	x	C
northern phalarope	M		U
Glaucous gull	WR		R
glaucous-winged gull	WR	x	U
herring gull	M		U
California gull	M	x	C
ring-billed gull	WR	x	C
mew gull	WR		U
bonaparte's gull	M		C
Thayer's gull	WR		C
Forster's tern	M	x	U
black tern	M	x	C
belted kingfisher	WR	x	C
bank swallow	M	x	C
rough-winged swallow	S	x	C
purple martin	SR	x	U
dipper	R	x	C
long-billed marsh wren	R	x	C
Myrtle warbler	WR		U

	Seasonality	Breeding Status	Relative Abundance
Townsend's Warbler	SR	x	C
Hermit Warbler	SR	x	U
MacGillivray's Warbler	SR	x	C
Black-throated Gray Warbler	SR	x	C
Wilson's Warbler	SR	x	C
Audubon's Warbler	SR	x	C
Red-winged Blackbird	R	x	C
Yellow-headed Blackbird	M	x	C
Evening Grosbeek	R	x	C
Song Sparrow	R	x	C

APPENDIX C

APPENDIX C

ECONOMIC METHODOLOGY

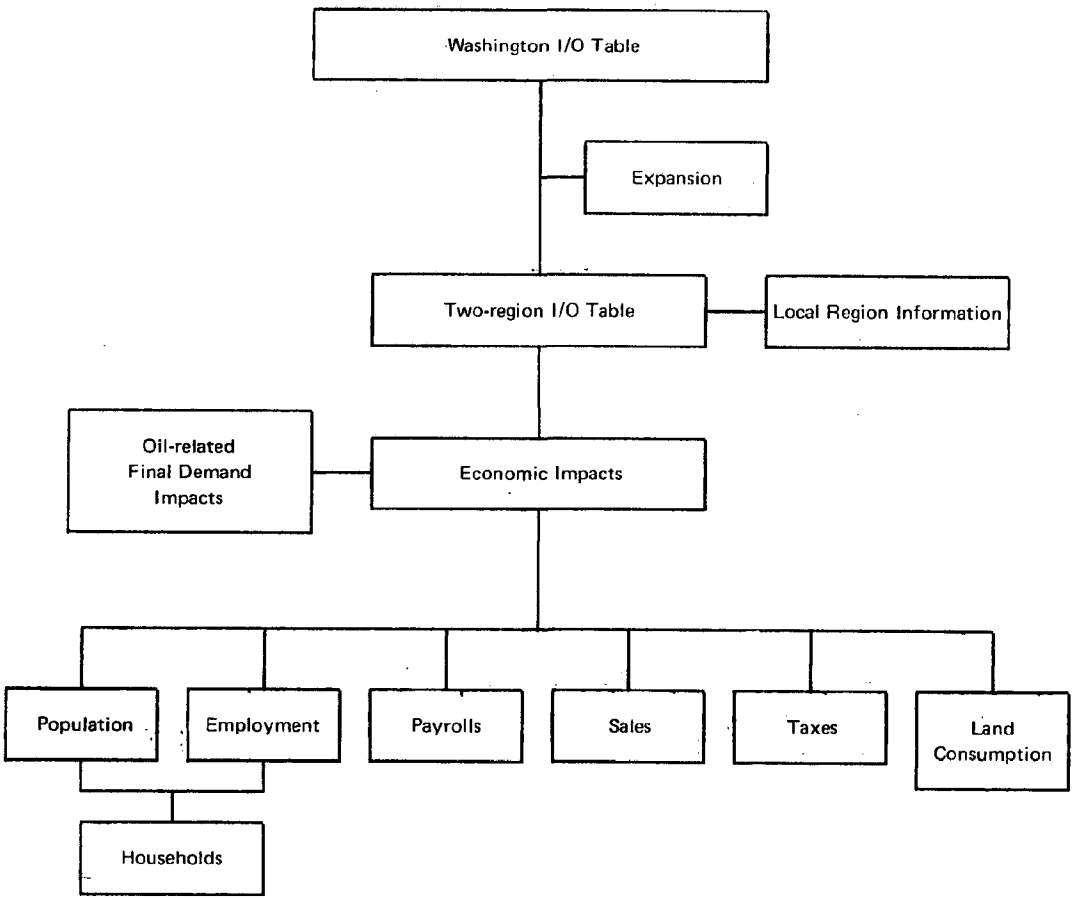
1. Introduction

The economic approach has been discussed qualitatively in Chapter of the report. This appendix outlines in detail the quantitative relationships embodied in the model. Section 1 reviews the approach and comments on some important characteristics of input-output models. Section 2 analyzes the economic and employment impacts. In Section 3 population and land use impacts are estimated. Section 4 summarizes the tax impacts at the direct, indirect, and induced levels. Finally, Section 5 lists and discusses the data sources used to construct the model.

An input-output framework has been utilized to estimate economic impacts of Alaskan oil-related development; Figure 1 summarizes the model's operating procedure. The procedure is based on two 2-region input-output tables for Washington: one for Pierce, King, Kitsap, and Snohomish Counties as region 1 and the rest of the state as region 2 and the other for Clallam, Whatcom, and Skagit Counties as region 1 and the rest of the state as region 2.

Both matrices are based on the Washington I-O study for 1967.* The Washington study includes 51 separate sectors, with most of the disaggregation occurring in manufacturing and primary production industries. Because of the

*While a Washington state I-O matrix for 1972 is available, regional matrices have not been developed. Because of changes made in sector definition and in the manner of sampling, the results of the 1972 I-O table cannot be used to update the 1967 two-region tables. However, it is unlikely that significant changes occurred during that time period.


Washington I/O Table
Expansion
Two-region I/O Table
Local Region Information
Oil-related Final Demand Impacts
Economic Impacts
Population
Employment
Payrolls
Sales
Taxes
Land Consumption
Households

previously small size of oil-related activities in Washington, many of the oil- and logistics-related industries are located in sectors of which they constitute only a small part. Therefore, the sectors may not accurately represent the production function of these activities; it was necessary to add sectors to the matrix which could more closely estimate the impact of oil-related activities.

We were fortunate in finding two previously developed 2-region I-O matrices for Washington for the sets of regions described previously. The matrix with Whatcom, Clallam, and Skagit Counties as region 1 was provided by the Oceanographic Institute and was originally developed using the Moore-Peterson technique which is described below. The second table was based on survey data.

Utilizing two-region tables, it is possible to trace the inter-regional flows of impacts from the small direct-impact region to the rest of the state and thereby isolate that part of economic activity which occurs in the small region.

The estimates of oil-related activity are derived from our assessment of the four scenarios and act as the exogenous driving force of the model. The construct we have employed is capable of separately estimating the impact of each development. These individual impact estimates can then be aggregated to demonstrate the total impact of each scenario, which includes several separate components located in different regions.

The I-O table can directly calculate industry sales at the direct, indirect, and induced level. Using appropriate multipliers obtained from several sources this impact can be translated into payroll, employment, households, and population. These in turn can be translated into new demands for housing, commercial, and industrial areas. Our analysis also incorporates a technique for estimating tax revenues for both state and local government emanating from the increased economic activity of oil-related development.

A major problem of the I-O approach is that it is a static model, assuming relationships found among industries at a particular point in time are constant through time. In the study conducted by Beyers, he found that over a four-year period in the State of Washington there were some significant changes in the coefficients in the input/output matrix.* While a forecast of total sales appears to be reasonably accurate, there were major changes in some individual sectors. This leads to the conclusion that the coefficients are dynamic in character.

There are several causes of these dynamic characteristics: changes in technology, changes in trading patterns as regards import levels, changes in product mix, and changes in relative prices of inputs. Each could cause the input/output coefficients to change. Finally, I-O assumes an economy that experiences constant returns to scale. The assumption of such a production function is a frequent one in the field of economics, but industry

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*Beyers, W. B., "On the Stability of Regional Interindustry Models: The Washington Data for 1963 and 1967," Journal of Regional Science, December, 1972, pp. 363-374.

studies have shown it is not necessarily the case. Therefore, changes in the amount of activity in any one industry could well affect the distribution of purchases from its suppliers and thereby change the coefficients.

2. Economic and Employment Impacts

In performing the economic impact analysis, we are fortunate that Washington already has a Leontief type input/output matrix. These matrices have been developed by the University of Washington on a periodic basis since 1963. Because of the small size of oil-related industries in Washington, they are grouped into large sectors of which they produce only a small percentage of total sales. Because of the different production functions for the other industries included in these sectors the sectoral coefficients may not properly represent the production functions of the oil-related activities. Therefore, several additional sectors for specific oil-related developments, both petroleum flow related and logistical support, were constructed:

Petroleum flow activities*

- Petroleum refinery construction
- Pipeline construction
- Fixed berth monobuoy construction
- Petroleum refinery operations
- Pipeline and transfer facility operation
- Tanker operation

*The basis for the estimation of these sectors was the previous work by the consultants to the Oceanographic Commission for their report, Offshore Petroleum Transfer Systems for Washington State: A Feasibility Study, 1975.

Logistical support activities

Water transportation

Pipeline transportation

Air transportation

Warehousing and whoesaling

The methods employed to construct I-O coefficients for these sectors are reviewed in Section 5.

As mentioned above, the matrix with King, Pierce, and Snohomish Counties as Region 1 was developed by the University of Washington from primary survey data.* The matrix with Clallam, Skagit, and Whatcom Counties as region 1 was developed by the Oceanographic Commission from the 1967 state I-O table using the Moore-Peterson Technique.** That technique is described below.

The direct requirement coefficients for the state matrix can be expressed as a function of the level of interindustry transactions and total output of each industry:***

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*We wish to thank Professor William Beyers of the University of Washington for making this information available to us.

**Our assessment utilized the matrices developed by the Oceanographic Institute and their consultants in their prior discussion. The following indicates how two-region tables are developed using the Moore-Peterson technique.

***For our analysis, "i" and "j" refer to any two sectors of the matrix.

2.a) $a = [x][X]^{-1}$

where a is an n x n matrix of coefficients representing the percentage of total purchases by industry j which are from industry i;

x is an n x n matrix of the level of purchases by industry j of the products of industry i;

X is an n x n diagonal matrix of total output in each industry.

Regional interindustry flows are initially estimated as follows:

2.b) $x^{1*} = [a]X^1$

where x^{1*} is an n x n matrix whose elements equal an initial estimate of interindustry flow in region 1 under the assumption that the interindustry relationships in the regions are the same as those in the state;

X^1 is an n x n diagonal matrix of sales in region 1;

a was defined above in 2.a).

The sum of all interindustry flows will equal the difference between total output of each sector in the region and final demands to the region:

2.c) $W^1 = X^1 - Y^1$

where W^1 is a 1 x n vector of interindustry transactions for region 1;

Y^1 is an 1 x n vector of exogenously determined final demands to region 1;

X^1 was defined above in 2.b) but is used as a 1 x n vector.

If the industrial structures of the region and the state are not equal, T^1 will not equal zero.

2.d) $$T_j^1 = \sum_{i=1}^{n} x_{ij}^{1*} - W_j^1 \text{ for all } j = 1 \text{ to } n$$

where T^1 is an 1 x n vector representing purchases by firms in region 1 from firms in the rest of the state (region 2);

x_{ij}^1 was defined above in 2.b);

W^1 was defined above in 2.c).

The Moore-Peterson technique reduces the excess estimate of regional interindustry transactions, T^1, proportionately across all sectors.

2.e) $$t^1 = [T^1][X^1]^{-1}$$

where t^1 is a 1 x n vector representing the percentage that interindustry transactions in region 1 calculated assuming an equal industrial structure in region 1 as the state, are greater than the actual level of interindustry transactions in region 1;

T^1 was defined above in 2.d);

X^1 was defined above in 2.b); used as an n x n diagonal matrix.

It is assumed that purchases by industry i are reduced proportionately across all sectors. This assumption is overly simplified but the lack of data does not provide any method for increasing the complexity of the formulation.

2.f) $$x^1 = [a][I - t^1]$$

where x^1 is an n x n matrix of transactions levels for region 1;

a was defined above in 2.a);

t^1 was defined above in 2.e) but used as an n x n diagonal matrix;

I is an n x n identity matrix.

The direct requirement coefficients can now be easily calculated by multiplying the x^1 matrix by the inverse output control totals matrix for each industry in region 1.

2.g) $$a^1 = [x][X^1]^{-1}$$

where a^1 is an n x n matrix of direct requirements coefficients for region 1;

x^1 was defined above in 2.f);

X^1 was defined above in 2.b).

Since we assume the same production process for all firms in each industry i, regardless of their location in the state, we must assume that if a^1_{ij} is less than a_{ij} for any ij combination, that there are imports to the local region from the rest of the state. The import coefficient for imports to region 1 from the rest of the state can be expressed as:

2.h) $$m^{21} = a - a^1$$

where m^{21} is an n x n matrix of coefficients representing the direct requirement purchases by firms in region 1 from firms in region 2;

a was defined above in 2.a);

a^1 was defined above in 2.g).

These two matrices, a^1 and m^{21}, describe the column coefficients for region 1. The have the following characteristic:

2.i) $$\sum_{i=1}^{n} a_{ij} = \sum_{i=1}^{n} (m^{21} + a^1) \quad \text{for all } j = 1 \text{ to } n$$

To estimate the intra- and interregional coefficients from region 2 we proceed as follows. State sales coefficients are first calculated.

2.j) $b = [X]^{-1}[x]$

where b is an n x n matrix whose coefficients represent the percentage of total sales of industry i which are interindustry sales to industry j;

x was defined above in 2.a);

X was defined above in 2.a).

Similar sales coefficients are calculated for region 1.

2.k) $b^1 = [X^1]^{-1}[x^1]$

where b^1 is an n x n matrix representing the percentage of total sales of industry i in region 1 which are interindustry sales to industry j in region 1;

x^1 was defined above in 2.f);

X^1 was defined above in 2.b).

The difference between the sales coefficients equals that amount of sales of industries in region 1 which are interindustry sales to industries in region 2.

2.l) $e = b - b^1$

where e is an n x n matrix of coefficients equaling the percentage of sales in industry i in region 1 to industry j in region 2;

b was defined above in 2.j);

b^1 was defined above in 2.k).

Since we would expect the ratio x^1_{ij}/X^1_j to be smaller than the ratio x_{ij}/X_j for any ij combination, the e_{ij} should all be greater than or equal to zero. If the e_{ij} are greater than or equal to zero and we further assume that industry i in region 1 exports the same percentage of its total production to out-of-state firms as industry i in the state, e_{ij} must represent the amount of product produced in region 1 and sold to industries in region 2.

The value of these shipments from region 1 to region 2 equals:

2.m) $$M^{12} = [e][X^1]$$

where M^{12} is an n x n matrix of interregional transactions which equals the flows of interindustry products from region 1 to region 2;

e was defined above in 2.1);

X^1 was defined above in 2.b).

We can now define interindustry flows in region 2:

2.n) $$x^2 = x - M^{12} - x^1 - M^{21}$$

where x^2 is an n x n matrix of interindustry flows in region 2;

x was defined above in 2.a);

M^{12} was defined above in 2.m);

x^1 was defined above in 2.f);

M^{21} is an n x n matrix of interregional interindustry flows from region 2 to region 1; $M^{21} = [m^{21}][X^1]$.

Direct requirement coefficients can now be calculated for region 2.

2.o) $$a^2 = [x^2][X - X^1]^{-1}$$

where a^2 is an n x n matrix of direct requirements inter-industry coefficients for region 2.

x^2 was defined above in 2.n);

X was defined above in 2.a);

X^1 was defined above in 2.b).

We can define region 2's interindustry import coefficients from region 1 as:

2.p) $$m^{12}_{ij} = a_{ij} - a^2_{ij}$$

where m^{12} is an n x n matrix of coefficients representing the direct requirement purchases of firms in region 2 from firms in region 1;

a_{ij} was defined above in 2.a);

a^2_{ij} was defined above in 2.o).

Using the four direct requirement n x n matrices developed above we can construct a two-region matrix of the following form:

2.q) $$[Z] = \begin{vmatrix} a^1 & m^{12} \\ m^{21} & a^2 \end{vmatrix}$$

This calculation completes the Moore-Peterson process.

We used the two matrices provided us to complete the following calculations. We continue to denote the two-region coefficient matrix as the Z matrix with individual elements z_{kg}, where k = 1 to 2n, g = 1 to 2n.

Oil-related final demands are supplied to the model exogenously and are disaggregated by region. Let Y^1_t represent an n x 1 vector of final demands

to region 1 at year 2, and Y_t^2 represent an n x 1 vector of final demands to region 2 at year w. We can construct a 2n x 1 vector of total final demands in the following manner:

2.r)

$$Y_t = \begin{bmatrix} Y_t^1 \\ Y_t^2 \end{bmatrix}$$

Total impact of oil-related activities in year t can then be estimated in the following form.

2.s) $$R_t = (I - Z)^{-1} Y$$

where R_t is a 2n x 1 vector of sales impacts of oil-related final demands in year t disaggregated into two regions;

I is a 2n x 2n identity matrix;

Z is defined above in 2.q);

Y is defined above in 2.r).

More localized impact estimates can also be calculated using the following formulation. The "^" indicates that the coefficients are derived from the $(I - Z)^{-1}$ matrix but are at the same location as in the Z matrix.

2.t)

Geographic Location of Final Demand	Geographic Location of Impact	Calculation Required
Region 1	Region 1	$\hat{a}^1 Y_t^1$
Region 1	Region 2	$\hat{m}^{21} Y_t^1$
Region 2	Region 1	$\hat{m}^{12} Y_t^2$
Region 2	Region 2	$\hat{a}^2 Y_t^2$

One of the major problems with I-O analysis is that it does not reflect the timing of the secondary impacts which arise from a given final demand.

While there exists no universal estimate of the time required to allow the multiplier effect to occur, recent work has been completed in the state of Washington to estimate the timing of secondary impacts in response to an initial increase in personal income. This work has shown that a significant portion of the total response will occur as long as four years after the initial stimulus. This work is incorporated into our assessment of the impacts of oil-related development on Washington. The total impact resulting from a final demand is calculated using equation 2.s. The secondary impact is then subtracted from the total impact and is distributed over a four-year period. Final demands are allocated to the initial year. Therefore, to determine the total impacts on Washington of oil-related activity in any year, it is necessary to include not only the final demand impacts for that year but also secondary impacts from that year and the three previous years. The equational specification of this method is shown below in equation 2.u.

DISTRIBUTION OF MULTIPLIER IMPACTS OVER TIME

Year	Percent of Total Impact
1 (initial impact period)	31.5%
2	31.7
3	16.8
4	14.7
Total	94.7%*

*Does not sum to 100% because some small parts of total impact occur more than three years after the year of initial impact.

Source: Washington State Economic Model, Washington State Department of Revenue.

2.u) $$H_t = \sum_{f=t-3}^{t} \phi_f (R_f - Y_f) + Y_t$$

where H_t is the actual impact on the economy of the final demands from year t-2 to t;

ϕ_f is the percentage of total impact resulting from final demand in year 2--R_t--that occurs during year f.

R_f was defined above in equation 2.s).

In a manner similar to that used in equation 2.t) to measure the total impact of the final demands in any year on each region of the state, the following equation shows the manner in which actual impacts on each part of the state are computed:

2.v)

Geographic Location of Final Demand	Geographic Location of Impact	Calculation Required
Region 1	Region 1	$\sum_{f=t-3}^{t} \phi_f (\hat{a}^1 Y_f^1 - Y_f^1) + Y_t^1$
Region 1	Region 2	$\sum_{f=t-3}^{t} \phi_f (\hat{m}^{21} Y_f^1) - Y_f^1) + Y_t^1$
Region 2	Region 1	$\sum_{f=t-3}^{t} \phi_f (\hat{m}^{12} Y_f^2) - Y_f^2) + Y_t^2$
Region 2	Region 2	$\sum_{f=t-3}^{t} \phi_f (\hat{a}^2 Y_f^2 - Y_f^2) + Y_t^2$

We assume that for each industry the exogenously determined employment multiplier will be equal for both regions and will equal the average state employment multiplier. We can calculate employment impacts in each region in the following manner:

2.w)

$$K_t^1 = \alpha \sum_{f=t-3}^{t} \phi_f(\hat{a}_1 Y_f^1 + \hat{m}^{12} Y_f^2 - Y_f^1) + Y_t^1$$

$$K_t^2 = \alpha \sum_{f=t-3}^{t} \phi_f(\hat{a}^2 Y_f^2 + \hat{m}^{21} Y_f^2 - Y_f^2) + Y_t^2$$

where K_t^1 is an n x 1 vector which equals the number of full-time equivalent jobs in sector i in region 1 supported by Alaskan oil-related development at time t;

K_t^2 is an n x 1 vector which equals the number of full-time equivalent jobs in sector i in region 2 supported by Alaskan oil-related development at time t;

$\hat{a}^1$ was defined above in 2.g);

Y_f^1 was defined above in 2.r);

$\hat{m}^{12}$ was defined above in 2.m);

Y_f^2 was defined above in 2.r;

$\hat{a}^2$ was defined above in 2.o);

$\hat{m}^{21}$ was defined above in 2.h);

α is an n x 1 vector of employment multipliers which express the number of full-time jobs per dollar of sales for each industry;

ϕ_f was defined above in 2.u).

To calculate the wage and salary income we assume that for each industry the exogenously determined payroll multiplier will be equal for both regions and will equal the average state payroll multiplier. We can calculate payroll impacts in each region as follows:

2.x)

$$P_t^1 = \delta \sum_{f=t-3}^{t} \phi_f (\hat{a}^1 Y_f^1 + \hat{m}^{12} Y_f^2 - Y_f^1) + Y_t^1$$

$$P_t^2 = \delta \sum_{f=t-3} \phi_f (\hat{a}^2 Y_f^2 + \hat{m}^{21} Y_f^1 - Y_f^2) + Y_t^2$$

where P_t^1 is an n x 1 vector which equals the payroll in sector i in region 1 supported by Alaskan oil-related development at time t;

P_t^2 is an n x 1 vector which equals the payroll in sector i in region 2 supported by Alaskan oil-related development at time t;

$\hat{a}^1$ was defined in 2.g);

Y_f^1 was defined in 2.r);

$\hat{m}^{12}$ was defined in 2.m);

Y_f^2 was defined in 2.r);

$\hat{a}^2$ was defined in 2.o);

$\hat{m}^{21}$ was defined in 2.h);

δ is an n x 1 vector of payroll multipliers which express the payroll per dollar sales in each industry;

ϕ_f was defined in 2.u).

3. Population and Land Use Impacts

Estimates of employment impacts conducted in Section 2 will be the basis for estimating population and residential land consumption impacts. Our analysis is unable to project for the distant future the number of oil-related jobs which will be held by persons who would live in either region

in the absence of these jobs. We would expect that there would be some. Our analysis will estimate the number of people and households who will be supported by oil-related development and the amount of residential land they will consume.

Population in each region supported by oil-related development can be calculated as follows:

3.a)

$$O_t^1 = \omega^1 \left(\sum_{i=1}^{n} K_{it}^1 \right)$$

$$O_t^2 = \omega^2 \left(\sum_{i=1}^{n} K_{it}^2 \right)$$

where O_t^1 is the population supported in region 1 at time t by oil-related activities;

ω_t^1 is a ratio of population to employment for region 1;

K_t^1 is the employment in industry i in region 1 at time t;

O_t^2 is the population supported in region 2 at time t by oil-related activities;

ω_t^2 is a ratio of population to employment for region 2;

K_t^2 is the employment in industry i in region 2 at time t.

Households are estimated on the basis of population and household size estimates:

3.b)

$$F_t^1 = O_t^1 / \rho_t^1$$

$$F_t^2 = O_t^2 / \rho_t^2$$

where F_t^1 is the number of households in region 1 at time t supported by oil-related activity;

O_t^1 is defined above in 3.a);

ρ_t^1 is a population per household ratio for region 1;

F_t^2 is the number of households in region 2 at time t supported by oil-related activities;

O_t^2 is defined above in 3.a);

ρ_t^1 is a population per household ratio for region 2.

Residential land consumption will be based on exogenously determined residential land per household estimates.

3.c) $$L_t^1 = \sigma^1 F_t^1$$

$$L_t^2 = \sigma^2 F_t^2$$

where L_t^1 is the amount of residential land needed in region 1 at time t to house families supported by oil-related development;

σ_t^1 is an exogenously determined estimate of land consumption per household in region 1;

F_t^1 was defined above in 3.b);

L_t^2 is the amount of residential land needed in region 2 at time t to house families supported by oil-related development;

σ_t^2 is an exogenously determined estimate of land consumption per household in region 2;

F_t^2 was defined above in 3.b).

4. Tax Revenues

Washington's tax structure is based largely on a series of excise taxes; the sales tax and the business and occupation tax generate most of the state's tax revenues. Washington, however, has no state income tax on either personal or business income. Therefore, the local and state tax burden on Washington's residents is approximately equal to the average burden for all states.

In our assessment of the impact of oil-related developments, we have concentrated our estimate of tax revenues on the following sources of taxation: sales and use taxes, business and occupation taxes, special excise taxes, and property taxes.

The sales tax structure in Washington applies to most retail sales and to selected personal services. Tax exempt items include personal and professional services, medical drugs and cigarettes. In addition, a 2% tax is applied to transient accommodations for use in funding stadium construction in lieu of that portion of the sales tax. The total tax rate at transient accommodations is the same as for the general sales tax. Sales tax receipts were estimated in the following manner:

4.a) $$S_t = (\lambda_t + \eta_t)H_t$$

where S_t is a 2n x 1 vector of state and local sales tax receipts by sector for year t;

λ_t is a 2n x 2n diagonal matrix of the state sales tax rate times the percentage of sales in sector i that are taxable at time t; it is assumed that $\lambda_{ij} = \lambda_{ik}$ for all j and k;

η_t is a 2n x 2n diagonal matrix of the local sales tax rate times the percentage of sales in sector i that are taxable at time t; it is assumed that $\eta_{ij} = \eta_{ik}$ for all j and k;

H_t was defined in 2.u).

The business and occupation tax is levied on the gross revenues of varying firms. The tax rate varies by business type but ranges from a low of 0.01% for purchasers of wheat, oats, dry peas, corn and barley to be sold at wholesale to a high of 1.0% for service and miscellaneous businesses. Business and occupation taxes are estimated in the following manner:

4.b) $$B_t = \psi_t H_t$$

where B_t is a 2n x 1 vector of business and occupation tax receipts by sector for year t;

ψ_t is a 2n x 2n diagonal matrix of the state sales tax rate times the percentage of sales in sector i that are taxable at time t; it is assumed that $\psi_{ij} = \psi_{ik}$ for all j and k;

H_t was defined above in 2.u).

Several selective excise taxes are applied in Washington including taxes on the sales of gasoline, cigarettes and alcoholic beverages. Revenues from these tax sources are estimated in the following equation:

4.c) $$Q_t = (v_t + c_t + h_t)(0_t^1 + 0_t^2)$$

where Q_t is the amount of cigarette, gasoline, and alcoholic beverage taxes collected in year t;

v_t is an exogenous estimate of gasoline tax revenues per capita in year t;

c_t is an exogenous estimate of cigarette tax revenues per capita in year t;

h_t is an exogenous estimate of alcoholic beverage tax revenue per capita in year t;

O_t^1 was defined in 3.a);

O_t^2 was defined in 3.a).

The state levies a universal property tax of $3.60 per $1,000 of property values for equalization of school taxes across districts. The tax rate is based on a 100% evaluation of all taxable property. Estimates of the amount of revenue generated by this source from oil-related development is based on both property values related to business development and expansion and to personal income.

4.d) $$D_t = \tau_t(P_t^1 + P_t^2) + W_t$$

where D_t is the state property tax revenue generated during year t;

τ_t is an n x 1 vector of the state property tax rate in year t times an exogenously determined amount of residential property value per dollar of income in year t;

P_t^1 was defined in 2.x);

P_t^2 was defined in 2.x);

W_t is an exogenously determined amount of commercial property value in year t.

Total tax revenues will equal:

4.e) $$T_t = \sum_{i=1}^{2n} (S_{it} + B_{it}) + Q_t + D_t$$

where T_t is total tax revenues generated in year t;

S_{it} was defined in 4.a);

B_{it} was defined in 4.b);

Q_t was defined in 4.c);

D_t was defined in 4.d).

5. Data Sources

This section identifies the sources of information used in the analysis and, when appropriate, describes how required information was derived from both primary and secondary sources. In order to facilitate understanding of the section, the variables are discussed in the order in which they appear in the review of the model presented in sections 2, 3, and 4.

A. Additional sectors for the I-O matrices

As discussed previously, it was necessary to construct coefficients for some additional sectors if accurate estimates of logistical support and petroleum flow activities were to be made. Specifically, logistical support activities were expected to be concentrated in the following sectors:

- Water transportation, SIC category 44;
- Air transportation, SIC category 45;
- Durable and non-durable wholesale trade, SIC categories 50 and 51.

Petroleum flow activities would fall in the following categories:

- Petroleum Refinery Construction, SIC category, pt. 1511;
- Pipeline Construction, SIC category, pt. 1511;
- Monobuoy-Dock Construction, SIC category, pt. 1621;

- Petroleum Refining, SIC category 29;
- Pipeline Operation, SIC category 46; and
- Tanker Operations, SIC category 4421.

Estimates have previously been made of the interindustry relationships for the petroleum flow activities and these interrelationships have been incorporated into an I-O model used in a recent assessment of alternative oil transfer systems.* This information has been incorporated directly into this analysis.

Because the sectors in which the logistical activities will concentrate are not separated from other sectors in the Washington I-O matrix, it was necessary to construct estimates of these sectors from secondary data. Three sources of information were used to construct the estimates: the 1967 Washington I-O table; the 1967 Input-Output Structure of the U.S. Economy; and County Business Patterns for both the United States and the State of Washington.

To illustrate the method used to construct the estimates of the sectors, we will analyze the steps used to construct an estimate of wholesaling activities. The method used to construct the other sector estimates is similar. In the Washington I-O table wholesaling and retailing activities are combined in a single sector, whereas in the national table they are disaggregated into two sectors. Call the wholesaling sector w and the

*Oceanographic Commission of Washington, Offshore Petroleum Transfer Systems for Washington State, 1975.

retailing sector r and the combined sectors in the Washington I-O matrix c. The transactions table for the national I-O matrix indicates for sectors w and r their purchases from other sectors of the economy, while the Washington I-O matrix indicates purchases by sector c from other industries. Let the purchases by sector w from industry i be represented as x_{iw}, purchases from sector i by sector r be represented as x_{ir}, and purchases by sector c from industry i be represented by x_{ic}. Then total intermediate purchases equal the following:

5.a)

$$\bar{X}^N_w = \sum_{i=1}^{k} x^N_{iw}$$

$$\bar{X}^N_r = \sum_{i=1}^{k} x^N_{ir}$$

$$\bar{X}^W_c = \sum_{i=1}^{n} x^W_{ic}$$

where $\bar{X}^N_w$ is the total intermediate purchases of the wholesaling sector for the national I-O matrix;

$\bar{X}^N_r$ is the total intermediate purchases of the retailing sector for the national I-O matrix;

$\bar{X}^W_c$ is the total intermediate purchases of the retail and wholesale sectors of the Washington I-O matrix;

x^N_{iw} is the level of purchases of the wholesaling sector from industry i in the national I-O matrix;

x^N_{ir} is the level of purchases of the retailing sector from industry i in the national I-O matrix;

x^W_{ic} is the level of purchases of the retail and wholesale sectors from industry i in the Washington I-O matrix.

There are more sectors in the national I-O matrix than there are in the Washington I-O matrix, e.g., k>n. Therefore, it is necessary to collapse some of the sectors of the national matrix. This was done using the definitions of the sectors for each matrix as defined by the SIC categories represented. Direct technical coefficients were calculated:

5.b

$$a^N_{iw} = x^N_{iw}/\bar{X}^N_w \qquad \text{for } i = 1 \text{ to } n$$

$$a^N_{ir} = x^N_{ir}/\bar{X}^N_r \qquad \text{for } i = 1 \text{ to } n$$

$$a^W_{ic} = x^W_{ic}/\bar{X}^W_c \qquad \text{for } i = 1 \text{ to } n$$

where a^N_{iw} is the direct coefficient of purchases of the wholesaling sector from industry i for national interindustry transactions data;

a^N_{ir} is the direct coefficient of purchases of the retail sector from industry i for national interindustry transactions data;

a^W_{ic} is the direct coefficient of purchases of the wholesaling and retailing sector from industry i for Washington interindustry transactions data;

a^W_{ir} is the direct coefficient of purchases of the retail sector from industry i for Washington interindustry transactions data;

and, all other variables were defined in 5.a).

Because there is less leakage in the national economy than in the Washington economy, it is safe to assume the following:

5.c)

$$a_{iw}^{N} > a_{iw}^{W} \qquad \text{for all } i = 1 \text{ to } n;$$

$$a_{ir}^{N} > a_{ir}^{W} \qquad \text{for all } i = 1 \text{ to } n.$$

We can compare intermediate purchases as a percentage of total sales for both retailing and wholesaling operations at both the national and state level.

5.d)

$$\gamma^{N} = \frac{\bar{X}_{w}^{N} + \bar{X}_{r}^{N}}{X_{w}^{N} + X_{r}^{N}}$$

$$\gamma^{W} = \frac{\bar{X}_{w}^{W} + \bar{X}_{r}^{W}}{X_{w}^{W} + X_{r}^{W}}$$

where γ^{N} is the ratio between intermediate and total sales for the retail and wholesale sector at the national level;

γ^{W} is the ratio between intermediate and total sales for the retail and wholesale sectors in Washington;

X_{w}^{N} is the total sales of all wholesale operations in the nation as derived from County Business Patterns;

X_{r}^{N} is the total sales of all retail operations in the nation as derived from County Business Patterns;

X_{w}^{W} is the total sales of all wholesale operations in Washington as derived from County Business Patterns;

X_{r}^{W} is the total sales of all retail operations in Washington as derived from County Business Patterns;

and, all other variables were defined above in 5.a).

Because there are greater leakages in the Washington economy than there are in the national economy, it is probable that $\gamma^N > \gamma^W$. We assume that the greater leakages in the Washington economy are equally divided between the wholesale and retail sectors. Therefore, we can calculate the percentage of additional leakage as:

5.e)

$$\beta = \frac{\gamma^N - \gamma^W}{\gamma^N}$$

where β is the percentage difference between national interindustry purchases as a percentage of total purchases and Washington interindustry sales as a percentage of total purchases;

and, all other variables were defined in 5.d).

We now make the further assumption that production technology of Washington firms in both the retail and wholesale sectors is the same as the national technology. Certainly, there can be expected to be some minor variations, but these will probably be minor, and in addition, no source of information exists which would enable us to make accurate corrections. Therefore, we can assume that any differences which appear between Washington and national interindustry coefficients derive from the comparatively greater need of Washington firms to import from outside the state. β is an estimate of the magnitude of these additional imports. Using this coefficient we can calculate estimates for Washington direct purchase interindustry coefficients.

5.f) $$a^W_{iw} = (1 - \beta)a^N_{iw} \qquad \text{for } i = 1 \text{ to } n$$

$$a^W_{ir} = (1 - \beta)a^N_{ir} \qquad \text{for } i = 1 \text{ to } n$$

where a^W_{iw} is the estimated direct purchases coefficient for wholesaling operations from industry in Washington;

a^W_{ir} is the estimated direct purchases coefficient for retail operations from industry i in Washington;

and all other variables were described above in equations 5.e) and 5.b).

The calculations of row coefficients is far easier. In this case let us assume the row coefficients for retail and wholesale operations in Washington are represented as a^W_{cj}. Utilizing the transactions table for the national I-O matrix we can construct estimates of national I-O coefficients for the sectors in the Washington I-O matrix for both retail and wholesale operations. Let these direct purchases coefficients for wholesale and retail operations be given by a^N_{wj} and a^N_{wr}, respectively. We know that the sum of the coefficients for wholesale and retail operations we hope to estimate for Washington will equal the total coefficient for combined wholesale and retail operations -- a^W_{cj}. Any difference between the wholesale and retail coefficients at the state and national level can be attributed to the need for Washington industries to import a greater percentage of their intermediate requirements than is true for the nation as a whole. The additional percentage of imports can be calculated:

5.g)

$$\Lambda = \frac{a^N_{wj} + a^N_{rj} - a^W_{cj}}{a^N_{wj} + a^N_{rj}}$$

where Λ is the percentage difference between national interindustry sales as a percentage of total sales and Washington interindustry sales as a percentage of total sales;

a^N_{wj} is the direct purchases coefficient of the purchases of industry j from the wholesale industry at the national level;

a^N_{rj} is the direct purchases coefficient of the purchases of industry j from the retail industry at the national level;

a^W_{cj} is the direct purchases coefficient of the purchases of industry j from the wholesale and retail industries in Washington.

Assuming that the production process of all sectors in Washington is the same as it is for the nation and that the only differences in I-O coefficients occur because of different leakage rates, row coefficients for the wholesale and retail sectors in Washington can be calculated as follows:

5.h)

$$a^W_{wj} = (1 - \Lambda)a^N_{wj} \qquad \text{for all } j = 1 \text{ to } n$$

$$a^W_{rj} = (1 - \Lambda)a^N_{rj} \qquad \text{for all } j = 1 \text{ to } n$$

where a^W_{wj} is the estimated direct purchases coefficient for industry j of the output of the wholesale sector in Washington;

a^W_{rj} is the estimated direct purchases coefficient for industry j of the output of the retail sector in Washington;

and, all other variables have been defined above in 5.g).

Given these two sets of coefficients for each sector, we now have the necessary expanded coefficient matrix. However, this procedure does not estimate the interindustry coefficients between the wholesale and retail sectors, nor the purchases of the wholesale and retail sectors from themselves. The method used to make these calculations utilized the row coefficients from the national I-O matrix as maximum total and then used a formulation similar to that above and a series of simultaneous equations to obtain the final estimates of these four coefficients.

As indicated previously, two 2-region I-O matrices were used. Each considered a small part of Washington as one region and the rest of the state as the other region. The specific definition of the regions used in each matrix and their applicability in this study is shown in Table C-1.

TABLE C-1

Matrix	Region 1 Boundaries	Region 2 Boundaries	Categories of Final Demands Applied
1	Clallam, Whatcom, Skagit, and Grays Harbor Counties	Rest of Washington	Oil flows, Pipeline Operation and Construction, Refinery Operation
2	Pierce, Kitsap, King, and Snohomish Counties	Rest of Washington	Logistical Support Activities

Because the linkages between Washington and the rest of the country are not indicated in the I-O matrices, the models are capable of estimating only the impact of oil-related developments on Washington.

Matrix 1 (see Table C-1) was taken from a recent report completed by the Oceanographic Institute of Washington. The matrix was derived from the 52-sector 1967 Washington I-O matrix. In addition, several additional sectors were incorporated into the matrix for petroleum transfer and refinery operations. The direct coefficients of this matrix are listed in Table C-2.

Matrix 2 of Table C-1 was taken from work recently completed at the University of Washington to disaggregate the 1967 state I-O matrix into a two-region matrix for the four central Puget Sound Counties and the rest of the state. To this sixteen-sector matrix were added the four sectors of air and sea transportation, whoesaling and retail operations. The direct coefficients of the resulting matrix are shown in Table C-3.

Payroll multipliers are explicit in the I-O matrices as they include a row for payroll expenditures as one part of total industry purchases and a column for payroll consumption. By endogenizing personal income and expenditures of personal income it is unnecessary to make separate estimates of the induced impacts. The payroll multipliers used are those used in the previous Oceanographic study and the I-O model for Central Puget Sound. They represent the percentage of total business expenditures that accrue to payrolls, a percentage that has probably not changed

TABLE C-2

TWO-REGION INVERSE INPUT-OUTPUT MATRIX[a]

		1	2	3	4	5	6	7	8	9	10
1. Agriculture - Forestry - Mining	1	1.036067	0.040420	0.023276	0.002174	0.000394	0.002758	0.002167	0.002474	0.009660	0.003903
2. Food Products	2	0.048812	1.066899	0.021556	0.015808	0.002834	0.009293	0.015477	0.018709	0.021058	0.033941
3. Forest Products	3	0.013161	0.028929	1.273920	0.012300	0.005443	0.008561	0.014669	0.014054	0.041629	0.027928
4. Chemicals	4	0.003699	0.000718	0.005114	1.010606	0.000773	0.000224	0.000982	0.000710	0.000920	0.001047
5. Petroleum	5	0.034082	0.017635	0.026556	0.035761	1.003545	0.009197	0.015648	0.018342	0.020107	0.026263
6. Metals	6	0.002109	0.003335	0.003317	0.003493	0.000473	1.011808	0.052914	0.024311	0.003039	0.004723
7. Fabricated Metals and Machinery	7	0.007275	0.047800	0.018063	0.010709	0.001478	0.005249	1.029678	0.013277	0.011960	0.010291
8. Transportation Equipment	8	0.001766	0.001226	0.002658	0.001282	0.000753	0.000843	0.001738	1.023490	0.001799	0.018400
9. Miscellaneous Manufacturing	9	0.015070	0.018657	0.018895	0.013985	0.002571	0.010502	0.022788	0.017173	1.049419	0.023632
10. Transport Services	10	0.018134	0.030213	0.065524	0.018245	0.021524	0.015579	0.012053	0.011562	0.032303	1.047496
11. Utilities	11	0.020377	0.015492	0.035105	0.061387	0.016109	0.045232	0.024135	0.019896	0.033463	0.028622
12. Communication	12	0.012856	0.016184	0.016253	0.013911	0.002277	0.007608	0.014171	0.015307	0.017743	0.023259
13. Construction	13	0.040541	0.030438	0.057320	0.044034	0.013348	0.027008	0.044411	0.055340	0.055785	0.088211
14. Trade	14	0.090400	0.081301	0.134662	0.097298	0.014659	0.056728	0.097549	0.115251	0.121169	0.166580
15. Finance, Insurance, Real Estate	15	0.022320	0.017738	0.032915	0.023202	0.009565	0.016370	0.025522	0.027799	0.030193	0.049202
16. Services	16	0.061360	0.041304	0.070781	0.062982	0.012051	0.035145	0.066108	0.071384	0.081598	0.097204
17. Pipeline Construction	17	0.000004	0.000005	0.000006	0.000004	0.000001	0.000003	0.000004	0.000005	0.000005	0.000007
18. Petroleum Construction	18	0.000002	0.000001	0.000002	0.000004	0.000000	0.000000	0.000000	0.000000	0.000001	0.000001
19. Dock-buoy Operation	19	0.000006	0.000007	0.000008	0.000006	0.000001	0.000003	0.000005	0.000006	0.000007	0.000009
20. Pipe-dock Operation	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21. Shipping	21	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22. Petroleum Operation	22	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23. Agriculture - Forestry - Mining	23	0.108076	0.229586	0.143438	0.025767	0.005056	0.023088	0.024377	0.027934	0.068360	0.042393
24. Food Products	24	0.043117	0.047359	0.061602	0.042379	0.008302	0.025604	0.040073	0.047191	0.053339	0.068035
25. Forest Products	25	0.006606	0.008127	0.009345	0.006346	0.001468	0.003801	0.005280	0.005776	0.007347	0.008725
26. Chemicals	26	0.012203	0.005687	0.016834	0.029989	0.002354	0.001397	0.003714	0.003057	0.004323	0.004540
27. Petroleum	27	0.004142	0.005763	0.005861	0.003470	0.000830	0.002063	0.002813	0.003055	0.004195	0.004713
28. Metals	28	0.000972	0.001427	0.001417	0.000966	0.000212	0.000546	0.000674	0.000846	0.001068	0.001228
29. Fabricated Metals and Machinery	29	0.005637	0.010985	0.008823	0.005979	0.001174	0.003369	0.007357	0.006017	0.006853	0.007830
30. Transportation Equipment	30	0.000768	0.001016	0.001162	0.000697	0.000199	0.000429	0.000571	0.000616	0.000844	0.000998
31. Miscellaneous Manufacturing	31	0.009321	0.011014	0.012988	0.008916	0.002070	0.005317	0.007723	0.008415	0.010516	0.012697
32. Transport Services	32	0.009843	0.013790	0.019267	0.009152	0.004414	0.006028	0.007065	0.007528	0.012161	0.015437
33. Utilities	33	0.020807	0.021685	0.031699	0.037542	0.009195	0.024880	0.019028	0.017992	0.026524	0.026539
34. Communication	34	0.010320	0.011615	0.014066	0.010055	0.002188	0.005843	0.008832	0.009574	0.011926	0.014341
35. Construction	35	0.021447	0.026172	0.030202	0.020822	0.004945	0.012423	0.017069	0.018428	0.023713	0.028084
36. Trade	36	0.076938	0.089269	0.109450	0.075565	0.016276	0.044669	0.065430	0.072565	0.088429	0.108788
37. Finance, Insurance, Real Estate	37	0.038382	0.039970	0.055094	0.038107	0.011949	0.024541	0.036194	0.039324	0.046430	0.064816
38. Services	38	0.072826	0.075025	0.095473	0.071580	0.015563	0.041593	0.064972	0.070168	0.085979	0.101569
39. Value Added Local	39	0.434783	0.343125	0.639621	0.492464	0.078140	0.296486	0.519933	0.649082	0.645720	0.901637
40. Value Added Other Washington	40	0.272598	0.330343	0.383334	0.264906	0.062571	0.157501	0.218500	0.236184	0.302306	0.359447

a. Region 1: Clallam, Whatcom, and Skagit Counties; Region 2: the rest of Washington.

TABLE C-2 (Continued)

		11	12	13	14	15	16	17	18	19	20
1. Agriculture - Forestry - Mining	1	0.001495	0.003655	0.005524	0.003957	0.002482	0.003381	0.001701	0.007451	0.007715	0.000153
2. Food Products	2	0.011170	0.027405	0.017960	0.033825	0.019213	0.028033	0.013704	0.018860	0.019086	0.001511
3. Forest Products	3	0.014931	0.023001	0.088203	0.025077	0.014891	0.018703	0.008670	0.015199	0.015566	0.000637
4. Chemicals	4	0.000556	0.000630	0.002953	0.001122	0.000451	0.001903	0.000280	0.000485	0.000878	0.000020
5. Petroleum	5	0.012314	0.028561	0.025773	0.034739	0.020873	0.020202	0.013401	0.018751	0.017927	0.001834
6. Metals	6	0.002382	0.004316	0.028726	0.003164	0.001915	0.002582	0.001298	0.002229	0.001978	0.000068
7. Fabricated Metals and Machinery	7	0.008606	0.024128	0.064421	0.010941	0.006166	0.011745	0.005937	0.009102	0.005929	0.000272
8. Transportation Equipment	8	0.001084	0.002123	0.002877	0.002964	0.001468	0.001747	0.000979	0.001205	0.001097	0.000038
9. Miscellaneous Manufacturing	9	0.010580	0.029120	0.080468	0.049478	0.027498	0.056676	0.018740	0.033673	0.083998	0.008646
10. Transport Services	10	0.013067	0.015479	0.031306	0.022416	0.014785	0.014432	0.008882	0.009553	0.009426	0.000513
11. Utilities	11	1.110780	0.029595	0.023249	0.051666	0.021527	0.035081	0.011680	0.014815	0.013998	0.011557
12. Communication	12	0.009304	1.027217	0.015867	0.029526	0.019276	0.045935	0.010537	0.011354	0.010025	0.000422
13. Construction	13	0.041049	0.090252	1.049054	0.078635	0.058786	0.069254	0.035988	0.045105	0.040648	0.001206
14. Trade	14	0.059880	0.169248	0.126666	1.175342	0.129745	0.143248	0.077714	0.094763	0.084867	0.002296
15. Finance, Insurance, Real Estate	15	0.019265	0.043114	0.029136	0.054681	1.057781	0.041960	0.017892	0.022158	0.021529	0.000609
16. Services	16	0.070104	0.101150	0.075281	0.123129	0.086693	1.116460	0.051495	0.062092	0.054817	0.001797
17. Pipeline Construction	17	0.000003	0.000007	0.000005	0.000007	0.000005	0.000006	1.000004	0.000005	0.000004	0.000001
18. Petroleum Construction	18	0.000000	0.000000	0.000001	0.000001	0.000000	0.000001	0.000000	1.000000	0.000001	0.000000
19. Dock-buoy Operation	19	0.000005	0.000009	0.000006	0.000010	0.000007	0.000008	0.000005	0.000007	1.000006	0.000001
20. Pipe-dock Operation	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000
21. Shipping	21	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22. Petroleum Operation	22	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23. Agriculture - Forestry - Mining	23	0.019862	0.041140	0.044800	0.044373	0.030221	0.038061	0.022121	0.029760	0.028630	0.004756
24. Food Products	24	0.033616	0.069247	0.047534	0.072027	0.051458	0.061655	0.038459	0.048368	0.041782	0.008960
25. Forest Products	25	0.005868	0.008496	0.006696	0.009747	0.007322	0.008468	0.005947	0.010931	0.008947	0.002628
26. Chemicals	26	0.002583	0.003382	0.009491	0.004956	0.002603	0.006850	0.001946	0.003181	0.004503	0.000438
27. Petroleum	27	0.003072	0.004484	0.003749	0.005211	0.003923	0.004535	0.003233	0.005859	0.006396	0.001275
28. Metals	28	0.000851	0.001268	0.001271	0.001369	0.001012	0.001211	0.001981	0.005724	0.003855	0.000376
29. Fabricated Metals and Machinery	29	0.005098	0.009345	0.012207	0.008598	0.006090	0.007761	0.028328	0.043904	0.014484	0.001782
30. Transportation Equipment	30	0.000635	0.000903	0.000771	0.001056	0.000794	0.000907	0.000691	0.000848	0.000675	0.000272
31. Miscellaneous Manufacturing	31	0.008195	0.012376	0.009743	0.014380	0.011020	0.012511	0.009018	0.015482	0.019454	0.003075
32. Transport Services	32	0.007652	0.010857	0.011252	0.013027	0.009490	0.010624	0.009987	0.009767	0.008046	0.002637
33. Utilities	33	0.055206	0.026523	0.021562	0.033896	0.021504	0.029262	0.015638	0.020111	0.017239	0.056429
34. Communication	34	0.008926	0.014389	0.010908	0.016840	0.012332	0.017402	0.010330	0.012066	0.009805	0.003626
35. Construction	35	0.019684	0.027126	0.021724	0.031786	0.024259	0.027716	0.019554	0.024657	0.020387	0.009057
36. Trade	36	0.064755	0.106728	0.083850	0.120613	0.069505	0.103426	0.075536	0.087713	0.072676	0.024224
37. Finance, Insurance, Real Estate	37	0.033763	0.059448	0.043693	0.072538	0.066945	0.059073	0.036844	0.044092	0.041355	0.009359
38. Services	38	0.072084	0.101553	0.078950	0.120854	0.088898	0.109307	0.079978	0.104906	0.080319	0.020305
39. Value Added Local	39	0.325995	0.950743	0.572450	0.909957	0.617270	0.767694	0.427190	0.535102	0.481585	0.012418
40. Value Added Other Washington	40	0.248373	0.347641	0.277892	0.406865	0.310846	0.354722	0.251381	0.317144	0.261732	0.110991

TABLE C-2 (Continued)

		21	22	23	24	25	26	27	28	29	30
1. Agriculture - Forestry - Mining	1	0.000578	0.000445	0.000706	0.000605	0.000669	0.000501	0.000390	0.000466	0.000595	0.000530
2. Food Products	2	0.005744	0.003205	0.012095	0.013377	0.015692	0.011673	0.009147	0.010923	0.014231	0.012449
3. Forest Products	3	0.003305	0.002213	0.000968	0.001309	0.001098	0.000913	0.000639	0.000825	0.000980	0.000871
4. Chemicals	4	0.000181	0.000471	0.000083	0.000058	0.000080	0.000123	0.000045	0.000058	0.000056	0.000060
5. Petroleum	5	0.127582	0.007725	0.024339	0.016496	0.025911	0.020567	0.012240	0.024282	0.015348	0.015969
6. Metals	6	0.000427	0.000429	0.000117	0.000129	0.000144	0.000143	0.000081	0.000097	0.000689	0.000342
7. Fabricated Metals and Machinery	7	0.001347	0.000993	0.000655	0.000687	0.000822	0.000661	0.000477	0.000578	0.000747	0.000701
8. Transportation Equipment	8	0.000587	0.000191	0.000058	0.000051	0.000070	0.000058	0.000040	0.000053	0.000054	0.000054
9. Miscellaneous Manufacturing	9	0.003604	0.002310	0.000448	0.000407	0.000504	0.000420	0.000281	0.000352	0.000480	0.000409
10. Transport Services	10	0.018780	0.002099	0.001082	0.000857	0.001122	0.000992	0.000585	0.000901	0.000847	0.000805
11. Utilities	11	0.005665	0.013988	0.001006	0.000749	0.001034	0.001781	0.000550	0.000928	0.000879	0.000732
12. Communication	12	0.002705	0.001975	0.000312	0.000253	0.000315	0.000305	0.000176	0.000227	0.000281	0.000244
13. Construction	13	0.011951	0.010113	0.000690	0.000752	0.000958	0.000832	0.000515	0.000740	0.000767	0.000707
14. Trade	14	0.022999	0.014060	0.001893	0.001655	0.002005	0.001805	0.001111	0.001453	0.001748	0.001533
15. Finance, Insurance, Real Estate	15	0.007114	0.010386	0.000623	0.000504	0.000654	0.000582	0.000351	0.000504	0.000538	0.000487
16. Services	16	0.014254	0.008197	0.001651	0.001281	0.001634	0.001586	0.000909	0.001182	0.001470	0.001369
17. Pipeline Construction	17	0.000002	0.000001	0.000011	0.000113	0.000011	0.000008	0.000007	0.000007	0.000008	0.000009
18. Petroleum Construction	18	0.000000	0.000000	0.000002	0.000001	0.000003	0.000135	0.000001	0.000000	0.000001	0.000001
19. Dock-buoy Operation	19	0.000003	0.000001	0.000015	0.000140	0.000155	0.000012	0.000010	0.000011	0.000012	0.000013
20. Pipe-dock Operation	20	0.044840	0.004797	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21. Shipping	21	1.000000	0.039850	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22. Petroleum Operation	22	0.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23. Agriculture - Forestry - Mining	23	0.010888	0.005219	1.132501	0.277753	0.160243	0.039757	0.031775	0.044111	0.038293	0.041716
24. Food Products	24	0.020618	0.009078	0.105405	1.126251	0.107017	0.079394	0.065478	0.070780	0.075817	0.086493
25. Forest Products	25	0.004408	0.001781	0.022813	0.040673	1.268617	0.023286	0.021161	0.021266	0.024174	0.023827
26. Chemicals	26	0.001437	0.003506	0.016169	0.006915	0.022955	1.041264	0.005172	0.002964	0.005424	0.004406
27. Petroleum	27	0.125080	0.005812	0.019495	0.013356	0.021272	0.016610	1.017848	0.010776	0.012068	0.012966
28. Metals	28	0.000632	0.000757	0.003437	0.005097	0.005374	0.005009	0.002570	1.013518	0.053735	0.016090
29. Fabricated Metals and Machinery	29	0.002863	0.003360	0.014889	0.060663	0.030289	0.019649	0.011049	0.013992	1.039792	0.021836
30. Transportation Equipment	30	0.005655	0.000395	0.002942	0.002629	0.004509	0.002575	0.002580	0.002327	0.002870	1.024602
31. Miscellaneous Manufacturing	31	0.005415	0.003569	0.028867	0.033993	0.039595	0.029478	0.023120	0.027701	0.036512	0.031425
32. Transport Services	32	0.009395	0.002241	0.030830	0.046913	0.069972	0.031874	0.039555	0.030377	0.023745	0.023502
33. Utilities	33	0.013747	0.016246	0.046734	0.042640	0.076710	0.106475	0.050842	0.086187	0.051118	0.045099
34. Communication	34	0.005401	0.002556	0.028072	0.026355	0.038389	0.030861	0.022008	0.025053	0.029446	0.031255
35. Construction	35	0.014815	0.005864	0.073095	0.067258	0.106059	0.081336	0.072117	0.072473	0.076226	0.087072
36. Trade	36	0.043438	0.020906	0.212174	0.211335	0.316180	0.234813	0.184833	0.203685	0.220628	0.245470
37. Finance, Insurance, Real Estate	37	0.023717	0.009646	0.075910	0.071646	0.112615	0.082291	0.073650	0.075676	0.081409	0.086717
38. Services	38	0.035611	0.015998	0.164324	0.144219	0.215590	0.176751	0.133317	0.146956	0.170469	0.180806
39. Value Added Local	39	0.130079	0.075890	0.007679	0.007117	0.008768	0.007467	0.004864	0.006512	0.007451	0.006750
40. Value Added Other Washington	40	0.182016	0.073867	0.910967	0.857527	1.347723	1.038311	0.862932	0.928301	0.997865	1.142276

TABLE C-2 (Continued)

		31	32	33	34	35	36	37	38	39[b]	40[c]
1. Agriculture - Forestry - Mining	1	0.015531	0.000934	0.001026	0.001203	0.001649	0.001534	0.001532	0.001433	0.006216	0.001245
2. Food Products	2	0.406691	0.021665	0.023993	0.028564	0.040364	0.036962	0.036760	0.034615	0.047711	0.029126
3. Forest Products	3	0.012758	0.001679	0.001846	0.001956	0.004016	0.002318	0.002256	0.002055	0.033429	0.001981
4. Chemicals	4	0.000369	0.000125	0.000117	0.000131	0.000107	0.000142	0.000147	0.000131	0.000992	0.000145
5. Petroleum	5	0.038037	0.054445	0.030998	0.035010	0.026603	0.039511	0.038146	0.035330	0.045797	0.038111
6. Metals	6	0.001398	0.000216	0.000214	0.000249	0.000362	0.000272	0.000279	0.000254	0.004527	0.000258
7. Fabricated Metals and Machinery	7	0.018393	0.001167	0.001255	0.001468	0.001964	0.001863	0.001866	0.001740	0.014475	0.001523
8. Transportation Equipment	8	0.000541	0.000115	0.000105	0.000119	0.000106	0.000134	0.000138	0.000123	0.003693	0.000133
9. Miscellaneous Manufacturing	9	0.007420	0.000737	0.000746	0.000863	0.000975	0.001028	0.001117	0.000957	0.039166	0.000895
10. Transport Services	10	0.012398	0.001992	0.001523	0.001738	0.001935	0.002087	0.002097	0.001912	0.025627	0.001840
11. Utilities	11	0.007064	0.001730	0.002065	0.001627	0.001510	0.001937	0.001881	0.001780	0.042372	0.001703
12. Communication	12	0.004112	0.000479	0.000469	0.000540	0.000588	0.000634	0.000681	0.000590	0.031938	0.000560
13. Construction	13	0.012285	0.001596	0.001372	0.001568	0.001775	0.001873	0.001930	0.001728	0.141683	0.001627
14. Trade	14	0.032132	0.003068	0.002957	0.003383	0.004202	0.004178	0.004290	0.003862	0.294072	0.003524
15. Finance, Insurance, Real Estate	15	0.007279	0.001102	0.000923	0.001054	0.001131	0.001246	0.001458	0.001157	0.065448	0.001104
16. Services	16	0.017243	0.002535	0.002565	0.002775	0.002847	0.003337	0.003520	0.003166	0.160440	0.002886
17. Pipeline Construction	17	0.000017	0.000016	0.000017	0.000019	0.000011	0.000020	0.000021	0.000018	0.000012	0.000022
18. Petroleum Construction	18	0.000001	0.000001	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002	0.000001	0.000001
19. Dock-buoy Operation	19	0.000028	0.000025	0.000026	0.000029	0.000025	0.000030	0.000031	0.000028	0.000016	0.000032
20. Pipe-dock Operation	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21. Shipping	21	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22. Petroleum Operation	22	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23. Agriculture - Forestry - Mining	23	0.200311	0.075915	0.082331	0.092327	0.079929	0.098190	0.101485	0.090436	0.069513	0.103190
24. Food Products	24	0.170215	0.159022	0.169360	0.190821	0.114099	0.200979	0.206479	0.184835	0.118328	0.216420
25. Forest Products	25	0.070717	0.049702	0.053035	0.054297	0.104394	0.057981	0.057120	0.050498	0.013767	0.057027
26. Chemicals	26	0.010175	0.007697	0.007779	0.007399	0.014299	0.009553	0.008096	0.012232	0.005416	0.008040
27. Petroleum	27	0.027921	0.044055	0.025445	0.028729	0.021261	0.032283	0.031247	0.028888	0.007234	0.031364
28. Metals	28	0.007160	0.007468	0.007509	0.008527	0.031358	0.007547	0.007508	0.006866	0.001915	0.007595
29. Fabricated Metals and Machinery	29	0.034555	0.026389	0.032870	0.047277	0.083853	0.033622	0.032976	0.033691	0.012593	0.033400
30. Transportation Equipment	30	0.005317	0.020869	0.005448	0.005745	0.005049	0.006788	0.006280	0.005439	0.001456	0.006469
31. Miscellaneous Manufacturing	31	1.089764	0.054500	0.060676	0.071969	0.105833	0.094624	0.094160	0.088878	0.019911	0.073465
32. Transport Services	32	0.068566	1.066404	0.051901	0.049094	0.054027	0.058450	0.058118	0.048099	0.017728	0.054349
33. Utilities	33	0.103075	0.079974	1.223354	0.097445	0.065869	0.116164	0.105074	0.106644	0.040452	0.101339
34. Communication	34	0.059228	0.055849	0.058696	1.069543	0.042394	0.076884	0.075246	0.093834	0.021980	0.069451
35. Construction	35	0.161208	0.163691	0.182936	0.200811	1.113260	0.195953	0.212719	0.184254	0.043424	0.216032
36. Trade	36	0.465372	0.436672	0.479079	0.540603	0.348312	1.565538	0.593561	0.516422	0.175249	0.608775
37. Finance, Insurance, Real Estate	37	0.166891	0.169034	0.172960	0.192289	0.119847	0.218627	1.254600	0.192475	0.092716	0.205773
38. Services	38	0.347931	0.309588	0.385259	0.384116	0.248983	0.428316	0.439134	1.410436	0.162049	0.417870
39. Value Added Local	39	0.136039	0.013697	0.013007	0.014768	0.017995	0.018087	0.018367	0.016776	1.688726	0.015433
40. Value Added Other Washington	40	2.104104	1.999890	2.234059	2.521318	1.483883	2.564279	2.723037	2.373884	0.556854	2.862836

b. Personal Consumption Expenditures, Region 1.
c. Personal Consumption Expenditures, Region 2.

Source: Oceanographic Institute of Washington.

TABLE C-3

TWO-REGION INVERSE INPUT-OUTPUT MATRIX[a]

		1	2	3	4	5	6	7	8	9	10
1. Agriculture - Forestry - Mining	1	1.056791	0.111408	0.031605	0.005811	0.003774	0.020609	0.006361	0.001549	0.001619	0.009323
2. Food Products	2	0.112723	1.100252	0.046286	0.041301	0.026602	0.041323	0.041191	0.010917	0.004475	0.068915
3. Forest Products	3	0.016341	0.029824	1.222864	0.012218	0.009618	0.010043	0.013468	0.002760	0.002885	0.013847
4. Chemicals	4	0.015388	0.007990	0.023692	1.057795	0.006216	0.006820	0.006797	0.002435	0.001937	0.004976
5. Petroleum	5	0.010430	0.004294	0.006101	0.007905	1.004237	0.002600	0.003227	0.000629	0.000608	0.035446
6. Metals	6	0.000980	0.001817	0.001923	0.002128	0.000474	1.013430	0.040268	0.002531	0.000167	0.000874
7. Fabricated Metals and Machinery	7	0.010662	0.036625	0.018987	0.016277	0.004011	0.014658	1.034066	0.004184	0.001747	0.007728
8. Transportation Equipment	8	0.004184	0.001468	0.001659	0.001199	0.000757	0.001240	0.001902	1.006416	0.000149	0.002851
9. Miscellaneous Manufacturing	9	0.027177	0.020577	0.018157	0.014948	0.008945	0.025940	0.022834	0.004276	1.004060	0.018923
10. Air Transportation Services	10	0.029739	0.030593	0.032699	0.033885	0.019498	0.034740	0.024430	0.005069	0.005452	1.096858
11. Utilities	11	0.031906	0.024670	0.041761	0.076981	0.030657	0.058065	0.031323	0.005997	0.003564	0.031831
12. Communication	12	0.029798	0.019809	0.022286	0.022492	0.011391	0.019208	0.021738	0.005727	0.002620	0.033018
13. Construction	13	0.010005	0.006528	0.008369	0.008350	0.009242	0.007647	0.006067	0.001660	0.000717	0.012583
14. Retail Trade	14	0.182286	0.120729	0.146190	0.133261	0.085495	0.129396	0.132891	0.039138	0.014725	0.186740
15. Finance, Insurance, Real Estate	15	0.077396	0.055378	0.067462	0.058340	0.045860	0.061242	0.061226	0.015496	0.006637	0.084057
16. Services	16	0.167128	0.106583	0.128295	0.127819	0.075485	0.119739	0.130035	0.032648	0.014029	0.167222
17. Wholesale Trade	17	0.054466	0.040214	0.058114	0.043386	0.026732	0.056558	0.035767	0.018725	0.016936	0.036015
18. Water Transportation Services	18	0.009536	0.005842	0.018304	0.004004	0.002063	0.006111	0.007602	0.001019	0.002322	0.004742
19. Drilling Platform Construction	19	0.000012	0.000008	0.000010	0.000010	0.000006	0.000009	0.000010	0.000003	0.000001	0.000013
20. Agriculture - Forestry - Mining	20	0.115107	0.176295	0.021252	0.018263	0.010923	0.041292	0.017733	0.004658	0.003651	0.024868
21. Food Products	21	0.024548	0.023623	0.016502	0.014163	0.008887	0.015848	0.013589	0.003948	0.002117	0.019422
22. Forest Products	22	0.009049	0.008026	0.046224	0.006048	0.003902	0.006258	0.005946	0.001651	0.000838	0.007934
23. Chemicals	23	0.002494	0.002837	0.001770	0.001252	0.000746	0.001921	0.000974	0.000558	0.000555	0.000876
24. Petroleum	24	0.034294	0.022292	0.024626	0.023460	0.016336	0.018106	0.017028	0.004606	0.002228	0.026036
25. Metals	25	0.000240	0.000459	0.000234	0.000189	0.000075	0.000801	0.008183	0.000947	0.000048	0.000148
26. Fabricated Metals and Machinery	26	0.001527	0.001614	0.001370	0.000944	0.000575	0.001247	0.000797	0.000393	0.000344	0.000925
27. Transportation Equipment	27	0.000953	0.000170	0.000099	0.000048	0.000028	0.000070	0.000047	0.000032	0.000012	0.000207
28. Miscellaneous Manufacturing	28	0.003115	0.003277	0.002479	0.001631	0.000985	0.002677	0.001472	0.000567	0.000413	0.001934
29. Air Transportation Services	29	0.017350	0.016396	0.018308	0.018459	0.010640	0.019138	0.013347	0.002814	0.002996	0.017965
30. Utilities	30	0.014916	0.012946	0.011646	0.010708	0.005995	0.010801	0.009359	0.002699	0.001330	0.012980
31. Communication	31	0.003782	0.004297	0.002457	0.001818	0.001078	0.002393	0.001580	0.000604	0.000470	0.003059
32. Construction	32	0.001907	0.002006	0.003080	0.000994	0.000608	0.001156	0.000908	0.000300	0.000181	0.001265
33. Retail Trade	33	0.033543	0.035362	0.017053	0.012840	0.007561	0.016043	0.011707	0.005909	0.003094	0.014202
34. Finance, Insurance, Real Estate	34	0.009425	0.010433	0.010485	0.005733	0.002778	0.005732	0.004129	0.001459	0.001039	0.006647
35. Services	35	0.023479	0.027303	0.015204	0.010631	0.006300	0.014572	0.009355	0.003429	0.002595	0.014336
36. Wholesale Trade	36	0.021629	0.020263	0.023311	0.014994	0.008854	0.023509	0.010635	0.008069	0.008753	0.005754
37. Water Transportation Services	37	0.006398	0.004142	0.011286	0.002981	0.001648	0.004183	0.004997	0.000769	0.001414	0.003901
38. Drilling Platform Construction	38	0.000002	0.000003	0.000001	0.000001	0.000001	0.000001	0.000001	0.000000	0.000000	0.000001
39. Value Added Local	39	1.231423	0.800669	1.047016	0.962527	0.622037	0.935205	0.962954	0.255945	0.099446	1.303036
40. Value Added Other Washington	40	0.212732	0.255739	0.118857	0.089295	0.052904	0.120219	0.078788	0.027843	0.021525	0.098016

a. Region 1: King, Pierce, and Snohomish Counties; Region 2: the rest of Washington.

TABLE C-3 (Continued)

		11	12	13	14	15	16	17	18	19	20
1. Agriculture - Forestry - Mining	1	0.008471	0.009441	0.010887	0.009542	0.009485	0.008059	0.008661	0.005820	0.003328	0.003807
2. Food Products	2	0.056461	0.067162	0.034192	0.068239	0.068154	0.059016	0.062072	0.041690	0.024155	0.024711
3. Forest Products	3	0.020272	0.021172	0.079218	0.020337	0.018082	0.015505	0.016908	0.009775	0.005515	0.005325
4. Chemicals	4	0.006667	0.006137	0.014205	0.006003	0.005872	0.009795	0.082565	0.003609	0.002035	0.008337
5. Petroleum	5	0.002930	0.005748	0.005693	0.004171	0.004068	0.004907	0.005746	0.003176	0.000854	0.001345
6. Metals	6	0.002088	0.002127	0.025429	0.000908	0.000907	0.000997	0.002447	0.005034	0.000325	0.001022
7. Fabricated Metals and Machinery	7	0.013133	0.025038	0.069729	0.008596	0.008379	0.011340	0.045547	0.005371	0.002861	0.008468
8. Transportation Equipment	8	0.001999	0.001933	0.002183	0.001849	0.001873	0.001478	0.001716	0.005580	0.000721	0.001571
9. Miscellaneous Manufacturing	9	0.020484	0.026406	0.074912	0.031871	0.033219	0.042521	0.043100	0.016101	0.008006	0.010467
10. Air Transportation Services	10	0.025154	0.079860	0.017271	0.018772	0.033986	0.022615	0.022486	0.011119	0.005919	0.009844
11. Utilities	11	1.167840	0.035547	0.023029	0.053629	0.036317	0.043624	0.038526	0.018246	0.010970	0.014332
12. Communication	12	0.027184	1.035650	0.018801	0.037296	0.036162	0.057393	0.044238	0.022087	0.010001	0.011547
13. Construction	13	0.021248	0.018742	1.004872	0.014558	0.015974	0.011602	0.010200	0.006724	0.002973	0.004806
14. Retail Trade	14	0.180837	0.213883	0.108043	1.224094	0.240118	0.172669	0.198527	0.131626	0.076775	0.052094
15. Finance, Insurance, Real Estate	15	0.082485	0.095683	0.052860	0.113097	1.144856	0.088445	0.097488	0.061046	0.030913	0.042735
16. Services	16	0.201094	0.185080	0.113230	0.211438	0.213830	1.198573	0.214148	0.120673	0.061298	0.060650
17. Wholesale Trade	17	0.047057	0.046862	0.026555	0.044646	0.044152	0.034181	1.040026	0.027145	0.015127	0.013642
18. Water Transportation Services	18	0.004226	0.005567	0.003903	0.005107	0.005562	0.004096	0.004898	1.003537	0.003339	0.007638
19. Drilling Platform Construction	19	0.000013	0.000016	0.000008	0.000016	0.000016	0.000013	0.000015	0.000010	1.000016	0.000002
20. Agriculture - Forestry - Mining	20	0.022609	0.027411	0.020557	0.027435	0.027590	0.022374	0.025453	0.016594	0.009558	1.119746
21. Food Products	21	0.017742	0.022298	0.011319	0.021200	0.021873	0.016649	0.020150	0.012630	0.007203	0.083024
22. Forest Products	22	0.008003	0.009618	0.007124	0.010062	0.009587	0.007457	0.009123	0.005689	0.003240	0.017181
23. Chemicals	23	0.001676	0.001205	0.000766	0.001034	0.001085	0.000824	0.009341	0.000616	0.000315	0.012008
24. Petroleum	24	0.022799	0.028173	0.018222	0.027004	0.028252	0.024149	0.025613	0.016177	0.009330	0.044481
25. Metals	25	0.000191	0.000291	0.002163	0.000154	0.000151	0.000153	0.000545	0.000113	0.000732	0.000867
26. Fabricated Metals and Machinery	26	0.001014	0.001126	0.000626	0.001061	0.001050	0.000783	0.005085	0.000658	0.000318	0.004263
27. Transportation Equipment	27	0.000047	0.000087	0.000039	0.000049	0.000060	0.000043	0.000051	0.000429	0.000016	0.000270
28. Miscellaneous Manufacturing	28	0.001803	0.002262	0.001210	0.003234	0.002207	0.001536	0.004677	0.001572	0.000626	0.012870
29. Air Transportation Services	29	0.013788	0.043031	0.009581	0.010120	0.018574	0.012410	0.011235	0.005927	0.003177	0.017586
30. Utilities	30	0.012080	0.014813	0.007680	0.017243	0.014906	0.011363	0.014943	0.008701	0.004969	0.035825
31. Communication	31	0.001876	0.002640	0.001287	0.003118	0.002357	0.001585	0.004225	0.001782	0.000614	0.018778
32. Construction	32	0.001144	0.001461	0.000869	0.002036	0.001454	0.001046	0.001576	0.000970	0.000435	0.008001
33. Retail Trade	33	0.013526	0.018364	0.009266	0.014998	0.029003	0.011597	0.015255	0.008160	0.004172	0.144789
34. Finance, Insurance, Real Estate	34	0.004986	0.006803	0.003673	0.008625	0.006425	0.004412	0.007972	0.004323	0.001761	0.044353
35. Services	35	0.011476	0.015841	0.007824	0.016633	0.014112	0.009580	0.019277	0.008942	0.003739	0.125603
36. Wholesale Trade	36	0.012895	0.010838	0.007231	0.006463	0.008651	0.006138	0.007238	0.003760	0.001772	0.043195
37. Water Transportation Services	37	0.003322	0.004329	0.002783	0.003970	0.004296	0.003229	0.003791	0.002415	0.001369	0.006207
38. Drilling Platform Construction	38	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000010	0.000012
39. Value Added Local	39	1.322001	1.559508	0.790350	1.607283	1.598562	1.270085	1.452160	0.965748	0.571092	0.199414
40. Value Added Other Washington	40	0.091140	0.129922	0.066171	0.104366	0.118358	0.079618	0.113069	0.058897	0.030711	1.237953

TABLE C-3 (Continued)

		21	22	23	24	25	26	27	28	29	30
1. Agriculture - Forestry - Mining	1	0.007818	0.000515	0.001541	0.000837	0.001034	0.001951	0.002296	0.001492	0.002979	0.001632
2. Food Products	2	0.021494	0.002847	0.009018	0.004762	0.006016	0.008343	0.007916	0.008834	0.020030	0.009081
3. Forest Products	3	0.004334	0.001319	0.003413	0.002619	0.003174	0.002960	0.002634	0.002943	0.004820	0.005980
4. Chemicals	4	0.004280	0.001870	0.006223	0.003705	0.002616	0.004130	0.002565	0.004090	0.003372	0.004221
5. Petroleum	5	0.001246	0.000562	0.001202	0.000655	0.000701	0.001017	0.000773	0.000916	0.020437	0.001120
6. Metals	6	0.002979	0.001388	0.001538	0.000467	0.001408	0.037277	0.069081	0.000798	0.000821	0.001523
7. Fabricated Metals and Machinery	7	0.045173	0.002640	0.007614	0.003255	0.004335	0.011888	0.012903	0.006242	0.006417	0.008845
8. Transportation Equipment	8	0.001095	0.000391	0.001116	0.000860	0.000660	0.001066	0.004145	0.001166	0.002065	0.001223
9. Miscellaneous Manufacturing	9	0.010693	0.003700	0.009100	0.004233	0.004863	0.012229	0.006676	0.007434	0.009621	0.008792
10. Air Transportation Services	10	0.009483	0.004613	0.009469	0.005075	0.006761	0.008442	0.006757	0.006775	0.055203	0.008241
11. Utilities	11	0.009649	0.002859	0.029944	0.012276	0.029946	0.008447	0.008625	0.006592	0.013408	0.007457
12. Communication	12	0.009049	0.002595	0.009709	0.004186	0.006114	0.007434	0.005875	0.006955	0.014693	0.009020
13. Construction	13	0.002726	0.003707	0.003243	0.004985	0.002469	0.002046	0.001826	0.002132	0.003361	0.005131
14. Retail Trade	14	0.042577	0.013835	0.043065	0.022808	0.027431	0.040569	0.036202	0.039850	0.060360	0.045376
15. Finance, Insurance, Real Estate	15	0.032897	0.010692	0.034893	0.023223	0.024293	0.031391	0.026463	0.031899	0.044277	0.038875
16. Services	16	0.043135	0.012388	0.048693	0.023005	0.028931	0.037217	0.031102	0.036860	0.060381	0.058096
17. Wholesale Trade	17	0.011770	0.005900	0.011412	0.006136	0.009596	0.010972	0.011081	0.010302	0.013695	0.011215
18. Water Transportation Services	18	0.003093	0.001916	0.001740	0.000882	0.001311	0.002175	0.001538	0.002097	0.005044	0.001793
19. Drilling Platform Construction	19	0.000002	0.000001	0.000002	0.000001	0.000001	0.000002	0.000002	0.000001	0.000002	0.000002
20. Agriculture - Forestry - Mining	20	0.244073	0.008522	0.025994	0.012826	0.014759	0.024489	0.020162	0.072897	0.030105	0.027537
21. Food Products	21	1.090682	0.016844	0.054269	0.028339	0.030774	0.052301	0.040297	0.061172	0.066165	0.061497
22. Forest Products	22	0.031130	1.013107	0.013036	0.008784	0.008451	0.014893	0.009652	0.037486	0.014805	0.018957
23. Chemicals	23	0.004532	0.001712	1.027396	0.001844	0.001905	0.003452	0.001841	0.003766	0.002345	0.002717
24. Petroleum	24	0.025474	0.066378	0.030310	1.018461	0.011953	0.021904	0.016917	0.031126	0.040796	0.024106
25. Metals	25	0.001179	0.000347	0.001714	0.000122	1.009147	0.025065	0.016948	0.001089	0.000272	0.000749
26. Fabricated Metals and Machinery	26	0.025650	0.003934	0.005176	0.001666	0.001964	1.020130	0.008800	0.007064	0.003311	0.005891
27. Transportation Equipment	27	0.000206	0.000140	0.000225	0.000120	0.000127	0.000218	1.026392	0.000243	0.000997	0.000259
28. Miscellaneous Manufacturing	28	0.016324	0.012999	0.009672	0.005117	0.005578	0.013123	0.008791	1.039571	0.010998	0.011925
29. Air Transportation Services	29	0.018875	0.012904	0.019815	0.010825	0.006658	0.014797	0.007959	0.011342	1.053501	0.014528
30. Utilities	30	0.028265	0.010082	0.076312	0.023523	0.044175	0.036487	0.024142	0.051705	0.030649	1.170392
31. Communication	31	0.014825	0.006764	0.016860	0.007574	0.008865	0.017929	0.010693	0.020466	0.021017	0.018616
32. Construction	32	0.006541	0.050109	0.006443	0.005573	0.003843	0.005335	0.003900	0.007269	0.006089	0.017004
33. Retail Trade	33	0.106348	0.038835	0.117639	0.061457	0.066551	0.113679	0.088397	0.129701	0.131345	0.133625
34. Finance, Insurance, Real Estate	34	0.035846	0.129771	0.037277	0.022159	0.022137	0.040354	0.029673	0.046269	0.045538	0.046331
35. Services	35	0.092479	0.065583	0.109138	0.053120	0.058014	0.110014	0.075381	0.134601	0.118345	0.147707
36. Wholesale Trade	36	0.034249	0.022894	0.036047	0.019585	0.032541	0.031466	0.027338	0.037225	0.029903	0.036872
37. Water Transportation Services	37	0.004162	0.007769	0.003297	0.001549	0.003212	0.005269	0.002404	0.004384	0.006276	0.003181
38. Drilling Platform Construction	38	0.000009	0.000003	0.000010	0.000005	0.000006	0.000010	0.000008	0.000012	0.000011	0.000012
39. Value Added Local	39	0.177535	0.051865	0.169151	0.069963	0.117923	0.155988	0.155393	0.130982	0.242148	0.166300
40. Value Added Other Washington	40	0.909250	0.321776	1.049530	0.546265	0.591737	1.013173	0.774598	1.163892	1.131686	1.194040

TABLE C-3 (Continued)

		31	32	33	34	35	36	37	38	39[b]	40[c]
1. Agriculture - Forestry - Mining	1	0.001722	0.001468	0.002030	0.001649	0.001433	0.002217	0.001666	0.000605	0.009640	0.001631
2. Food Products	2	0.009722	0.006559	0.011602	0.009284	0.007997	0.013328	0.007169	0.003361	0.070233	0.008991
3. Forest Products	3	0.003556	0.003696	0.007205	0.003530	0.003011	0.006160	0.002976	0.001282	0.014712	0.003459
4. Chemicals	4	0.003394	0.002899	0.003793	0.003358	0.003557	0.046564	0.002411	0.001364	0.005064	0.003232
5. Petroleum	5	0.001834	0.000748	0.002204	0.001249	0.000976	0.003385	0.001732	0.000382	0.002063	0.001012
6. Metals	6	0.002579	0.022943	0.000869	0.000838	0.000907	0.002360	0.002620	0.000399	0.000663	0.000688
7. Fabricated Metals and Machinery	7	0.018285	0.012221	0.006855	0.006455	0.008477	0.027637	0.004527	0.002630	0.007294	0.006297
8. Transportation Equipment	8	0.001446	0.000912	0.001414	0.001469	0.001197	0.001351	0.002890	0.000547	0.001866	0.001581
9. Miscellaneous Manufacturing	9	0.011189	0.022174	0.015604	0.009671	0.012066	0.022896	0.007987	0.003981	0.020524	0.008906
10. Air Transportation Services	10	0.015796	0.006093	0.009016	0.009724	0.007645	0.012024	0.005571	0.002957	0.016402	0.007513
11. Utilities	11	0.007929	0.006159	0.022599	0.007848	0.006632	0.016755	0.005919	0.002905	0.028370	0.007571
12. Communication	12	0.008456	0.005946	0.014472	0.008450	0.009412	0.020001	0.008674	0.003133	0.027768	0.008298
13. Construction	13	0.002393	0.001755	0.006037	0.002411	0.002091	0.004112	0.002523	0.000863	0.008447	0.002312
14. Retail Trade	14	0.050024	0.030440	0.059592	0.052594	0.042029	0.059777	0.034698	0.016767	0.222790	0.050447
15. Finance, Insurance, Real Estate	15	0.039052	0.025350	0.054482	0.040498	0.038819	0.049559	0.030319	0.014521	0.087216	0.039563
16. Services	16	0.042120	0.029927	0.067731	0.041906	0.035444	0.080609	0.037599	0.015479	0.176689	0.041559
17. Wholesale Trade	17	0.011608	0.008040	0.014626	0.011140	0.009285	0.014538	0.009023	0.004531	0.039928	0.010644
18. Water Transportation Services	18	0.002165	0.001469	0.002156	0.002094	0.001717	0.002289	0.001621	0.001545	0.005022	0.002046
19. Drilling Platform Construction	19	0.000002	0.000001	0.000002	0.000002	0.000001	0.000003	0.000001	0.000001	0.000017	0.000002
20. Agriculture - Forestry - Mining	20	0.032299	0.029950	0.031696	0.033964	0.029056	0.029862	0.021041	0.012432	0.027742	0.034935
21. Food Products	21	0.072615	0.038401	0.069670	0.076420	0.065992	0.063006	0.047035	0.028413	0.020858	0.080270
22. Forest Products	22	0.021930	0.068695	0.019291	0.021253	0.018021	0.016872	0.011428	0.006945	0.009354	0.018490
23. Chemicals	23	0.002858	0.007424	0.002807	0.002975	0.006712	0.044231	0.001867	0.001174	0.000872	0.002770
24. Petroleum	24	0.028971	0.026459	0.026976	0.029464	0.028174	0.026905	0.017911	0.010505	0.026984	0.028033
25. Metals	25	0.000460	0.005633	0.000255	0.000273	0.000310	0.000948	0.000245	0.003776	0.000124	0.000229
26. Fabricated Metals and Machinery	26	0.007470	0.058203	0.003818	0.004156	0.005085	0.023747	0.002664	0.004945	0.000901	0.003787
27. Transportation Equipment	27	0.000324	0.001226	0.000279	0.000316	0.000253	0.000251	0.002188	0.000113	0.000044	0.000318
28. Miscellaneous Manufacturing	28	0.016636	0.055394	0.018228	0.024329	0.032631	0.024280	0.010095	0.005080	0.001788	0.013650
29. Air Transportation Services	29	0.043255	0.010118	0.011089	0.019507	0.013483	0.013317	0.007083	0.003870	0.009084	0.010580
30. Utilities	30	0.039384	0.025067	0.044728	0.040715	0.048429	0.034870	0.021011	0.013696	0.014340	0.034569
31. Communication	31	1.027196	0.014045	0.023678	0.029368	0.049447	0.026902	0.015331	0.007960	0.001744	0.021017
32. Construction	32	0.017943	1.006856	0.010094	0.013351	0.010752	0.007306	0.005367	0.002728	0.001248	0.007556
33. Retail Trade	33	0.158067	0.082403	1.153649	0.178677	0.133850	0.134856	0.101331	0.061664	0.011880	0.174149
34. Finance, Insurance, Real Estate	34	0.056227	0.037526	0.060598	1.104044	0.054107	0.051228	0.035760	0.019217	0.005030	0.052455
35. Services	35	0.144679	0.092963	0.145387	0.175180	1.172120	0.142455	0.092778	0.053280	0.010653	0.144060
36. Wholesale Trade	36	0.038666	0.021736	0.035624	0.038573	0.030675	1.031824	0.023692	0.014201	0.004966	0.037832
37. Water Transportation Services	37	0.004032	0.002691	0.003686	0.004136	0.003205	0.003605	1.002666	0.001414	0.003956	0.003915
38. Drilling Platform Construction	38	0.000014	0.000007	0.000013	0.000015	0.000012	0.000012	0.000009	1.000016	0.000001	0.000016
39. Value Added Local	39	0.169023	0.120457	0.220842	0.160271	0.141138	0.261656	0.123502	0.058704	1.661151	0.154288
40. Value Added Other Washington	40	1.414098	0.736833	1.348793	1.493331	1.201544	1.203522	0.907823	0.557032	0.087529	1.576646

b. Personal Consumption Expenditures, Region 1.
c. Personal Consumption Expenditures, Region 2.

Source: Professor William Beyers, University of Washington.

significantly since the I-O matrix was constructed. (See Table C-4.) However, the employment multipliers are based on 1967 data and wage rates. Therefore, the multipliers would tend to seriously overestimate employment since sales per employee have increased dramatically. We have increased the employment multipliers by the percentage that wages in each industry have increased since 1967, utilizing information from County Business Patterns. The resultant employment multipliers are shown in Table C-5.

Population estimates are based on labor force participation rates. These rates have changed dramatically in the past decade as a higher percentage of the population is in the working years and a greater percentage of women have entered the labor force. Recent issues of the U.S. Department of Labor publication Employment and Earnings indicate that approximately 62% of the population over 16 is in the labor force, up from 60% in 1970.* Since the proportion of the population aged 16 and under has decreased during that same time period, the effective rise in the overall labor force participation rate has been even greater. Recent estimates for the state of Washington place the labor force participation rate at approximately 44% for the state as a whole with higher rates for the metropolitan areas and lower rates for rural areas. However, these rates include all age groups in the population.**

The population which can be expected to migrate to Washington to accept any petroleum-related jobs will be of working age and can therefore be expected

*U.S. Department of Labor, Employment and Earnings, February, 1977, p. 12.
**Washington Pocket Data Book, 1976.

TABLE C-4

EMPLOYMENT AND PAYROLL MULTIPLIERS FOR MATRIX 1[a]

Sector	Employment Multiplier[b]	Payroll Multiplier[c]
1. Agriculture - Forestry - Mining	0.03865	0.21251
2. Food Products	0.01282	0.13437
3. Forest Products	0.02231	0.25079
4. Chemicals	0.01800	0.25573
5. Petroleum	0.00172	0.02590
6. Metals	0.01071	0.15154
7. Fabricated Metals and Machinery	0.02451	0.27028
8. Transportation Equipment	0.02533	0.36082
9. Miscellaneous Manufacturing	0.03478	0.32906
10. Transport Services	0.03529	0.46484
11. Utilities	0.01086	0.14483
12. Communication	0.02633	0.53003
13. Construction	0.01628	0.23633
14. Trade	0.06404	0.48063
15. Finance, Insurance, Real Estate	0.03723	0.31809
16. Services	0.05066	0.39936
17. Pipeline Construction	0.01241	0.29829
18. Petroleum Construction	0.00998	0.24000
19. Dock-buoy Operation	0.00998	0.25000
20. Pipe-dock Operation	0.00162	0.03496
21. Shipping	0.00080	0.01902
22. Petroleum Operation	0.00110	0.06237
23. Agriculture - Forestry - Mining	0.03349	0.21251
24. Food Products	0.01101	0.13437
25. Forest Products	0.01933	0.25079
26. Chemicals	0.01550	0.25573
27. Petroleum	0.00149	0.02590
28. Metals	0.00928	0.15154
29. Fabricated Metals and Machinery	0.02124	0.27028
30. Transportation Equipment	0.02195	0.36082
31. Miscellaneous Manufacturing	0.03014	0.32906
32. Transport Services	0.03057	0.46484
33. Utilities	0.00941	0.14483
34. Communication	0.03039	0.53003
35. Construction	0.01411	0.23633
36. Trade	0.05553	0.48063
37. Finance, Insurance, Real Estate	0.03226	0.31809
38. Services	0.04389	0.39936
39. Value Added Local	0.00008	0.00392
40. Value Added Other Washington	0.00008	0.00392

a. Region 1 is Clallam, Grays Harbor, Skagit, and Whatcom Counties; Region 2 is the rest of the state.
b. Person years of employment per million dollars of sales.
c. Personal income per dollar of sales.

Sources: Oceanographic Institute of Washington; 1972 Census of Manufacturing; 1972 Census of Wholesale Trade; 1972 Census of Retail Trade; 1972 Census of Selected Services; 1972 Census of Transportation; 1972 Census of Agriculture; Arthur D. Little, Inc.

TABLE C-5

EMPLOYMENT AND PAYROLL MULTIPLIERS FOR MATRIX 2[a]

Sector	Employment Multiplier[b]	Payroll Multiplier[c]
1. Agriculture - Forestry - Mining	0.03349	0.21251
2. Food Products	0.01101	0.13437
3. Forest Products	0.01933	0.25079
4. Chemicals	0.01550	0.25573
5. Petroleum	0.00149	0.02590
6. Metals	0.00928	0.15154
7. Fabricated Metals and Machinery	0.02124	0.27028
8. Transportation Equipment	0.02195	0.36082
9. Miscellaneous Manufacturing	0.03014	0.32906
10. Air Transportation Services	0.03057	0.46484
11. Utilities	0.00941	0.14483
12. Communication	0.03039	0.55083
13. Construction	0.01411	0.23633
14. Retail Trade	0.08830	0.23633
15. Finance, Insurance, Real Estate	0.03226	0.31809
16. Services	0.04389	0.39936
17. Wholesale Trade	0.02533	0.36082
18. Water Transportation Services	0.00789	0.16237
19. Drilling Platform Construction	0.00100	0.02500
20. Agriculture - Forestry - Mining	0.03865	0.21251
21. Food Products	0.01282	0.13437
22. Forest Products	0.02231	0.25079
23. Chemicals	0.01800	0.25573
24. Petroleum	0.00172	0.02590
25. Metals	0.01071	0.15154
26. Fabricated Metals and Machinery	0.02451	0.27028
27. Transportation Equipment	0.02533	0.36082
28. Miscellaneous Manufacturing	0.03478	0.32906
29. Air Transportation Services	0.03529	0.46484
30. Utilities	0.01086	0.14483
31. Communication	0.02633	0.53003
32. Construction	0.01628	0.23633
33. Retail Trade	0.10190	0.52326
34. Finance, Insurance, Real Estate	0.03723	0.31809
35. Services	0.05066	0.39936
36. Wholesale Trade	0.03572	0.09400
37. Water Transportation Services	0.00910	0.16237
38. Drilling Platform Construction	0.00100	0.02500
39. Value Added Local	0.00008	0.00392
40. Value Added Other Washington	0.00008	0.00392

a. King, Kitsap, Pierce, and Snohomish Counties are region 1; the rest of the state is region 2.
b. Person-years of employment per million dollars of sales.
c. Personal income per dollar of sales.

Sources: Professor William Beyers, University of Washington; 1972 Census of Manufacturing; 1972 Census of Wholesale Trade; 1972 Census of Retail Trade; 1972 Census of Selected Services; 1972 Census of Transportation; 1972 Census of Agriculture; Arthur D. Little, Inc.

to have a relatively high labor force participation rate. We have assumed a civilian labor force participation rate of 45% for any in-migrant population. However, because it is likely that some people will migrate to oil-impacted regions in search of oil-related employment and find themselves unable to obtain any employment, the actual percentage of people employed will be somewhat lower. Justification for the assumption that a mild increase in employment does not necessarily result in a decline in the unemployment rate can be seen in the development of California where a rapid increase in employment opportunities during the 1950s and 1960s did not reduce an unemployment rate that was consistently among the highest in the nation.

Because the in-migrant workers will be in the age group in which they are most likely to have families, the average household size will be larger than for the population as a whole. Table C-6 shows 1970 and 1976 population per household estimates for various communities in Washington. Unfortunately, none of the major urban centers in the region have updated their population per household estimates. Based on the figures in Table C-6, however, it is clear that there is a wide degree of variance among communities. Therefore, it is not possible to accurately predict the exact household size for new in-migrants to Washington. Based on the assumption that the household size for the in-migrant population would be larger than that for the total population, we have used a population per household estimate of 3.0.

TABLE C-6

CHANGE IN HOUSEHOLD SIZE FOR SELECTED WASHINGTON COMMUNITIES
1970-1976

Community	1970 Household Size	1976 Household Size
Bonney Lake	3.435	3.141
Bothell	3.305	2.738
Centralia	2.590	2.394
Dayton	2.648	2.419
Edmonds	3.280	2.876
Fife	3.025	2.317
Issaquah	3.149	2.704
Kalama	3.107	2.718
Moses Lake	3.303	2.910
Nooksack	3.067	3.153
Port Orchard	3.089	2.556
Redmond	3.362	2.901
Sumner	2.916	2.548
Warden	3.688	3.405
Yarrow Point	3.484	3.138

Source: Population Studies Division, Office of Program Planning And Fiscal Management, State of Washington.

Residential development densities vary widely throughout the impact region. Densities are generally greater in the central Puget Sound region than elsewhere in the state. Residential housing densities in the communities in the impact area range from less than two to more than four units per acre. Because most of the direct jobs created in oil-related companies will have relatively high salaries, we anticipate that a high percentage of the in-migrant population will live in single-family homes. The incomes of those Washington residents working on oil development equipment in Alaska will be substantially higher than those of the average Washington resident and so these people can be expected to occupy more land per household. Therefore, we have assumed that residential housing density for in-migrants will be approximately 2.5 units per acre. We consider this a maximum estimate and utilize it as a method for estimating the maximum impacts that this development might have on the state.

The model estimates sales, business and occupation, gasoline, cigarette, alcoholic beverage and state property tax revenues. The state levies a sales tax of 4.5% on the sale of almost all tangible personal property, measured by the total selling price of the commodity. However, there are exemptions for intermediate use goods and medicines. Therefore, the effective tax rate cannot be applied to all sales. However, the Department of Revenue issues quarterly estimates of total sales by sector and of total taxable sales. By applying the sales tax rate to the percentage of total sales that are taxable, an effective sales tax rate can be determined.

The sales tax rates used for each sector are shown in Table C-7.* Also included is the applicable local sales tax rate, which is levied at the rate of 0.5% on taxable sales.

Business and occupation taxes are levied against the gross income (receipts) of business before deductions for operating expenses, taxes or any other losses or expenses. A business firm may report its income under several classifications; any portion taxed under one category is not generally taxed under any other classification.

The business and occupation tax is imposed on all transactions except those specifically exempted or as limited by the Federal Constitution. These include business subject to the public utilities tax, agricultural production, Red Cross, interstate commerce, real estate rentals and sales except commissions. In addition there are several specific exemptions: inventory tax credit, manufacturer's tax credit, and the pollution control credit. Therefore, the effective tax rate is less than the actual rate. The Department of Revenue provides quarterly estimates of Business and Occupation tax receipts and of business gross income by type of activity. From these listings we have derived the effective Business and Occupation tax rates by sector. (See Table C-8.**)

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*We have used the sales tax rates applicable during the fourth quarter of 1975 and the first quarter of 1976.

**We have used the business and occupation tax rates applicable during the fourth quarter of 1975 and the first quarter of 1976.

TABLE C-7

EFFECTIVE SALES TAX RATES

Sector	State Tax as a Percentage of Total Sales	Local Tax as a Percentage of Total Sales
Agriculture-Forestry-Mining	0.0 %	0.0 %
Food Products	0.150	0.0167
Forest Products	0.150	0.0167
Chemicals	0.150	0.0167
Petroleum	0.150	0.0167
Metals	0.150	0.0167
Fabricated Metals and Machinery	0.150	0.0167
Transportation Equipment	0.150	0.0167
Miscellaneous Manufacturing	0.150	0.0167
Transport Service	0.439	0.0488
Utilities	0.439	0.0488
Communication	0.439	0.0488
Construction	2.173	0.241
Trade	1.7	0.189
FIRE	0.185	0.021
Services	1.186	0.132
Pipeline Construction	0.0	0.0
Petroleum Construction	0.0	0.0
Dock Buoy Operation	0.0	0.0
Pipe-Dock Operation	0.0	0.0
Shipping	0.0	0.0
Refining Operation	0.0	0.0167

Sources: Department of Revenue, State of Washington, "Quarterly Business Review," Fourth Quarter 1975, First Quarter 1976.

TABLE C-8

EFFECTIVE BUSINESS AND OCCUPATION TAX RATES

Sector	Tax as a Percentage of Total Sales
Agriculture-Forestry-Mining	0.432%
Food Products	0.340
Forest Products	0.415
Chemicals	0.401
Petroleum	0.419
Metals	0.407
Fabricated Metals and Machinery	0.420
Transportation Equipment	0.376
Miscellaneous Manufacturing	0.369
Transport Service	0.467
Utilities	0.667
Communication	0.479
Construction	0.0416
Trade	0.342
FIRE	0.623
Services	0.635
Pipeline Construction	0.0416
Petroleum Construction	0.0416
Dock Buoy Operation	0.467
Pipe-Dock Operation	0.467
Shipping	0.467
Refining Operation	0.419

Sources: Department of Revenue, State of Washington, "Quarterly Business Review," Fourth Quarter 1975, First Quarter 1976.

A recent study by the Department of Revenue estimated that an in-migrant population can be expected to consume 125 packages of cigarettes per capita on an annual basis. This is somewhat higher than the latest reporting period's estimate of actual consumption in Washington -- 100 -- but lower than the national average -- 145. However, because of the higher percentage of people of working age expected in an in-migrant population, the 125 figure has been used in this study also.

The cigarette tax in Washington is presently $0.16 per pack and is collected by means of stamps purchased by cigarette wholesalers. A discount of $1.85 per 1000 cigarettes or $0.037 per package is allowed wholesalers for costs incurred in attaching the stamps. Therefore, the effective rate is $0.123 per package. Using the estimate of 125 packages per capita per annum, state revenues per capita are $15.375.*

The primary Washington tax on motor vehicle fuel is the $0.09 per gallon gasoline tax. Revenues from the tax are used to finance construction and maintenance of highways and streets. The distribution of tax proceeds is somewhat complex. The following entities and funds receive parts of the tax: Puget Sound Reserve Account for ferry system bonds; Urban Arterial Trust Account; Motor Vehicle Bond Redemption Fund; Puget Sound Ferry Operation Account, and state and local general highway funds. As part of its assessment of the state revenues to be generated by the Trident submarine base in Kitsap County, the Department of Revenue estimated motor vehicle

*Estimates based on research conducted by Research and Information Division, Washington State Department of Revenue, "Forecast of State Revenues from Trident Related Activity," January 27, 1977.

fuel taxes by year. These estimates, which were done on a per vehicle basis, can be estimated on a per capita basis using information provided by the Department of Motor Vehicles concerning average persons per vehicle. Annual motor vehicle fuel tax receipts per capita are shown in Table C-9.*

Washington derives revenue from alcoholic beverages in three ways: specific excise or general sales taxes, license fees, and the profits of the state monopoly on liquor sales. Special taxes are imposed on the following alcoholic beverages: spirits, beer, wine, and spirits sold in original containers. Proceeds of the revenues are distributed to the state's general fund, to counties, cities, and towns, and to the University of Washington and Washington State University for medical and biological research. Some funds are earmarked for the Department of Social and Health Services for alcohol rehabilitation. The Department of Revenue has forecast these taxes on a per capita basis. Fiscal 1974 revenues of $87.6 million were divided by the April 1974 population estimate -- 3,488,100 -- to yield a per capita estimate of $25. This has been used for the in-migrant population estimated by this study.

Final demands to Washington's economy from petroleum development activities in Alaska can be expected to come in several forms. Chapters I-IV outlined the major impacts that would accrue to the state and estimated their timing through 1985. In order to utilize these estimates in the I-O models presented previously, it was necessary to translate these quantity impacts into their resultant dollar impacts on the Washington economy.

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*Ibid.

TABLE C-9

ANNUAL PER CAPITA MOTOR VEHICLE FUELS TAX RECEIPTS

Year	Receipts
1977	$39.28
1978	40.53
1979	41.39
1980	42.23
1981	43.44
1982	43.72
1983	44.05
1984	44.29
1985	44.58

Source: Research and Information Division, Washington State Department of Revenue, "Forecast of State Revenues from Trident Related Activity," January 27, 1977.

In general, the several types of impacts can be further disaggregated into construction and operational impacts. Table C-10 indicates the timing of the different types of impacts. As indicated, most construction impacts will be completed by 1981, while many of the operational impacts will not begin until 1979 or 1980. Puget Sound can expect to receive Prudhoe Bay oil as soon as the Alyeska pipeline becomes operational, but unless the Northern Tier Pipeline is completed, flows of Alaskan oil into Puget Sound will not be significant. Heavy flows of equipment through Washington will occur primarily during periods of peak construction of offshore and onshore crude production facilities and a natural gas pipeline and associated facilities.

In our assessment of the impacts of Alaskan oil development on Washington we have taken two approaches: one which considers all impacts including those which will only replace current oil industry impacts on Washington, and a second which will consider only new impacts. The advantage of the first method is that it allows the Department of Ecology to determine the total impact of Alaska's oil on Washington, while the second indicates what additional developments will take place and what impact they will have on the state. We will indicate for each part of the impact whether it is a new or a replacement impact.

Marine terminal expansion costs are estimated in Table C-11. This will be a new impact of Alaskan oil development. This information is taken from Table IV-6 but inflated to 1976 dollars using the 8% inflation rate assumed in the Department of Commerce and Economic Development Study from

TABLE C-10

TIMING OF OIL-RELATED IMPACTS ON WASHINGTON

Impact Category	1977	1978	1979	1980	1981	1982	1983	1984	1985
Oil Refineries									
Expansion and Construction[c]	o[a]	x[b]	x	o	o	o	o	o	o
Use of Alaskan Crude[d]	o	x	x	x	x	x	x	x	x
Tankers									
To Puget Sound Refineries[e]	o	x	x	x	x	x	x	x	x
To Northern Tier Pipeline	o	o	o	x	x	x	x	x	x
Northern Tier Pipeline									
Construction[g]	o	x	x	o	o	o	o	o	o
Operation[h]	o	o	o	x	x	x	x	x	x
El Paso Alaska Natural Gas Pipeline									
Construction[i]	o	o	x	x	x	o	o	o	o
Crude Oil Development[j]	o	o	o	x	x	x	x	x	x
Washington Laborers in Alaska[k]	o	o	o	x	x	x	x	x	x
Washington Oil-related Equipment Manufacture[l]	o	o	x	x	x	x	x	x	x

a. Indicates negligible impact on Washington.
b. Indicates significant impact on Washington.
c. Detailed estimate of direct impacts listed in Table C-11.
d. Detailed estimate of direct impacts listed in Table C-12.
e. Detailed estimate of direct impacts listed in Table C-13.
f. Detailed estimate of direct impacts listed in Table C-14.
g. Detailed estimate of direct impacts listed in Table C-15.
h. Detailed estimate of direct impacts listed in Table C-15.
i. Impact will be water and airfreight shippers; impacts in Tables C-16 and C-17.
j. Impact will be on water and airfreight shippers; impacts listed in Tables C-18 and C-19.
k. Detailed estimate of direct impacts listed in Table C-20.
l. Detailed estimate of direct impacts listed in Table C-21.

TABLE C-11

MARINE TERMINAL EXPANSION COSTS
(thousands of 1976 dollars)

Year	SHELL[a]	TEXACO[b]	MOBIL[c]
1978	$17,064	$1,080	$11,340
1979	17,064	0	0
1980	0	0	0
1981	0	0	0
1982	0	0	0
1983	0	0	0
1984	0	0	0
1985	0	0	0

a. Each year of construction includes $9.18 million for berth construction and $7.884 million for terminal-tankage construction. Figures from Table IV-6 allocated to two construction projects and inflated by 8% to obtain 1976 dollars.
b. Year of construction is for berth facilities. Figure from Table IV-6 inflated by 8% to obtain 1976 dollars.
c. Each year of construction includes $7.553 million for berth construction and $3.807 million for terminal-tankage construction. Figures from Table IV-6 allocated to two construction projects and inflated by 8% to obtain 1976 dollars.

Sources: "Assessment of Alternative Crude Oil Marine Terminal Locations in Washington State," Economic Policy Analysis Division, Washington State Department of Commerce and Economic Development; Arthur D. Little, Inc., estimates.

which the information was derived. Because of the need of the refineries to expand their marine terminal facilities in order to switch from receiving oil through pipelines to receiving oil from tankers, it is expected that this construction will take place in the near future. The allocation between a two-year construction period, however, is based only on the amount of time required for similar projects in other locations. It is possible that all projects could be completed in a one-year time period.

Refined costs for Alaskan crude are derived from a variety of sources. The recently completed assessment of petroleum transfer systems for Washington conducted by the Oceanographic Institute developed estimates of refinery operating costs for refineries in Puget Sound.* These costs have been inflated from their 1974 levels as reported in that document to July 1976 levels using the Nelson cost index as reported in the Oil and Gas Journal.** The refining costs refer only to the amount of Alaskan crude that can be used in each refinery. Since the amount produced by the refineries will not change with the introduction of Alaskan crude, this is solely a replacement impact. (See Table C-12.) Alaskan crude capacities were presented in Table IV-7. Cost estimates are based on those developed by the Oceanographic Institute but were adjusted slightly to include the business and occupation tax as a cost

*Oceanographic Commission of Washington, ibid., pp. V-22-V-24.
**Nelson, W. L., "Nelson Cost Indexes," Oil and Gas Journal, January 3, 1977, p. 78.

TABLE C-12

REFINING COSTS FOR ALASKAN CRUDE OIL IN EXISTING PUGET SOUND REFINERIES[a]
(thousands of 1976 dollars)

Year	Cost[b]
1978	$69.755
1979	69.755
1980	69.755
1981	69.755
1982	69.755
1983	69.755
1984	69.755
1985	69.755

a. Assumes Alaskan crude capacities at 96 MBPD for ARCO, 19.5 MBPD for Texaco, and 17.875 MBPD for Mobil for total of 133.375 MBPD. See Table IV-7 for Alaska crude capacities of Puget Sound refineries.

b. Costs based on refinery operating cost estimates given in Offshore Petroleum Transfer Systems for Washington State: A Feasibility Study, Oceanographic Commission of Washington, 1975. Escalated to third quarter 1976 dollars using Nelson refinery operating cost index, The Oil and Gas Journal, January 3, 1977.

Sources: Oceanographic Commission of Washington, Offshore Petroleum Transfer Systems for Washington State: A Feasibility Study, January 1975; Nelson Cost Indexes, The Oil and Gas Journal, January 3, 1975; Arthur D. Little, Inc., estimates.

of refining. The change in the Nelson index between 1974 and 1976 was then applied to this base. These final demands are applied to the Refining Operations sector of matrix 1 of Table C-1.

Tanker delivery costs of Alaskan crude to Puget Sound refineries are presented in Table C-13. Since most of the oil for the refineries had previously entered from a pipeline to Canada, the economic impacts of the tanker movements are new impacts on Washington. Two sets of cost estimates are presented for each landing port. These estimates differ because of the size of ship assumed for each scenario. The high cost estimates assume that the larger ships of the Jones Act fleet will travel to the most distant ports -- California -- which means that smaller and more expensive ships will travel to Puget Sound ports. The low estimate assigns larger ships to Puget Sound ports. However, in the case of Cherry Point, tankers have been limited to a maximum size of 125,000 deadweight tons. The cost figures do not include any pipeline transportation costs that would be required from either Port Angeles or Kitimat to the Puget Sound refineries. Tanker cost estimates were derived as part of an assessment for the Port of Long Beach of the differing economic costs of alternative delivery methods for getting Alaskan crude oil to the Midwest.* These costs refer only to that amount of crude which can be refined by Puget Sound refineries as determined in Table IV-7. These final demands are applied against the shipping sector of matrix 1 of Table C-1.

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*Port of Long Beach, Sohio West Coast to Mid-Continent Pipeline Project, Draft Environmental Impact Report, 1977.

TABLE C-13

ALASKAN CRUDE OIL DELIVERY COSTS TO PUGET SOUND REFINERIES[a]
(thousands of 1976 dollars)

	Off-loading Point					
	Port Angeles[a]		Cherry Point[b]		Kitimat[c]	
Year	High	Low	High	Low	High	Low
1978	$17,118	$13,964	$22,073	$22,073	$14,415	$11,261
1979	17,118	13,964	22,073	22,073	14,415	11,261
1980	17,118	13,964	22,073	22,073	14,415	11,261
1981	17,118	13,964	22,073	22,073	14,415	11,261
1982	17,118	13,964	22,073	22,073	14,415	11,261
1983	17,118	13,964	22,073	22,073	14,415	11,261
1984	17,118	13,964	22,073	22,073	14,415	11,261
1985	17,118	13,964	22,073	22,073	14,415	11,261

a. Includes 35.28 million bbls/yr for ARCO; 7.166 million bbls/yr for Texaco; and, 6.569 million bbls/yr for Mobil, based on Table IV-7.
b. Cost estimates are $0.34898/bbl for high estimate and $0.028469/bbl for low estimate.
c. Cost estimates for $0.4500/bbl for both high and low estimate.
d. Cost estimates are $0.29338/bbl for high estimate and $0.22959/bbl for low estimate.

Source: SOHIO Pipeline -- Long Beach to Midland, Texas, Draft EIR.

Tanker costs for transporting oil from Valdez to selected Puget Sound ports for transfer to the proposed Northern Tier Pipeline are shown in Table C-14. Transport costs per barrel are the same as those used in Table C-13 and are derived from the same source using identical assumptions. Two levels of costs are provided for the two possible throughput levels of the Northern Tier Pipeline -- 600 MBPD and 800 MBPD. As is easily seen, potential Northern Tier impacts are far greater than those which will be caused by the demand of Puget Sound refineries alone. These final demands are also applied against the shipping sector of matrix 1 of Table C-1.

The Washington portion of the construction cost of the proposed Northern Tier Pipeline, which will be a new impact on Washington, is estimated at $288.4 million. (See Table C-15.) This estimate is based on the proposal of the Northern Tier Pipeline company as prepared by Butler Engineering Associates.* Costs for the Washington sector of the pipeline were estimated as the proportion of total costs that the length of the pipeline in Washington is of the total pipeline length. The cost of all marine terminal facilities associated with the project was allocated to Washington. A construction period of two years is suggested by Butler Engineering but the disaggregation of total construction expenditures between the two years is based on similar projects and would be dependent on the exact start-up date for the project. This final demand will be applied to the

*Butler Engineering Associates, Inc., "Preliminary Engineering Design and Construction Cost Estimate: Northern Tier Pipeline System," 1976.

TABLE C-14

ALASKAN CRUDE TRANSPORT COST TO NORTHERN TIER PIPELINE
(thousands of 1976 dollars)

	Off-loading Point					
	Port Angeles[a]		Cherry Point[b]		Kitimat[c]	
Year	High	Low	High	Low	High	Low
600 MBPD						
1980	$ 76,427	$62,347	$ 98,550	$ 98,550	$64,360	$50,280
1981	76,427	62,347	98,550	98,550	64,360	50,280
1982	76,427	62,347	98,550	98,550	64,360	50,280
1983	76,427	62,347	98,550	98,550	64,360	50,280
1984	76,427	62,347	98,550	98,550	64,360	50,280
1985	76,427	62,347	98,550	98,550	64,360	50,280
800 MBPD						
1980	$101,902	$83,129	$131,400	$131,400	$85,813	$67,040
1981	101,902	83,129	131,400	131,400	85,813	67,040
1982	101,902	83,129	131,400	131,400	85,813	67,040
1983	101,902	83,129	131,400	131,400	85,813	67,040
1984	101,902	83,129	131,400	131,400	85,813	67,040
1985	101,902	83,129	131,400	131,400	85,813	67,040

a. Cost estimates are $0.34898/bbl for high estimate and $0.28469/bbl for low estimate.
b. Cost estimates are $0.4500/bbl for both low and high estimates.
c. Cost estimates are $0.29338/bbl for high estimate and $0.22959/bbl for low estimate.

Source: SOHIO Pipeline -- Long Beach to Midland, Texas, Draft EIR.

TABLE C-15

NORTHERN TIER PIPELINE CONSTRUCTION AND OPERATING COSTS[a]
(thousands of 1976 dollars)

Year	Construction Expenditures[b]	Operation Expenditures[c]
1978	$144,184	$ 0
1979	144,184	0
1980	0	31,736
1981	0	31,736
1982	0	31,736
1983	0	31,736
1984	0	31,736
1985	0	31,736

a. Portion in Washington only, including marine terminal and storage facilities at Port Angeles. Assumes 600 MBPD pipeline.
b. Marginal construction cost to increase capacity to 800 MBPD is $18.043 million.
c. Marginal annual operating cost to increase capacity to 800 MBPD is $12.177 million.

Source: Butler Associates, "Preliminary Engineering Design and Construction Cost Estimate," 1976.

pipeline and marine terminal construction sectors of matrix 1 of Table C-1. The operating costs for the Northern Tier Pipeline are also shown in Table C-15. These are also calculated as a percentage of total operating costs based on the percentage of total pipeline mileage in Washington, plus the cost of the marine terminal.* Total impacts are calculated by using these operating cost estimates as a final demand against the pipeline and marine terminal operating sector of matrix 1 of Table C-1.

Washington will be a transshipment point for construction materials required for the El Paso Alaska natural gas line and LNG facility. Because Washington served as a center for logistical support activities for the construction of the Alyeska pipeline, it is not perfectly obvious as to whether these impacts should be considered as new or replacement impacts. We have chosen to consider them as new impacts since they will support new and different projects in Alaska from those supported previously through Washington. The revenues accruing to Washington as a result of this activity are shown in Tables C-16 and C-17, for marine and air transportation respectively. The total amount of commodity flows to Alaska is taken from Table IV-23. Based on experiences of the Alyeska pipeline, allocations were made to marine and airfreight operations. Marine freight rates were determined by allocating different freight to different carriers based on the capacity and nature of their service and then calculating the appropriate freight rate for each type of commodity based on the freight rates of the different carriers. Airfreight

*Butler Associates, ibid.

TABLE C-16

MARINE SHIPPING REVENUES FOR EQUIPMENT TO BE TRANSSHIPED THROUGH WASHINGTON FOR EL PASO ALASKA GAS PIPELINE AND LNG PLANT[a]
(millions of 1976 dollars)

	1979	1980	1981
Alaskan Pipeline			
Main Line Pipe[b]	$30.167	$30.167	$ 0
Compressor Stations[c]	0	1.446	1.446
Construction Equipment[c]	0.957	0	0
Miscellaneous[d]	0.271	0.477	0.289
Subtotal	$31.395	$32.090	$ 1.735
Alaskan LNG Plant			
Plant Equipment[c]	$ 8.383	$ 8.383	$ 1.524
Construction Equipment[c]	0.470	0.107	0
Subtotal	$ 8.853	$ 8.493	$ 1.524
Total	$40.248	$40.583	$ 3.259

a. Cargo volumes based on Table IV-23. Rates based on those of Totem Ocean Trailer Express.
b. Assumes all main line pipe listed in Table IV-23 moves by water.
c. Assumes 80% of indicated categories moves by water and 20% by airfreight.
d. Assumes 50% of miscellaneous cargos move by water and 50% by airfreight.
e. Assumes 90% of plant equipment moves by water and 10% by air freight.

Sources: Totem Ocean Trailer Express, Inc., Freight Tariff No. 1, 1976; Crowley Tug and Barge, Inc.; Sea Land; Arthur D. Little, Inc., estimate based on information from El Paso Natural Gas Company.

TABLE C-17

AIRFREIGHT SHIPPING REVENUES FOR EQUIPMENT TO BE TRANSSHIPPED THROUGH WASHINGTON FOR EL PASO ALASKA GAS PIPELINE AND LNG PLANT[a]
(millions of 1976 dollars)

	1979	1980	1981
Alaskan Pipeline			
Compressor Station[b]	$ 0	$ 2.205	$ 2.205
Construction Equipment[b]	1.929	0	0
Miscellaneous[c]	2.082	3.671	2.224
Subtotal	$ 4.011	$ 5,876	$ 4.429
Alaskan LNG Plant			
Plant Equipment[d]	$ 7.762	$ 7.762	$ 1.411
Construction Equipment[b]	1.000	0.227	0
Subtotal	$ 8.762	$ 7.989	$ 1.411
Total	$12.773	$13.865	$ 5.840

a. Cargo volumes based on Table IV-23. Rates based on discussions with airfreight operators at Sea-Tac International Airport.
b. Assumes 20% of indicated cargo moves by airfreight and 80% by water.
c. Assumes 50% of indicated cargo moves by airfreight and 50% by water.
d. Assumes 10% of indicated cargo moves by airfreight and 90% by water.

Sources: Pacific Northwest Airlines; Pan American Airlines; Western Airlines; Arthur D. Little, Inc., estimate based on information from El Paso Natural Gas Company.

rates were assumed at a constant rate of $500 per ton which several air-freight operators in Seattle indicated was the average charge currently being assessed against oil-related airfreight traffic to Alaska. Air carriers are expected to carry approximately 8% of all freight moving to Alaska for the pipeline and LNG facility. Because of the prompt service currently being offered by Totem Ocean Trailer Express, it was assumed that direct truck traffic to Alaska would be minimal.

The impacts of commodities shipped through Washington for crude oil development in Alaska are shown in Tables C-18 and C-19. Total cargo volumes are based on Table IV-23. Freight is allocated between water and air transport on the basis of the allocations for previous shipment of oil-related freight. Sources for both air and water freight rates are the same as those used in Tables C-16 and C-17. The impact of this development will continue for a longer time period than for the gas pipeline and associated LNG facility. These impacts are applied to the water and air transportation sectors of matrix 2 of Table C-1.

One of the major impacts of oil-related developments for Washington will be the number of Washington residents who will hold oil-related jobs in Alaska. These will be new jobs and will therefore be new impacts on Washington. The numbers of people are estimated in several tables in Chapter IV. Utilizing the wage rates assumed in Table IV-34, Table C-20 estimates the wages that will be returned to Washington by residents working in Alaska. Because of the uncertainty of the exact number of

TABLE C-18

MARINE SHIPPING REVENUES FOR EQUIPMENT TO BE TRANSSHIPED THROUGH WASHINGTON FOR ALASKAN PETROLEUM DEVELOPMENT[a]
(millions of 1976 dollars)

	1980	1981	1982	1983	1984	1985
Offshore						
Drilling Materials						
Steel Casing	$ 1.162	$ 1.936	$ 2.710	$ 3.485	$ 3.746	$ 4.269
Drilling Muds	2.659	4.432	6.205	7.978	8.875	9.773
Well Completion Equipment[b]	0.024	0.073	0.121	0.169	0.187	0.206
Miscellaneous[c]	0.020	0.033	0.046	0.059	0.065	0.072
Subtotal	$ 3.865	$ 6.474	$ 9.082	$11.691	$12.873	$14.320
Pipeline						
Steel Pipe	$ 1.370	$ 2.283	$ 3.196	$ 4.109	$ 4.109	$ 4.109
Coating	1.815	3.717	5.204	6.691	6.691	6.691
Welding Materials and Miscellaneous[c]	0.007	0.012	0.016	0.021	0.021	0.021
Subtotal	$ 3.192	$ 6.012	$ 8.416	$10.821	$10.821	$10.821
Platform Installations						
Modules	$ 1.080	$ 1.800	$ 2.520	$ 3.240	$ 3.240	$ 3.240
Piling	0.231	0.308	0.385	0.462	0.462	0.462
Cement	0.011	0.019	0.026	0.033	0.033	0.033
Subtotal	$ 1.322	$ 2.127	$ 2.931	$ 3.735	$ 3.735	$ 3.735
Total Offshore	$ 8.379	$14.613	$20.429	$26.247	$27.429	$28.876
Onshore						
Drilling Materials						
Steel Casing	$ 1.706	$ 1.706	$ 1.706	$ 1.706	$ 1.706	$ 1.706
Drilling Muds	4.986	4.986	4.986	4.986	4.986	4.986
Well Completion Equipment[b]	0.088	0.088	0.088	0.088	0.088	0.088
Miscellaneous[c]	0.037	0.037	0.037	0.037	0.037	0.037
Subtotal (Total Onshore)	$ 6.817	$ 6.817	$ 6.817	$ 6.817	$ 6.817	$ 6.817
Total Revenues	$15.196	$21.430	$27.246	$33.064	$33.246	$35.693

a. Cargo volumes based on Table II-9. Rates based on those of Totem Ocean Trailer Express.
b. Assumes 70% of well completion equipment moves by water and 30% by airfreight.
c. Assumes 50% of welding materials and miscellaneous cargos move by water and 50% by airfreight.

Sources: Totem Ocean Trailer Express, Inc.; Freight Tarrif No. 1, 1976; Arthur D. Little, Inc., estimates.

TABLE C-19

AIRFREIGHT SHIPPING REVENUES FOR EQUIPMENT TO BE TRANSSHIPPED THROUGH WASHINGTON FOR ALASKAN PETROLEUM DEVELOPMENT[a]
(thousands of 1976 dollars)

	1980	1981	1982	1983	1984	1985
Offshore						
Drilling Materials						
Well Completion Equipment[b]	$ 86.3	$ 259.1	$ 432.0	$ 604.8	$ 669.6	$ 734.4
Miscellaneous[c]	150.0	250.0	350.0	450.0	501.0	551.0
Subtotal	$ 236.3	$ 261.6	$ 782.0	$1,054.8	$1.170.6	$1,285.4
Pipeline						
Welding Materials and Miscellaneous[c]	$ 62.5	$ 104.3	$ 145.8	$ 187.5	$ 187.5	$ 187.5
Subtotal	$ 62.5	$ 104.3	$ 145.8	$ 187.5	$ 187.5	$ 187.5
Total Offshore	$ 298.8	$ 365.9	$ 927.8	$1,242.3	$1,358.1	$1,472.9
Onshore						
Drilling Materials						
Well Completion Equipment[b]	$ 313.2	$ 313.2	$ 313.2	$ 313.2	$ 313.2	$ 313.2
Miscellaneous[c]	281.3	281.3	281.3	281.3	281.3	281.3
Subtotal (Total Onshore)	$ 594.5	$ 594.5	$ 594.5	$ 594.5	$ 594.5	$ 594.5
Total Revenues	$ 893.3	$ 960.4	$1,522.5	$1,836.8	$1,952.6	$2,067.4

a. Cargo volumes based on Table II-9. Rates based on discussions with airfreight operators at Sea-Tac International Airport.
b. Assumes 30% of indicated cargo moves by airfreight and 70% by water.
c. Assumes 50% of indicated cargo moves by airfreight and 50% by water.

Sources: Pacific Northwest Airlines; Pan American Airlines; Western Airlines; Arthur D. Little, Inc., estimates.

TABLE C-20

WAGES AND WASHINGTON COMPONENT OF CONSUMPTION
OF WASHINGTON RESIDENTS OF OFFSHORE LABOR FORCE
(millions of 1976 dollars)

	1980	1981	1982	1983	1984	1985
Total Wages - Best Estimate[a]	$33.428	$65.556	$97.683	$105.211	$112.739	$120.268
Consumption in Washington - Best Estimate[b]	28.414	55.723	83.031	89.429	95.828	102.228
Consumption in Washington - Low Estimate[c]	20.057	39.337	58,610	63.127	67.643	72.161
Total Wages - Low Estimate[d]	6.686	13.111	19.537	21.042	22.548	24.053
Consumption in Washington - Best Estimate	5.683	11.145	16.606	17.886	19.166	20.446
Consumption in Washington - Low Estimate	4.011	7.867	11.722	12.625	13.529	14.432

a. Includes 75% of all skilled and semiskilled offshore personnel. See Tables IV-32 and IV-33.
b. Assumes 85% of payroll returned to Washington.
c. Assumes 60% of payroll returned to Washington.
d. 20% of the high estimate.

Washington residents who will find work in Alaska, a range of estimates is offered. Similarly, ranges are offered of the percentage of the payroll that will be returned to Washington. This labor force would be involved in crude oil development operations only. This income will act as a final demand to the personal consumption sectors of the I-O matrix and will be applied to matrix 2 of Table C-1.

Table C-21 estimates the impact of drilling/production platform construction on Washington. Currently Kaiser industries has an option on land at the Port of Everett and at Grays Harbor for the purpose of constructing drilling/production platforms for use in offshore Alaskan waters. Kaiser anticipates being able to construct approximately 40 platforms over a ten-year period at a cost of between $50 and $100 million per platform. Preliminary calculations by the Port of Everett and Kaiser Engineering indicate that approximately $15 million will be required to prepare the site for construction and that it is unlikely that any platforms could be completed before the end of 1979.* All final demands will be applied to the construction sector of matrix 2 of Table C-1. These construction activities would be a new impact on Washington since similar platforms have never before been constructed in the state.

*Interview with John Belford, Manager, Port of Everett, November 1976.

TABLE C-21

OFFSHORE DRILLING/PRODUCTION PLATFORM CONSTRUCTION
(millions of 1976 dollars)

Year	Facility Preparation	Platform Construction[a]
1977	$6.0[b]	$ 0
1978	9.0[b]	0
1979	0	75.0[c]
1980	0	225.0[d]
1981	0	300.0[e]
1982	0	300.0
1983	0	300.0
1984	0	300.0
1985	0	300.0

a. Platform costs are expected to vary widely, dependent upon the specifications required for a platform in a specific area. Costs will range between $50 and $100 apiece. Average cost of $75 million/platform used.
b. Two-year preparation costs to include $5 million for dredging, settling, and dike construction; $5 million for other land costs; and $5 million investment by developer for construction facilities.
c. Completion of one platform.
d. Completion of three platforms.
e. Completion of four platforms.

Sources: Interview with John Belford, Manager, Port of Everett; Arthur D. Little, Inc., estimates.

APPENDIX D

TABLE D-1

DIRECT ECONOMIC IMPACT OF LOGISTIC SUPPORT ACTIVITIES
(low estimate; thousands of 1976 dollars)

Year	Scenario Component: Waterborne Commerce for Crude Oil Development[a]	Airborne Commerce for Crude Oil Development[b]	Waterborne Commerce for El Paso Gas Line[c]	Airborne Commerce for El Paso Natural Gas Line[d]	Washington Residents Working in Alaska[e]	Manufacturing of Oil Platforms in Washington	Total
1977	$ 0	$ 0	$ 0	$ 0	$ 0	$ 6,000	$ 6,000
1978	0	0	0	0	0	9,000	9,000
1979	0	0	40,248	12,773	0	75,000	128,021
1980	15,196	893	40,583	13,865	4,011	225,000	299,548
1981	21,430	960	3,259	5,840	7,867	300,000	339,356
1982	27,246	1,523	0	0	11,722	300,000	340,491
1983	33,064	1,837	0	0	12,625	300,000	347,526
1984	33,246	1,953	0	0	13,529	300,000	348,728
1985	35,693	2,067	0	0	14,432	300,000	352,192
Total	$165,875	$9,233	$84,090	$32,478	$64,186	$1,815,000	$2,170,862

a. From Table C-18. New impact.
b. From Table C-19. New impact.
c. From Table C-16. New impact.
d. From Table C-17. New impact.
e. From Table C-20. New impact.
f. From Table C-21. New impact.

TABLE D-2

DIRECT ECONOMIC IMPACT OF SCENARIO II-A
(low estimate; thousands of 1976 dollars)

	Scenario Component			
Year	All Scenario I Components[a]	Crude Oil Delivery to Northern Tier Pipeline[b]	Northern Tier Construction and Operation Costs[c]	Total
1978	$121,312	$ 0	$144,184	$ 265,496
1979	108,892	0	144,184	253,076
1980	91,828	62,347	31,736	185,911
1981	91,828	62,347	31,736	185,911
1982	91,828	62,347	31,736	185,911
1983	91,828	62,347	31,736	185,911
1984	91,828	62,347	31,736	185,911
1985	91,828	62,347	31,736	185,911
Total	$781,172	$374,082	$478,784	$1,634,038

a. From Table XI-4. Replacement impact during each year is $69.755 million.
b. From Table C-14; Port Angeles destination. Assumes 600 MBPD. New impact.
c. From Table C-15. Assumes 600 MBPD. New impact.

TABLE D-3

DIRECT ECONOMIC IMPACT OF SCENARIO II-B
(low estimate; thousands of 1976 dollars)

Year	Scenario Components: Refinery Operating Costs[a]	Pipeline Construction and Operations Costs[b]	Tanker Transport Costs[c]	Total
1978	$ 69,755	$159,184	$ 22,073	$ 251,012
1979	69,755	159,184	22,073	251,012
1980	69,755	33,000	54,238	156,993
1981	69,755	33,000	54,238	156,993
1982	69,755	33,000	54,238	156,993
1983	69,755	33,000	54,238	156,993
1984	69,755	33,000	54,238	156,993
1985	69,755	33,000	54,238	156,993
Total	$558,040	$516,368	$369,574	$1,443,982

a. From Table C-12. Replacement impact.
b. From Table C-15. Assumes a capacity of 730 MBPD from Port Angeles to the origin of the pipeline spur, a capacity of 600 MBPD for the remainder of the Northern Tier Pipeline, and a capacity of 130 MBPD for the pipeline spur. New impact.
c. From Table C-14. Assumes 730 MBPD. New impact.

TABLE D-4

DIRECT ECONOMIC IMPACT OF SCENARIO III
(low estimate; thousands of 1976 dollars)

Year	Scenario Components: All Scenario I Components[a]	Crude Oil Delivery to Northern Tier Pipeline[b]	Northern Tier Pipeline Construction and Operations Costs[c]	Total
1978	$121,312	$ 0	$139,668	$ 260,980
1979	108,892	0	144,248	253,140
1980	91,828	98,550	29,000	219,378
1981	91,828	98,550	29,000	219,378
1982	91,828	98,550	29,000	219,378
1983	91,828	98,550	29,000	219,378
1984	91,828	98,550	29,000	219,378
1985	91,828	98,550	29,000	219,378
Total	$781,172	$591,300	$457,916	$1,830,388

a. From Table XI-4. Replacement impact during each year of $69.755 million.
b. From Table C-14. Assumes 600 MBPD and Cherry Point Destination. New impact.
c. From Table C-15. Assumes a landing capacity of 730 MBPD, a capacity of the Northern Tier Pipeline of 600 MBPD, and a capacity of a spur pipeline from the landing site to the Puget Sound refineries of 130 MBPD. New impact.

TABLE D-5

DIRECT ECONOMIC IMPACTS OF SCENARIO IV
(low estimate; thousands of 1976 dollars)

Year	Scenario Components: Crude Oil for Local Refineries Delivered to Kitimat[a]	Crude Oil for Midwest Refineries Delivered to Kitimat[b]	Refining Costs for Puget Sound Refineries[c]	Total
1978	$ 22,073	$ 0	$ 69,755	$ 91,828
1979	11,261	50,280	69,755	131,296
1980	11,261	50,280	69,755	131,296
1981	11,261	50,280	69,755	131,296
1982	11,261	50,280	69,755	131,296
1983	11,261	50,280	69,755	131,296
1984	11,261	50,280	69,755	131,296
1985	11,261	50,280	69,755	131,296
Total	$100,900	$351,960	$558,040	$1,010,900

a. From Table C-14. New impact.
b. From Table C-14. Assumes Kitimat as destination and throughput of 600 MBPD. New impact.
c. From Table C-12. Replacement impact.

TABLE D-6

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS*
LOGISTIC SUPPORT ACTIVITIES
(low estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978	$ 15,000	$ 18,951	$ 397	$ 757	$ 56	74	7
1979	128,021	178,842	5,441	19,619	800	1,560	103
1980	299,548	444,354	16,595	36,539	2,318	3,343	299
1981	339,356	599,500	25,846	37,264	3,550	4,091	460
1982	340,491	609,968	32,248	39,926	4,372	4,680	569
1983	347,526	640,098	35,820	43,638	4,870	5,151	636
1984	348,728	645,128	36,860	44,126	5,000	5,230	655
1985	352,192	651,772	37,784	44,998	5,118	5,319	671
1986**	-0-	203,488	23,543	20,675	3,447	3,147	453
1987**	-0-	101,588	11,776	10,328	1,725	1,572	226
1988**	-0-	47,744	5,551	4,859	814	739	107

*All impacts are net impacts; i.e., there are no replacement impacts.
**Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE D-7

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS*
LOGISTIC SUPPORT ACTIVITIES
(low estimate; thousands of 1976 dollars)

Year	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978	173	18	58	6	23	2	$ 44	$ 1	$ 69	$ 1	$ 21	$ 2	$ 135	$ 4
1979	3,674	248	1,225	83	490	33	633	21	701	15	471	26	1,804	62
1980	7,871	724	2,624	241	1,050	97	1,435	61	1,590	44	968	78	3,993	182
1981	9,625	1,114	3,209	371	1,283	149	1,746	94	1,802	68	1,132	120	4,680	282
1982	11,010	1,378	3,670	459	1,468	184	1,971	117	1,864	84	1,275	149	5,110	350
1983	12,118	1,540	4,039	513	1,616	205	2,137	132	1,940	93	1,405	167	5,482	391
1984	12,303	1,585	4,101	528	1,640	211	2,164	136	1,948	95	1,428	172	5,540	403
1985	12,512	1,624	4,171	541	1,668	217	2,197	140	1,969	97	1,458	177	5,624	414
1986**	7,400	1,095	2,467	365	987	146	1,018	95	313	65	812	119	2,143	279
1987**	3,697	548	1,232	183	493	73	509	47	156	33	405	59	1,070	140
1988**	1,739	258	580	86	232	34	239	22	74	15	190	28	503	66

*All impacts are net impacts; i.e., there are no replacement impacts.
**Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE D-8

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO II-A - NORTHERN TIER PIPELINE WITHOUT PUGET SOUND SPUR
(low estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$265,496	$386,056	$ 66,973	$59,265	$ 7,860	2,953	779
1979[b]	253,076	292,804	129,982	62,355	15,279	3,510	1,514
1980[c]	185,911	225,943	123,302	16,217	14,535	1,502	1,430
1981[d]	185,911	225,539	113,993	14,827	13,471	1,328	1,315
1982[e]	185,911	219,960	91,689	12,350	10,873	1,044	1,052
1983[f]	185,911	215,700	73,965	10,390	8,800	818	841
1984[f]	185,911	215,700	73,965	10,390	8,800	818	841
1985[f]	185,911	215,700	73,965	10,390	8,800	818	841
1986[g]	-0-	19,880	49,361	3,916	5,873	387	562
1987[g]	-0-	9,908	24,603	1,952	2,927	193	280
1988[g]	-0-	4,624	11,481	911	1,366	90	131

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 60% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE D-9

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO II-A - NORTHERN TIER PIPELINE WITHOUT PUGET SOUND SPUR
(low estimate; thousands of 1976 dollars)

Year	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	6,970	1,838	2,323	612	929	245	$332	$226	$ 687	$109	$1,074	$215	$2,096	$ 552
1979[b]	8,282	3,573	2,760	1,191	1,104	476	535	441	717	212	1,215	423	2,469	1,077
1980[c]	3,544	3,375	1,181	1,125	472	450	493	422	1,018	215	432	403	1,943	1,042
1981[d]	3,133	3,102	1,044	1,034	417	413	441	394	1,016	214	490	376	1,848	985
1982[e]	2,463	2,481	821	827	328	330	358	321	990	185	313	301	1,663	809
1983[f]	1,931	1,985	643	661	257	264	291	262	971	162	152	243	1,515	669
1984[f]	1,931	1,985	643	661	257	264	291	262	971	162	152	244	1,516	669
1985[f]	1,931	1,985	643	661	257	264	291	262	971	162	153	244	1,516	670
1986[g]	912	1,325	304	441	121	176	116	175	90	108	110	162	319	447
1987[g]	454	660	151	220	60	88	58	87	45	54	54	81	159	222
1988[g]	212	308	70	102	28	41	27	40	21	25	25	37	74	104

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 60% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE D-10

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO II-B - NORTHERN TIER PIPELINE WITH PUGET SOUND SPUR
(low estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$251,012	$247,781	$ 57,497	$54,988	$ 6,829	2,721	678
1979[b]	251,012	264,454	115,359	60,679	13,702	3,348	1,360
1980[c]	179,066	213,804	111,616	14,969	13,277	1,377	1,308
1981[d]	179,066	214,148	103,821	13,778	12,370	1,224	1,208
1982[e]	179,066	210,233	85,470	11,748	10,202	989	987
1983[f]	179,066	206,806	69,413	9,972	8,304	783	794
1984[f]	179,066	206,806	69,413	9,972	8,304	783	794
1985[f]	179,066	206,806	69,413	9,972	8,304	783	794
1986[g]	-0-	18,513	46,324	3,711	5,542	366	530
1987[g]	-0-	9,227	23,089	1,850	2,762	183	264
1988[g]	-0-	4,306	10,775	863	1,289	85	123

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 65% of gross impacts in all categories.
f. Net impacts will be approximately 60% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE D-11

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO II-B - NORTHERN TIER PIPELINE WITH PUGET SOUND SPUR
(low estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	6,421	1,599	2,140	533	856	213	$305	$197	$446	$ 92	$ 993	$187	$1,746	$477
1979[b]	7,902	3,209	2,634	1,069	1,053	427	495	395	523	184	1,170	380	2,189	961
1980[c]	3,250	3,086	1,083	1,028	433	411	462	386	962	192	397	368	1,823	948
1981[d]	2,889	2,850	963	950	385	380	415	362	964	194	360	344	1,741	902
1982[e]	2,334	2,329	778	776	311	310	344	301	946	172	297	283	1,588	757
1983[f]	1,848	1,873	616	624	246	249	282	247	930	152	242	229	1,454	630
1984[f]	1,848	1,873	616	624	246	249	282	247	930	152	242	229	1,454	631
1985[f]	1,848	1,873	616	624	246	249	282	247	930	152	243	230	1,455	631
1986[g]	864	1,250	288	416	115	166	110	165	84	102	105	153	300	421
1987[g]	430	623	143	207	57	83	55	82	42	50	51	75	149	210
1988[g]	201	290	67	96	26	38	25	38	19	23	24	35	69	98

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 90% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 65% of gross impacts in all categories.
f. Net impacts will be approximately 60% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE D-12

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO III - NORTHERN TIER PIPELINE WITH CHERRY POINT TERMINAL
(low estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$231,496	$248,041	$ 55,077	$49,206	$ 6,518	2,453	645
1979[b]	236,076	264,693	110,503	54,558	13,078	3,039	1,294
1980[c]	219,378	257,833	116,413	15,719	13,738	1,399	1,347
1981[d]	219,378	261,965	118,501	15,280	13,946	1,325	1,355
1982[e]	219,378	260,063	105,987	13,733	12,444	1,142	1,200
1983[f]	219,378	258,399	95,036	12,378	11,130	981	1,064
1984[f]	219,378	258,399	95,036	12,378	11,130	981	1,064
1985[f]	219,378	258,399	95,036	12,378	11,130	981	1,064
1986[g]	-0-	26,041	63,425	4,848	7,428	479	710
1987[g]	-0-	12,980	31,612	2,416	3,702	239	354
1988[g]	-0-	6,057	14,752	1,128	1,728	111	165

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 85% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 75% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.
g. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE D-13

GROSS DEMOGRAPHIC, TAX, AND LAND USE IMPACTS
SCENARIO III - NORTHERN TIER PIPELINE WITH CHERRY POINT TERMINAL
(low estimate; thousands of 1976 dollars)

	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
Year	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	5,789	1,522	1,929	507	771	203	$293	$188	$ 530	$ 90	$ 892	$179	$1,716	$ 459
1979[b]	7,172	3,054	2,390	1,018	956	407	470	378	606	182	1,057	361	2,135	923
1980[c]	3,301	3,179	1,100	1,059	440	423	461	401	1,167	209	407	380	2,037	992
1981[d]	3,126	3,199	1,042	1,066	416	426	439	410	1,185	230	393	388	2,019	1,029
1982[e]	2,693	2,832	897	944	359	377	384	369	1,176	219	344	345	1,905	934
1983[f]	2,315	2,512	771	837	308	334	335	332	1,168	209	301	308	1,806	850
1984[f]	2,315	2,512	771	837	308	334	335	332	1,168	209	302	308	1,806	850
1985[f]	2,315	2,512	771	837	308	334	335	332	1,168	209	302	309	1,807	851
1986[g]	1,130	1,676	376	558	150	223	146	222	118	139	137	206	402	568
1987[g]	563	835	187	278	75	111	72	110	58	69	67	101	200	283
1988[g]	262	389	87	129	35	51	34	51	27	32	31	47	93	132

a. Net impacts will be approximately 90% of gross impacts in all categories.
b. Net impacts will be approximately 85% of gross impacts in all categories.
c. Net impacts will be approximately 80% of gross impacts in all categories.
d. Net impacts will be approximately 75% of gross impacts in all categories.
e. Net impacts will be approximately 70% of gross impacts in all categories.
f. Net impacts will be approximately 65% of gross impacts in all categories.
g. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

TABLE D-14

GROSS SALES, EMPLOYMENT, AND INCOME IMPACTS
SCENARIO IV - KITIMAT-TRANS MOUNTAIN PIPELINE
(low estimate; thousands of 1976 dollars)

Year	Final Demand Sales	Total Sales		Wage and Salary Income		Person Years of Employment	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	$ 91,828	$ 96,086	$ 9,402	$3,289	$1,118	242	108
1979[b]	131,296	143,216	26,761	5,623	3,127	430	301
1980[c]	131,296	148,885	39,724	6,706	4,612	537	444
1981[d]	131,296	152,673	48,324	7,476	5,605	613	539
1982[e]	131,296	154,250	52,009	7,715	6,018	636	578
1983[e]	131,296	154,250	52,009	7,716	6,018	636	578
1984[e]	131,296	154,250	52,009	7,716	6,018	636	578
1985[e]	131,296	154,250	52,009	7,716	6,018	636	578
1986[f]	-0-	15,319	34,709	3,162	4,016	312	386
1987[f]	-0-	7,635	17,299	1,576	2,002	155	192
1988[f]	-0-	3,563	8,073	736	934	73	90

a. Net impacts will be approximately 15% of gross impacts in all categories.
b. Net impacts will be approximately 35% of gross impacts in all categories.
c. Net impacts will be approximately 45% of gross impacts in all categories.
d. Net impacts will be approximately 45% of gross impacts in all categories.
e. Net impacts will be approximately 45% of gross impacts in all categories.
f. Secondary impacts only.

Source: Arthur D. Little, Inc., estimates.

TABLE D-15

GROSS DEMOGRAPHIC, LAND USE, AND TAX IMPACTS
SCENARIO IV - KITIMAT-TRANS MOUNTAIN PIPELINE
(low estimate; thousands of 1976 dollars)

Year	Supported Population		Supported Households		Land Consumption (acres)		Sales Taxes		B & O Taxes		Other Taxes		Total Taxes	
	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1978[a]	571	254	190	84	76	33	$147	$ 32	$415	$ 18	$ 74	$ 29	$ 637	$ 81
1979[b]	1,014	710	338	236	135	94	194	91	634	55	130	83	961	231
1980[c]	1,266	1,046	422	348	168	139	227	135	660	82	161	125	1,050	344
1981[d]	1,445	1,272	481	424	192	169	250	164	678	100	185	154	1,114	420
1982[e]	1,501	1,365	500	455	200	182	258	176	685	109	192	165	1,136	452
1983[e]	1,501	1,365	500	455	200	182	258	176	685	109	192	166	1,136	453
1984[e]	1,501	1,365	500	455	200	182	258	176	685	109	193	166	1,137	453
1985[e]	1,501	1,365	500	455	200	182	258	176	685	109	193	166	1,137	454
1986[f]	735	911	245	303	98	121	94	118	70	72	89	111	254	303
1987[f]	366	454	122	151	48	60	47	58	35	36	43	55	126	151
1988[f]	171	211	57	70	22	28	22	27	16	16	20	26	59	70

a. Net impacts will be approximately 15% of gross impacts in all categories.
b. Net impacts will be approximately 35% of gross impacts in all categories.
c. Net impacts will be approximately 45% of gross impacts in all categories.
d. Net impacts will be approximately 45% of gross impacts in all categories.
e. Net impacts will be approximately 45% of gross impacts in all categories.
f. Secondary impacts only.

Total Taxes may not equal sum of Sales, B & O, and Other Taxes due to rounding.

Source: Arthur D. Little, Inc., estimates.

APPENDIX E

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