VOLUME THREE
ENVIRONMENTAL SETTING AND ASSESSMENT
FOR
A LIQUEFIED NATURAL GAS TERMINAL
GRASSY POINT, PORT SIMPSON BAY
NORTHERN BRITISH COLUMBIA

by

Dome Petroleum Limited

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VOLUME THREE

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1.00 THE ENVIRONMENTAL ASSESSMENT PROGRAM

1.10 INTRODUCTION

Grassy Point on Port Simpson Bay is the preferred site on the British Columbia coast selected by Dome Petroleum Limited (Dome) for its proposed Liquefied Natural Gas (LNG) process plant and export terminal to load carriers specifically designed to carry LNG. These carriers will approach the proposed terminal utilizing a variety of route alternatives shown in Figure 2-2.1. It is assumed that out-bound carriers will use the reverse course.

Gas will be supplied to the project site by pipeline as described in Volume One of this Application. The pipeline portion of the project will be the subject of a separate application, however, an environmental overview of the pipeline has been prepared by Westcoast Transmission Company Limited for Dome Petroleum and is included as Volume Four of the Application.

This report is to address concerns related to both the Federal and Provincial Governments for the potential implications of trans-shipment of LNG by carrier and the LNG terminal operations to the marine environment. This report comprises the environmental setting and the environmental assessment for the proposed project, and to provide the basis for achieving or bettering all government environmental requirements for permits, licenses and approvals.

1.20 OBJECTIVES

The specific objectives of the program for project environmental assessment were:

1. Identify, review, interpret and summarize all available environmental information (literature) relevant to the proposed project.

2. Identify and conduct necessary field programs to obtain the specific environmental data necessary to supplement the existing data base.

3. Identify federal and provincial regulatory requirements necessary for obtaining environmental approvals including licenses, permits, approvals, environmental assessment and contingency planning.

4. Identify resource areas that might be affected by the proposed project or the effects of a spill of LNG.

5. To provide necessary information for engineering design and/or to meet governmental environmental requirements.

1.30 SCOPE OF WORK

1.3.1 Existing Environmental Data

To gather baseline environmental and socio-economic information and to prepare the environmental assessment for the Western LNG Project, Dome has retained the following British Columbia consulting firms:

- ARESCO Ltd. - Historic and Archaeological Resources
- Beak Consultants - Vegetation and Wildlife
- Canadian Resourcecon Limited - Socio-Economic and Benefit Cost
- Environmental Sciences Limited - Oceanography, Meteorology and Fisheries
- Swan Wooster Engineering Co. - Fresh Water Supply Study
- Tera Environmental Consultants Ltd. - Land Forms, Terrain Analysis, Surficial Geology and Seismicity

The environmental studies by these experts in each of the scientific disciplines were compiled into this environmental assessment of the LNG Project.

Existing baseline information was obtained from many research sources. The sources included published literature, public and private research surveys conducted in the recent past and special field surveys undertaken by the various consultants on behalf of Dome. The Provincial Government agencies contacted for information included Ministries of Energy, Mines and Petroleum Resources, Environment (Fish and Wildlife Branch and Waste Management Branch), Forests; Lands, Parks, and Housing, Transportation and Highways, Provincial Secretary and Public Services, Human Resources, Health, Labour, Tourism, and Industry and Small Business Development. Information from Environment Canada, specifically Fisheries and Oceans, Atmospheric Environment Service, Environmental Protection Service, and Canadian Wildlife Service was sought. Other federal agencies contacted include Energy Mines and Resources (Geological Survey of Canada), Indian and Northern Affairs and Public Works Canada. Information was obtained from industry and trade associations as well.

1.3.2 Site Specific Monitoring Programs

Additional site specific information on wind speed and direction, humidity and temperture is necessary for the design of marine and shore based facilities. A meteorological station was established in May 1981 at a site on Port Simpson Bay with guidance from the Atmospheric Environment Service to collect this data. Wave, current and temperature/density measurements are needed at the entrance to Port Simpson Bay (Inskip Passage), in the manoevering area, and in the vicinity of the wharf. An oceanographic program designed in cooperation with the Marine Environmental Data Service was implemented in May 1981 to gather current, wave, tide, salinity and temperature information. Additional field work is required to choose a prepared local stream to be developed as a fresh water supply source and to determine hydrological and fisheries information for that stream. Should other data gaps be identified, studies will be undertaken to allow complete understanding of the environmental resources of the Project area.

1.40 GOVERNMENT REQUIREMENTS

The work conducted and reported in this document, "Environmental Setting and Assessment Western LNG Project" was based on the requirements generally outlined in various federal and provincial environmental assessment guidelines and the Canadian Standards Association Standard Z276 - Liquefied Natural Gas (LNG) - Production, Storage and Handling.

1.50 STUDY AREA

For the purposes of this report the study area was broken into two sections. The first, the Marine Approaches, provides a regional perspective to the resources encountered by an LNG carrier as it approaches the terminal or as it

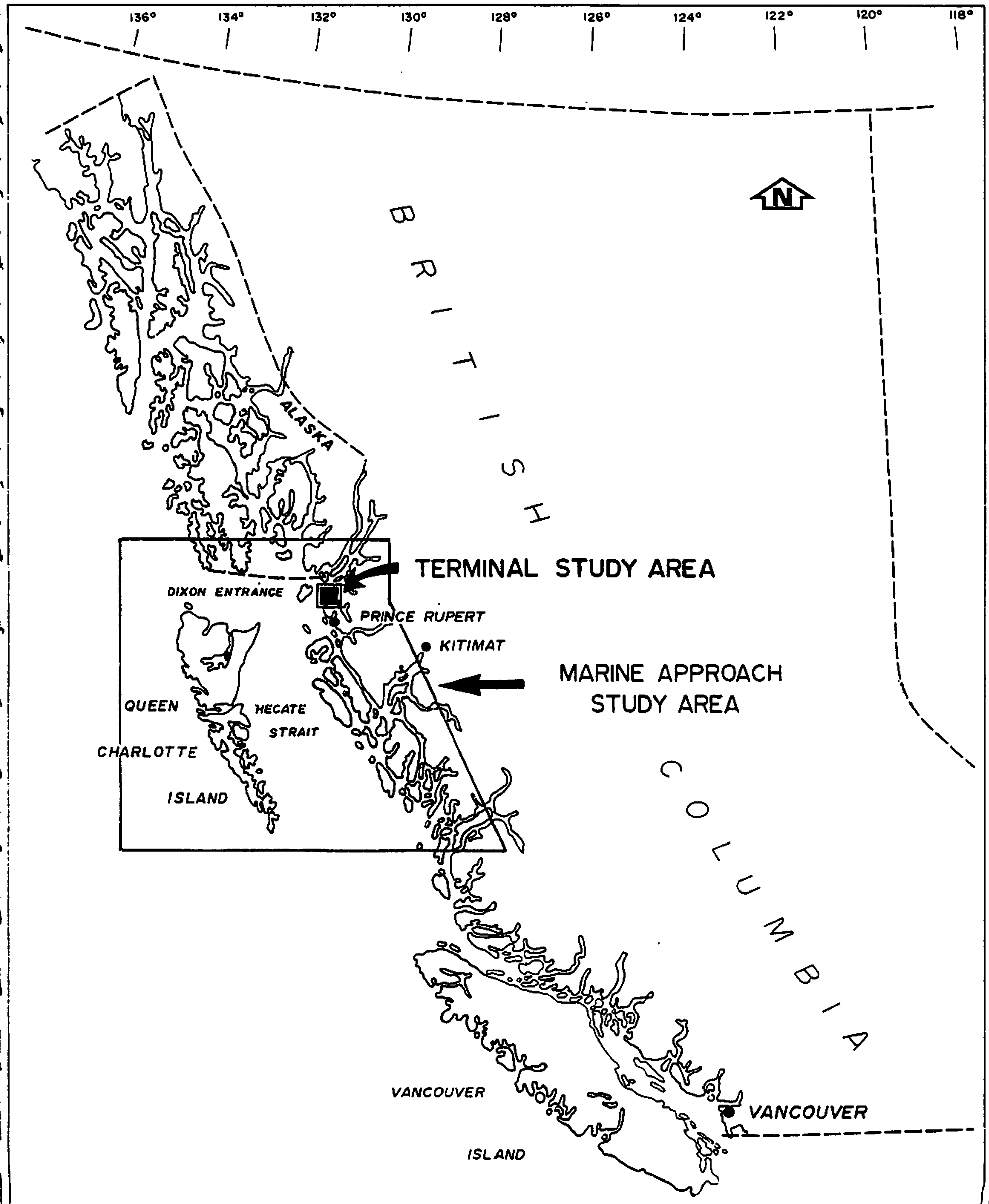


FIGURE 1.5.1
STUDY AREAS

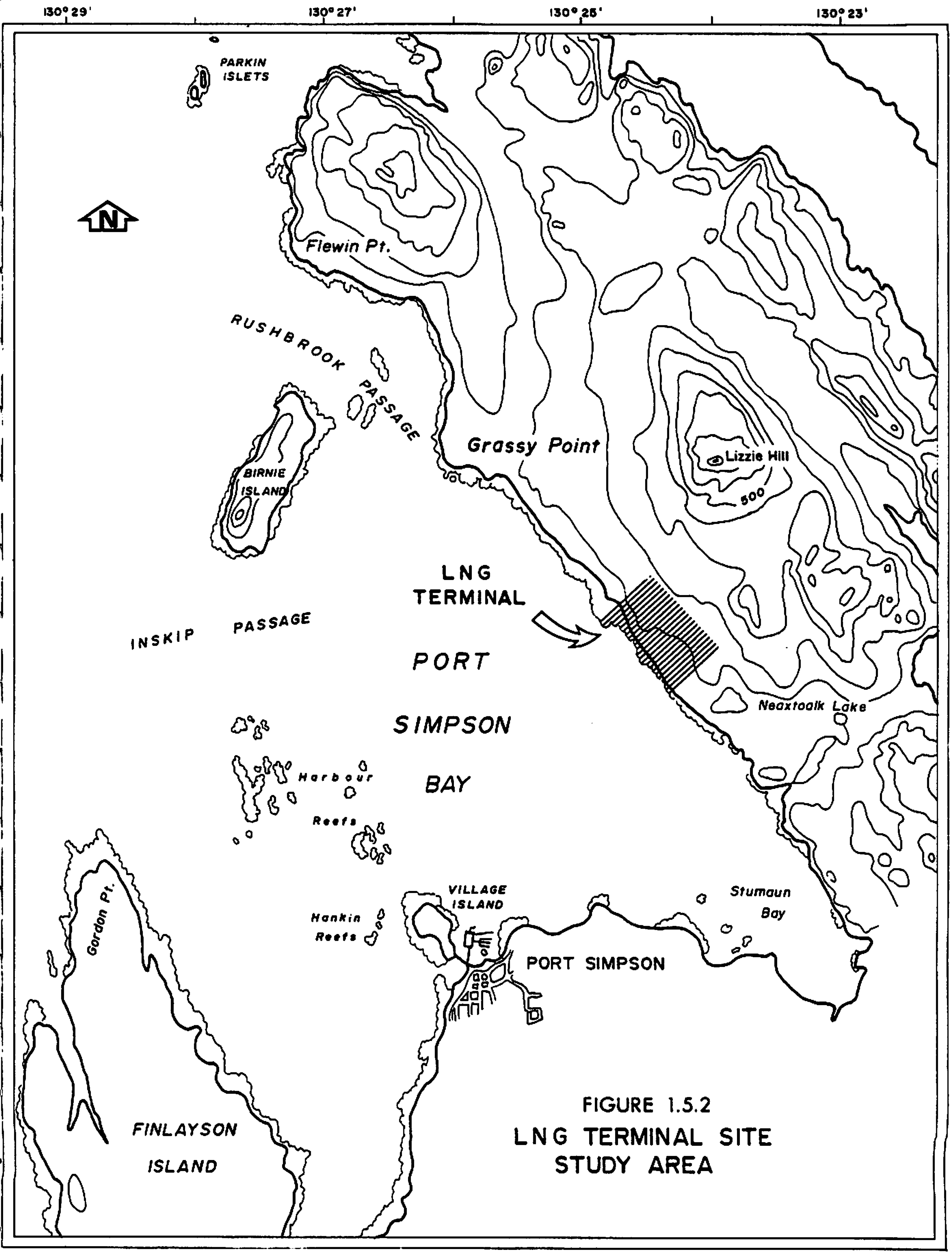


FIGURE 1.5.2
LNG TERMINAL SITE
STUDY AREA

departs the terminal for its Japanese offloading terminals. The second, the Terminal, provides the scale of area where the LNG process plant and terminal are located. The third concept of the project, the pipeline, is subject of a separate report as the resources considered are affected by a linear development rather tha marine approaches or a specific plant location.

1.5.1 Marine Approaches

Figure 1-5.1 shows the study area for the Marine Approaches. The Marine approaches generally address Canadian marine waters from the 12 mile limit headland to headland on the west to an imprecise imaginary line along the coast of the British Columbia mainland to the east, the U.S./Canada border to the north and an imaginary line drawn east and west at about 51°45' north latitude.

1.5.2 Terminal

Figure 1-5.2 shows the study area for the Terminal including Inskip Passage, the Community of Port Simpson and the shoreline of Port Simpson Bay.

1.60 USE OF RESOURCE MAPPING

To aid in the environmental assessment of the proposed project, and to aid in the engineering design of the LNG carriers, their approach routes and the development of the LNG process plant and terminal, resource base mapping of both the Marine Approaches and the Terminal were prepared.

For each of the resources, the mapping and text of the environmental assessment includes: locations of sensitive areas, a description of the biological resources utilizing that area, an identification of terrain, shoreline and ocean bottom geological characteristics, an estimate of time of year during which the area is probably sensitive to disruption, as well as an estimate of the degree of sensitivity, and finally an identification of resource utilization.

2.00 DESCRIPTION OF PROPOSED LIQUEFIED NATURAL GAS (LNG) TERMINAL AND CARRIER APPROACHES

A detailed description of the Western LNG Project and the carrier approaches can be found in Volume One of the Application. For the convenience of the reader a brief description of the Terminal and the carrier approaches follows:

2.10 TERMINAL

Natural gas from existing producing areas within Western Canada will be brought to the preferred site by pipeline at a rate of 14.3 million cubic metres per day. The gas will be liquefied by cooling it to approximately -160°C. The LNG will be stored in any of four 79,500 cubic metre cryogenic storage tanks while awaiting shipment to Japan in any of the five 125,000 cubic metre capacity dedicated LNG carriers. A loading wharf designed to accomodate a single 125,000 cubic metre capacity LNG carrier and a construction supply wharf will also be provided. These LNG carriers will use gas turbine propulsion and carry about 4600 tonnes of Bunker fuel for auxiliary power and for operating loading pumps while at dock. Loading of bunkers at Grassy Point would not generally be conducted and no storage is planned.

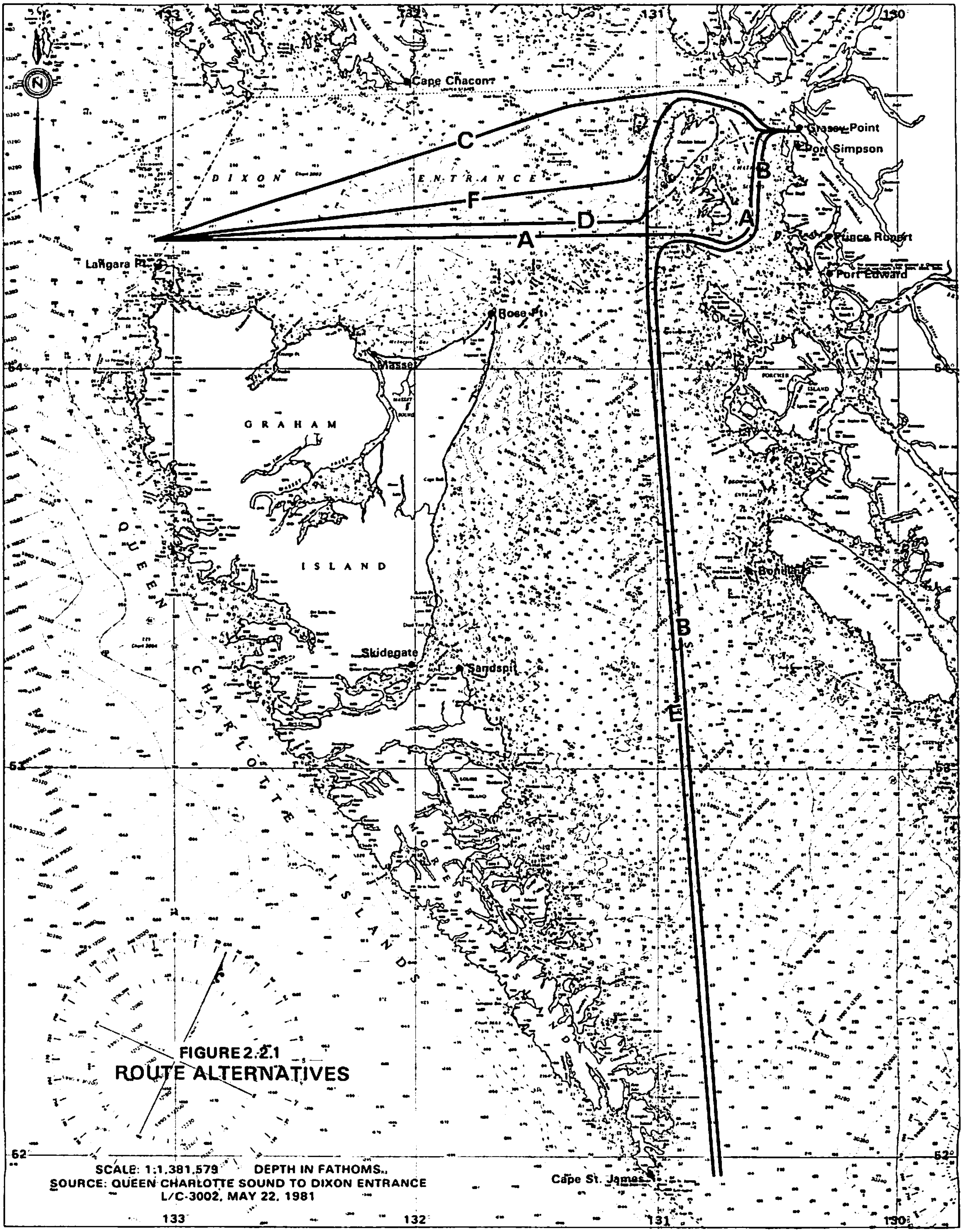


FIGURE 2.2.1
ROUTE ALTERNATIVES

SCALE: 1:1,381,579   DEPTH IN FATHOMS.
SOURCE: QUEEN CHARLOTTE SOUND TO DIXON ENTRANCE
L/C-3002, MAY 22, 1981

2.20 MARINE APPROACHES

Three alternative marine approaches were evaluated and are considered acceptable (Figure 2-2.1):

1. Dixon Entrance to Triple Island Pilot Boarding Station, across Brown Passage to Chatham Sound, thence north into Port Simpson via Inskip Passage.

2. Dixon Entrance to and through Caamano Passage, then north of Dundas Island into Chatham Sound and to Port Simpson via Inskip Passage.

3. Hecate Strait to Triple Island Pilot Boarding Station, thence as per (1) above.

The approaches to Port Simpson, steaming through Chatham Sound, are free of navigational hazards. The Sound is wide and deep and no course alterations are required until the vessel is off Port Simpson harbour entrance. No valid reasons are therefore perceived why tugs should be required to meet and escort the design-ship until it has reached the position of 54° 33.1' north 130° 31.2' west, in which position she will be 3.9 km due east of the western end on Inskip Passage.

Dome plans to have four tugs available in Port Simpson, two of which would be 35 tonnes and the other two of approximately 50 tonnes bollard pull. It was appreciated that, with the design-ships being equipped with bow-thrusters, four tugs would seldom be required to be employed.

As a general rule, the design-ships will not attempt to enter harbour in visibility conditions of less than 0.9 km.

3.00 EXISTING ENVIRONMENT

3.1.0 PHYSICAL-CHEMICAL OCEANOGRAPHY

3.1.1 Marine Approaches

The earliest oceanographic studies on the North Coast were concerned with providing a better understanding of the movements and ranges of many of the commercial fish species, especially halibut and salmon. The major oceanographic cruises of the early to mid-1950's ("Hecate", "Coastal-Seaways" and "Monitor" Projects) provided the first substantial data bases for assessment of oceanographic conditions in offshore waters of the west and north coasts.

More recently (in the 1970's) the increased offshore transport of oil by tankers prompted several government-sponsored current and water structure studies in the Queen Charlotte Sound/Hecate Strait region. The emphasis in most of these studies has been to refine our understanding of the tidal and non-tidal circulation patterns along the coast.

3.1.1.1 Geography, Bathymetry and Runoff

Dixon Entrance is entered between Queen Charlotte Islands on the south, and Dall and Prince of Wales Islands on the north, and extends from Langara Island and Cape Muzon in a general east direction to the Dundas Islands, a distance of about 100 km, with an average width of more than 50 km (Figure 3-3.1). At its western entrance Dixon Entrance is over 90 km wide (Cape Muzon to Langara Point). It is divided into a northern and a southern channel (each 350-400 m deep) by Learmonth Bank which lies 36 km due north of Langara Point and rises to within 35 m of the surface (Crean 1967). Further east, these two channels merge to form a single channel which rises gradually to a sill depth of 270 m south of Cape Chacon.

Three important major seaways adjoin eastern Dixon Entrance: Clarence Strait stretching over 185 km northward to its junction with Sumner Strait; Hecate Strait reaching 250 km southward to Queen Charlotte Sound; and Chatham Sound lying to the east of a group of barrier islands (Dundas, Baron, Dunira, Melville, Prescott and Stephens Islands are the largest). North of the Dundas Islands, a deep (800 m) passage running east-west connects Chatham Sound and Dixon Entrance to Portland Inlet.

Hecate Strait separates the Queen Charlotte Islands from the numerous outer islands of the north mainland coast of British Columbia. It is about 48 km wide in its northern entrance, between Rose Spit on the west and Stephens Island on the east, gradually widening southward to about 140 km in its southern entrance, between Cape St. James on the west and Price Island on the east. Northern Hecate Strait consists mainly of a broad shallow bank less than 50 m deep with a narrow, slightly deeper (80 - 150 m) channel adjacent to its eastern shores. The southern part of Hecate Strait is generally deeper (average depth of about 185 m).

Queen Charlotte Sound is located south of Hecate Strait bounded to the east by the outer shores of the B.C. mainland coast and to the south by the north tip of Vancouver

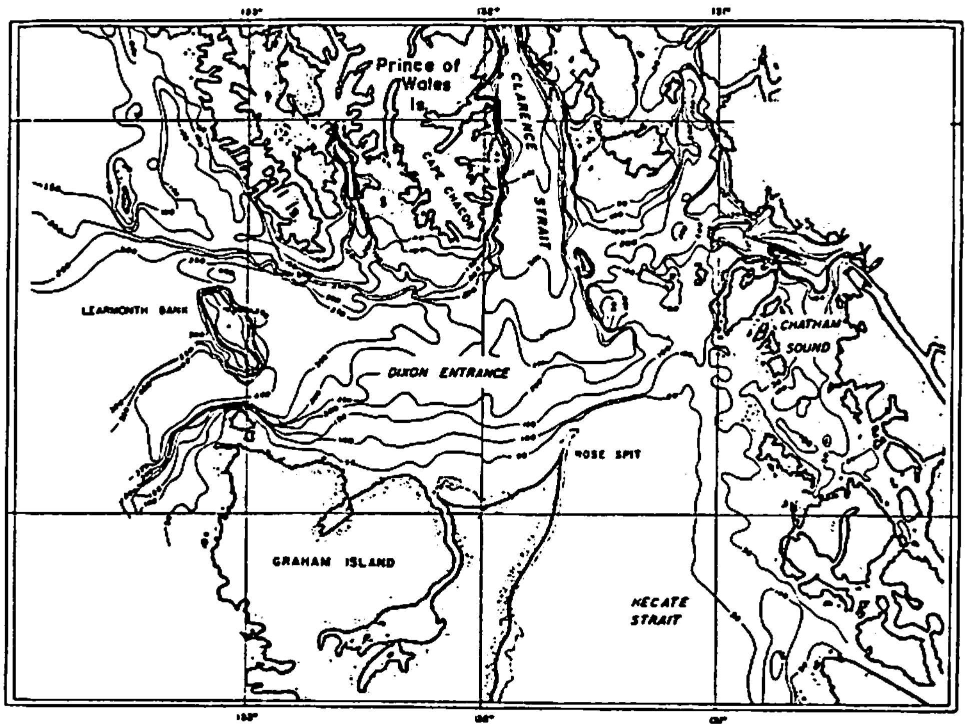


Figure 3-1.1 Bathymetry (m) of Dixon Entrance/North Hecate Strait (from Crean, 1967)

Island. Its western entrance is marked roughly by the 1828 m (1000 fathom) depth contour. Eastward of the 1828 m depth contour, depths decrease rapidly so that the majority of Queen Charlotte Sound is less than 250 m deep. A broad shallow bank (Goose Island Bank) characterizes the central region whose depths are an average 45 m but can drop to less than 35 m on the eastern edge. The two deeper channels north and south of this bank (Mitchell's Trough and Goose Island Trough) have depths in excess of 180 m.

Chatham Sound is generally less than 100 m deep with many shoals and islands. The Skeena River, which is the second largest river entering the coastal waters of British Columbia, drains into south Chatham Sound. It has two periods of greater flow which occur each year. The largest is in late spring (May-June) as a result of snow-melt from higher elevations, and the smaller peak in Autumn or early winter due to runoff caused by direct precipitation.

The Nass River empties into the west side of Portland Inlet through Nass Bay at the juncture of Observatory Inlet and Portland Canal. It has a freshet maximum in June which is smaller and much broader than that of the Skeena. Rain in the fall can produce peaks in Nass flow that exceed the flow during spring runoff.

Chatham Sound is strongly influenced by discharge from both the Nass and Skeena Rivers, especially during freshet. About 20 small streams on the Tsimpsean Peninsula also contribute large volumes of fresh water to Chatham Sound, particularly during fall rains. The Skeena River water is very turbid, particularly during the spring freshet or heavy autumn rains. The turbidity usually arises from glacial flour scoured from the glaciated regions of the river headwaters, while some of it is derived from suspended particulates (silt, etc.) from the lower sections of the drainage basin.

3.1.1.2 Ice Conditions

No documented evidence was found of icebergs or ice floes having been encountered by marine traffic using Canadian waters in the open Dixon Entrance, Hecate Strait, or Queen Charlotte Sound areas. There are sources of glacial icebergs along the Alaskan Panhandle and further north, however any ice reaching the Pacific from these areas is probably carried northward as part of the Alaskan stream.

Surface winter ice (2 to 5 cm thick) is frequently reported, however, in the numerous enclosed bays and more sheltered inlets of the north B.C. Coast where there is significant freshwater input. Thicker "chunks" of ice (up to 20 cm thick) are also periodically reported near the mouths of larger rivers especially during the break-up of their upstream reaches, e.g., the Nass River and the Skeena River.

3.1.1.3 Waves and Tsunamis

Waves

Offshore the Queen Charlotte Islands "swell" directions prevail from the west, southwest and northwest in all seasons. "Sea" directions are seasonably more variable. In spring and summer they are primarily from the south to northwest directions whereas in the autumn and perhaps the winter there is more variability. The maximum frequency of rough to high seas and high swell occurs in the autumn. The lowest frequency of high waves occurs in summer. Table 3-1.1 summarizes these waves.

TABLE 3-1.1

SEASONAL/ANNUAL SUMMARY % FREQUENCIES OF SEA AND SWELL - OFFSHORE WEST COAST QUEEN CHARLOTTE ISLANDS

SEA

	Winter	Spring	Summer	Autumn	Annual
% Calm or Confused	No Data	1	4	2	2.33
% Slight (20.9 m)	No Data	23	25	10	19.33
% Moderate(0.9-1.5m)	No Data	28	31	20	26.33
% Rough (1.5-2.4 m)	No Data	20	22	24	22.00
% Very Rough (2.4 - 3.7 m)	No Data	20	13	26	19.67
% High (≥ 3.7 m)	No Data	5	18	18	10.34
					100.00

SWELL

	Winter	Spring	Summer	Autumn	Annual
% No Swell	3	8	6	1	4.50
% Confused	0	0	0	0	0.00
% Low (0.3 - 1.8 m)	15	39	29	7	22.50
% Moderate(1.8-3.7m)	42	34	45	39	40.00
% High (>3.7 m)	40	19	20	53	33.00
					100.00

Source: Canadian Hydrographic Service Sailing Directions 1977

The frequency of high seas offshore the Charlotte/ Dixon Entrance increases with distance seaward in all seasons. The average wave period throughout the year is about 12 seconds. There have been no permanent wave recording stations in Dixon Entrance, and the only longer term wave measurements in Hecate Strait and Queen Charlotte Sound were those taken at the 1968-1969 SEDCO-135 drill sites.

Environment Canada has taken measurements from two wave-rider buoys in South Chatham Sound (Figure 3-1.2). At Station 104 the measurement period was September 28, 1972 to June 13, 1973 (259 days). Most waves were recorded with periods from two to six seconds although a secondary peak occurred between seven to ten seconds. The largest significant wave height on record was about 1.9 m (average height of 1/3 highest waves). The most probable maximum wave height observed over the period of record was 2.9 m. Figure 3-1.3 illustrates the results obtained.

Tsunamis

A tsunami is a group of water gravity waves with long period usually generated by a submarine seismic disturbance such as a fault movement or a submarine landslide. The actual generating mechanism is not well known. Most recorded tsunamis have been associated with strong earthquakes (greater than 6.5 on the Richter scale) in which the epicentres either bordered on or were within 40 km of the ocean floor (Wiegel, 1964).

Once generated, a tsunami consists of a group of waves which spread rapidly away from their source, obtaining speeds of up to 250 m/s (approximately 500 knots) in the deep ocean. The interval between successive crests or troughs is typically between 10 and 40 minutes. In the open sea, the

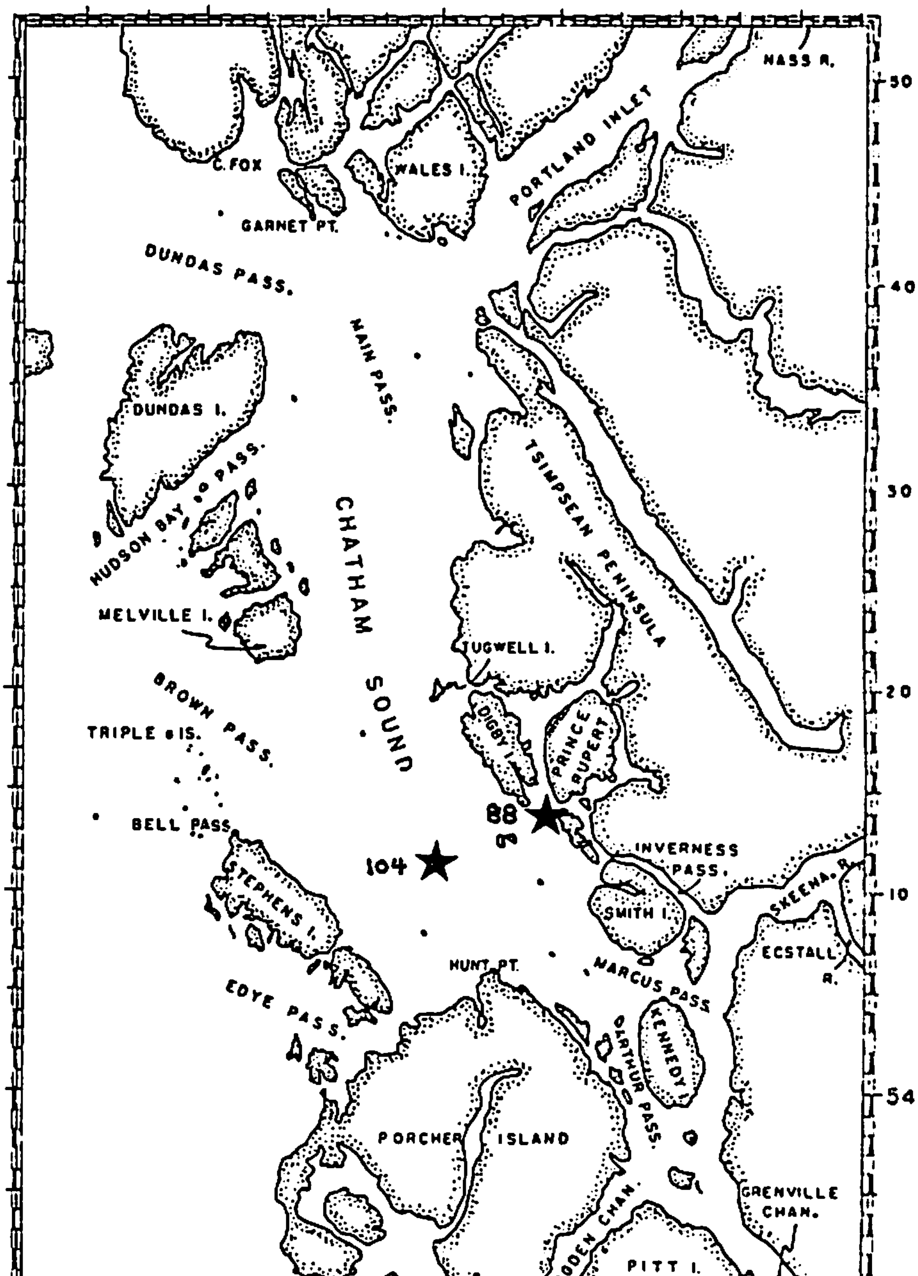


Figure 3-1.2 Locations of Environment Canada wave stations in Chatham Sound

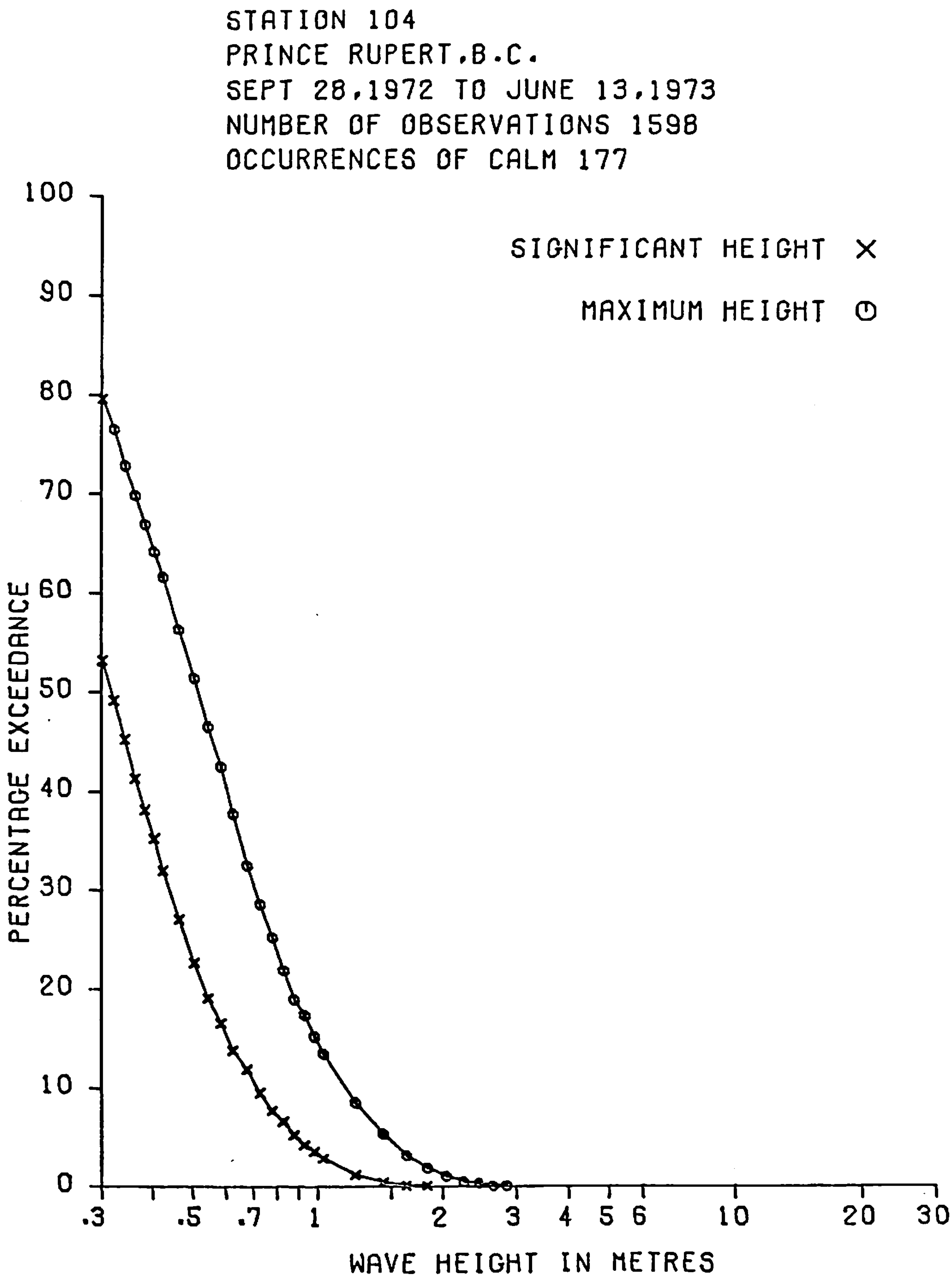


Figure 3.1.3. Maximum and significant wave heights statistics at Station 104, Chatham Sound (from MEDS, Ottowa)

height of the wave is very small, usually not exceeding 0.3 m but in harbours, bays and at the head of inlets the wave can be very large and destructive, especially near the generating source. In a harbour, a tsunami usually appears as a rapid rise and fall of the water, accompanied by very strong currents. Usually the first wave is not the highest, but can be exceeded by the second or third wave (McDonald et al., 1980).

The British Columbia coast has received several tsunamis caused by earthquakes from around the Pacific Ocean. The effects along the B.C. coast have varied considerably depending on the proximity to the open ocean and the localized bathymetry and topography. Table 3-1.2 shows a list of the major tsunamis in the Pacific area since 1945 (from Murty and Henry, 1972). The largest and most damaging tsunamis on record for the British Columbia coast was that caused by the March 27, 1964 earthquake near Anchorage, Alaska. The wave amplitude was greater than 5.2 m when it reached Port Alberni. The water rose 2.7 m above high water causing considerable damage (Wigen and White, 1964). The size and shape of the tsunamis waves differed markedly along the B.C. coast. Table 3-1.3 shows the characteristics of this Alaskan tsunami at several west coast stations where tide gauges were either operating or where the tsunami was observed visually.

The largest visually observed tsunami from the Alaskan earthquake was at Shields Bay on the west coast of the Queen Charlotte Islands. The crest was reported to be 5.2 m above spring water (or 9.8 m above tidal datum) severely damaging an established logging camp there. In comparison the maximum rise or fall of the tsunami at Prince Rupert, Bella Bella and Tasu on the inside north mainland coast were only 2.7 m, 1.9 m, and 1.9 m respectively (Table 3-1.3).

The Chilean earthquake of May 22, 1960, was not as severe as the March 1964 earthquake in Alaska, nevertheless it generated a significant tsunami which reached the British Columbia Coast at approximately 12:21 GMT May 23. Table 3-1.4 shows the characteristics of this recorded tsunami at several stations along the B.C. coast (from Wigen, 1960). The travel time was 17 hours and 10 minutes.

Wigen (1960) describes:

"Twenty-one tide gauges were in operation, and 17 of these showed either a wave sequence or a marked distortion of the normal tide pattern."

"Size and shape of the waves differed markedly, even on the exposed portions of the coast. Greatest recorded range was shown on the Tofino gauge, with maximum amplitude of 4.4 feet (1.34 m). Waves of greater amplitude may have occurred at places without gauges. On the west coast of the Queen Charlotte Islands at Shields Bay, where a tide gauge was installed in July, loggers reported that the water poured in and out of the bay with a violence that resembled Seymour Narrows. One took photographs half an hour apart during the height of the disturbance, and it appeared from these that the maximum wave amplitude was not less than seven feet (2.13 m)."

"At no gauge station then in operation did the maximum wave crest reach higher than the highest recorded tide. However at Shields Bay large logs were left stranded above the apparent extreme high water. On the west coast of Vancouver Island a playing field at an Indian village was reported inundated."

TABLE 3-1.2

MAJOR TSUNAMIS IN THE PACIFIC AREA AFTER 1945 (From Murty and Henry, 1972)

Date of Occurrence of Earthquake	Epicentral Area	Magnitude on Richter Scale	Damage Due to the Resulting Tsunami in Canada
April 1, 1946	Aleutian	7-1/4	Oscillations of water level occurred (Zerbe, 1953). Wave amplitude at Tofino, B.C. was 0.58 m (Berkman and Symons, 1964.
November 4, 1952	Kamchatka	8-1/4 to 8-1/2	Oscillations of water level are greater than for the 1946 tsunami (Zerbe, 1953). Wave is noticed by ships in Victoria Harbour but no damage. Wave amplitude at Tofino was 0.61 m (Berkman and Symons, 1964).
March 9, 1957	Aleutian	8 to 8-1/2	No documented information is available.
May 22, 1960	Chile	8-1/4 to 8-1/2	Wave amplitude at Tofino was 1.40 m and probably greater than 2.13 m at Shields Bay (Wigen, 1960). Some minor damage.
March 28, 1964	Alaska	8.4 to 8.75	The wave amplitude was more than 5.18 m at Port Alberni (Wigen and White, 1964). Damage worth 10 million dollars in the twin cities of Alberni and Port Alberni. Damages amounting to 100,000 dollars and 150,000 dollars at Hot Springs Cove and Zeballos respectively (Spaeth and Berkman, 1967).

TABLE 3-1.3

CHARACTERISTICS OF ALASKA TSUNAMIS OF MARCH 27-29, 1964 ALONG B.C. COAST (from Wigen and White, 1964)

Gauge Station	Lat.	Long.	Initial Wave				Maximum Rise or Fall			Tsunamis Crest (m)	High High Water (m)	Diff. (m)	Extreme High (m)
			Time of Arrival GMT	Period 1st to 2nd Crest	Initial Rise (m)	Following Fall (m)	Time of Beginning	Duration	Height (m)				
Ocean Falls	52 21	127 41	0800	32 min.	2.19	3.81	0825	15	3.81 F	-	-	-	-
Prince Rupert	54 19	130 20	0652	92	0.30	1.77	0812	56	2.71 R	7.68	7.50	+0.18	7.98
Bella Bella	52 10	128 08	0653	39	0.98	1.92	0724	20	1.92 F	-	-	-	-
Tasu	52 10	458 08	0533	70	0.88	1.92	0552	22	1.92 F	-	-	-	-
Alert Bay	50 35	126 56	0739	29	1.16	1.74	0753	18	1.74 F	-	-	-	-
Tofino	49 09	125 55	0700	20	1.04	1.55	0850	24	2.47 F	4.27	4.02	+0.25	4.75
Port Alberni	49 14	124 49	0800	87 (est.)			More than 17			6.37	3.72	+2.65	4.51
Victoria	48 25	123 24	0802	50	0.67	1.46	0818	39	1.46 F	2.56	2.93	-0.37	3.69
Fulford Harbour	48 46	123 27	0835	40	0.40	0.43	1353	22	0.61 R	-	-	-	-
Pt. Atkinson	49 20	123 15	0907	90	0.09	0.21	1250	52	0.24 R	-	-	-	-
Vancouver	49 17	123 07	0920	120	0.06	0.15	1105	45	0.18 R	-	-	-	-
Shields Bay	53 19	132 25	-	-	-	-	-	-	-	5.18 m above spring high water.	-	-	-

TABLE 3-1.4

CHARACTERISTICS OF CHILEAN TSUNAMIS OF MAY 23, 1960 ALONG B.C. COAST (from Wigen, 1960)

Tide Gauge	Lat.	Long.	Time of Arrival	Maximum Rise/Fall	Gauge Status
Barkley Sound	49 00	125 21	0422	1.04	Temporary
Tofino	49 09	125 55	0421	1.34	Permanent
Cape St. James	51 56	131 01	0421	0.43	One Year
Copper I	52 21	131 10	0447	0.21	Temporary
McKenney Is.	52 39	129 29	0503	0.55	Temporary
Prince Rupert	54 19	130 20	Indef	Indef	Permanent
Klemtu	52 36	128 31	0520	0.40	Temporary
Griffin Pass	52 46	128 21	0536	0.43	Temporary
Victoria	48 25	123 22	0458	0.73	Permanent
Fulford Hr.	48 46	123 27	Indef	0.30	Permanent
Caulfield	49 20	123 15	Indef	Indef	Permanent
Vancouver	49 17	123 07	-	-	Permanent
Alert Bay	50 35	126 56	0545	0.46	Permanent
Johnson Pt.	51 07	127 32	0740	0.15	Temporary
Bamford Lagoon	51 00	127 15	-	-	Temporary
Seymour Inlet	51 05	126 53	Indef	0.03	Temporary
Frederick Sound	51 02	126 44	-	-	Temporary
Nugent Sound	51 05	127 15	0803	0.15	Temporary
Belize Inlet	51 07	127 17	0813	0.06	Temporary
Mereworth Sound	51 11	127 25	0840	0.15	Temporary
Allison Sound	51 10	127 00	-	-	Temporary

> "The distortion that occurred to the Prince Rupert curve is similar to the response there to the 1952 and 1957 tsunamis. Under certain storm conditions a similar oscillation has been noted."

Seaconsult (1976) discussed the currents generated by tsunamis as part of their Kitimat oil terminal assessment:

> "Currents associated with tsunamis in nonresonant conditions can be evaluated using the same technique used to calculate tidal currents. With amplitudes comparable, or even a bit larger than in Bella Bella (6 ft., say), and a period of about 45 min., we find currents of 1.4 knots. Much larger displacements can occur at the head of an inlet than at its mouth under resonance conditions (this is what happened to Alberni Inlet in 1964)."

3.1.1.4 Tides

The tides on the north B.C. coast are of the mixed type, having two lows and two highs in a tidal day and a large diurnal inequality between succeeding lows and highs. The only active permanent tide gauges are at Prince Rupert where tidal records have been taken since May 1906, Langara Point where observations have been taken since February 1973, Bella Bella where tidal records have been taken since July 1961 and Queen Charlotte City where tidal records have been taken since June 1963. The largest tidal range reported at Prince Rupert is 7.7 m and the mean range is 4.9 m. The largest tidal range reported at Bella Bella is 5.5 m and the mean range 3.6 m. Changes in atmospheric pressure and the influence of winds are also responsible for changes in sea level, causing a yearly atmospheric range of about 30 cm on the North Coast.

3.1.1.5 Circulation

Mean circulation off the west coast of British Columbia is primarily determined by the large scale wind systems. Drift currents approach the North American Coast between 47°N and 53°N latitude. The flow divides a portion turning northwards (Alaskan Stream) toward the Gulf of Alaska and part turning southward (California Current) to form a southerly drift toward the tropics. The division area usually moves northward in the summer (from 40°N in the winter to about 50°N in summer). The speeds of these currents are relatively weak; estimates range between 5 and 12 cm/s.

Tidal induced currents in the offshore North Coast areas rarely exceed 0.2 km/h away from the coast and are rotary. The rotation of the direction vector may be either clockwise or counter-clockwise depending upon location and type of tide, and is repeated approximately every 12 hours and 25 minutes (semidiurnal).

Numerous short term direct current measurements have been made in Queen Charlotte Sound and Hecate Strait during the Pacific Oceanographic Group cruise programs of the early 1950's. The Institute of Ocean Sciences conducted direct current measurements in Queen Charlotte Sound - Hecate Strait in 1977.

The primary characteristics of surface water movement in the inner Queen Charlotte Sound - Hecate Strait Region is a general northerly flow. In winter the driving force for these currents is the predominant south-easterly winds. At the northern boundary of Hecate Strait it turns seaward (westerly) through Dixon Entrance.

In the spring and early summer the south-easterly winds subside and freshwater discharges, primarily from the Nass and Skeena Rivers, increase to their annual maxima. The general northerly currents weaken and a wide-spread estuarine structure is established in North Hecate Strait and Dixon Entrance.

During the winter period of strong southeast winds, less dense surface waters accumulate along the coast displacing the deeper water offshore. During the summer period of weak southeast winds the accumulated surface waters move offshore allowing the landward return of the deep waters.

In South Queen Charlotte Sound near Triangle Island the reported currents in June 1955 were rotary at all depths, changing direction continually in a clockwise manner with a semi-diurnal period. The principal direction of the flood was northeast and that of the ebb southwest. Maximum speeds were slightly over 50 cm/sec and occurred during the flood. The residual movement was easterly into Queen Charlotte Sound at speeds of 5 to 11 cm/sec.

A brief review of the yet unpublished 1977 IOS current data seemed to indicate a net movement northwest in Queen Charlotte Sound and South Hecate Strait. The tidal currents measured in central Queen Charlotte Sound were mostly rotary showing no preferred direction.

South Chatham Sound is essentially a large estuary with a fresh surface layer moving northwards under the influence of the Coriollis force and prevailing winds. Most water is transported north (70%) along the near-shore of the Tsimpsean Peninsula with a relatively small volume escaping through Brown Passage (NEAT, 1975).

3.1.1.6 Salinity, Temperature and Density

Dixon Entrance

According to Crean (1967) the horizontal distributions of seasonal surface salinities in Dixon Entrance show three persistent features:

1. A distribution of relatively low salinity water in Chatham Sound, Clarence Strait, the northern shores and west central Dixon Entrance. In summer, salinities are generally lowest due to peak discharge of major rivers. The remainder of the year salinities in most areas range around 31.5‰ except in Clarence Strait and northeast Dixon Entrance.

2. A horizontal gradient of salinity at the mouth of Dixon Entrance which is strongest in summer and weakest in spring and winter.

3. An irregular area of water in the northern part of Hecate Strait which displays a higher salinity (greater than 305‰ in summer and greater than 31.5‰ during the remainder of the year) than the rest of Dixon Entrance.

Crean (1967) also concluded that the major change in surface salinity in Dixon Entrance occurs in summer as a result of dilution due the the spring freshet of the Skeena River, the Nass River and coastal drainage areas.

During peak summer runoff of the Skeena River, the Nass River and other coastal drainage areas, the depth of the halocline is shallowest and the gradient is sharpest. At depth, salinity is higher in summer and autumn than in winter and spring.

The horizontal distribution of surface temperature in Dixon Entrance is also very seasonal. In spring, variations in surface termperature throughout the region are small with the warmest water (8° to 9°C) in northern Hecate Strait. In summer a relatively high surface temperature (13.0°C) is found in southern Clarence Strait and along the north shore of Dixon Entrance coincident with a lower salinity water. In autumn, the surface temperature is lower in Dixon Entrance (10.0°C) than either seaward or in Hecate Strait. In winter, the variation in surface temperature across the entire Dixon Entrance area is relatively small (maximum range of 6.0° to 7.5°C).

The strongest annual thermocline is observed in Dixon Entrance in the summer, coincident at depth with the halocline. In winter the water column becomes very nearly isothermal surface to bottom, i.e., between 6° and 7°C. The deeper water (below 75-100 m) experiences a warming from summer to winter.

The density structure is chiefly determined by salinity. In summer, warm surface temperatures enhance the already strong stratification caused by estuarine discharge.

Chatham Sound

The surface salinity of Chatham Sound is largely dependent on the strongly seasonal discharge of the Nass and Skeena Rivers. Depending on location, wind, tide and river discharge the depth of the surface layer varies from about 6 to 12 m. During normal river conditions the discharge from the Skeena moves northward past Digby Island and along the Tsimpsean Peninsula. Near the peak of freshet in June 1948, the amount of fresh water in the Sound was at least four times that present during normal conditions.

During periods of unsteady discharge, Trites (1956) found that relatively large cells of fresh water discharged into Chatham Sound. These cells are gradually dispersed as they move seaward by spreading out laterally and mixing with the more saline water.

Hecate Strait/Queen Charlotte Sound

Temperature and salinity data have been collected from numerous coastal stations in the Queen Charlotte Sound/ Hecate Strait/Dixon Entrance area. Langara Island and Cape St. James are two such stations located in "oceanic" areas. Both have little annual variation in salinity (32.25‰ ± 0.25‰).

Triple Island and Ivory Island stations are found within areas influenced by snow-melt run-off. Minimum surface salinities at both these stations occur in late spring-early summer. At Triple Island station the June-July surface salinity minima (approx. 29‰) is related to the peak discharges of the Skeena and Nass Rivers. At Ivory Island a slightly lower (26.5‰) but later (July-August) salinity minima is attributed to the peak discharges of the Dean and Bella Coola rivers.

McInnes Island Station has a winter salinity minimum in November due to heavy winter rains. Bonilla Island shows the salinity effects of both snow-melt run-off and heavy fall-winter rains. It has a salinity minima in July-August and another one in late autumn.

The seasonal variations within Hecate Strait and Queen Charlotte Sound can be summarized as follows. In spring, there is little variation in surface salinity. Lowest salinities (<31‰) are found along the eastern mainland shores and highest salinities (approximately 32‰) at the western approaches to Queen Charlotte Sound and Dixon Entrance. The warmest water (approximately 8°C) is located in Central Queen Charlotte Sound and the coldest water (approximately 7°C) in Dixon Entrance.

In summer much lower salinities and marked horizontal salinity gradients are found in northeast Hecate Strait and north Dixon Entrance attributed to the northerly outflow of high spring-summer discharges from the Nass and Skeena rivers. A tongue of cold water in south Hecate Strait/Queen Charlotte Sound results from the colder flushing of surface waters from Queen Charlotte Strait. In central Dixon Entrance, salinities are about 2‰ less than in spring and in central Hecate about 0.5 to 1‰ less. Temperatures throughout the region are about 4 to 5°C higher than those in spring. The warmest waters (>14.5°C) are found in central Queen Charlotte Sound.

In fall, the horizontal gradients of temperature and salinity are reduced. A cold relatively less saline tongue of water is still apparent from Queen Charlotte Strait but wider spread and less defined. The small warm area (13.0°C) in central Queen Charlotte Sound is all that remains of the temperature maxima observed in summer. Average temperatures in all areas are about 2.0°C lower than summer. Salinities in Queen Charlotte Sound are slightly higher (>31.5‰) attributed to increased mixing of subsurface waters because of greater wind speeds.

In winter relatively uniform temperature conditions prevail. Surface temperatures are highest in southwest Queen Charlotte Sound (8°C) and lowest in a small area off Rose Spit at the eastern side of Dixon Entrance (6.0°C). The maximum horizontal salinity variation in all areas is only about 1.5‰. A north-south alignment of the isohalines in Hecate

Strait-Queen Charlotte Sound indicate a northerly flow. Highest salinities (>31.5‰) are found along the east coast of the Queen Charlotte Islands.

The dominant features of the vertical structure in mid-summer (July-August) in Hecate Strait/Queen Charlotte Sound are the thin mixed or near-mixed surface layer, and underlying this layer, the relatively marked gradients associated with the thermocline, halocline, pycnocline and oxycline. During this period these gradients are at their minimum depth.

During late winter the thermocline disappears, temperatures decrease, and near-isothermal conditions may extend to depths of 150-200 m. However, the vertical gradients of salinity, density and dissolved oxygen remain, but are considerably deeper than those observed in mid-summer. In the shallower areas, marked vertical gradients are indicated in the near-bottom waters. Temperature inversions are common features during late winter.

3.1.1.7 Dissolved Oxygen

The seasonal variations in dissolved oxygen within Dixon Entrance/Hecate Strait/Queen Charlotte Sound areas are all closely tied to the cyclic alternation of coastal water masses with accompanying distinct fluctuations in salinity, temperature and density. In winter there is a wind-driven accumulation of surface waters in the coastal region. The oxycline is displaced downward by this accumulation of surface waters until it reaches its maximum depth in December. Subsurface waters become relatively highly oxygenated (increases range from 1 to 3 mg/l) as they are gradually replaced by surface waters.

During the spring and summer, surface waters relax seaward, causing an onshore movement of deeper water into Hecate Strait and Queen Charlotte Sound which is low in dissolved oxygen. As a result, the lowest annual oxygen content of deeper waters is found in summer. In July 1954 and June 1955 the oxygen content was less than 2.0 mg/l at depths below 250 m.

3.1.1.8 Turbidity and Light Transmissibility

In Chatham Sound and Dundas Passage and to a lesser extent along the north shore of Dixon Entrance, the primary control of turbidity is the fluctuation in discharge of the Nass and Skeena rivers, as well as the smaller local streams. The most turbid times of the year in these areas are (1) June-July, associated with snow melt and consequently the spring freshet of the two larger rivers and (2) October-November, corresponding to the heavy fall rains.

During the oceanographic cruises of the 1950's and 1960's, Secchi disc measurements in Chatham Sound indicated extinction depths of 8 to 12 m during the winter, early spring and late summer. In the same area, the extinction depths in late spring, early summer and fall were reduced to only 2-3 m. A reduction in turbidity with distance offshore occurs at Dixon Entrance caused by continued entrainment of salt water into the seaward moving brackish surface layer.

In the deeper, open ocean areas away from the influence of fresh water runoff in outer Queen Charlotte Sound and Dixon Entrance, the water visibility is primarily controlled by the density of planktonic organisms. The result is a summer reduction in light transmissibility throughout the upper water column. Secchi disc extinction depths are typically 5-7 m or lower. In winter months the vertical visibility may be as great as 30 m (Adkins 1977).

Parsons (1965) compiled and summarizes Secchi disc readings from data reports for Hecate Strait and Queen Charlotte Sound. The data indicate maximum Secchi disc depths of about 19 m in mid-winter and minimum Secchi disc depths of about 4 m in June.

3.1.1.9 Chemical Oceanography

The most recent publication which identifies sources and in some cases summarizes the available pertinent chemical oceanographic data for the north B.C. coast is a broad chemical oceanographic inventory of B.C. coastal waters conducted in 1980 by Mr. Paul Erickson of Seakem Oceanography Ltd. for Trans Mountain Pipeline Limited and presented in McDonald et al. (1980). This appendix summarizes the important sources of chemical data identified by Mr. Erickson and presents some of his pertinent findings concerning the northeast Pacific and north B.C. coast.

Three classes of chemical parameters were considered in Mr. Erickson's report: hydrocarbons (including tar balls), heavy metals and nutrients. The hydrocarbons addressed are those commonly used as petroleum indicators, including polycyclic aromatic hydrocarbons (PAH). Tar balls or pelagic tar are lumps or accretions of floating oil residues most of which are derived from crude petroleum sludge from the cargo tank washings of tankers. Trace metals were identified as those metals which are: 1) trace constituents of sea water; 2) relatively abundant minor components of petroleum; and 3) toxic to marine organisms. The nutrients considered were: nitrogen (as nitrate), phosphorus (as orthophosphate) and silicon (as silicate). An adequate supply of all three elements is essential to primary production. Other inorganic nutrient compounds of nitrogen such as ammonia and nitrite were not included. However, data for these species are available in many of the studies listed in the cited references of McDonald et al (1980).

Hydrocarbons and Pelagic Tar

In the northeast Pacific region the only major hydrocarbon data collected are a series of surface seawater measurements collected on a "Ship-of-Opportunity" program by tankers travelling between Cook Inlet, Alaska and San Francisco (Brown et al 1976). On two trips in February and September, 1974, surface bucket samples were collected from the bow of the ship and from a ship's sanitary water line with an intake at 10 m. The cruise track is shown in Figure 2.2.10-1 of Mr. Erickson's report and the results summarized in Table 2.2.10-1.

Compared with other results, the data indicated that hydrocarbon levels were higher in coastal waters, and in general higher in the Atlantic and Mediterranean Sea than in the Pacific. However, the levels recorded along the Cook Inlet - San Francisco route were the highest for Pacific Ocean waters.

Vertical profiles of hydrocarbon concentrations were also obtained at a GEOSECS (50°N,. 176°W) station in the North Pacific (Brown et al 1976). Cretney et al (1977) have reported an average PAH concentration in surface water at Station P (50°N, 145°W) of 0.038 g/L (expressed in terms of chrysene equivalents) for examples collected in 1973.

As part of an environmental assessment of the northeast Gulf of Alaska, Shaw (1976) measured surface hydrocarbon levels at a number of stations on the continental shelf and in adjoining inlets. Non-volatile hydrocarbon (carbon tetrachloride extractable) concentrations were in the range 0.02 to 3.2 ppb with a mean of 0.47 ppb.

The only study of hydrocarbons to date in the north British Columbia coastal region was carried out in Kitimat Arm, Douglas Channel and adjoining inlets and passages out to Hecate Strait (Erickson et al 1979). Non-polar hydrocarbons (defined as the total n-alkanes in the range C_{10}-C_{35}, resolved but unidentified hydrocarbons and UCM in a G.C. elution trace of a sample extract) and PAH were measured in surficial sediments and intertidal mussels (M. edulis). PAH (expressed in chrysene equivalents) was also determined in seawater at 4 depths from surface to near bottom. Samples were collected on three occasions from June 1978 to February 1979 at sites indicated in Figure 2.3.10-1 of Mr. Erickson's report.

Information on the relative abundance of tar balls in the northeast Pacific is very limited. In 1973, from a trans Pacific cruise at latitude 35°N, Wong et al (1974) found a relatively high frequency of tar. No tar was found from 35°N to the north of Juan de Fuca Strait along 125°W.

A series of tows were also made at Ocean Station P (50°N, 145°W) between 1973 and 1975. A total of 113 tows were carried out of which 31 contained tar. The average concentration of tar was 0.04 mg/m^2 with a range of 0 to 1.9 mg/m^2 (Green, 1976).

The only source of tar ball information on the north B.C. coast were from 10 surface net tows carried out as part of the 1978-79 Kitimat study (Erickson et al 1979). No traces of tar were found on any of these tows.

Trace Metals

Oceanic background concentrations for most metals in the northeast Pacific were not known until recently due to a lack of adequate precautions in sampling and analysis (Erickson 1978; Settle and Patterson 1980). A list of the most commonly studied trace metals and their open ocean concentrations is given in Table 3.1.5 (from McDonald et al 1980). These values are considered the best available estimates of baseline concentrations.

Trace metal studies in the north B.C. coast region are summarized in Table 2.3.11-1 of Mr. Erickson's report. The locations of various studies are indicated in Figure 2.3.11-1. Much of the data is site specific in that it has been collected as part of a monitoring program in response to a marine outfall and thus not generally representative of baseline concentrations. No detailed extensive surveys have been conducted on the north coast.

TABLE 3.1.5
CONCENTRATIONS OF TRACE METALS IN THE NORTH PACIFIC
(from McDonald et al 1980)

Metal	Open Ocean Values (g.kg^{-1})	Reference
V	1.7	Battelle Northwest unpublished data
Hg	0.003	Battelle Northwest unpublished data
Ni	0.2 - 0.7	Bruland 1980
Zn	0.005 - 0.6	Bruland 1980
Cu	0.3	Bruland 1980
Cd	0.0002 - 0.1	Bruland 1980
Pb	0.001 - 0.015	Schaule and Patterson 1978
Co	0.04	Robertson 1970

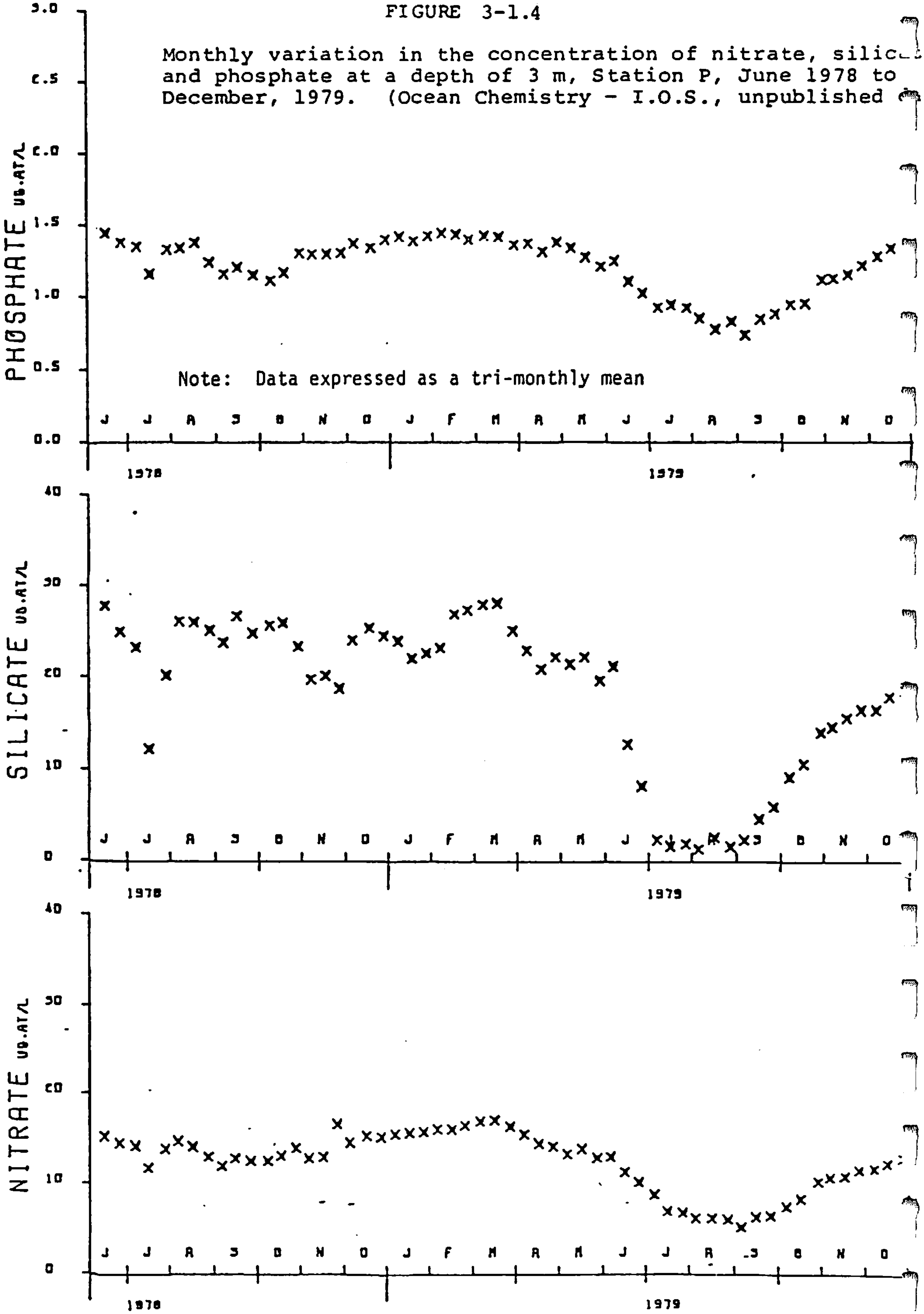


FIGURE 3-1.4

Monthly variation in the concentration of nitrate, silicate and phosphate at a depth of 3 m, Station P, June 1978 to December, 1979. (Ocean Chemistry - I.O.S., unpublished data)

The available nutrient data for the north B.C. coast region is summarized in Table 2.3.12-1 of Mr. Erickson's report. By far the most intensely studied area of this region is the Kitimat Arm/Douglas Channel system out to Hecate Strait (MacDonald et al 1978; Erickson 1979). Parsons (1965) reviewed the features of nutrient distributions in Hecate Strait and Queen Charlotte Sound. There is a very limited amount of information available on nutrients in Dixon Entrance and off the west side of the Queen Charlottes.

3.1.2 Terminal

3.1.2.1 Geography and Bathymetry

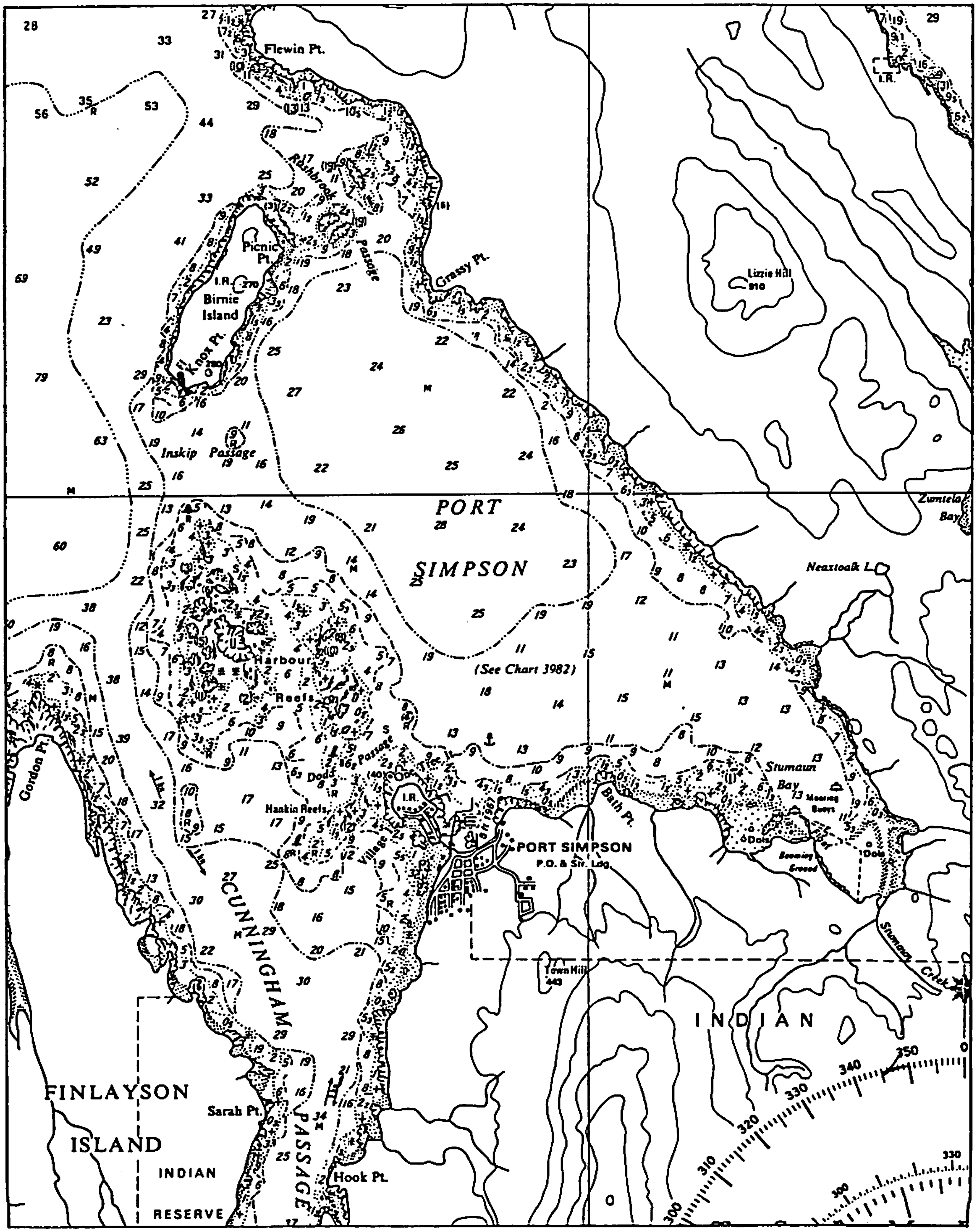
Port Simpson Bay lies on the northwest tip of the Tsimpsean Peninsula. According to Canadian Hydrographic Service (1977):

> "The harbour of Port Simpson is one of the most spacious on the north part of the British Columbia coast. It is easy of access, having no strong tidal streams, and is well sheltered from all but west winds. The west approach lies between the north end of Finlayson Island and Knox Point (54°35'N, 130°28'W) on the south side of Birnie Island, about 1-1/2 miles NNE. Harbour Reefs, which consist of two groups of rocks, which dry from 2 to 15 feet (0^m6 to 4^m6), with a narrow and shallow passage between them, lie about 8 cables south of Knox Point. These reefs form a natural breakwater to Port Simpson and afford the harbour some protection from heavy seas caused by strong west winds."

At the head of Port Simpson Bay, is Stumaun Bay exhibiting large areas of sand and mud flats overlying fluvial gravel (NEAT, 1975, Vol. IV). Several streams flow into Stumaun Bay, the largest of which is the small intertidal estuary of Staumaun Creek. Port Simpson settlement lies on the southern shore, close to the west end of the harbour; the terminal site is planned for the northeastern shore. Inskip Passage is the primary deep water passage leading into Port Simpson Bay north of Harbour Reefs and south of Birnie Island.

The Canadian Hydrographic Service (1977) also briefly describe the shoreline characteristics. The northeast shore of the port is fringed with a rocky beach, backed by steep high land; the south shore, east of the settlement, is not so regular or so steep. The topography of the proposed terminal site area is relatively gentle, with slopes usually less than 10% except for a forested beach cliff lying immediately along the shore. The microtopography shows ridge and swale characteristics immediately inland from the beach with undulations up to 20 m in amplitude (NEAT, 1975, Vol. I). The general bathymetry of Port Simpson Bay is shown in Figure 3-1.5. The average depth of the centre of the Bay is approximately 50-60 m.

Stumaun Creek with a length of 4.0 km and a drainage area of 15 km^2 drains into the head of Stumaun Bay. It is formed by the confluence of two branches at the high tide line (NEAT, 1975). The main fork is steeper and drains an entirely mountainous area, the west fork drains an area of rolling terrain and has more shallow gradients. Both forks show peak flows in fall due to rainfall with possible large flows over 8.5 m^3/s. Minimum flows on the main fork area are 0.056 m^3/s and on the west fork 0.028 m^3/s. The mean monthly runoff and calculated flood hydrographs for Stumaun Creek (Figures 3-1.6 and 3-1.7) were calculated by Northwest Hydraulic Consultants from available precipitation information for the Skeena and Nass rivers, the topography and mean



1" = 3240'

Figure 3-1.5. Bathymetry (fathoms) of Port Simpson Bay

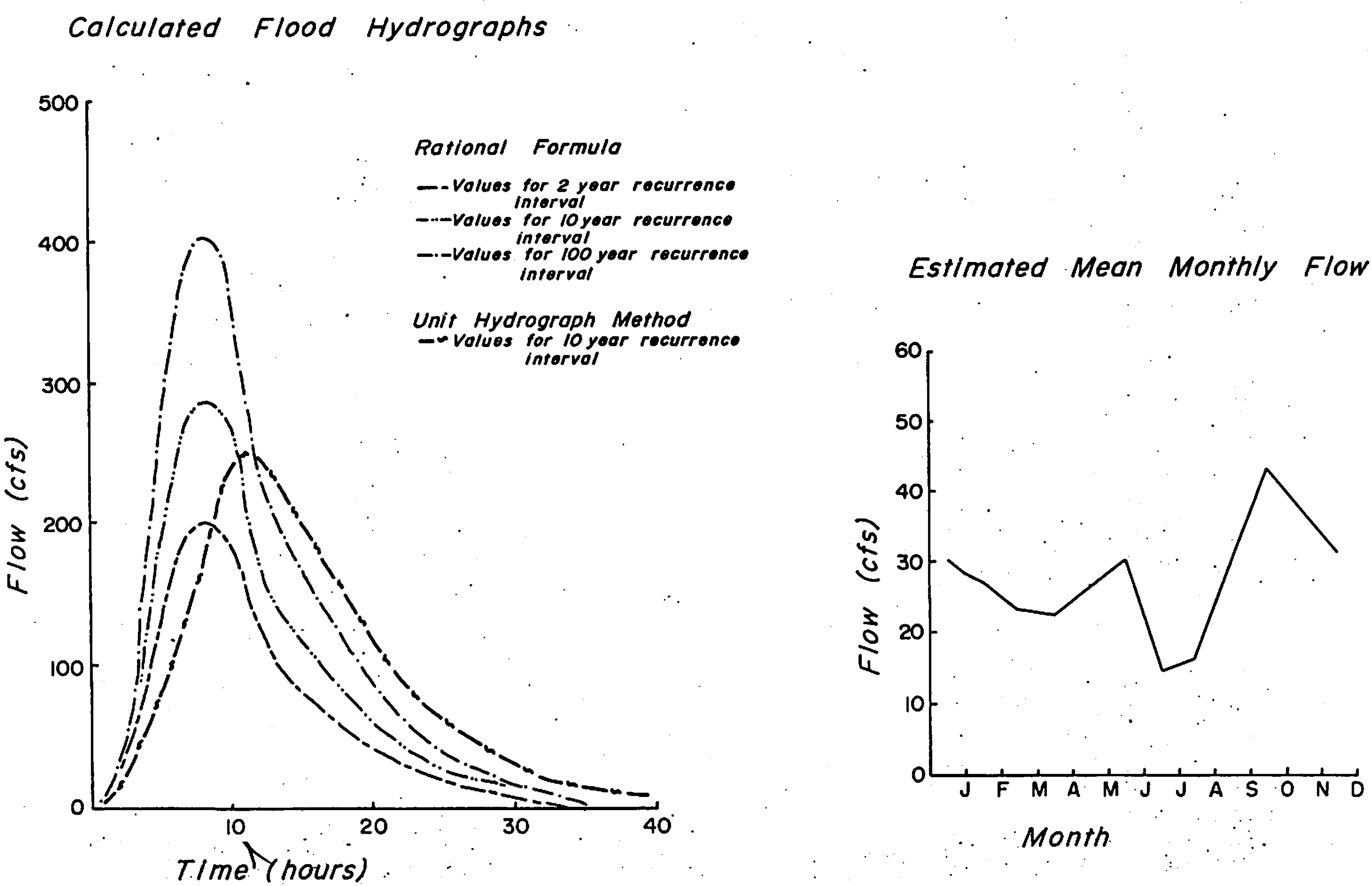
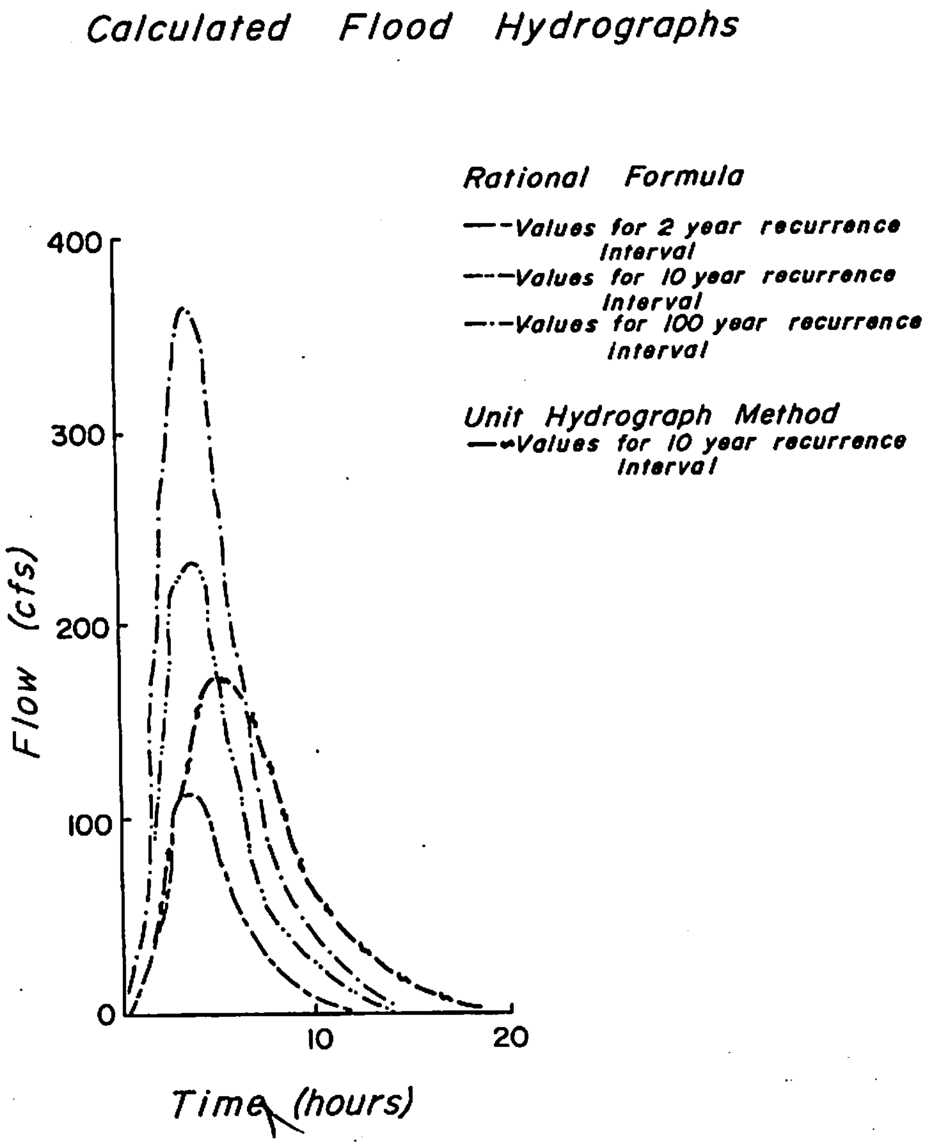


Figure 3-1.6. Hydrographs for the main fork of Stumaun Creek (from NEAT, 1975)



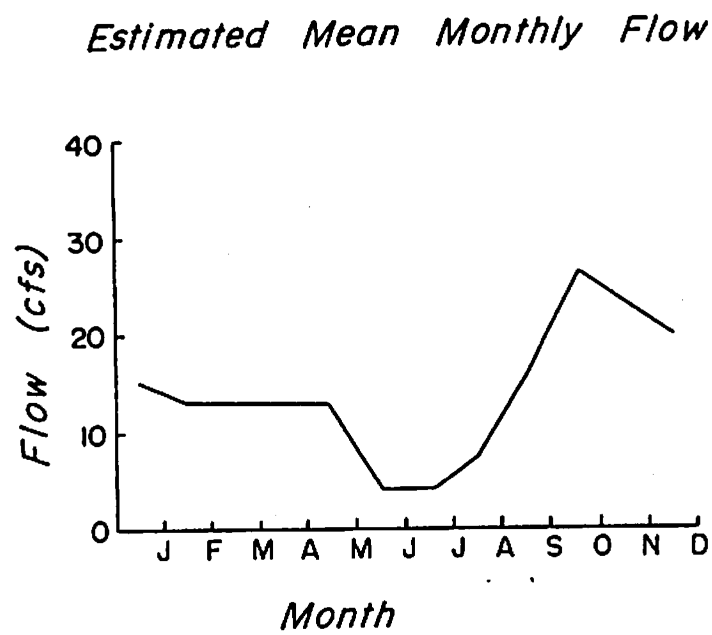


Figure 3-1.7 Hydrographs for the west fork of Stumaun Creek (from NEAT, 1975)

monthly evapotranspiration because no stream gauges had been operational on Stumaun Creek to that time (NEAT, 1975).

3.1.2.2 Ice Conditions

During the winter months ice can build up in the freshwater outflow streams discharging into Port Simpson Bay. In January and February thin sheet ice has also been observed over parts of Port Simpson Bay during periods of sustained sub-zero air termperatures. Local fishermen report periods of "slush ice" on the surface waters both during and after winter snow storms. However, most of this type of ice should break up relatively easily with tug boats.

3.1.2.3 Waves, Tsunamis and Storms

Waves

There have been no direct long term wave measurements in Port Simpson Bay. The closest available wave records were taken by the Wave Climate Study Group (Marine Environmental Data Service, 1978) at stations 88 and 104 southwest of Prince Rupert (Figure 3-1.2) and at station 113 near Kincolith.

During the 1974-75 environmental assessment of potential bulk loading facilities on the Tsimpsean Peninsula (NEAT, 1975), the wave climatology of Port Simpson Bay was addressed. The waves were hindcast by Swan Wooster Engineering Co. Ltd. Using four years of wind records from Digby Island Airport and the wave statistics from station 104 southwest of Prince Rupert, Swan Wooster concluded that swell contributions to the total wave field within Port Simpson were insignificant in comparison to the local wind-generated waves. They forecast 600 hours per year of 0.3 m swell from the west-northwest in Port Simpson. Diffraction of the swell around the north tip of Dundas Island apparently significantly reduces the height of incoming swell from Dixon Entrance.

The Swan Wooster predictions for wind-generated waves are shown in Figure 3-1.8. A total of 2700 hours per year of wind-generated waves (31% of the total annual hours) are forecast in Port Simpson Bay. Most of the wave action (approximately 86% of the total annual wave hours) are projected to be less than 0.6 m in height. Port Simpson is relatively well sheltered from the strong southerly winds which occur with the frequent passage of cyclonic frontal systems over the North Coast. Port Simpson Bay is, however, relatively exposed to westerly winds and waves, especially those from the west-northwest (the direction of greatest wave fetch through Inskip Passage). According to two interviewed inhabitants of Port Simpson (Mr. Gustav Paulson and Mr. Gary Dudoward) there are usually "two or three" strong westerly wind sessions each year which cause all of Port Simpson Bay to "blow up". The largest waves observed during these strong westerlies appear to be about 2.5 m. The Swan Wooster predictions indicate expected annual wind waves of 1.8 to 2.5 m from the west for one hour; 1.2 m to 1.8 m from the west for 21 hours; 0.6 m to 1.2 m from the west for approximately 350 hours; and 0 to 0.6 m from the west and southwest for approximately 2,328 hours.

The wave characteristics during the strong westerly wind sessions at Port Simpson can also be calculated from recent wave theories given the speed of the wind over the sea surface and the distance over which it acts (the fetch). Seaconsult (1976) summarized applicable wave theory from Wiegel (1964) and Wilson (1966) for fetch-limited cases and presented calculations of wind-generated waves for Kitimat Harbour. The following calculations of extreme wave characteristics for the Port Simpson area were generated from the

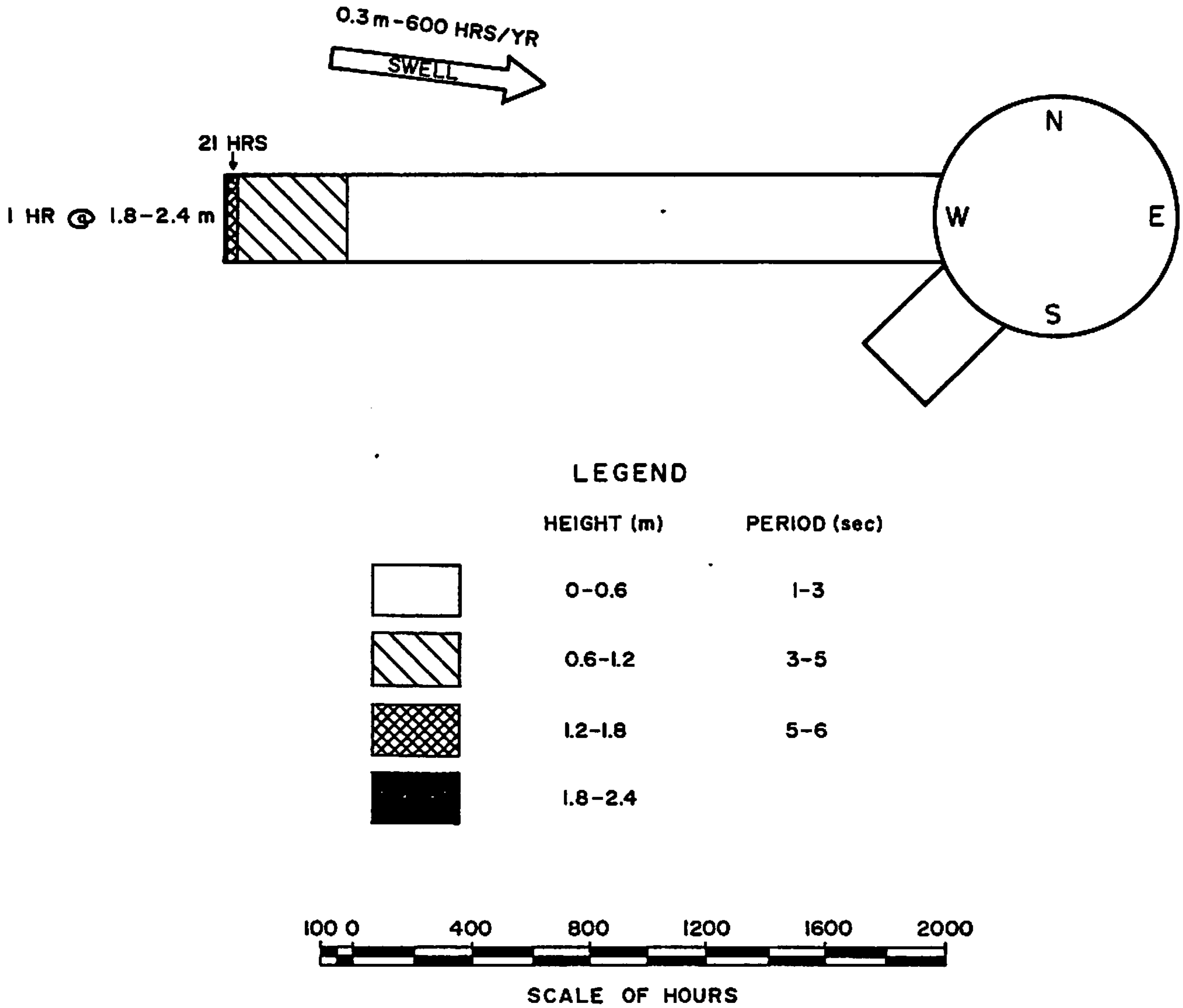


Figure 3-1.8 Annual Wave Predictions for Port Simpson Bay by Swan Wooster Engineering in 1974 (from NEAT, 1975).

summarized wave theory as presented in Seaconsult (1976) and Wiegel (1964).

The longest line-of-sight fetch to the proposed LNG docksite in Port Simpson Bay as it presently exists is from the west to west- northwest out Inskip Passage approximately 25 km to Dundas Island. The extreme hourly wind speed with a return period of one year as calculated from the Digby Island wind record is approximately 62 km/hr (pers. comm. Dr. T. Jandali (ESL)).

Taking F (fetch) = 25 km (82,000 feet); g = 9.75 m sec^{-2} (32 feet. sec^{-2}); and U (hourly wind speed) = 62 km/hr (56 ft/sec), the significant wave height ($H_{1/3}$) generated along this direct fetch can be calculated according to Seaconsult (1976):

$$H_{1/3} \text{ (1 year return)} = 0.30 \frac{U^2}{g} \; 1 - \frac{1}{\left(1 + 0.004 \frac{gF}{U}^{1/2}\right)^2}$$

$$= 1.76 \text{ m } (5.78 \text{ ft.}) \quad \text{[in British units]}$$

This significant wave height is representative of the "worst expected annual hour" of deep water waves that could approach Inskip Passage. The significant wave heights within Port Simpson Bay and near the proposed docksite would in all probability be somewhat less taking into account the diffraction, refraction and reflection which occurs because of the Harbour Reefs and the nature of Inskip Passage.

According to the graphical fit given by Wiegel (1964, pg. 205) The mean wave period (Tmean) during these maximum hourly winds is related to the significant wave height: Tmean = (2.77 H1/3) 4/9 = 4.67 seconds when H1/3 is expressed in feet. The corresponding wave period of the significant waves and the highest waves would be TH max

$T_{H1/3}$ = 1.10 T_{mean} = 5.13 seconds. This means an average of 770 waves/hour would be expected during this maximum annual wind event. The height of the highest wave H_{max} would be according to Seaconsult (1976):

$$H_{max}(n) = 0.706 \quad (\ln(n))^{1/2} H_{1/3} \quad \text{(in British units)}$$

$$H_{max}(770) = 0.706 \quad \ln(770)^{1/2} H_{1/3}$$

$$= 3.2 \text{ m} \quad (10.5 \text{ ft.})$$

Perhaps the absolute worst case would be to examine the waves generated during a westerly wind with a once in a 100 year return period. The maximum hourly wind speed with a 100 year return period as estimated from the Digby Island records is U = 87 km/hr (pers. comm. Dr. T. Jandali (ESL)). With the same fetch F = 25 km, such a sustained hourly west wind could generate a significant wave height $H_{1/3}$ (100 yr) = 2.64 m with a period $T_{H1/3}$ = 6.4 seconds. The mean wave period T_{mean} would be about 5.8 seconds. Approximately 620 waves would be expected during this worst wind hour expected in 100 years. The height of the expected maximum wave approaching Inskip Passage within this group would be:

$$H_{max}(620) = 0.706 \quad \ln(620)^{1/2} H_{1/3}$$

$$= 4.7 \text{ m} \quad (15.5 \text{ ft.})$$

As discussed earlier the complicated bathymetry of the Harbour Reefs surrounding Inskip Passage will cause diffraction, refraction and reflection of the incoming wave field thus reducing the significant wave heights inside the Bay, especially in the geometric shadow. Diffraction and refraction will be most evident during the lowest tides. Considerable wave energy would also be lost by waves breaking over the reefs.

To examine these physical effects on the incoming wave fields to Port Simpson Bay more precisely, Dome Petroleum Limited has installed a waverider buoy near the proposed LNG docksite on May 1, 1981 (Figure 3-1.9). Here the significant wave heights are being recorded and will be correlated with monitored hourly wind speeds taken at Port Simpson.

Tsunamis

As discussed in section 3.1.1.3, the characteristics and effects of tsunamis along the British Columbia coast have been extremely variable depending on the proximity to the open ocean and the localized bathymetry and topography. Interviews with Mrs. I. Clausen, Mr. H. Sampson, Mr. R. Wessley, and Mr. G. Paulsen of Port Simpson indicate that in the last 21 years there have been no significant visually observed tsunamis in Port Simpson. After the March 27, 1964 earthquake near Sitka a warning was issued for the people of Port Simpson to seek higher ground areas. However, for those who remained to observe the tsunamis there were no apparent visual effects to be observed (pers. comm. Harry Sampson and Ron Wessley, residents of Port Simpson). Sid Wigen (IOS) notes that the tsunamis may have arrived after dark, however. The March 27 tsunamis did arrive at Prince Rupert (0652 GMT March 27 or 2552 LST March 27, 1964) and considerable damage was done to the fish docks there and at the Metlakatla Reserve (pers. comm. Mr. R. Johnson of Prince Rupert and Mrs. I. Clausen and Mr. H. Sampson, residents of Port Simpson). The maximum amplitude of the tsunamis recorded at Prince Rupert was 2.7 m (Table 3-1.3). It's period (first to second crest) was 92 minutes.

The largest tsunami displacements, such as those which occurred at Port Alberni in 1964 usually occurred because of resonance which amplifies the wave near the head

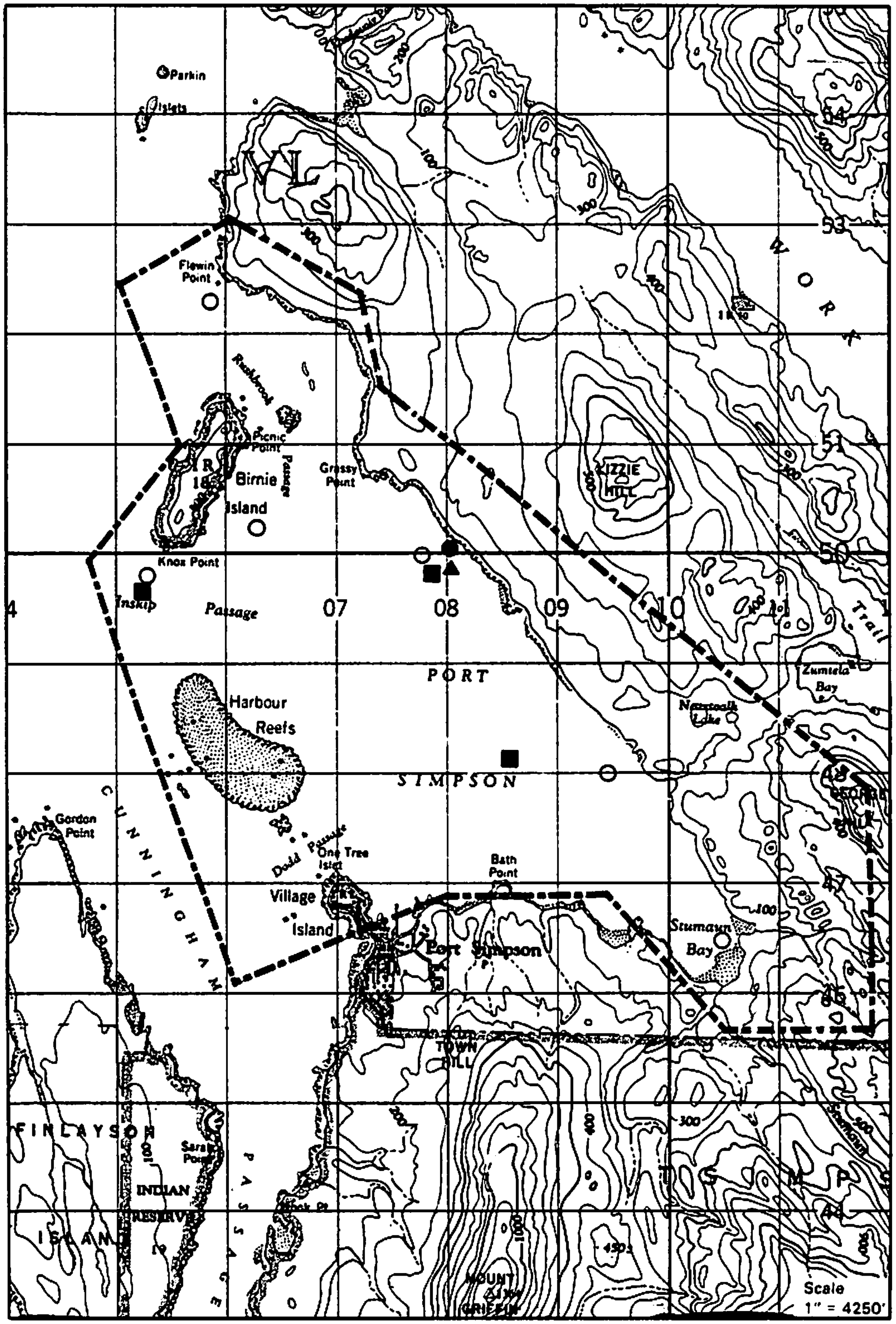


FIGURE 3-1.9 OCEANOGRAPHIC STUDY SITES OCCUPIED BY DOME PETROLEUM LIMITED IN 1981

of these inlets rather than at their mouths. For an open-ended basin, wave resonance occurs if the length of the basin is equal to about 1/4 of the wavelength. Port Simpson Bay is approximately 4 km long and Inskip Passage, its major deep passage connecting it to Chatham Sound, is approximately 1 km wide. There are also numerous shallow connections through the Harbour Reefs which filter out some wave energies and a secondary entry from the north through Rushbrook Passage (approximately 0.5 km wide). Assuming the Bay is approximately rectangular with an average depth of 40 m, the forcing period of tsunamis at the entrance necessary to generate quarter wave resonance would have to be about 13.5 minutes. This is considerably lower than most tsunamis observations along the coast during the March, 1964 earthquake (Table 3-1.3). Dundas Island, Dunira Island and Melville Island probably reduce and modify considerably some of the larger waves incoming from Dixon Entrance and Hecate Strait by refraction and diffraction.

A study commissioned in June 1981 by Dome Petroleum Limited to examine the 1902-1926 tidal records at Port Simpson for tsunamis occurrences should aid in the determination of some of these effects but it is not expected at this time that there should be significant tsunamis resonance effects within Port Simpson Bay for the larger earthquake events.

Internal Waves

Internal waves are those found within a fluid that has some vertical density discontinuity. No direct measurements are available as to the existence or not of internal waves within Port Simpson Bay. However, the vertical salinity and temperature profiles taken within the Bay in November, 1974 demonstrate a significant vertical density gradient. A layer of warmer brackish surface water was observed to a depth of about 10 m with cooler more saline waters beneath. As a result internal waves could occur periodically within Port Simpson Bay.

3.1.2.4 Tides

A general description of the tides on the northern coast which also applies to Port Simpson has been presented in Section 3.1.1.4. There is no present direct measurements of tides within Port Simpson. However, according to Canadian Hydrographic Service records, there were 25 years of interrupted tidal data collected at Port Simpson between 1902 and 1926. The actual records are stored in microfiche at the Institute of Ocean Sciences Library, Patricia Bay, B.C. Port Simpson is classified as a "secondary tidal station". The predicted tides are all referenced to the primary recording station at Prince Rupert. Table 3-1.6 shows the tidal information and differences for Port Simpson compared to Prince Rupert (source: Canadian Hydrographic Service 1980). A typical tidal curve for Prince Rupert and other north coast stations are shown in Figure 3-1.10. The observed tide contains both diurnal and semidiurnal components. The times of higher high water and lower low water at Port Simpson are within 5 minutes of those at Prince Rupert. The mean tidal range at Port Simpson is 4.8 m and the large tidal range is 7.4 m.

On May 2, 1981 Dome Petroleum Limited installed a tide gauge in Port Simpson Bay near the proposed terminal site (Figure 3-1.9). The collected information will be used to establish major tidal constituents in the Bay and as necessary input to on-going circulation studies there.

TABLE 3-1.6

INFORMATION AND TIDAL DIFFERENCES FOR PORT SIMPSON (FROM CANADIAN HYDROGRAPHIC SERVICE, 1980)

Index No.	Secondary Port	Time Zone	Position		Differences						Range		Mean Water Level (m)
					Higher High Water			Lower Low Water					
			Lat. N	Long. W	Time	Mean Tide (m)	Large Tide (m)	Time	Mean Tide (m)	Large Tide (m)	Mean Tide (m)	Large Tide (m)	
	Area 7 Chatham Sound				Reference: Prince Rupert								
9390	Port Simpson	+8	54° 34'	130° 26'	-0 04	-0.24	-0.27	+001	-0.08	-0.03	4.82	7.44	3.69

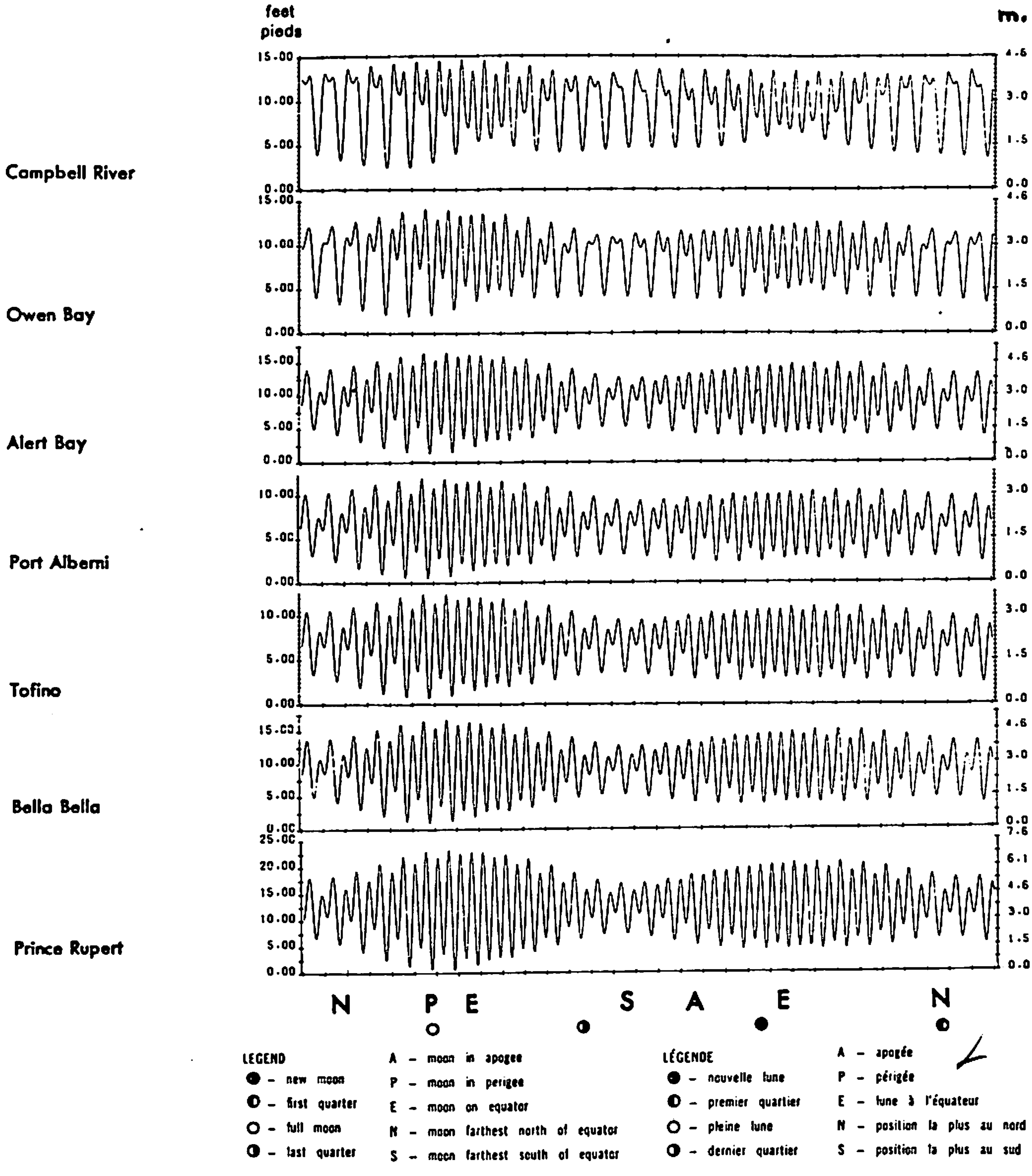


Figure 3-10 Typical tide curves for north B.C. coast stations (from Canadian Hydrographic Service, 1980)

3.1.2.5 Currents

The only currents data available for the immediate Port Simpson area are Canadian Hydrographic Service estimates of peak tidal currents in the approach passages and a 24 hour set of direct measurements taken by Dobrocky Seatech at their station S-3 approximately 500 m offshore from the proposed LNG terminal area south of Grassy Point (Figure 3-1.11). The Dobrocky measurements were made hourly over one complete tidal cycle at four depths on November 7-8, 1974 (Figure 3-1.12). Most measured currents were less than 0.3 knots; the peak current measured was 0.7 knots to the southwest at a depth of 20 m. No correlation was available with winds at the time of measurement. Although the data is very limited, i.e., 24 hours, the Dobrocky data appears to indicate a tendency for south to southwesterly flow opposite the proposed LNG terminal site during flood and a north to northeasterly flow during ebb.

On May 1, 1981 Dome Petroleum Limited initiated direct current measurements at three sites within Port Simpson Bay (Figure 3-1.9) to further define the circulation features. Dome also conducted 10 days of current-following drogue studies within the Bay from May 23 to June 2, 1981.

3.1.2.6 Salinity, Temperature, Density & Dissolved Oxygen

Although numerous oceanographic cruises entering the Dixon Entrance Region have sampled salinity, temperature and oxygen at stations in northern Chatham Sound, Dundas Passage and the entrance to Portland Inlet, it was possible to find only one published set of hydrographic stations within Port Simpson Bay itself. As part of an investigation of the environmental considerations of a bulk loading facility on the Tsimpsean Peninsula (NEAT, 1975), Dobrocky Seatech

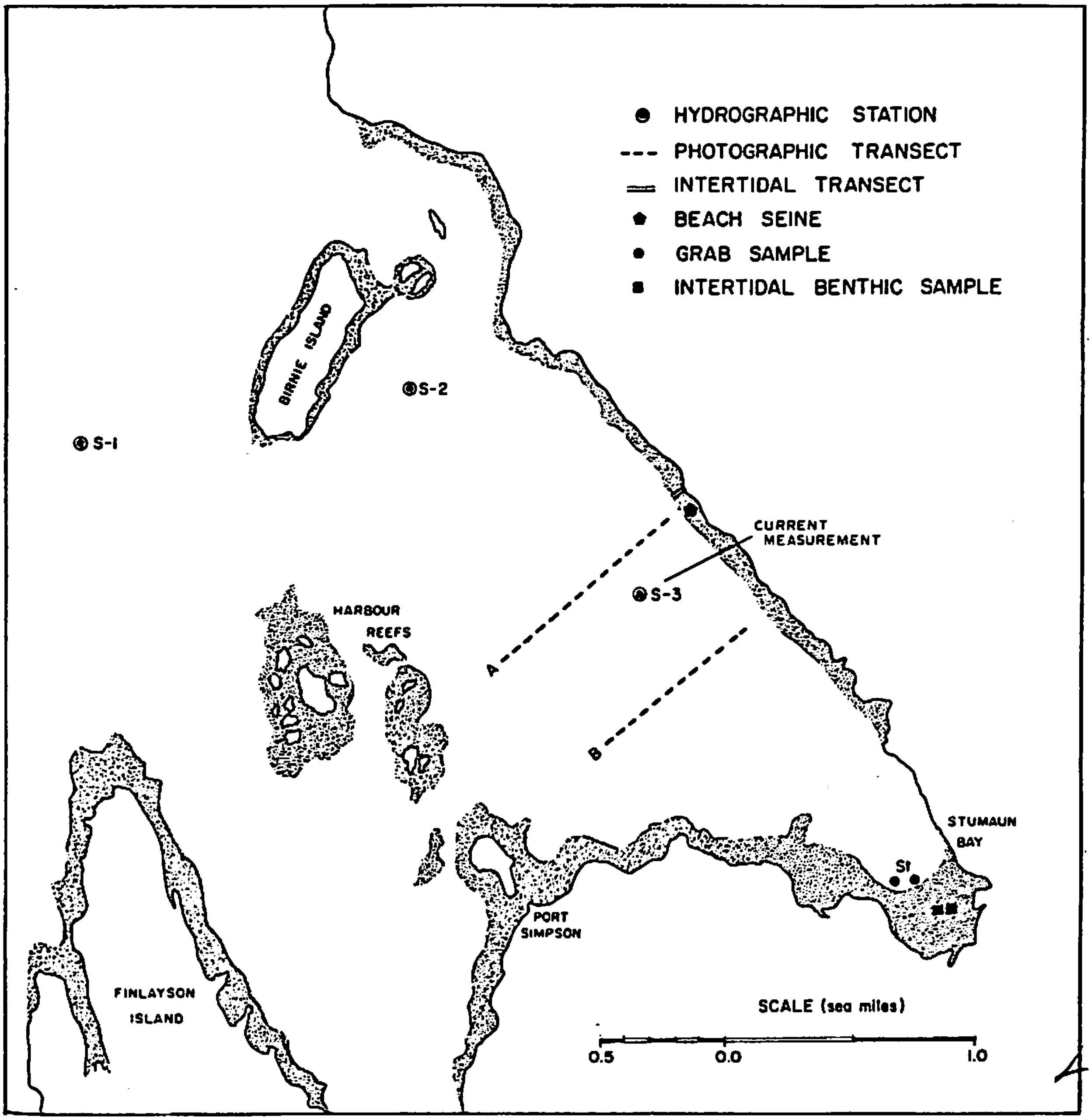


Figure 3-1.11 Location of Dobrocky SeaTech oceanographic measurements in November, 1974 (from NEAT, 1975)

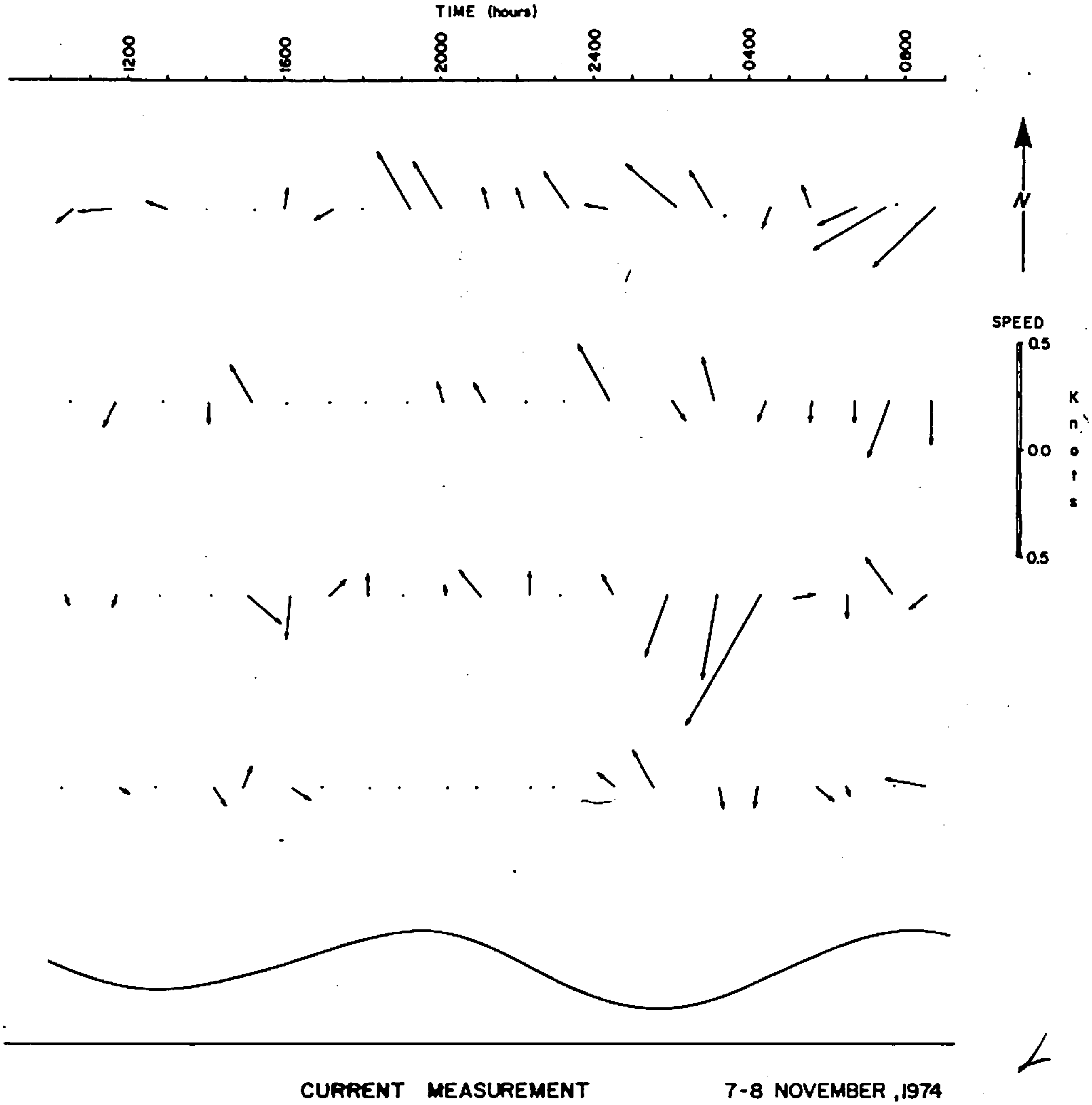


Figure 3-1.12. Current measurements in Port Simpson Bay at Station S-3, November 7-8, 1974 (from NEAT, 1975)

sampled two stations inside Port Simpson Bay and one outside Birnie Island for salinity, temperature and dissolved oxygen in November, 1974 (Lee Doran and Associates, 1975). The exact locations of the three hydrographic stations sampled in the vicinity of Port Simpson are shown in Figure 3-1.11. Station S-3 in 40 m of water is close to the proposed LNG Terminal site.

Figure 3-1.13 shows the temperature, salinity and dissolved oxygen profiles measured at these three stations. Near the surface, the salinity both inside and outside Port Simpson Bay was about 27‰ increasing quite gradually at 30‰ near the bottom. There was a halocline between 5 and 10 m at Station S-2. Stumaun Creek must have been past its peak discharge as the freshening effect on the surface layer was not significant. Stations in the vicinity of Prince Rupert, in November, 1974 showed lower salinity at the surfaces (15-20‰) with a deeper thermocline (10-20 m) inside the harbour and a sharp (1-10 m) shallow thermocline just outside the harbour. The effect of the Skeena River is more apparent in Prince Rupert.

Seasonal salinity information is not available for Port Simpson. However, a decrease in salinity throughout the water column would be expected in early summer due to the freshet of the Nass and Skeena rivers as well as perhaps in October due to the increased precipitation runoff from local streams.

At all three stations sampled in November by Dobrocky in Port Simpson Bay the water temperature increased with depth from about 8.5°C at the surface to 9-9.25°C near the bottom. At station S-1 outside the Bay, the temperature dropped slightly near the bottom to 8.75°C, although each

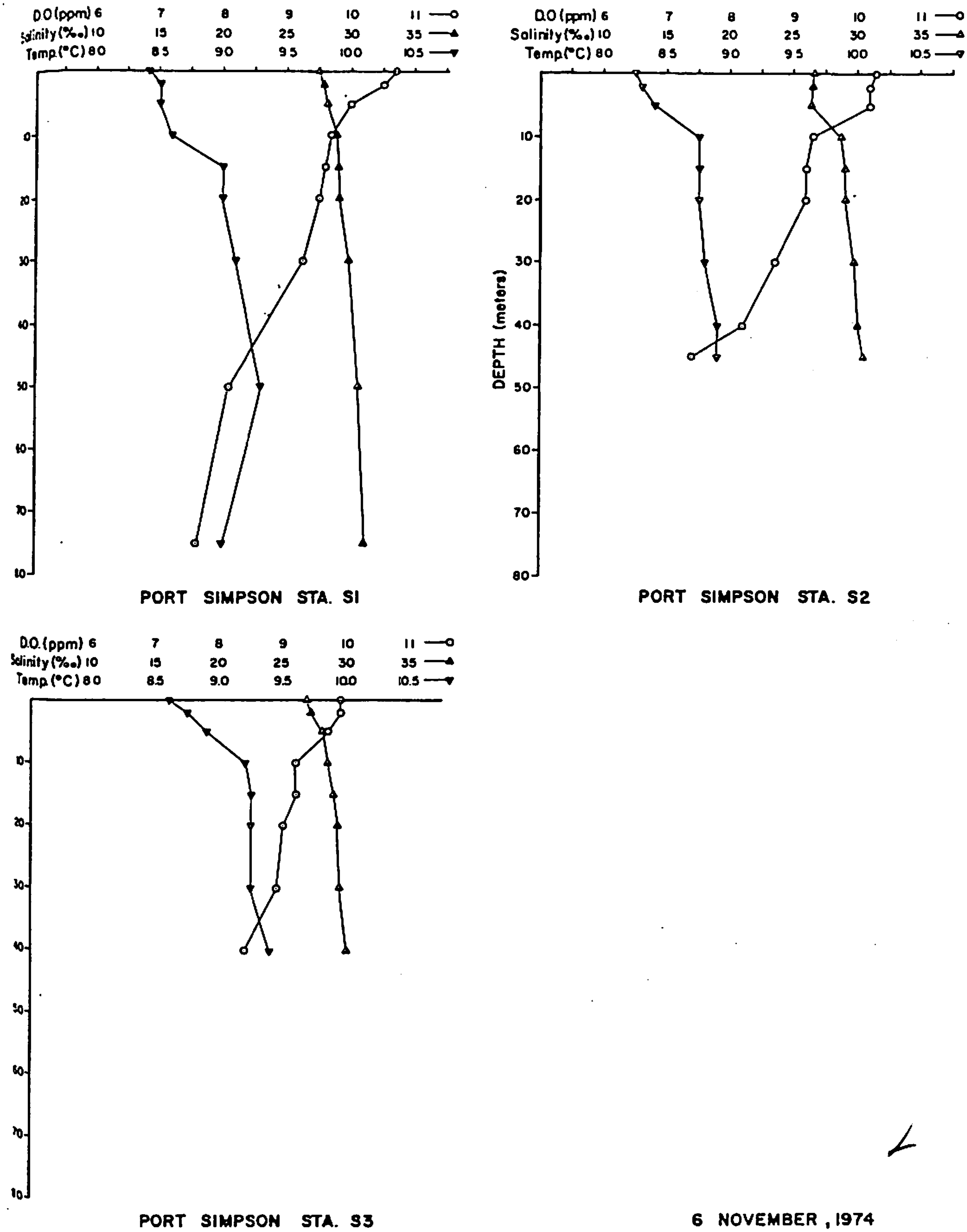


Figure 3-1.13. Salinity, temperature and dissolved oxygen profiles, Port Simpson Bay, November 6, 1974 (from NEAT, 1975)

station had a negative thermocline coincident with its halocline.

It is expected that the surface temperature in Port Simpson will follow an annual cycle similar to that of Triple Island with maximum values in summer (August) and minimum values in February - March. The annual range at Triple Island is 6.4°C to 12.7°C. Modifications in the timing and amplitude of the cycle may arise due to differences in the stability of the water column caused by fresh water input, exposure to wind, differences in tidal mixing, and proximity to oceanic influences. Port Simpson Bay should experience the growth of a thermocline in summer followed by its decay in the fall due to surface cooling and wind mixing. A subsequent warming of the deeper water should also occur. In fall and early winter the cooling and wind-mixing processes would probably eliminate the thermocline creating a near isothermal, colder water column and with further cooling a negative thermocline "inversion".

Dissolved oxygen levels in Port Simpson Bay in November 1974 were from 10 to 10.5 mg/l (ppm) at the surface decreasing to 9.25 mg/l (ppm) at 40 m and 8.75 mg/l (ppm) at 75 m at station S-1, which is similar to that measured in nearby areas in Chatham Sound at this time of year. These are the only dissolved oxygen measurements available for Port Simpson. However, the natural seasonal variations are probably similar to that described for Hecate Strait and Chatham Sound in section 3.1.1.6.

On May 23, 1981 Dome Petroleum Limited initiated a program of seasonal salinity, temperature and dissolved oxygen measurements at several locations within and outside Port Simpson Bay (Figure 3-1.9).

3.1.2.7 Turbidity and Light Transmissibility

The only light transmission measurements taken within Port Simpson Bay were those conducted by Dobrocky Seatech in November 1974. Although their data were not presented in a report, Lee Doran and Associates Ltd. (1975) discussed the Dobrocky light transmissibility measurements in Port Simpson and compared them to measurements taken simultaneously in Prince Rupert:

> "The waters of Port Simpson are less strongly influenced by the Skeena outflows. Average surface salinity on November 6, 1974 was 27.0 parts per thousand at Port Simpson by comparison with 19.1 parts per thousand in Prince Rupert one week earlier. Port Simpson waters are clearer than those of the Prince Rupert area, showing a uniform transmissibility of 48 percent from the surface to 30 metres and a slight increase below that depth."

The turbidity in Port Simpson Bay should be somewhat affected by the freshet of the Nass and the Skeena rivers and also heavy rain storms which can increase the discharge of Stumaun Creek suddenly (from as little as 0.06 m^3/sec to over 8.5 m^3/sec). Plankton blooms in summer will also create additional turbidity and light restrictions in the water column.

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3.2.0 CLIMATOLOGY AND METEOROLOGY

3.2.1 MARINE APPROACHES

3.2.1.1 Available Data Base

The most relevant climatic data for the marine approach through Dixon Entrance are those contained in the U.S. publication "Summary of Synoptic Meteorological Observations" (SSMO) for the Queen Charlottes area. The specific area covered, extends between 53° and 56° North latitude, and from the coastline to 135 west longitude. The period of record varies with the specific climatic element; however, for the most part, the record extends from 1906 to 1970.

Although there are land based meteorological stations on small islands and along the north coast of the Queen Charlottes, data from these were not used due to the influence of the land masses on climatic elements. However, since SSMO data did not provide precipitation statistics, measurements recorded at Langara (northwestern tip of the Queen Charlottes) were extracted and presented.

Environment Canada operates several climatic stations along Hecate Strait. Data collected at two stations (Cape St. James and McInnes Island) operating at the southern entrance were extracted for presentation to describe prevailing conditions there. Climatic data for the remainder of the southern approach were extracted from the "Summary of Synoptic Meteorological Observations" for the Vancouver area. The specific area covered extended between 50° and 53° North Latitude, and from the coastline to 134° West Longitude.

3.2.1.2 Temperature

Mean monthly and annual temperatures prevailing over Dixon Entrance are presented in Table 3-2.1. The warmest month is August with a mean temperature of 13.8°C, and the coldest month is January with a mean temperature of 3.6°C. The annual average temperature is 9.6°C. These values are all within 2°C averages reported for Prince Rupert (Table 3-2.1).

Mean monthly and annual temperatures prevailing over Hecate Strait and at the southern entrance are presented in Tables 3-2.2 through 3-2.4. These data indicate that the warmest month is August with an average temperature of approximately 14°C, and the coldest month is January with an average temperature between 3° and 6°C. The annual average temperature as reported by the two stations at the southern entrance is approximately 8.3°C, while the average annual temperature over the open water within Hecate Strait is 10.4°C.

Table 3-2.1 also presents monthly and annual, maximum and minimum recorded temperatures. These may not be a true indication of actual extreme values, as the synoptic observations vary both temporally and spacially. Maximum and minimum annual temperatures are 22.2° and -7.2°C respectively.

Extreme monthly and annual maximum and minimum temperatures that have been recorded at Cape St. James, McInnis Island and over Hecate Strait are also presented in Tables 3-2.2 through 3-2.4. The extreme maximum and minimum temperatures have been recorded at McInnes Island and are 32° and -15.6°C respectively.

TABLE 3-2.1

TEMPERATURE STATISTICS (°C)
Queen Charlottes 1906-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean	3.6	5.3	4.4	6.6	9.6	11.8	13.6	13.8	12.6	10.0	6.9	5.2	9.6
Maximum	11.7	12.8	11.1	16.7	17.8	20.6	22.2	21.2	18.9	16.7	12.2	11.7	22.2
Minimum	-7.2	0.0	-2.8	1.7	3.9	6.1	8.9	9.4	7.2	2.8	-2.2	-2.2	-7.2

TABLE 3-2.2

TEMPERATURE STATISTICS
Cape St. James 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Daily Temperature (°C)	3.6	4.6	4.7	6.3	8.8	10.7	12.6	13.7	12.6	9.5	6.6	4.9	8.2
Mean Daily Maximum Temperature (°C)	5.2	6.1	6.6	8.3	11.2	13.0	14.9	15.9	14.6	11.2	8.3	6.5	10.2
Mean Daily Minimum Temperature (°C)	2.1	2.9	2.8	4.2	6.3	8.3	10.2	11.4	10.6	7.8	4.9	3.2	6.2
Extreme Maximum Temperature (°C)	10.6	12.2	17.8	16.7	23.3	28.3	24.4	21.7	22.8	16.7	14.4	11.1	28.3
Extreme Minimum Temperature (°C)	-12.2	-10.6	-11.7	-2.2	1.1	1.1	5.0	5.6	5.0	-2.2	-6.1	-10.0	-12.2

TABLE 3-2.3

TEMPERATURE STATISTICS
McInnis Island 1941-1971

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Daily Temperature (°C)	3.0	4.6	4.9	7.1	9.8	12.3	13.8	14.3	12.9	9.5	5.9	4.1	8.5
Mean Daily Maximum Temperature (°C)	4.7	6.4	7.3	9.7	12.7	14.9	16.4	16.8	15.1	11.3	7.7	5.8	10.7
Mean Daily Minimum Temperature (°C)	1.3	2.8	2.6	4.5	6.9	9.5	11.2	11.8	10.6	7.6	4.2	2.4	6.3
Extreme Maximum Temperature (°C)	12.2	14.4	18.3	18.9	26.1	32.2	21.1	25.0	23.3	18.3	13.9	12.2	32.2
Extreme Minimum Temperature (°C)	-11.7	-11.1	-11.7	-3.3	0.6	6.1	8.3	7.8	6.1	0.6	-9.4	-15.6	-15.6

TABLE 3-2.4

TEMPERATURE STATISTICS
Vancouver SSMO 1902-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Daily Temperature (°C)	6.3	6.8	6.4	7.7	9.6	11.6	13.7	14.9	13.9	11.6	9.3	7.4	10.4
Extreme Maximum Temperature (°C)	12.2	13.9	12.2	15.6	17.8	17.8	21.1	21.7	21.1	18.3	15.6	14.4	21.7
Extreme Minimum Temperature (°C)	-4.4	1.1	0.0	1.1	2.8	7.2	8.9	8.9	7.2	3.9	1.7	-1.1	-4.4

3.2.1.3 Precipitation

Mean and extreme rainfall and snowfall data recorded at Langara are presented in Table 3-2.5.

Mean and extreme rainfall and snowfall recorded at Cape St. James and McInnis Island are presented in Tables 3-2.6 and 3-2.7 respectively.

Rainfall: Rainfall at Langara is heaviest during the fall, with October as the wettest month (251 mm). July is the driest month with a total rainfall of 80 mm. Total annual rainfall is approximately 1615 mm, and a total of 239 days per year are associated with some form of measurable precipitation. The greatest amount of rainfall in 24 hours is 88.4 mm.

The least amount of rain falls during early summer, and the most during late fall and early winter. McInnis Island records a total annual rainfall of 2360 mm, while Cape St. James has only 1400 mm. The larger precipitation at McInnis Island is due to the influence of the coastal mountains on the precipitation patterns. The total number of days with measurable precipitations at these two stations are very similar (225 days at Cape St. James, and 221 days at McInnis Island). Thus, the difference in rainfall is largely due to variation in intensity. The greatest rainfall in 24 hours recorded at McInnis Island is 156 mm.

Snowfall: Monthly and annual snowfall data at Langara are presented in Table 3-2.5. Annual snowfall is approximately 61 cm, over half this amount falls during December and January. The greatest snowfall in 24 hours is 31 cm.

TABLE 3-2.5

PRECIPITATION STATISTICS
Langara 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Rainfall (mm)	140.7	120.9	121.9	114.3	82.8	84.1	80.0	103.4	159.8	251.0	186.4	169.4	1614.7
Mean Snowfall (mm)	19.1	9.4	11.2	1.5						0.3	4.3	15.5	61.3
Mean Total Precipitation (mm)	159.5	130.0	133.4	115.8	82.8	84.1	80.0	103.4	159.8	251.5	190.8	184.7	1675.8
Greatest Rainfall in 24 hours (mm)	47.5	46.0	51.1	54.9	65.3	38.9	32.0	46.0	49.3	57.7	88.4	54.9	88.4
Greatest Snowfall in 24 hours (cm)	20.3	30.2	21.3	7.9						7.4	22.9	31.5	31.5
Greatest Precipitation in 24 hours (mm)	49.3	46.0	51.1	54.9	65.3	38.9	32.0	46.0	49.3	57.7	88.4	54.9	88.4
Number of Days with Measureable Precipitation	19	19	20	20	17	17	17	18	20	26	24	22	239

TABLE 3-2.6

PRECIPITATION STATISTICS
Cape St. James 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Rainfall (mm)	140.7	117.3	114.3	99.6	75.7	67.6	59.9	78.0	121.4	188.5	170.2	164.6	1397.8
Mean Snowfall (mm)	11.7	4.3	6.9	1.3							2.0	9.1	35.6
Mean Total Precipitation (mm)	152.4	121.7	120.9	101.1	75.9	67.6	59.9	78.0	121.4	188.5	172.2	174.0	1433.4
Greatest Rainfall in 24 hours (mm)	40.9	46.2	54.4	44.5	44.5	63.5	47.8	61.0	59.2	59.9	53.3	54.6	63.5
Greatest Snowfall in 24 hours (cm)	22.6	15.2	28.4	6.1	4.6					4.6	10.2	23.9	28.4
Greatest Precipitation in 24 hours (mm)	40.9	46.2	54.4	44.5	44.5	63.5	47.8	61.0	59.2	59.9	53.3	54.6	63.5
Number of Days with Measureable Precipitation	22	21	21	20	15	15	14	15	18	25	24	24	235

TABLE 3-2.7

PRECIPITATION STATISTICS
McInnis Island 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Rainfall (mm)	240.3	176.3	209.0	156.2	125.0	101.1	113.8	137.4	206.2	291.3	306.3	298.2	2361.1
Mean Snowfall (mm)	35.1	22.9	13.5	3.0						0.8	6.6	18.0	99.9
Mean Total Precipitation (mm)	275.3	199.1	222.5	159.3	125.0	101.1	113.8	137.4	206.2	292.1	312.9	316.2	2460.9
Greatest Rainfall in 24 hours (mm)	104.4	116.1	79.5	68.6	71.4	63.0	54.6	69.6	102.9	156.0	71.4	104.6	156.0
Greatest Snowfall in 24 hours (cm)	51.6	14.5	21.8	10.7						12.2	22.9	35.6	51.6
Greatest Precipitation in 24 hours (mm)	104.1	116.1	79.5	68.6	71.4	63.0	54.6	69.6	102.9	156.0	71.4	104.6	156.0
Number of Days with Measureable Precipitation	20	18	19	19	16	14	13	15	17	24	23	23	221

Monthly and annual snowfall data for Cape St. James and McInnis Island are presented in Tables 3-2.6 and 3-2.7. Annual snowfall at McInnis Island is approximately 100 cm, while at Cape St. James it is approximately 36 cm.

Icing: Extreme values for freezing precipitation at Cape St. James are presented in Table 3-2.8. These represent the total ice accretion on a horizontal surface for return periods of 5 and 20 years.

TABLE 3-2.8

ICE ACCRETION ON HORIZONTAL SURFACES

(Cape St. James)

	Return Period (yrs)	
	5	20
Accretion (mm)	0.25	0.76

Source: Chaine et al. Wind and Ice Loading in Canada, 1974.

3.2.1.4 Relative Humidity

Mean monthly and annual relative humidity prevailing in Dixon Entrance are presented in Table 3-2.9. All monthly and annual values are in excess of 80%. These values are not unlike those presented for Prince Rupert (Table 3-2.25).

Mean monthly and annual relative humidity prevailing in Hecate Strait and at Cape St. James are presented in Tables 3-2.10 and 3-2.11. All monthly and annual values are in excess of 80%. The most humid months are July, August and September, with the largest monthly average of 92% occurring during July at Cape St. James.

TABLE 3-2.9

RELATIVE HUMIDITY (%)
Queen Charlottes 1906-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Relative Humidity	85	85	84	80	93	85	88	88	87	85	85	85	85

TABLE 3-2.10

RELATIVE HUMIDITY (%)
Vancouver SSMO 1902-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Relative Humidity	84	85	81	82	82	84	86	86	86	83	83	85	84

TABLE 3-2.11

RELATIVE HUMIDITY (%)
Cape St. James 1957-1966

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Relative Humidity	86	87	82	82	85	89	92	91	90	87	88	86	87

3.2.1.5 Barometric Pressure

Mean monthly and annual values for the barometric pressure prevailing in Dixon Entrance are presented in Table 3-2.12. The average annual value is 1013 mb, identical with that for Prince Rupert. Maximum and minimum observed pressures are 1038 and 976 mb respectively; also not unlike values recorded at Prince Rupert (Table 3-2.26).

Mean monthly and annual values for the barometric pressure prevailing over Hecate Strait and at Cape St. James are presented in Tables 3-2.13 and 3-2.14. Maximum and minimum pressures observed at Cape St. James are 1049 and 961 respectively. The annual average is approximately 1014 mb.

3.2.1.6 Visibility

The monthly and annual frequency of occurrence of fog in Dixon Entrance are presented in Table 3-2.15. Fog occurs on the average about 2.6% of the time on an annual basis with most frequent occurrences during July and August (6.5 and 4.8% respectively).

Monthly and annual frequency of occurrence of various visibility ranges in Dixon Entrance are depicted in Table 3-2.16. These visibility restrictions are due to all possible climatic conditions including fog. These data indicate that visibility is less than 0.9 km only 1.6% of the time on an annual basis. However, on a monthly basis, August has the most frequent occurrence (5.1%) of this visibility range.

The monthly and annual frequency of occurrence of fog in Hecate Strait are presented in Table 3-2.17. Fog occurs on the average about 6.8% of the time on an annual

TABLE 3-2.12

BAROMETRIC PRESSURE (millibars)
Queen Charlottes 1961-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean	1012	1011	1011	1014	1017	1017	1018	1016	1013	1008	1007	1008	1013
Maximum	1038	1036	1036	1034	1033	1031	1029	1032	1031	1028	1032	1036	1038
Minimum	983	987	980	987	993	998	1005	999	990	984	975	976	975

TABLE 3-2.13

BAROMETRIC PRESSURE (millibars)
Vancouver 1951-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean	1011	1013	1013	1015	1018	1017	1019	1018	1017	1012	1011	1010	1015
Maximum (monthly)	1041	1042	1039	1036	1034	1032	1032	1033	1035	1033	1037	1038	1042
Minimum (monthly)	979	979	984	992	996	995	995	997	986	981	983	981	979

TABLE 3-2.14

BAROMETRIC PRESSURE (millibars)
Cape St. James 1953-1972

Sea Level

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	Year
Mean	1089.9	1011.8	1011.9	1014.2	1017.1	1016.5	1019.0	1017.0	1015.4	1011.3	1009.8	1008.9	1013.6
Maximum (monthly)	1014.8	1020.1	1022.0	1020.2	1019.7	1019.3	1021.6	1019.3	1021.1	1019.7	1020.8	1017.1	1024.8
Minimum (monthly)	1003.6	1002.6	1005.0	1008.9	1012.1	1013.0	1014.6	1012.7	1011.1	1004.4	1001.1	1002.6	1001.1
Maximum (hourly)													1049.0
Minimum (hourly)													961.7

TABLE 3-2.15

OCCURRENCE OF FOG WITHOUT PRECIPITATION (%)
Queen Charlottes 1906-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Percent Occurrence	1.8	1.6	0.8	0.8	1.0	2.9	6.5	4.8	3.5	1.3	1.6	1.6	2.6

Source: Summary of Synoptic Meteorological Conditions

TABLE 3-2.16

VISIBILITY
(% Frequency)
Queen Charlottes 1976-1970

X - Distance	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
X < .9 km	0.7	0.3	0.7	0.3	0.3	2.6	3.0	5.1	1.2	1.6	0.8	1.3	1.6
.9 ≤ X < 1.8 km	2.8	0.3	0.4	0.3	0.0	2.6	1.0	9.3	1.2	1.0	0.4	1.8	1.8
1.8 ≤ X < 3.7 km	5.9	5.6	2.5	2.1	2.4	2.0	3.3	1.4	1.2	1.9	2.3	2.2	2.7
3.7 ≤ X < 9.2 km	6.6	8.9	5.6	5.4	4.3	6.6	8.4	6.2	7.1	8.7	7.3	6.2	6.8
9.2 ≤ X <18.4 km	19.3	26.4	16.1	14.6	13.7	14.6	22.0	14.4	22.3	22.2	22.6	26.5	19.3
18.4 ≤ X	64.8	58.4	76.7	77.4	73.8	71.7	62.3	63.6	67.0	64.6	66.7	61.9	67.7

TABLE 3-2.17

FOG OCCURRENCE
(without precipitation)
Vancouver SSMO 1902-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Frequency of Occurrence (%)	5.5	4.9	3.8	4.5	5.5	8.7	12.3	9.8	10.1	4.7	2.7	3.7	6.8

basis with the most frequent occurrences during July (12.3% of the time).

Monthly and annual frequency of occurrence of various visibility ranges in Hecate Strait and at Cape St. James are presented in Tables 3-2.18 and 3-2.19. These visibility restrictions are due to all possible climatic conditions including fog. These data indicate that visibility of between 1 and 8 km occurs approximately 13% of the time on an annual basis.

3.2.1.7 Wind

Seasonal and annual frequency of occurrence of wind by direction for the Dixon Entrance region are presented in Figure 3.2.1. The most frequent wind is from the southeast during spring, fall and winter. During summer predominant wind occurrence is from southeast, northwest and west. On an annual basis the most frequent direction is from the southeast 15%, followed by northwest 10%, and west 9%.

Seasonal and annual frequency of occurrence of wind by direction for Hecate Strait and Cape St. James are presented in Figures 3-2.2 and 3-2.3. Local topography plays a dominant role in dictating wind directions at Cape St. James. The predominant wind frequency appears to be from the northwest during spring, summer and fall. Prevailing wind directions over Hecate Strait are relatively more uniform with wind from the northwest during summer and southeast during winter.

Average seasonal and annual wind speeds (by direction) for Dixon Entrance are presented in Figure 3-2.4. Wind is strongest during winter (average speed of 32.2 km/hr), with strong wind from the southeast quadrant. Wind is weak-

TABLE 3-2.18

VISIBILITY
(% Frequency)
Vancouver SSMO 1902-1970

X - Distance	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
$X < .9$ km	1.6	2.7	1.7	1.4	1.6	3.4	4.2	3.8	3.8	3.0	1.8	1.4	2.7
$.9 \leq X < 1.8$ km	1.8	1.8	1.0	1.6	1.7	2.1	3.2	2.4	2.5	2.5	1.6	1.5	2.0
$1.8 \leq X < 3.7$ km	5.1	4.2	2.8	2.0	2.1	2.9	2.6	3.1	2.1	2.4	1.7	5.0	2.9
$3.7 \leq X < 9.2$ km	9.7	10.2	7.9	5.7	4.5	7.3	5.3	6.3	5.9	7.4	8.3	10.5	7.1
$9.2 \leq X < 18.4$ km	26.7	30.7	26.4	22.3	22.2	21.8	27.8	23.7	28.7	28.9	30.4	30.2	26.5
$18.4 \leq X$	55.2	50.4	60.2	67.1	67.3	62.5	56.9	60.7	56.9	55.8	56.3	51.5	58.8

TABLE 3-2.19

VISIBILITY
(Percent of Time)
Cape St. James 1953-1972

Visibility	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
0 - 800 m	7.8	7.2	4.9	3.3	6.0	10.8	12.7	11.9	12.5	11.9	5.9	6.3	8.4
1000 - 8000 m	19.5	19.8	13.8	11.0	9.4	9.0	8.1	8.2	10.7	15.2	15.4	20.6	13.4
>10,000 m	72.7	73.0	81.3	85.7	84.6	80.2	79.2	79.9	76.8	72.9	78.7	73.1	78.2

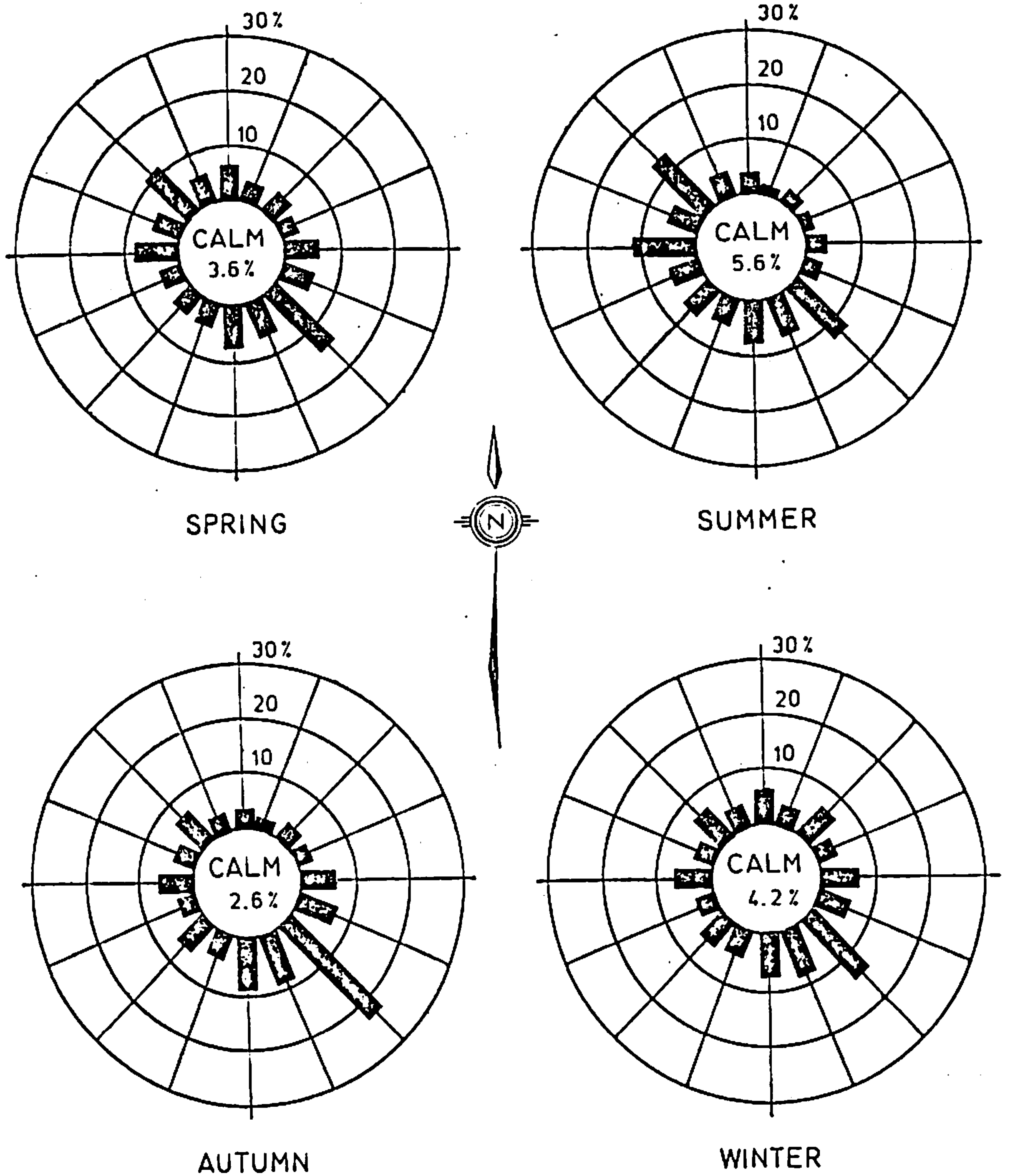


FIGURE 3-2.1.
SEASONAL AND ANNUAL
FREQUENCY OF WIND
Queen Charlottes

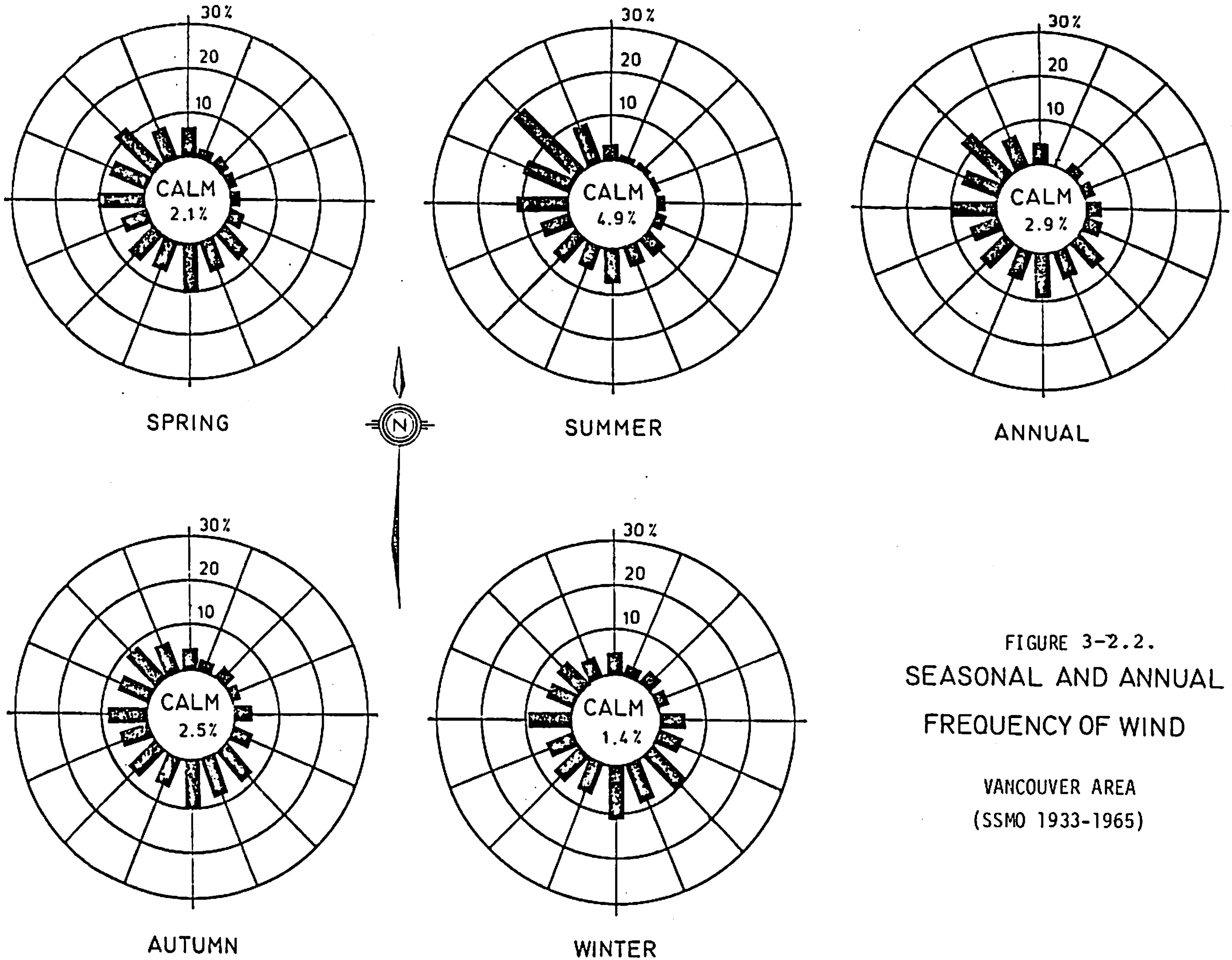


FIGURE 3-2.2.
SEASONAL AND ANNUAL FREQUENCY OF WIND

VANCOUVER AREA
(SSMO 1933-1965)

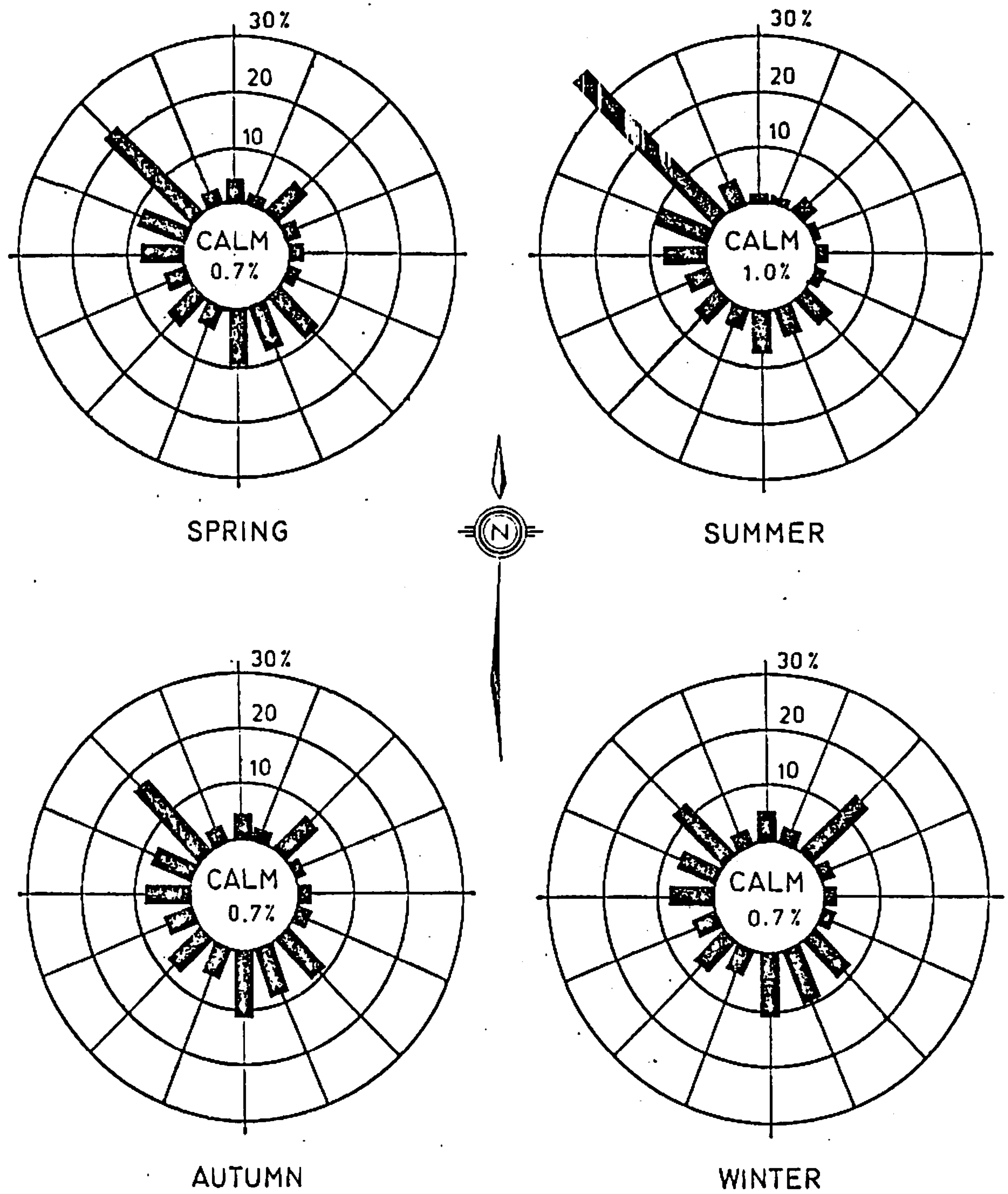


FIGURE 3-2.3.

SEASONAL AND ANNUAL FREQUENCY OF WIND

CAPE ST. JAMES
(1957-1972)

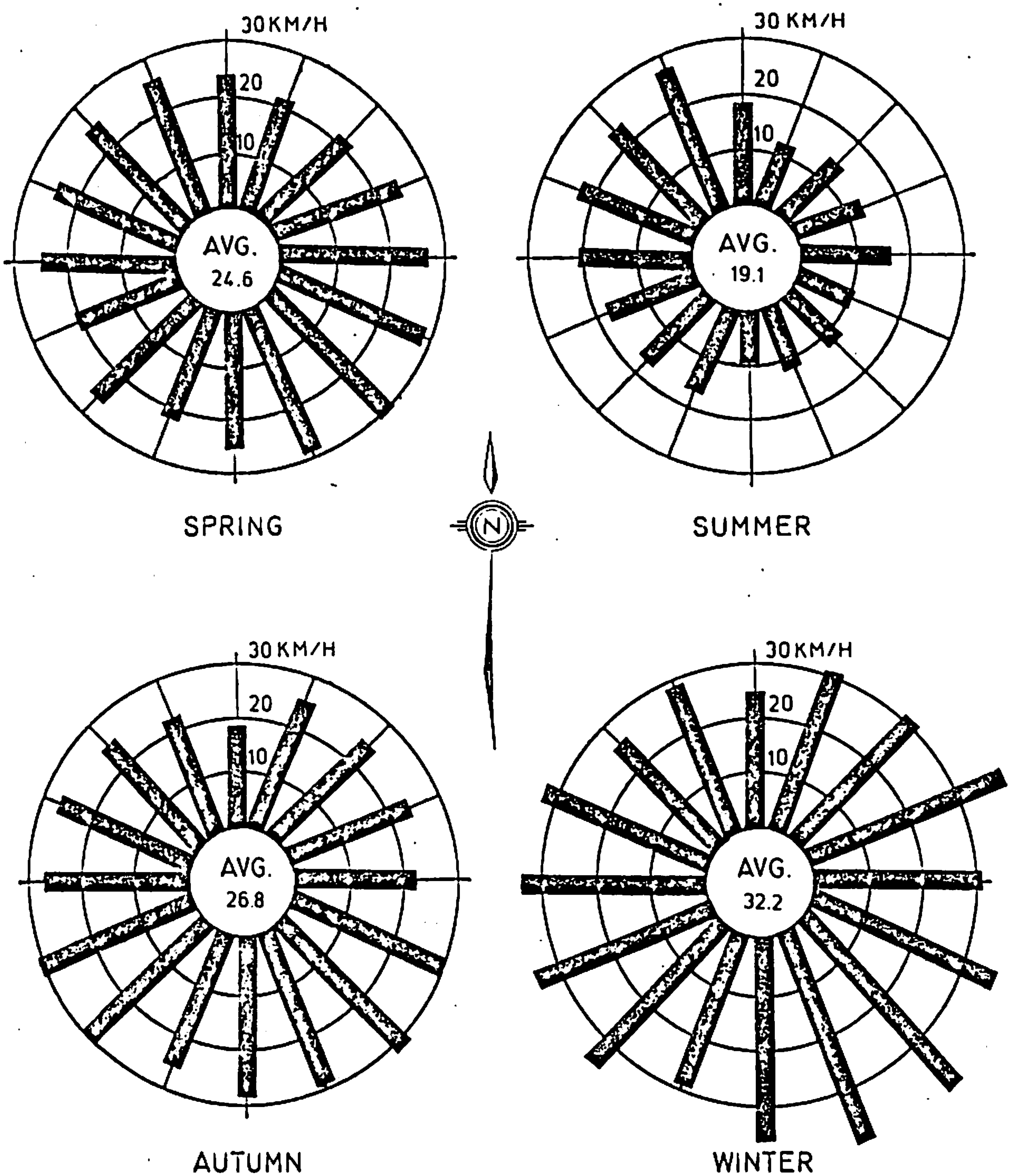


FIGURE 3.2.4.

AVERAGE SEASONAL AND

ANNUAL WIND SPEEDS

Queen Charlottes

est during summer (average speed of 19.1 km/hr), with strong wind from the the northwest quadrant.

Average seasonal and annual wind speeds (by direction) for Hecate Strait, and Cape St. James (corrected to 10 m above sea level) are presented in Figures 3-2.5 and 3-2.6. Wind is weakest during summer (average speed 22.1 km/hr) with highest averages for wind from the northwest.

3.2.1.8 Lightning

Thunderstorms and lightning are relatively infrequent along the north coast of British Columbia. The monthly and annual frequency of occurrence of thunder and lightning are depicted in Table 3-2.20. These events occur only 0.1% of all hourly observations. The most frequent occurrence is during the month of November (0.5% of the time). The annual average frequency of occurrence of thunder and lightning over Hecate Strait is less than 0.1% of the time.

3.2.2 TERMINAL

3.2.2.1 Available Data Base

The most relevant climatic data (for the proposed site) with a substantial historical record are measured at the Prince Rupert airport. Although some historical climatic data for Prince Rupert are available since 1908, continuous measurements at the airport did not commence until 1961. For consistency, data extracted and presented in this report are largely those from the airport (long term means and extremes of temperature an precipitation are excepted). In order to obtain climatic data for Port Simpson Bay, a meteorology tower to measure temperature, wind speed and direction and relative humidity was installed in May, 1981. Data from this

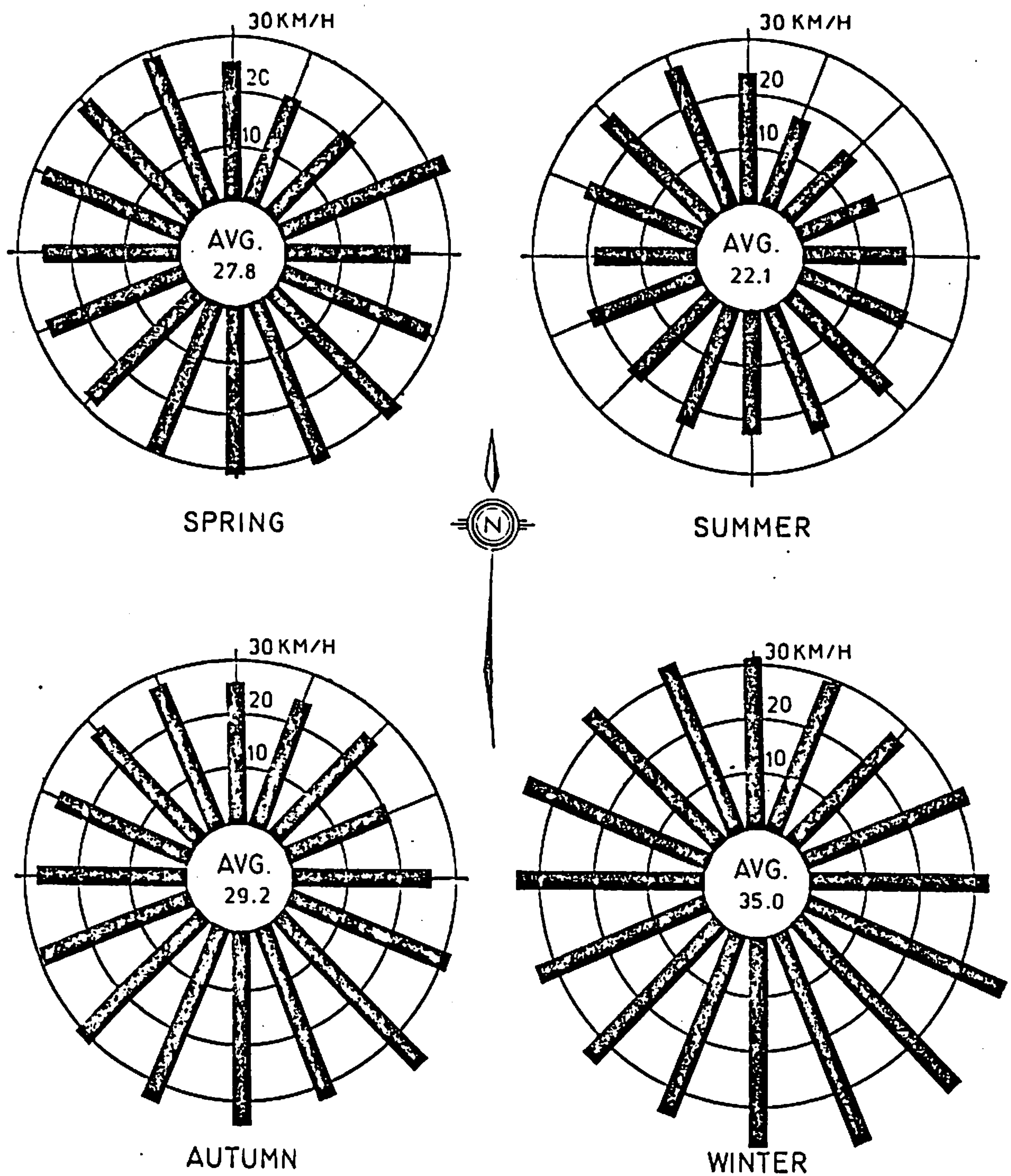


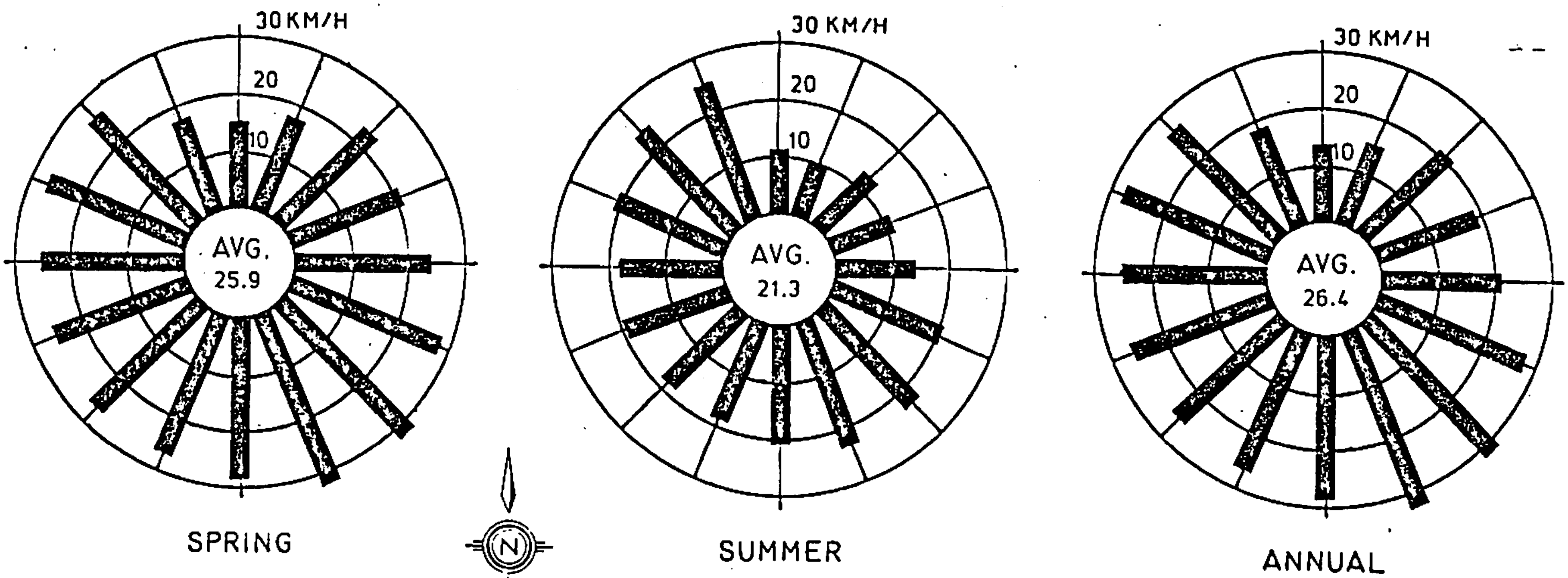
FIGURE 3-2.5.

AVERAGE SEASONAL AND

ANNUAL WIND SPEEDS

VANCOUVER AREA

(SSMO 1933-1965)



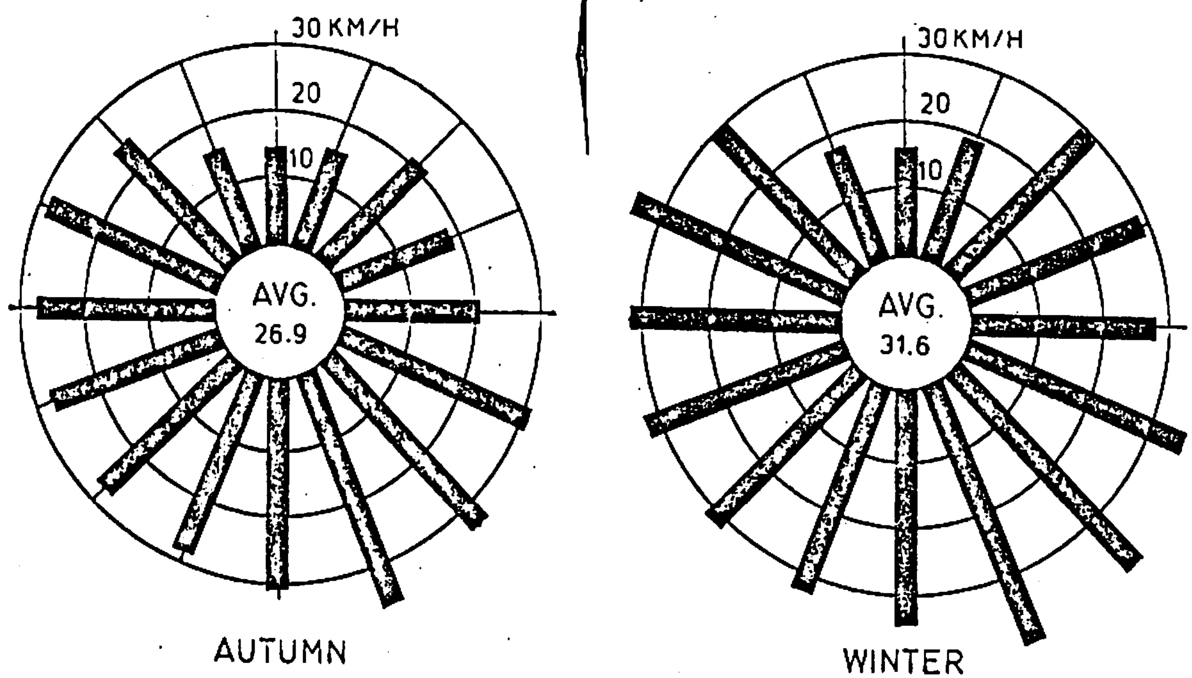


FIGURE 3-2.6.

AVERAGE SEASONAL AND ANNUAL WIND SPEEDS*

CAPE ST. JAMES

(1957-1972)

*Corrected to 10 meters above sea level

station will be compared with Prince Rupert airport data to define topographic effects and prediction of climatic extremes at Grassy Point.

3.2.2.2 Temperature

Mean and extreme monthly and annual temperatures recorded at Prince Rupert are presented in Table 3-2.21. The warmest month is August with a mean temperature of 13.9°C, and the coldest month is January with a mean temperature of 1.8°C. The annual average temperature is 7.7°C.

The extreme maximum and minimum temperatures recorded at Prince Rupert are 32.2°C and -21.1°C respectively.

3.2.2.3 Precipitation

The north coast of B.C. is exposed to a substantial amount of precipitation. Historical mean and extreme rainfall and snowfall data are depicted in Table 3-2.22.

Rainfall: Rainfall at Prince Rupert is most severe during the fall (September to December), with October as the wettest month (359 mm). May, June and July are relatively dryer with June having the least rainfall (107 mm). Total annual rainfall is approximately 2300 mm, and a total of 227 days per year are associated with some form of measurable precipitation.

The greatest amount of rainfall in a 24 hours period recorded at Prince Rupert is 141 mm. High intensity rainfall data predicted for Prince Rupert by AES is presented in Table 3-2.23.

TABLE 3-2.20

OCCURRENCE OF THUNDER AND LIGHTNING (%)
Queen Charlottes 1906-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Percent Occurrence	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.5	0.0	0.1

TABLE 3-2.21

TEMPERATURE STATISTICS
Prince Rupert 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Daily Temperature (°C)	1.8	2.7	3.7	6.2	9.6	11.8	13.6	13.9	12.0	8.7	5.1	2.9	7.7
Mean Daily Maximum Temperature (°C)	4.4	5.4	6.9	9.8	13.6	15.3	16.9	17.4	15.4	11.4	7.6	5.2	10.8
Mean Daily Minimum Temperature (°C)	-0.8	-0.1	0.5	2.6	5.6	8.3	10.1	10.5	8.6	5.9	2.6	0.7	4.5
Extreme Maximum Temperature (°C)	17.8	18.9	20.0	23.3	29.4	32.2	30.6	30.0	27.2	21.7	20.0	17.2	32.2
Extreme Minimum Temperature (°C)	-21.1	-17.2	-15.0	-6.7	-1.1	1.7	0.6	3.9	-1.1	-5.6	-11.7	-15.0	-21.1

TABLE 3-2.22

PRECIPITATION STATISTICS
Prince Rupert 1941-1970

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Rainfall(mm)	179.8	188.5	161.3	180.6	122.7	107.2	120.9	147.1	241.8	358.9	264.2	227.6	2301.6
Mean Snowfall(cm)	34.3	19.3	19.1	3.3						.3	5.1	31.8	113.2
Mean Total Precipitation (mm)	214.1	208.8	180.3	183.9	127.7	107.2	120.9	147.1	241.8	359.2	269.2	259.3	2414.5
Greatest Rainfall in 24 hours (cm)	125.0	78.0	103.6	71.1	65.5	48.1	67.1	70.6	94.7	141.0	137.9	125.5	141.0
Greatest Snowfall in 24 hours (cm)	38.1	27.9	25.9	25.4	22.9	1.3				5.1	16.5	27.9	38.1
Greatest Precipitation in 24 hours (mm)	125.0	78.0	103.6	71.1	65.5	48.0	67.1	70.6	94.7	141.0	137.9	125.5	141.0
Number of Days with Measurable Precipitation	20	17	20	19	17	16	16	16	17	24	22	23	227

TABLE 3-2.23

EXTREME RAINFALL INTENSITY (mm/hr)

(Prince Rupert)

Duration	Return Period (yrs)			
	2	5	10	25
15 min	26	32	36	43
24 hr	3.6	5.2	6.4	8.0

Snowfall: Snowfall along exposed coastal locations in northern British Columbia is not substantial. At Prince Rupert, a total of 113 cm fall annually, with the major portions falling during December and January. The greatest snowfall in 24 hours recorded at Prince Rupert is 38 cm.

Icing: The potential for freezing precipitation exists. Extreme values predicted for Prince Rupert are depicted in Table 3-2.24. These represent the total ice accretion on a horizontal surface for return periods of 5 and 20 years.

TABLE 3-2.24

ICE ACCRETION ON HORIZONTAL SURFACES

(Prince Rupert)

	Return Period (yrs)	
	5	20
Accretion (mm)	0.25	0.76

Source: Chaine et al, Wind and Ice Loading in Canada, 1974.

3.2.2.4 Relative Humidity

Mean monthly and annual relative humidity at Prince Rupert are presented in Table 3-2.25. Monthly averages are in the range of 80 to 90%. Typical of most coastal locations, the relative humidity is always high as depicted by the approximate monthly minimum values in Table 3-2.25 (not less than 70%).

3.2.2.5 Barometric Pressure

Historical records of the seasonal variation in barometric pressure at Prince Rupert are presented in Table 3-2.26. Mean, maximum and minimum monthly and annual values are shown. The maximum monthly pressure recorded is 1024 mb and the minimum is 1003 mb. Extreme hourly maximum and minimum values are 1036 and 959 mb respectively.

3.2.2.6 Visibility

The major restrictions to visibility are fog, certain forms of precipitation and smoke. Fog presents the greatest hazard since it usually restricts visibility more severely than does precipitation. However, snow can also seriously restrict visibility, particularly in coastal areas.

The monthly and annual frequency of occurrence of fog at Prince Rupert are depicted in Table 3-2.27. Fog is a condition associated with the presence of condensed water vapour in the atmosphere. It can be associated with severe visibility restrictions down to several meters (dense fog), or it can be very light with visibilities of the order of kilometers. Fog occurs on average about 13% of the time per year and is most frequent during the late summer July - September.

TABLE 3-2.25

RELATIVE HUMIDITY (%)
Prince Rupert 1962-1976

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Mean Relative Humidity	87	82	80	79	81	86	88	90	89	84	86	86	85
Approximate Maximum Relative Humidity	87	87	85	88	92	92	97	94	93	87	86	87	97
Approximate Minimum Relative Humidity	83	77	71	70	71	77	75	83	79	79	80	85	70

TABLE 3-2.26

BAROMETRIC PRESSURE (millibars)
Prince Rupert 1955-1972

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	Year
(1961-1972)													
Mean	1012.4	1010.1	1008.5	1011.6	1018.2	1015.4	1019.1	1015.4	1014.7	1015.7	1008.7	1011.3	1013.4
Maximum (monthly)	1023.8	1018.0	1022.7	1019.2	1018.6	1018.3	1021.0	1018.4	1020.4	1018.7	1013.7	1013.9	1023.8
Minimum (monthly)	1003.2	1004.0	1006.8	1009.3	1015.2	1014.4	1014.5	1012.3	1010.4	1004.3	1003.7	1004.0	1003.2
(1955-1962)													
Maximum (hourly)													1036.3
Minimum (hourly)													959.1

TABLE 3-2.27

FOG OCCURRENCE
(Percent of Time Fog is Present)
Prince Rupert 1962-1976

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Frequency of Occurrence (%)	12.2	12.4	10.0	9.9	7.9	13.8	17.0	19.5	18.0	13.6	10.7	12.4	13.2

Monthly and annual frequency of occurrence of various visibility ranges at Prince Rupert are presented in Table 3-2.28. These visibility restrictions are due to all possible climatic conditions including fog. These indicate that visibility restrictions to 600 meters occur approximately 12% of the time, 800-1200 meters occur 14% and 1600-4000 meters occur 37%. Again, the most frequent restrictions occur during July and August.

3.2.2.7 Wind

The most predominant wind, both in speed and frequency of occurrence is from the south east for northern coastal locations.

Seasonal and annual frequency of occurrence of wind by direction for Prince Rupert are depicted in Figure 3-2.7. Summer, is the only season that indicates pronounced wind frequency from the west. For all other seasons and the annual distribution, wind from the south east is by far the most frequent; approximately 27% of the time during autumn and winter.

Average seasonal and annual wind speeds (by direction) for Prince Rupert are presented in Figure 3-2.8. The annual average wind speed, regardless of direction, is 14.7 km/hr. Again, the predominance of the strength of south easterly wind is evident from the figure. The frequency of occurrence of various wind speeds regardless of direction are shown in Figure 3-2.9.

Data for the extreme hourly wind speed at Prince Rupert are presented in Table 3-2.29. Two sets of values are given for three return periods. The first is extracted from the climatic supplement to the National Building Code of

TABLE 3-2.28

VISIBILITY
(Percent of Time)
Prince Rupert 1962-1976

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
Ceiling 0-30 m and/or Visibility 0-600 m	5.0	4.5	5.5	2.5	3.1	14.3	27.5	32.2	29.5	7.5	4.2	6.5	11.9
Ceiling 60-120 m and/or Visibility 800-1200 m	17.9	8.9	9.4	4.3	5.9	22.5	30.1	28.7	19.1	7.4	5.3	14.9	14.5
Ceiling 150-275 m and/or Visibility 1600-4000 m	54.7	31.5	30.1	17.7	22.5	40.8	59.5	62.3	36.8	28.3	27.0	38.4	37.5

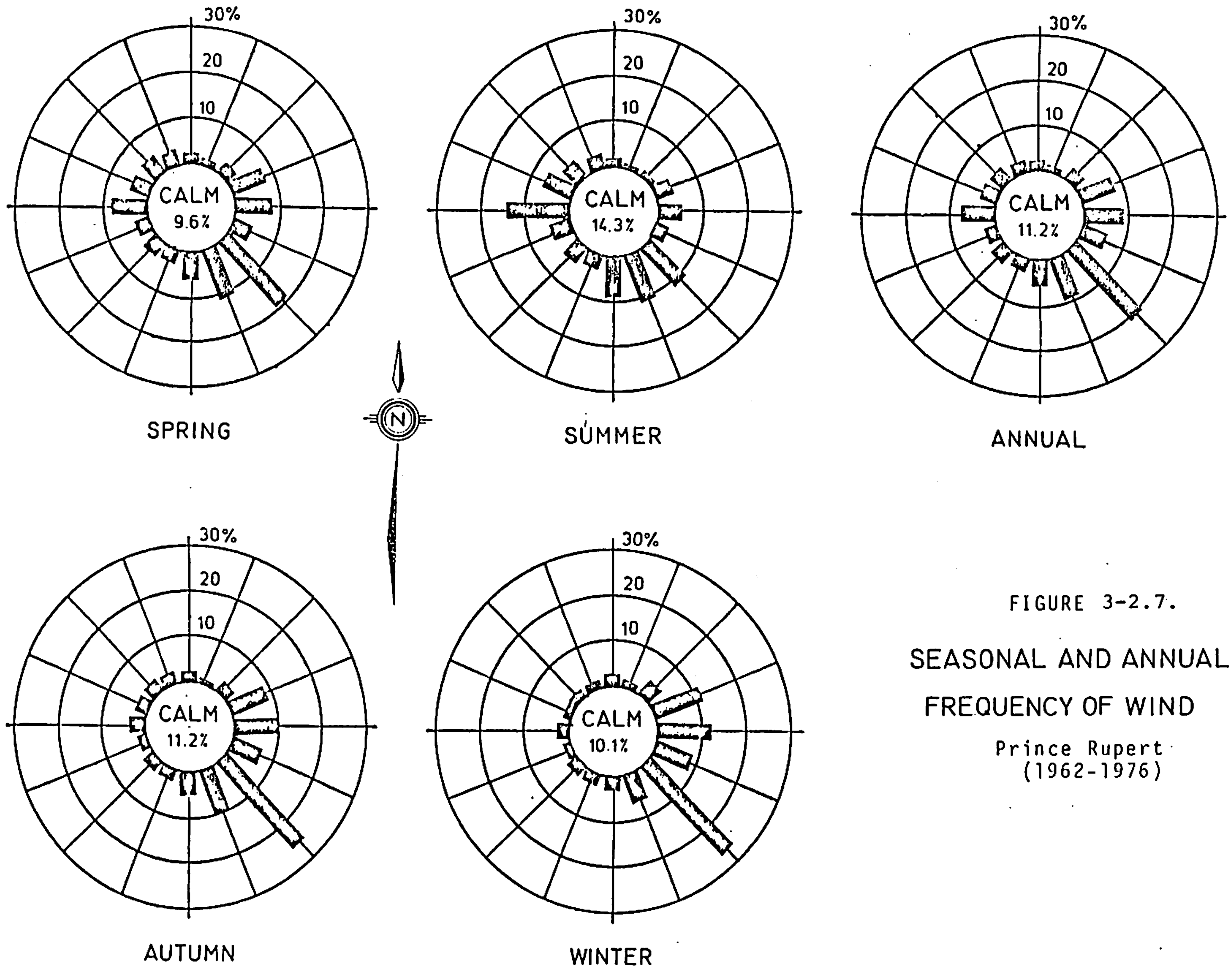


FIGURE 3-2.7.

SEASONAL AND ANNUAL FREQUENCY OF WIND

Prince Rupert
(1962-1976)

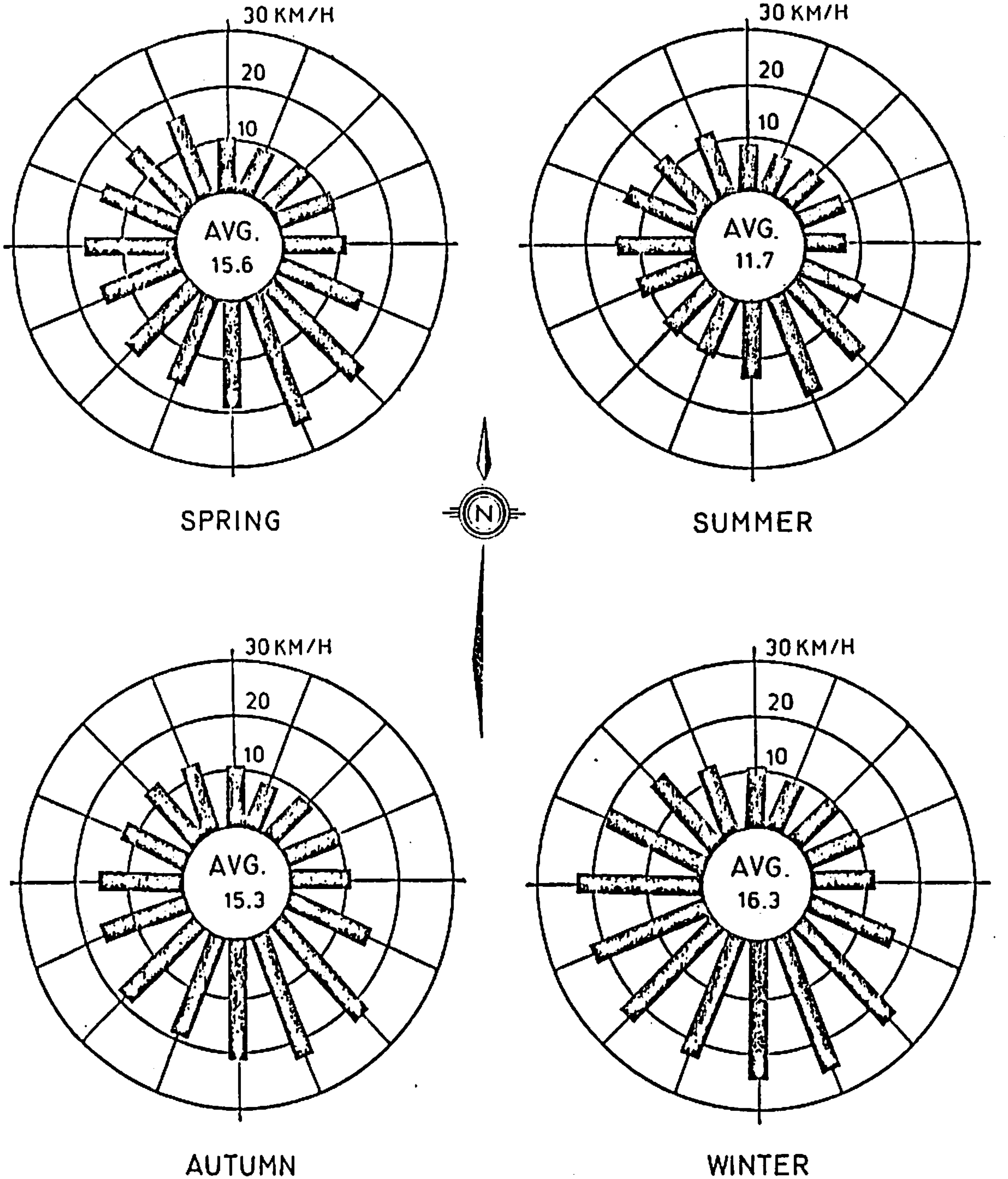


FIGURE 3-2.8.

AVERAGE SEASONAL AND

ANNUAL WIND SPEEDS

Prince Rupert

(1962-1976)

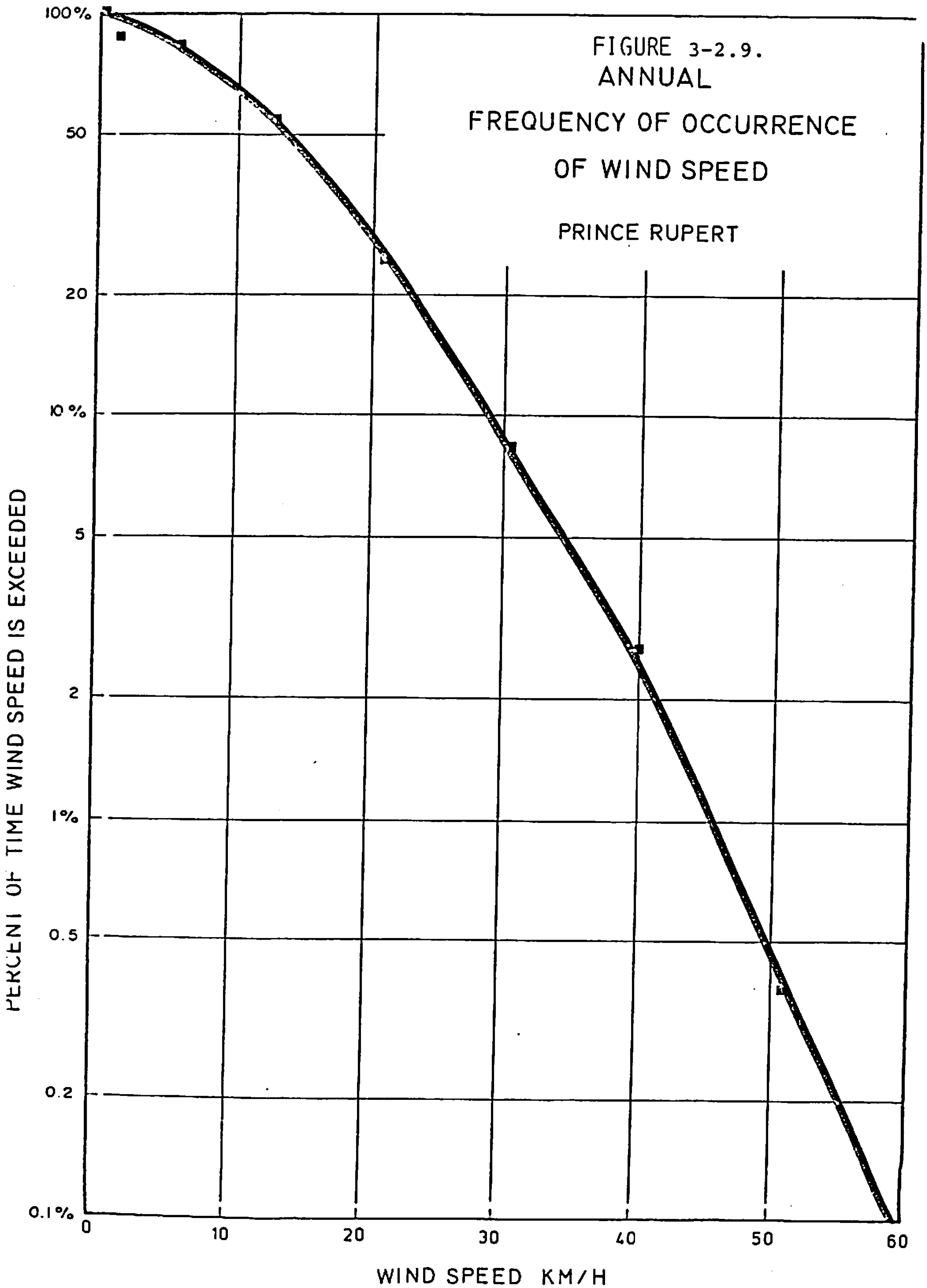


FIGURE 3-2.9.
ANNUAL
FREQUENCY OF OCCURRENCE
OF WIND SPEED
PRINCE RUPERT
100%
50
20
10 %
5
2
1%
0.5
0.2
0.1%
0
10
20
30
40
50
60
PERCENT OF TIME WIND SPEED IS EXCEEDED
WIND SPEED KM/H

TABLE 3-2.29

EXTREME HOURLY WIND SPEEDS (km/hr)
(Prince Rupert)

Source	Return Period (yrs)		
	10	30	100
National Building Code of Canada	92	100	109
Predicted Extremes	75	80	87

Canada; the second is derived from an analysis of the 15 years of wind data (1962-1976). Analysis was in the form of fitting the wind frequencies to a Weibull cummulative statistical distribution. Subsequently, through theoretical means, the extreme value distribution was derived and used to predict extreme wind speeds associated with various return periods. It is recommended that the values published in the National Building Code (NBC) be used for the design of structures against wind. However, for the purpose of wave forecasting the predicted extremes will be adequate. The rationale for this recommendation is that the NBC provides extreme wind speeds for some locations where no wind measurements are recorded based on extrapolating regional data. This process is subject to error, in view of the substantial influence of the complex coastal topography on wind.

3.2.2.8 Atmospheric Stability

The frequency of occurrence of wind speed by direction and stability class (according to Pasquill) were ordered and obtained from the Atmospheric Environment Service. A summary of these data is presented in Table 3-2.30. These indicate that, on average, stable conditions (poor atmospheric dispersal) occur about 21% on an annual basis, and most frequently during January (28%). These data are most useful when conducting dispersion modelling of air emissions to predict ambient air quality.

Portelli (1976) published seasonal and annual maximum mixing heights. These are presented in Table 3-2.31. Values for spring and summer are more than twice those for autumn and winter.

TABLE 3-2.30

PASQUILL STABILITY CLASS
FREQUENCY DISTRIBUTION (%)
Prince Rupert 1961-1979

Month	Stability Class						Total
	A	B	C	D-Day	D-Night	E+F	
January	0.0	0.6	4.6	20.8	45.8	28.2	100.0
February	0.0	2.4	5.4	25.1	44.9	22.0	100.0
March	0.1	2.8	7.3	31.5	36.2	22.1	100.0
April	0.4	4.6	8.4	37.1	29.7	19.8	100.0
May	0.5	6.0	11.9	39.4	22.9	19.3	100.0
June	0.3	4.2	10.2	47.4	22.4	15.5	100.0
July	0.2	4.4	11.8	44.3	22.7	16.6	100.0
August	0.3	5.5	11.0	36.9	25.5	20.8	100.0
September	0.3	4.8	8.5	32.1	30.5	23.8	100.0
October	0.0	1.8	5.6	29.6	43.8	19.2	100.0
November	0.0	1.2	4.7	22.0	46.2	25.9	100.0
December	0.0	0.0	3.4	21.0	50.9	24.7	100.0
Annual	0.2	3.2	7.8	32.3	35.0	21.5	100.0

Stability Classes:

A - very unstable
B - moderately unstable
C - slightly unstable
D - Day - neutral (day time)
D - Night - neutral (night time)
E & F - stable

TABLE 3-2.31

MEAN SEASONAL MAXIMUM AFTERNOON MIXING HEIGHTS

(Prince Rupert Region)

Season	Height (m)
Spring	1100
Summer	1100
Autumn	500
Winter	400
Year	800

3.2.2.9 Thunder Storms

Thunder storms are relatively infrequent at Prince Rupert. Statistical records for the period 1962-1976 indicate that only 20 counts of thunder storms occurred out of a total of 131,292 hourly observations. Most of these occurred during July to November.

3.2.3 References

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3.30 TERRAIN

3.3.1 Methodology

3.3.1.1 Approach

Published information was reviewed and utilized as a data base for the study. Provincial monochrome aerial photography (1:20,000 scale) was used to supplement the terrain and geological data and to map geotechnical hazards. National Topographic System maps at 1:50,000 and 1:250,000 scales were also used to obtain information. All data were transferred to 1:250,000 scale base maps.

An aerial reconnaissance of the area was conducted to check pre-typed geological and terrain units, and geotechnical features.

Terrain, bedrock and surficial geology and geotechnical hazards were mapped at a regional scale. Mapping and reports by the Geological Survey of Canada, B.C. Ministry of Energy, Mines and Petroleum Resources, the Terrestrial Studies Branch, B.C. Ministry of the Environment., and papers in scientific journals were used as a data base, along with reports undertaken for other local development projects (e.g., NEAT, 1975).

Reports and mapping by the Geological Survey of Canada and the United States Geological Survey were used along with scientific papers as a basis for the tectonic study of the area.

Data on the seismicity of the study area was obtained from the Pacific Geoscience Centre, Earth Physics Branch, Energy, Mines & Resources, Canada. This data included all recorded earthquake activity measured in the study area between 1899 and 1977. Site coordinates for Grassy Point were fed into the computer at the Pacific Geoscience Centre to obtain acceleration data and an estimation of seismic risk. Scientific papers were also consulted.

The response of surficial materials to seismic events was considered using data obtained from the terrain and seismicity analyses.

The coastal aspect of the study utilized Canadian Hydrographic Charts and airphoto interpretation. Coastline morphology was mapped using a modification of the Nearshore Physical Classification System developed by R. Bell-Irving of the Habitat Protection Directorate, Environment Canada, and used in "Comparative Risk Analyses" by the Department of Fisheries and Oceans, 1978, Canada. Intertidal habitat maps prepared by ESL Environmental Sciences Ltd. (Trans Mountain Pipeline Co. Ltd., 1980) were used as an additional data source for the regional overview mapping.

Mineral and Land Use Potential mapping of the area by the B.C. Ministry of Energy, Mines & Petroleum Resources was used to inventory the mining resources of the area. A search of the Ministry's annual Mines Reports and up-to-date claim maps was used to supplement this information and show present and potential resource utilization.

A search of district lots on record at the B.C. Ministry of Lands, Parks and Housing was made to establish whether any industrial aggregate and clay sources occur within the study area. Surficial geology data from the terrain analysis was superimposed on the resource information to establish potential aggregate and clay sources.

3.3.1.2 Nomenclature and Mapping Procedure

3.3.1.2.1 Terrain Classifications

The genetic materials are an important element in the demarcation of mapping units. Some units are characterized by monogenetic materials while others have a complex mix of two or three genetic materials. The genetic materials are defined and described in general terms below:

Bedrock: rock outcrop and rock covered by a thin mantle (less than 10 cm thick) of consolidated material, e.g. schist with thin cover of colluvium.

Colluvial: slope deposits; unconsolidated materials found on slopes or at the base of slopes; derived from the downslope movement and mixing of bedrock debris and deposits mantling the slopes; includes talus (blocks and boulders), and scree, slope wash deposits; probably sandy throughout the study area.

Morainal: till or boulder clay. Unstratified and unsorted materials transported and deposited by ice sheets and valley glaciers which have not been subjected to post depositional reworking; sandy, silty or clay dominated matrix with boulders, cobbles and blocks. Facies depends on source of material and mode of deposition, e.g. ablation till, flow till, basal till. Includes Glaciomarine deposits: unconsolidated materials related to glacial deposition in a marine environment; generally fine-grained matrix with scattered pebbles, etc.; some deposits are believed to be the result of submarine slumping of till, etc. (Armstrong and Brown, 1954).

Organic: materials accumulated by the growth and decay of vegetation (e.g. peat, coastal muskeg).

The following geological terms are used in the discussions of geology, terrain, and coastal morphology:

Dyke: a tabular body of igneous rock that cuts across the structure of adjacent rocks.

Normal Fault: a fault along which the hanging wall (the mass of rock above the fault plane) has been depressed relative to the footwall; i.e. in response to tension.

Thrust Fault: a fault along which the hanging wall has been raised at a low angle over the footwall; i.e. in response to compression.

Strike-slip Fault: a fault in which movement has been lateral, or along the fault strike.

Lineament: a structurally controlled alignment of topographic features.

Fractures: breaks in rocks due to folding or faulting.

Shear Zone: a zone along which the rock is fractured or crushed by extensive shearing.

Karst: limestone terrain in which solution of the rock has produced sinks, caverns, and underground drainage.

Horst: a block of the earth's crust which has been uplifted along faults relative to the rocks on either side.

Graben: a block of the earth's crust which has been downthrust along faults relative to the rocks on either side.

Cirque: a steep-walled bowl-like recess in a mountain, caused by glacial erosion.

En echelon: parallel structured features which are offset, like shingles on a roof.

Tombolo: a bar connecting an island to the mainland.

Shingle: a common term for coarse beach gravel, especially if consisting of flattish pebbles and cobbles.

3.3.1.2.2 Nearshore Physical Classification

A modification of the Nearshore Physical Classification System devised by R. Bell-Irving (Fisheries and Environment Canada, 1978) was used for mapping the coastal morphology at a scale of approximately 1:500,000. Definitions used by ESL Environmental Sciences Ltd. (Trans Mountain Pipe Line Company Ltd., 1980) were incorporated into this system. The classification system is outlined in Table 3-3.1, and definitions are given below.

Shoreline Exposure

Four categories of exposure were identified:

E1: exposed - subject to sea swell and unlimited wind fetch.

E2: partially exposed - shoreline partially shielded from prevailing winds by headlands or offshore reefs and islands; sea swell is attenuated.

E3: semi-protected - channel or inlet shoreline protected from sea swell but which may receive waves generated by moderate wind fetch.

E4: Protected - shoreline protected from sea swell and with restricted wind fetch.

TABLE 3-3.1

Nearshore Physical Classification Legend: Overview Mapping

Shoreline Exposure

E_1 - exposed
E_2 - partially exposed
E_3 - semi-protected
E_4 - protected
X - offshore reefs

Shoreline Zone

I - intertidal
S - supratidal

Substrate Material

r - rock
c - coarse
s - sand
m - mud
e - estuarine
a - man-made

Slope

1 - low
2 - moderate
3 - steep

Example: E_1XIrc1Sr2

Exposed shoreline with offshore reefs; gradually sloping rock and coarse substrate; moderately sloping rock supratidal zone.

Composite units: Substrate materials are given in order of abundance. Composite exposure and slope classes indicate an intermediate class, or a mixture with no order of abundance implied.

Note: Supratidal zone classification is omitted where no data are available.

The pressure of offshore reefs and islets is indicated.

The presence of <u>offshore reefs and islets</u> is indicated.

<u>Shoreline Zones</u>

Two shoreline zones are used for the classification of substrate and slope:

<u>Intertidal</u>: the area between mean low and mean high tide.

<u>Supratidal</u>: the area above mean high tide.

At the scale used, a separate beach zone was not delineated.

<u>Substrate Material</u>

A simplified classification of substrate material was used, with ranges as defined in Section 3.3.1.2.3

<u>Rock</u>: predominantly bedrock substrate with minor granular material.

<u>Coarse</u>: gravel, cobbles, and boulders.

<u>Sand, Mud</u>: as defined in Section 3.3.1.2.3

<u>Estuarine</u>: sand and mud found in river estuaries.

<u>Man-made</u>: port structures, or railway grades obscuring or replacing the natural shoreline.

Slope

Intertidal and supratidal slopes were classified as low, moderate, or steep. These classes roughly correspond to the definitions given in Section 3.3.1.2.3 although, at the scale used, the classification is subjective.

Mapping Procedure and Limitations of Mapping

Canadian Hydrographic charts at various scales were used to divide the coastline into segments of reasonably homogeneous characteristics. Substrate material was obtained from symbols on the charts, and from information on the ESL and Fisheries and Environment Canada maps (referenced above). Slope information was obtained from the latter two sources. No field work or air photo analysis was undertaken for mapping for the marine approaches position.

At a scale of 1:500,000, the mapping is generalized; several different shoreline types may be included in each mapped shoreline segment. The mapped units, therefore, give only an indication of the dominant or typical substrate and slopes found along a shoreline segment.

As no original field work was done, the accuracy and resolution of the mapping is limited by that of the published information. The ESL maps are considered fairly reliable for substrate material, as they are based on field observations. The Fisheries and Environment Canada maps are less reliable, partly because the mapping consists of point samples rather than continuous zones; however, they are the only source of information used for supratidal material and slope. Large-scale hydrographic charts were used for the Skeena estuary, Prince Rupert Harbour and Port Simpson Bay areas; these give reliable information on intertidal substrate and slope for these areas.

TABLE 3-3.2

Nearshore Physical Classification Legend: Large-scale Mapping

Shoreline Exposure

E_1 - exposed
E_2 - partially exposed
E_3 - semi-protected
E_4 - protected
X - offshore reefs

Shoreline Zone

I - intertidal
B - beach
S - supratidal

Beach/Substrate Material

r - rock
b - boulders
c - cobbles
g - gravel
s - sand
m - mud
a - man-made

Beach Type

BH - bayhead
CR - crescentric
CU - cuspate
ER - erosional
EF - estuarine flat
LI - linear
PO - pocket
RC - rock confined

Slope

1 - low
2 - moderate
3 - steep

Human Activity

Hh - habitation
Hi - industrial
Hr - recreational

Example: E2 X I $r^{g}2$ B_{CR} S2 Sr3 Hh

Partially exposed shoreline with offshore reefs; moderately sloping rock substrate with gravel mantle in intertidal zone; crescentric moderately sloping sand beach; steeply sloping rock supratidal zone; human habitation.

Composite units: Substrate materials are given in order of abundance. Superscripted substrate material (as in above example) indicates a mantle of that material overlying the substrate.

Notes:

1) Where the shoreline has been substantially altered (e.g. by fill or roadways), a slope is not given for the beach zone.

2) In the suprtidal zone, "r" includes bedrock with a thin mantle of surficial deposits.

3.3.1.2.3 Large Scale Shoreline Mapping

The classification used for mapping coastal morphology at a scale of 1:10,000 is similar to that described in Section 3.3.1.2.2, but with some differences allowing more detail at the larger scale. It is a modification of the Nearshore Physical Classification System devised by R. Bell-Irving (Fisheries and Environment Canada, 1978). The classification system is outlined in Table 3-2.2, and definitions are given below:

Shoreline Exposure

A four-category classification was used, as defined in Section 3.3.1.2.2.

Shoreline Zones

Three shoreline zones are defined for the classification of substrate and slope:

Intertidal: the area between mean low and mean high tide.

Beach: the area between mean high tide and the limit of extreme high water; the supralittoral zone.

Supratidal: the area immediately above extreme high tide; interpreted as the area with continuous terrestrial vegetation.

Substrate Material

Rock: predominantly bedrock.
Boulders: material larger than 256 mm.

Cobbles: material from 64 to 256 mm in size.
Sand: material from 0.0625 to 2 mm in size.
Mud: silt and clay; smaller than 0.0625 mm.

These sizes for granular material correspond to those commonly used for the mapping of surficial geology (Resource Analysis Board, 1978). Where used here to describe substrate, the terms indicate the dominant size range present; occasional larger fragments and abundant small interstitial material may be present.

Beach Types

Beach types were defined in terms of morphology.

Bayhead: sheltered accretional beach at the head of a bay.
Crescentic: long, wide arcuate beach between headlands.
Cuspate: accretional beach fringe built out from the shoreline.
Erosinal: foreshore dominated by erosion. Bedrock abrasion platform with veneer of very coarse materials, e.g., cobbles, boulders.
Estuarine Flat: beach or mud flats at the mouths of rivers.
Linear: long, straight accretional beach.

Pocket: isolated sheltered bayhead beach cut back into the head of a bay and affected only by high water.

Rock Confined: beach confined by bedrock outcrops or in bedrock depressions along the shore.

Human Activity

The presence of habitation, industrial activities, or recreational facilities was noted.

Slope

Three degrees of slope were used. Slope classes were chosen on a largely subjective basis, although they correspond as closely as possible to the following definitions:

Low: an intertidal zone wider than 60 m, or a slope of less than 10%.

Medium: an intertidal zone from 10 to 60 m wide, or a slope of 10% to 50%.

Steep: an intertidal zone less than 10 m wide, or a slope of greater than 50%.

Mapping Procedure and Limitations of Mapping

Air photos at a scale of approximately 1:20,000, and a Canadian Hydrographic chart at a scale of 1:40,000 (no. 3993, Work Channel) were used to delineate reasonably homogeneous segments of the coastline. Substrate materials were determined from the hydrographic charts and the photos, and from photos and notes taken from the air on a field inspection.

As no sampling of substrate material was undertaken, the dominant materials were determined by visual inspection. Slopes were also estimated visually, since low-tide air photos were not available.

The scale of mapping is greater than that of the air photos and the hydrographic charts used as sources of information; therefore, the map is more generalized than the scale of 1:10,000 would indicate.

3.3.2 Marine Approaches

3.3.2.1 Topography, Bedrock Geology, Surficial Deposits and Geotechnical Hazards

The study area includes the Tsimpsean Peninsula and part of the Kitimat Ranges of the Coast Mountains. The Tsimpsean Peninsula is part of the Hecate Depression - a physiographic subdivision of the British Columbian Coastal Trough (Holland 1976). The Kitimat Ranges abut the peninsula in the east. Portland Inlet, Chatham Sound and the Skeena River border the remaining sides of the peninsula.

The area is characterized by a marked northwest-southeast structural and topographic trend, and by a fjord coastline.

Three broad linear terrain units can be discerned within the study area. They trend northwest-southeast. (Hutchison, 1967. NEAT, 1975.)

- The Coastal Lowland adjacent to Chatham Sound;
- The Central Upland which forms the backbone of the Peninsula;
- The Coast Mountains which abut the peninsula on the east side.

These terrain units are discussed below.

The Coastal Lowland

The Coastal Lowland is situated on the western side of the Tsimpsean Peninsula. The inner islands, e.g. The Dundas group and Stephens Island, are included in this unit.


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BEDROCK GEOLOGY AND TECTONICS
TERA ENVIRONMENTAL CONSULTANTS LIMITED JULY 1981
BEDROCK GEOLOGY
Quaternary Drift
Tertiary Volcanics
Jurassic and Younger Intrusives (Coast Crystalline Belt)
Middle Jurassic Metavolcanics
Lower Jurassic or Older Metavolcanics
Lower Jurassic or Older Metasediments of Almadine-Amphibole Facies — Gneisses
Lower Jurassic or Older Metasediments of Almadine-Amphibole Facies — Hornblende Schists
Lower Jurassic and/or Older Metasediments of Greenschist Facies
Upper Palaeozoic and/or Older Gneiss Complex
TECTONICS
Transform Fault (with direction of movement)
Normal Fault (known)
Normal Fault (inferred)
CLARENCE STRAIT FAULT
QUEEN CHARLOTTE FAIRWEATHER FAULT
(ACTIVE)
QUEEN CHARLOTTE ISLANDS
GRAHAM
ISLAND
DIXON ENTRANCE
PRINCESS ROYAL ISLAND
CHATHAM SOUND
N
Map 3-3.1

The lowland has a gently undulating glacially-moulded topography of low rounded hills, separated by poorly-drained basins. In general the elevation is below 75-80 m above sea level, but isolated hills reach 450-460 m a.s.l. The elevation increases eastwards. The drainage of the lowland is poorly-organized and extensive areas of coastal muskeg occur in the low-lying basins. Drainage is incised and has a pronounced northwest-southeast trend in the east of the unit.

The terrain is developed on structurally complex metasediments of greenschist facies (slate, schist, etc.) (Hutchison,1965; 1967a & b). The mammilated topography is a result of differential erosion of the bedrock. The greenschist facies grades eastwards into more metamorphased metasediments of the almandine-amphibole facies (quartzite, hornblende schist). These rocks strike north to south and dip steeply to the east (30° to 40°) and form steep sided ridges near Port Simpson. Metasediments of greenschist facies and metavolcanic rocks occur in association with small plutons in the Dundas Islands and on Stephens Island.

The bedrock of Birnie Island, off Grassy Point is a Tertiary volcanic breccia, probably related to northeast trending dyke swarms in Portland Inlet (Hutchinson, 1967a).

The coastline of the Coastal Lowland is characterized by rocky headlands, which separate wide crescentic beaches. There are extensive flat intertidal zones and shallows adjacent to the coast. The headland-beach coastline is another reflection of differential erosion. (NEAT, 1975).

The area was covered by ice sheets during the Pleistocene. There is evidence (striae, erratics) that an ice sheet flowed north up Chatham Sound during the Fraser

Glaciation. The ice sheet was formed by the coalescence of Cordilleran and Queen Charlotte Islands ice masses. The ice sheet was responsible for moulding the landscape (NEAT, 1975). Glacial deposits are rare, but deposits of late Pleistocene glaciomarine drift occur below muskeg in some depressions (Hutchison, 1967a).

The floor of Chatham Sound and Hecate Strait were probably exposed during periods of low sea level associated with glacial events.

A series of glacial troughs has been identified on the floor of Dixon Entrance. They trend west-east (Hutchison, 1967a). They may be related to a Cordilleran ice mass.

The Central Upland

The Central Upland forms the backbone of the Tsimpsean Peninsula. It is the most extensive terrain unit. The Uplands are characterised by "moderately rugged" (Hutchison, 1967a; NEAT, 1975) terrain with rounded hill masses reaching elevations up to 900 m above sea level. There is a certain accordance of summit levels. These have been interpreted as remnants of a late Tertiary erosion surface which has been upwarped in the east (Holland, 1976).

The area is dissected by many glaciated valleys with over steeped trough walls. There are many valley-head cirque basins. The thresholds of the cirques occur between 360-450 m above sea level. (NEAT, 1975). There are hanging valleys and many other classic glacial features. There is a scarcity of scree in this area.

The terrain is developed on schists of the almandine-amphibole facies in the west. The grade of metamorphism increases eastwards where the schists are replaced by gneisses. These highly metamorphosed rocks form ridges up to 760 m a.s.l.

In the south of the Peninsula near the Skeena River, part of the Coast Plutonic Complex (Ecstall Pluton) was probably emplaced during the Cretaceous period. The structure of the surrounding metasediments was complicated by deformation associated with this event. Metavolcanic rocks occur around Mt. Morse, 3 km north of Prince Rupert.

The rounded summits of the upland reflect moulding by Pleistocene ice sheets, and the glacial troughs and other glacial features are evidence of valley glaciation. However, glacial deposits are rare. Higher levels are characterised by bedrock surfaces with a discontinuous cover of colluvium. Alluvium and morainal deposits occur in the bottoms of the larger river valleys and are covered by post-glacial alluvium. Bedrock is exposed in some over-steepened trough walls.

The Coast Mountains

The Kitimat Ranges of the Coast Mountains have a very rugged topography. The topographic trend is markedly northwest-southeast. Elevation increases from about 1060 m above sea level (in the study area) to 1524 m in the east.

The terrain is characterized by bare domal peaks and rounded summits developed in massive plutonic rock. Some peaks exhibit large scale sheeting. The summits are considered remnants of an ancient erosion surface which was overridden by Pleistocene ice sheets (Holland, 1976). Isolated higher peaks stand above this level. These were not covered by ice sheets.

Cirque basins occur on the north and northeast facing slopes. Cirques are found near sea level along the western flanks of the mountains (Work Channel). The mountains are dissected by catenary valleys. Glacial deposits are rare, but glacial and meltwater deposits may occur in the bottom of larger river valleys. There is a scarcity of scree because of the massive nature of the bedrock.

The drainage of the area was superimposed from a sedimentary or metasedimentary cover and incision (rejuvenation) has occurred during and since the end of the Pleistocene in response to isostatic readjustment (Holland, 1976).

The landscape is developed on monzonite-diorite rocks of the Quotoon Pluton (part of the Coast Plutonic Complex) adjacent to Work Channel. High grade gneiss occurs to the east of the Quotoon Pluton. It is replaced by gneiss of the almondine-amphibole facies associated with the Ponder Pluton east of the study area (Hutchison, 1967a).

The area was covered by Cordilleran ice during the Pleistocene. This ice mass was responsible for "rounding off" the topography. The glacial troughs were excavated by a more recent alpine glacial event. Many of the troughs were inundated to form fjords as sea level adjusted after this glacial phase. The many classic glacial features found in this area are related to this event and to a subsequent phase of cirque glaciation. (NEAT, 1975).

The glacial history of the area is complex. Glacial features are common, but deposits are rare. Some morainal deposits occur under alluvium in the valley fill of the Lachmach River valley. Colluvium is the dominant surficial deposit. Bedrock surfaces with a thin colluvial cover occur around higher peaks and on trough walls. Alluvium is restricted to the lower parts of the larger river valleys (NEAT, 1975).

The dominant geomorphological processes are debris slides, snow avalanches, gullying and bank erosion (Clague, 1978). Debris slides occur on slopes greater than 30° and are associated with minor drainages. They are initiated as small-scale slides on steep slopes and widen downslope. The slide debris is characteristically composed of less than a metre of topsoil and weathered rock, and vegetation. In areas with massive, resistant bedrock, the slides are completely composed of vegetation. Slide toes generally cover a distance of 30 - 310 m from the slope foot (NEAT, 1975).

Slide activity is associated with intense heavy rainfall and saturation of the mantle. Rainfall in excess of 100 mm in 48 hours may be a prerequisite for failure. There is on average, one storm event per year of this magnitude. Continued localised rainfall, local winds and seismic events

3.3.2.2 Regional Tectonics

A regional overview is necessary in a discussion of tectonics in the vicinity of Port Simpson and the Tsimpsean Peninsula.

The tectonic regime of the Alaska Panhandle and northwestern British Columbia has changed during geological time. A complex structural and outcrop pattern on land and on the continental shelf has resulted from these changes. (Johnson et al, 1972; Rogers, 1976). The tectonics of the area have been dominated by the interaction of the Pacific and American lithospheric plates (plate tectonics)(Tobin and Sykes, 1968).

The dominant tectonic influence during much of the Mesozoic period was an east-west compression associated with subduction of the Pacific plate at, or near, the continental margin (Attwater, 1970; Rogers, 1976). The compression was responsible for the markedly northwest-southeast structural and outcrop pattern and was associated with the emplacement of the Coast Plutonic Complex (Stacey, 1974; Holland, 1976; Berg et al, 1977; Brew & Ford, 1977).

The present tectonic environment is dominated by right lateral shear at the plate margin (along the Queen Charlotte-Fairweather transform fault) (Tobin & Sykes, 1968; Stacey, 1974; Rogers, 1976; Clowes and Knize, 1979; Riddihough et al, 1980) (Fig. 3-3.1). Structures and features associated with this movement cut across the older structural trends (Rogers, 1976). A north-south tension rift (eastern margin roughly 130^{o} W longtitude) was created by adjustment to the transform shear pattern. A north-south belt of Quaternary volcanism is associated with this graben north of 53°N latitude (Gabrielse & Wheeler, 1961; Stacey, 1974; Rogers, 1976, Souther, 1981). The primitive character of the basalts erupted during this phase of volcanic activity is indicative of a deep rift system (Rogers, 1976). The Tsimpsean Peninsula is situated at the southeastern margin of the rift. (See Figure 3-3.1.)

Most seismic activity in this region is associated with the Queen Charlotte-Fairweather Fault System which is an oblique underthrust associated with the northward motion of the Pacific Plate in relation to the American Plate (Attwater, 1970; Stacey, 1974; Rogers, 1976). The Chatham Strait - Denali fault system has been relatively inactive in the last four centuries, although it might once have been the dominant tectonic feature in the region (St. Amand, 1957; Naugler & Wageman, 1973; Rogers, 1976). Tectonically active

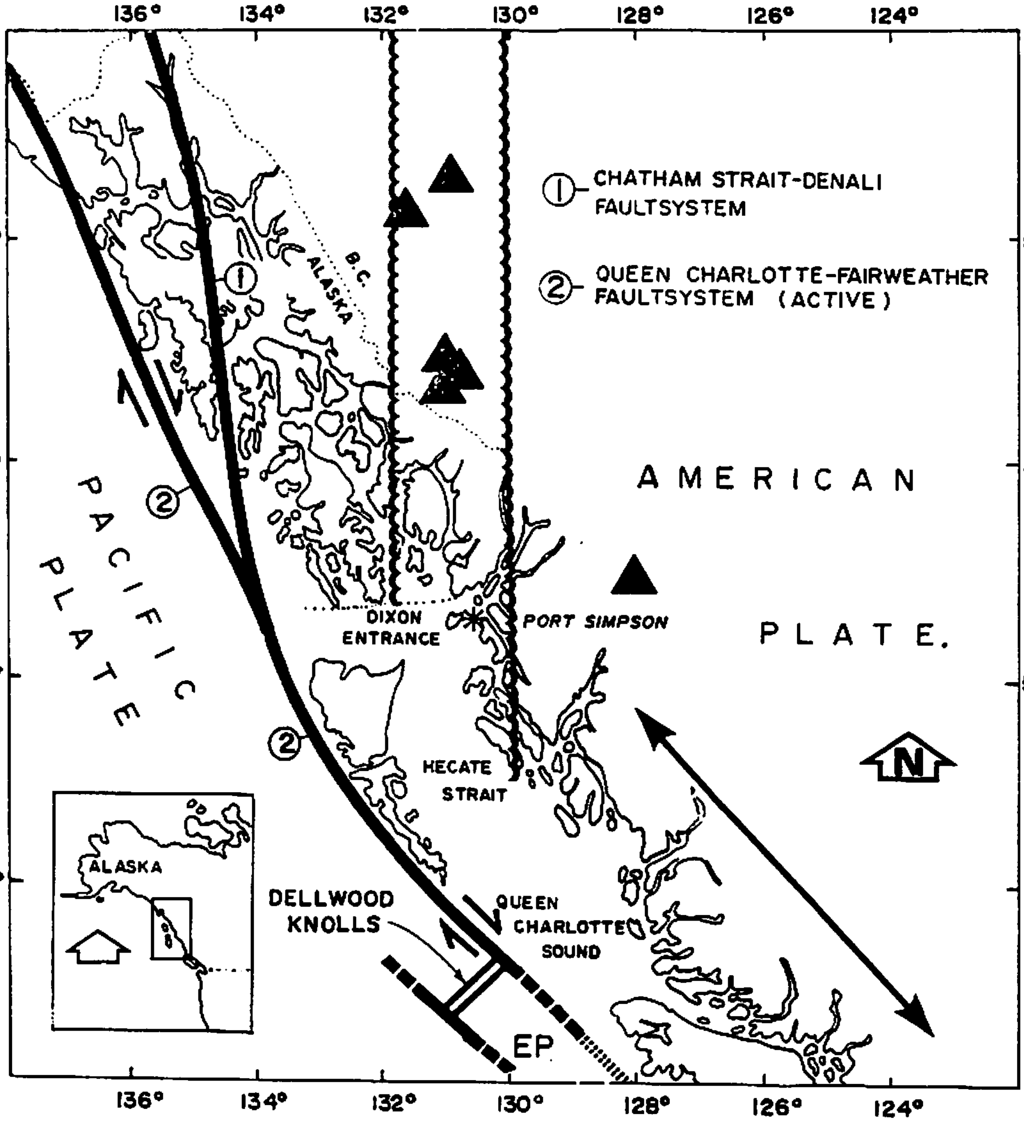


FIGURE 3.3.1
MAJOR FAULTS AND PLATE BOUNDARIES

LEGEND:

- TRANSFORM FAULT WITH DIRECTION OF MOVEMENT
- FAULT
- MARGINS of RIFT SYSTEM
- STRUCTURAL TREND
- SPREADING ZONE
- EXTINCT QUATERNARY VOLCANIC CENTRES
- SUBDUCTION ZONE
- EP EXPLORER PLATE

areas have changed with alterations in plate interaction (Rogers, 1976) during quaternary earth history.

Many workers have noted structural patterns in the Alaska-Northwestern British Columbia area (Peacock, 1935; St. Amand, 1957; Twenhofel & Sainsbury, 1957; Gabrielse & Wheeler, 1961; Holland, 1976; Brew & Ford, 1977; Berg et al, 1977). Two major structural patterns have been superimposed: a northwest-southeast system related to Mesozoic Compression and emplacement of Coastal Plutons; and a northeast-southwest pattern related to movement along the Queen Charlotte-Fairweather fault.

The Tsimpsean Peninsula is bounded by faults and structures related to both patterns. The Portland Inlet and Skeena River fault zones are related to the northeast-southwest pattern. The structure of Work Channel, Chatham Sound and Hecate Strait is considered to be an expression of the western contact of the Coast Plutonic Complex. This lineament can be traced from Alaska to south of Grenville Channel (Brew & Ford, 1977). The Hecate Strait fault system is composed of an echelon series of lineations which are also related to the western contact of the Coast Plutonic Complex (Sutherland Brown, 1968; NEAT, 1975).

3.3.2.3 Regional Seismicity

The study area as is virtually the entire coast of British Columbia is located in the zone of highest seismic risk in Canada (Zone 3, as defined by the seismic zoning map of Canada - Whitham et al, 1970). The zonation is based on the peak acceleration of earthquake shock waves expected at any location with a periodicity of 100 years. The boundary of Zone 3 is delineated by a peak acceleration of 6% gravity with a probability of 0.01 per annum that peak acceleration will be exceeded (Whitham et al, 1970).

Most seismic activity in this area is confined to a narrow offshore belt which approximates the trend of the Queen Charlotte-Fairweather fault system (Milne et al, 1978) (Fig. 3-3.2). The greatest strain release and almost all large-scale seismic events occur at significant distances from the mainland but many shocks have been felt on the mainland, for example, the effects of a very large magnitude event which occurred in 1972 in the Queen Charlottes (XI Modified Mercalli Scale) (Milne et al, 1978) - the largest seismic event recorded in Canada.

The strain energy of the Queen Charlotte-Fairweather fault system is at an historical low. Most of the accumulated strain was released in a XI Mercalli event southwest of Sitka in 1972 (Milne et al, 1978). The Tsimpsean Peninsula was considered to have reached seismic equilibrium (NEAT, 1975). However, there is a rapid rate of strain accumulation in this area and there is still probably sufficient strain available to generate an event with an intensity of at least X on the Mercalli Scale. (Milne et al, 1978) Considerable strain dissipation may take place, however, by small scale seismic events (Rogers, 1976).

One large scale seismic event occurred on the eastern side of Hecate Strait off Banks Island in 1929. The earthquake had an intensity of X on the Modified Mercalli Scale and generated a localized tsunami (tidal wave) which affected lowlying areas on the mainland (Slaney, 1973; Milne et al, 1978).

3.3.2.4 Seismic Response of Surficial Deposits

Severe seismic activity may have a considerable effect on the internal integrity and stability of surficial

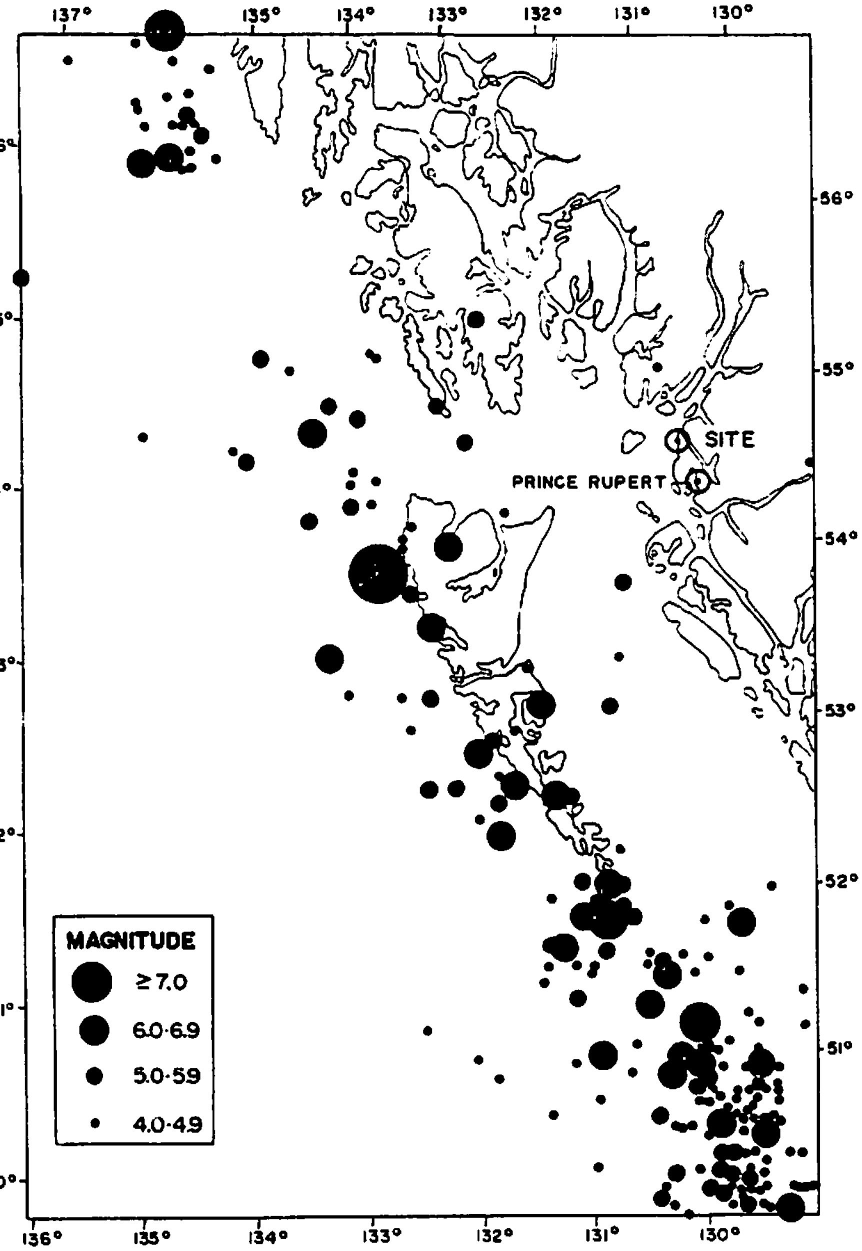


FIGURE 3.3.2
EARTHQUAKE EPICENTRES-QUEEN CHARLOTTE FAULT ZONE

NOTE: Uncertainties in the epicentre locations are on the order of 25 km; 50km for some of the older events (prior to 1971)

SOURCE: Hyndman, R.D. and R.M. Ellis, 1981. *Queen Charlotte fault zone: microearthquakes from a temporary array of land stations and ocean bottom seismographs.* Canadian Journal of Earth Sciences 18 (4) page 778.

deposits. Seismically-initiated ground failure can take place by such processes as liquefaction of sands, remoulding of sensitive clays, fault displacement and slope instability (Page et al, 1972; Nichols & Buchanan-Banks, 1974; Whitham & Hasegawa, 1975; Alley & Thomson, 1978; Clague, 1978; Maynard, 1979).

The type of surficial material and the prevailing ground-water conditions influence the period of ground motion and amplification of seismic vibration and are therefore responsible for local variations in earthquake intensity.

Certain surficial deposits could be severely affected by seismic events. Low density, normally consolidated saturated silts, clays and recent fill and organic deposits are likely to experience higher seismic intensities. Loose or moderately dense fine sands and silts with high water table conditions and organic deposits are susceptible to liquefaction. Unstable and potentially unstable slopes could fail during seismic events (Maynard, 1979).

Coherent bedrock could be affected by fault displacement but is comparatively stable and a good foundation for structures. Bedrock surfaces and near surface bedrock cover much of the study area. Tills are also comparatively good foundation materials because of overconsolidation by glacial ice. Tills are rare in this area. Colluvial materials are unstable because of their association with slopes liable to failure and because they are not very consolidated. Saturated fine sands and clays and organic deposits are liable to liquefaction during seismic events and therefore are not good foundation materials.

There has been little recognition in the literature that site conditions can alter seismic intensities, and few attempts at microzonation have been undertaken using this information (Maynard, 1979).

It has been suggested that a 50% increase (factor of 1.5) should be made in the seismic load factor on highly compressible sediments greater than 15 m in depth (e.g., very loose and loose coarse-grained deposits and very soft and soft fine-grained sediments) (Milne & Rogers, 1972).

An amplification factor of 1.3 should be employed for compact coarse-grained sediments and stiff fine-grained deposits with a depth greater than 15 m, and for very loose coarse-grained sediments and very soft and soft fine-grained materials less than 15 m deep (Milne & Rogers, 1972).

An amplification factor of 1.0 should be used for bedrock, very dense coarse-grained sediments, very stiff and hard fine-grained deposits, compact coarse-grained materials and firm and stiff fine-grained sediments less than 15 m deep (Milne & Rogers 1972; National Building Code of Canada, 1977; Maynard, 1979). Recently, however, it has been suggested that acceleration values for surficial deposits should be increased by a factor of 2 (Weichert, 1980. pers. comm.).

The northwestern coast of B.C. is well known for its debris slides, a phenomenon which occurs on steep slopes (40% to 60%) with thin soil mantle. The failure zone occurs at the bedrock-soil mantle interface which is often caused by heavy precipitation.

3.3.2.5 Mineral Potential

No significant mineral deposits are known in the Tsimpsean Peninsula although the geological environment of the Lower Jurassic metasedimentary rocks and proximity to plutons is favorable to mineralization. Small isolated deposits are possible, and present and future exploration is likely. There is no indication of mineral potential in the rocks of the Quotoon Pluton to the east of Work Channel. Further east, however, the geological environment is similar to that of the Tsimpsean Peninsula.

There is some indication of mineral potential in the area of the Ecstall Pluton in the south of the peninsula. The geological status has not been determined, but exploration is possible. A mineral and placer reserve is located in this area.

There is a deposit of limestone cropping out on the western side of Work Channel, south of Grace Point. This could be exploited as an industrial mineral source.

3.3.2.6 Industrial Aggregates and Clay

There are no extensive, economically significant aggregate or clay resources in the study area (NEAT, 1975).

3.3.2.7 The Coastline

The intertidal and supratidal substrates along the marine approaches are mapped on the nearshore physical classification map accompanying this report (Map 3-3.2). The shoreline of the northeast portion of the study area, corresponding to the area covered by the geological mapping and terrain discussion of Section 3.3.2.1, is described in more detail below.

Two alternative marine approaches exist to the Port Simpson-Prince Rupert area: a southern approach through Hecate Strait, and a northern approach through Dixon Entrance (Figure 1-1.3). From the east end of Dixon Entrance, the final approach to Chatham Sound can be made by two routes: one on the south through Brown Passage (Routes 1 and 2 on Figure 1-1.3), and one around the north end of Dundas Island (Route 3).

The southerly approach through Hecate Strait is bounded on the west by the Queen Charlotte Islands (Moresby and Graham Islands), and on the east by Aristazabel, Banks and Porcher Islands and numerous smaller islands off the British Columbia mainland. The islands along the east side of the strait are part of the Hecate Depression physiographic region (Holland, 1976); the coastline is characterized by numerous wide sounds and inlets, leading to the narrow fiords and channels of the inner coast. Although the topography of the outer islands is low-lying, local relief can be great, and the shoreline is primarily rocky. Bedrock and coarse (gravel, cobbles and boulders) material dominates the intertidal zone, and offshore rocks and islets are abundant.

The coasts of Moresby and Graham Islands, on the west side of Hecate Strait, are dissimilar. Moresby Island is part of the Insular Mountain chain; the coastline is steep and rocky, and punctuated by numerous sounds and inlets. Bedrock and coarse material dominante the intertidal zone, but the shoreline is steeper and offshore rocks and islets are less abundant than on the east side of the strait. The coast of Graham Island, and the northeast tip of Moresby Island is part of the Queen Charlotte Lowland and Argonaut Plain subdivisions of the Hecate Depression; relief is very gentle, and the shoreline shelves gently into Hecate Strait. The shoreline is dominated by long sandy beaches.

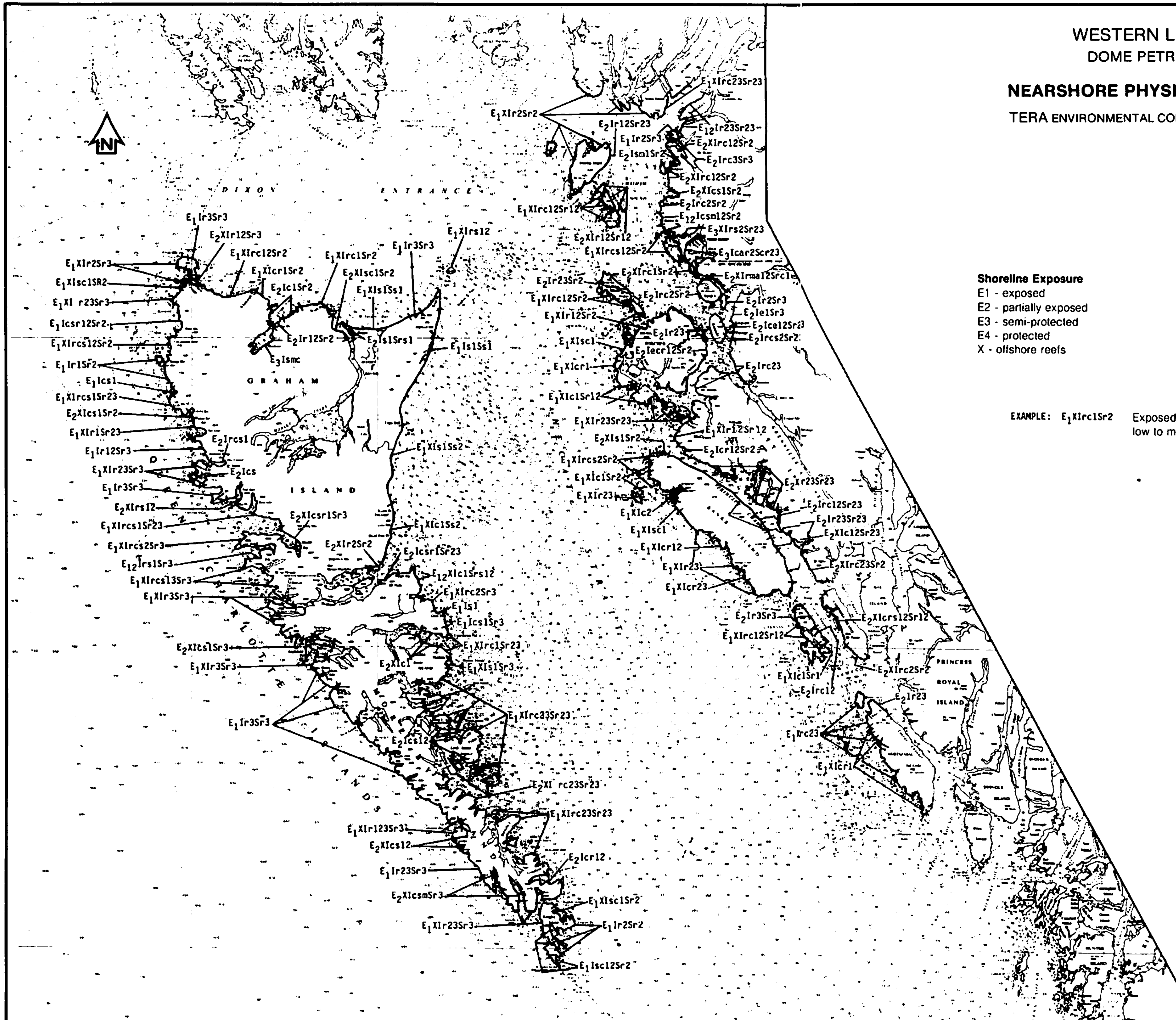
The northerly approach through the Dixon Entrance is bounded by Graham Island on the south, and by Prince of Wales Island and lesser islands of the Alaska coast on the north. The Alaska coast has not been mapped in this study.

The north coast of Graham Island from Langara Island to Masset Inlet is part of the Queen Charlotte Lowland; the shoreline is rocky and the intertidal substrate is predominantly rock and coarse material. From Masset Inlet to Rose Spit the coast is part of the Argonaut Plain; the shoreline consists of a nearly continuous sand beach, with rare bedrock outcrops.

The entrances to Prince Rupert Harbour and Port Simpson have primarily rocky shorelines, with some areas of sand and gravel between Prince Rupert and Port Simpson, and sand and mud in the Skeena River Estuary. Small islands, reefs and shoals are common. Shorelines along the northerly entrance to Chatham Sound are somewhat rockier and steeper than those along the southerly entrance.

Fisheries and Environment Canada (1978) has summarized the proportions of intertidal substrate material along segments of the north coast, as part of a biological risk index. However, this mapping is based on point samples rather than continuous coverage; by comparison with the maps in Trans Mountain Pipeline Company Ltd. (1980), the proportion of coarse substrate has been underestimated and the proportion of bedrock substrate has been overestimated.

The following summary gives a very approximate indication of the proportions of bedrock, coarse (gravel, cobbles and boulders), and fine (sand and mud) intertidal substrate in the shoreline segments discussed above, based on the nearshore physical classification map accompanying this



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NEARSHORE PHYSICAL CLASSIFICATION

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Shoreline Exposure
E1 - exposed
E2 - partially exposed
E3 - semi-protected
E4 - protected
X - offshore reefs

Substrate Material
r - rock
c - coarse
s - sand
m - mud
3 - estuarine
a - man-made

Shoreline Zone
I - intertidal
S - supratidal

Slope
1 - low
2 - moderate
3 - steep

EXAMPLE: $E_1XIrc1Sr2$ Exposed shoreline with reefs; bedrock and sand intertidal zone, with low to moderate slope; bedrock supratidal zone, steeply sloping.

SOURCE

Nearshore Classification after:
Fisheries and Environment Canada, 1978
Trans Mountain Pipe Line Co. Ltd., 1980

Map 3-3.2

report. The figures are intended to be only a very rough approximation; the totals for fine material are probably within plus or minus 5 or 10%, while those for bedrock and coarse material are accurate only to within 10 to 20%.

	Bedrock	Coarse	Fine
North coast Graham Island	40%	20%	40%
East coast Graham Island	5%	20%	75%
East coast Moresby Island	60%	30%	10%
Entrances to Chatham Sound	70%	20%	10%
Laredo Sound to Porcher Island	60%	35%	5%

The west coast is partially exposed to prevailing winds and swell, and to a considerable fetch, except where islands such as Finlayson Island, form protective barriers.

The most common wind direction in the study area is south-east (from wind data reported in NEAT, 1975); westerly and northerly winds are also frequent, depending on the exposure of particular stations.

The offshore zone is fairly shallow and gently shelves landward. Bedrock and mud are the dominant bottom materials. There are extensive reefs northwest of Port Simpson.

The intertidal zone (between mean low and mean high tide level) is dominated by a flat or gently shelving bedrock substrate with patches of fine grained material. Extensive shallows with fine grained material occur between Burnt Cliff Island and the Mainland. Small sand spits, such as those at Ryan Point on the north side of Duncan Bay, occur near headlands, and in places form tombolos connecting islands to the mainland (e.g., Village Island near Port Simpson and Swamp Island).

Beaches are wide and crescentic. They repose on wave cut bedrock platforms. Beach profiles are characteristically flat or gently sloping. Fine and coarse grained sands are the dominant beach materials. Log booms are common.

The supratidal zone, immediately above the beach, is commonly a flat or gently sloping bedrock surface. In some places, raised beach features occur inland of the present coast. These were abandoned as isostatic rebound of the land took place during and after deglaciation.

The coastline is compartmented and there is little interbeach sediment transport. Many pocket beaches occur. Beach material segregation is the dominant process. Coarse shingle and boulders occur at the back of beaches; bare bedrock surfaces form a central zone and fine-grained deposits occur at the front of beaches. Minor longshore drift occurs along individual beaches. Some sediment transport may occur by the offshore-nearshore sediment transport system (Clague & Bornhold in McCann 1980).

The coastline of Work Channel has no extensive beaches. Supratidal slopes are steep and cut in bedrock or mantled with colluvium. Small deltas have been built at the mouths of some drainages.

3.3.3 Terminal

3.3.3.1 Introduction

The study site is situated on a neck of land, northeast of Port Simpson Village, which separates Work Channel from Port Simpson Bay.

3.3.3.2 Physiography

Two physiographic units can be discerned at the site:

- The Coastal Lowland
- The Central Upland

These are discussed below.

The Coastal Lowland

The Coastal Lowland is characterized by gently-undulating, glacially- moulded terrain with low rounded northwest-southwest trending ridges separated by poorly drained glaciated valleys. The area slopes greatly to the west in the west (0-10%). Slope increases to 10-30% over a distance of 10 km in the east. Elevation reaches over 90 m.a.s.I. at the foot of Lizzie Hill and other masses at the boundary of the Central Upland.

The area is typically drained by slow-flowing streams flowing into Port Simpson Bay such as Good Water Creek.

The area was glaciated during the Pleistocene period. The trend of glacial striations and the distribution of erratics indicates that an ice sheet moved north along Hecate Strait and Chatham Sound during the Fraser glacial phase. The ice sheet was formed by Cordilleran and Queen Charlotte Islands Ice Masses. The ice sheet was responsible for moulding the landscape. The continental shelf was exposed during periods of low sea level associated with glacial events. Glacial deposits are rare because depositional zones on the continental shelf have been submerged by subsequent eustatic readjustments. Pockets of Late Pleistocene glaciomarine drift occur below coastal muskeg in some depressions (Hutchison, 1967a).

The Central Upland

The Central Upland is located to the east of the Coastal Lowland. The upland forms the backbone of the Tsimpsean Peninsula. The terrain is "moderately rugged" (Hutchinson, 1967a, Neat, 1975) with rounded hill masses reaching up to 900 m.a.s. Slope angles are in the order of 10-30%. The ridges trend northwest-southeast. The accordant summit levels of the upland have been interpreted as remnants of a late Tertiary erosion surface (Holland, 1976).

The ridges are separated by a wide glaciated valley occupied by drainage systems draining to Trail Bay and to a bay north of Flewin Point. These drainage systems are separated by poorly drained low saddles. Upland drainages discharge directly into Work Channel in the east.

The rounded summits of the upland are a result of moulding by Pleistocene ice sheets. Glacial deposits are rare. Higher elevations are characterized by bedrock surfaces.

3.3.3.3 Bedrock Geology and Tectonics

Bedrock Geology

The terrain is developed on structurally complex Mesozoic metasedimentary rocks of almandine-amphibole facies. Quantities and hornblende schists underlie the western part of coastal lowland. These rocks dip steeply to the east and form fairly steep-sided ridges. Differential erosion has resulted in the ridge and valley topography and the mainmillated 'microtopography' of the lowland.

The grade of metamorphism increases eastwards where gneisses replace the quartzites and schists. The eastern part of the coastal lowland and the uplands is developed on gneisses.

Tectonics

The bedrock of Birnie Island, off Grassy Point, is a Tertiary volcanic breccia, which is probably related to northeast trending dyke swarms in Portland Inlet (Hutchinson, 1967a). Work Channel, which bounds the study site on the east, is developed along a zone of structural weakness related to the Coast Range fault system which marks the western boundary of the coast plutonic complex at depth. There is minor evidence of past faulting with the same trend occurring in the study site and may account for the valley between Trail Bay and the northcoast of the Peninsula. A normal fault with the same trend occurs on the western side of Stumaun Bay and continues out to sea near Ben Hill. This structural feature could continue under Port Simpson Bay and could be associated with the volcanic bedrock of Birnie Island and/or Rushbrook Passage which separates Birnie Island from the mainland. Another normal fault aligns through the proposed site and has been dormant for much of the recent geological history. No active faults have been identified within the study site (McCammon, 1981, personal communication). Figure 3-3.3 illustrates this information.

3.3.3.4 Seismicity

All of the B.C. coast is located in the zone of highest seismic risk in Canada (Zone 3, as defined by the

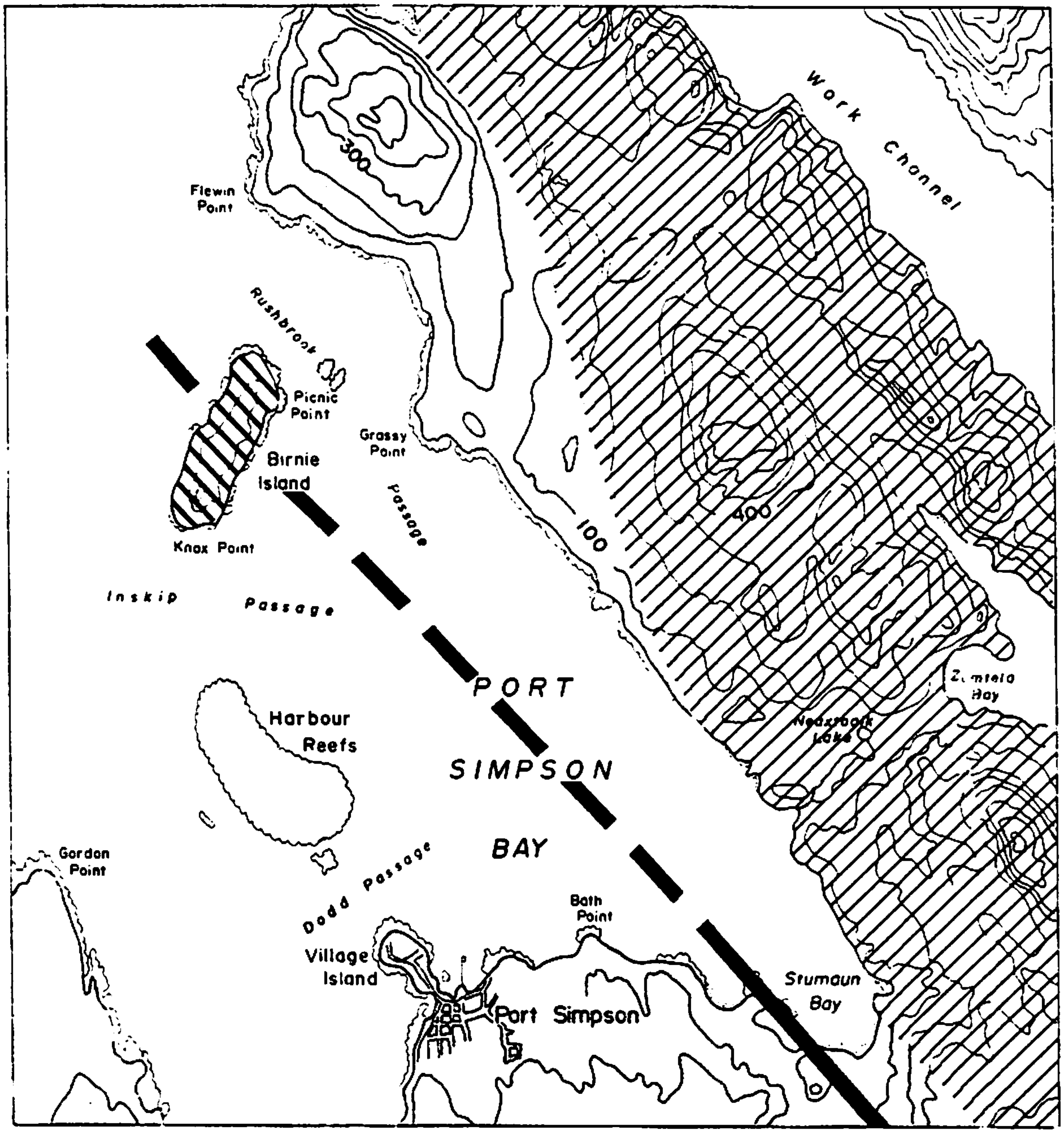

FIGURE 3.3.3
BEDROCK GEOLOGY · TECTONICS

LEGEND:

Tertiary Volcanic Breccia

Lower Jurasic or older Metasediment of Almadine-amphibole facies · Gneisses

Lower Jurasic or older Metasediment of Almadine-amphibole facies · Horneblende schists

Normal fault (known)

Normal fault (inferred)

seismic zoning map of Canada - Whitham et al, 1979) (See Regional Overview). The study site is located in one of the more favourable areas in this zone.

Seismic data was obtained for Grassy Point, near Port Simpson, from the Earth Physics Branch, Department of Energy, Mines and Resources, Canada. The information included a computed estimation of earthquake probability. Reported earthquakes which occurred in the period 1899-1977, with an intensity greater than II on the Modified Mercalli Scale were included in the analysis (see Appendix 1). Out of 2481 earthquake events (>II) catalogued for the region during this period, 124 events could have been felt at Grassy Point.

Grassy Point has experienced a peak acceleration of 7%g, (5.7 on the Richter Magnitude Scale); an event with an intensity of VII on the Modified Mercalli Scale. Such an event would be:

> "Noticed by automobile drivers. Walkers have difficulty keeping balance; weak chimneys break at roof lines; furniture breaks; poor masonry cracks; plaster, loose bricks, stones, tiles, cornices fall; small slides and caving develop along sand and gravel banks; water becomes turbid with mud; large bells ring; concrete irrigation ditches are damaged." (Holmes, 1965, cited by Alley & Thomson, 1978)."

The values in Table 3-3.3 are based on a statistical analysis of the recorded seismic events between 1899 and 1977. The data was processed to provide an estimate of the possible level of seismic activity in the near future. It is based on the assumption that the statistical pattern of the 1899-1977 data will be continued. Predicted values for return periods in excess of 100 years are likely to be altered by changes in the pattern of seismic activity.

The 100 year peak acceleration expected at Grassy Point has been computed as 8.2%g. (an intensity of VII on the Modified Mercalli Scale). There is a fairly significant probability of this peak acceleration being exceeded in one year. The probability of peak acceleration being exceeded in any one year is inversely related to the intensity of seismic events. If the 100 year return period has an acceleration amplitude <6%g it is unlikely that there is any seismic hazard. If the value is >6%g the possibility of a moderate or strong earthquake should be considered (Maynard, 1979).

TABLE 3-3.3

GRASSY POINT

SITE COORDINATES: 54° 36' N 130° 24' W
MODE FOR THIS SITE = -1.56
K FOR THIS SITE = .80

ACC100 FOR THIS SITE = 8.2 PER CENT GRAVITY

PROBABILITY OF ACC BEING EXCEEDED ONE YEAR	ACC IN PERCENTAGE GRAVITY	INTENSITY (MODIFIED MERCALLI)	EQUIVALENT RETURN PERIOD (IN YEARS)
.333	0	III	3
.100	1	V	10
.033	3	VI	30
.020	5	VII	50
.010	8	VII	100
.005	14	VIII	200

N.B. Acc = Acceleration

The values of acceleration are for compacted soil or bedrock. Other types of foundation material may alter the values by at least one unit of intensity. However, there is a factor of two uncertainty in all calculated accelerations which makes the estimation of seismic risk difficult on the basis of previous equations (Stevens & Milne, 1974). Seismic risk analysis based on peak acceleration has many problems, not least, the realization that peak acceleration is not a sufficiently stable parameter on which to base seismic risk data (Whitlam, 1975). Whitlam (1975) suggested that the use of design earthquakes for certain structures was a more realistic and scientifically more valid approach. This approach was used for the Trans-Alaska Oil Pipeline (Page et al, 1972).

3.3.3.5 Surficial Deposits

Morainal or glaciomarine deposits veneer the bedrock over much of the coastal lowland. Deeper pockets of drift occur in places. The depth of the surficial cover is controlled by the buried bedrock topography.

Bedrock surfaces are associated with a veneer of drift covering the western lower slopes of Lizzie Hill. The Uplands are characterized by veneers of colluvium or till over bedrock. The bedrock is markedly ridged with a northwest-southeast trend around Lizzie Hill. The valley emptying into Trail Bay is floored with a blanket of morainal material.

Extensive and deep organic deposits (coastal muskeg) occur over drift and bedrock surfaces on flat or gently sloping areas throughout the lowlands and the uplands. In places, organic deposits are associated with hummocky bedrock surfaces. Organic deposits occur on steep slopes near Neaxtoalk Lake. The organic deposits which have been probed are generally less than 3 m deep (McCammon, 1981, personal communication).

3.3.3.6 Seismic Response of Surficial Deposits

Moisture, status and compaction greatly influence the seismic response of surficial deposits. Saturated silts, sands and organic materials, for example, tend to greatly amplify seismic vibration. These deposits are very susceptible to seismically-induced liquefaction.

Bedrock is a comparatively good foundation medium although it is susceptible to fracture and fault displacement. Schist bedrock could fail along cleavage planes, fracture and liquefy if violently shaken. There are extensive areas with bedrock surfaces or near-surface bedrock at the site. Critical structures should be located in areas where foundations can be placed directly on bedrock or where pile foundations to bedrock can be employed.

Tills are comparatively good foundation materials because of glacial loading, but tills are rare at the site. Glaciomarine deposits have not undergone the same glacial pre-loading, are less-consolidated and may be susceptible to liquefaction and settlement (depending on their grain size and moisture conditions). Piling to bedrock should be used for construction.

Colluvial materials are potentially unstable because they are intimately related to slopes which could be susceptible to seismically-triggered failure. Piling to bedrock should be used for construction.

Saturated decomposed organic deposits are extensive (coastal muskeg). Such deposits are very susceptible to seismically-induced liquefaction and are not good foundation materials. Pilings should be used to anchor critical structures to bedrock. Fibrous peat is more stable, and occurs commonly in the area. It is important not to destroy the fibrous integrity of these organics through compaction or handling.

Alluvial deposits also greatly amplify ground motion and are potentially unstable because of potential liquefaction and settlement of saturated elements of the valley fill. Pile foundations anchored in bedrock should be used for critical structures.

3.3.3.7 Soils

The formation and distribution of soil types is intimately related to drainage conditions. All the soils found at the study site are characterized by high moisture content because of the great amount of precipitation. Soils representing three soil orders (organic, podzolic and regosolic) are found at the study site.

Lithic Fibrisols occur over much of the area. They are extremely acid (pH<4.0), shallow (1-3 m) organic soils which occur over bedrock. They are associated with poorly-drained flat or depressional areas with numerous lakes and slowly-flowing creeks. The lower part of the soil profile is characterized by undecomposed sphagnum and forest peat (Fungen and Lewis 1978 in Valentine et al).

Mesic fibrisols occur in close association with the lithic fibrisols. Mesic fibrisols occur in seepage collection sites. The solium is characterized by a deep layer of poorly-decomposed sphagnum material developed over partly-decomposed organic material. Mesic fibrisol profiles are commonly over 3 m deep.

Medium to coarse textured Ferro-Humic Podzols occur on colluvium-mantled steeper slopes and on moderately well-drained to imperfectly drained sites near to the coast. These soils are subject to continuous seepage and are intensely leached. Saturation is manifested in a high organic content and dull colouration. The profile is generally 1-2 m deep with a dark reddish B horizon with illuviated iron, aluminium and organic material.

Regosolic soils occur on the summits of the upland and near to creek beds, where horizonation has not taken place.

3.3.3.8 Mineral Resources

No significant mineral deposits are known to occur within the site although the geological environment of the Lower Mesozoic metasedimentary rocks and the proximity to plutons of the Coast Plutonic Complex is favourable to mineralization. Small isolated deposits are possible and there is a likelihood of present and future exploration in the area.

3.3.3.9 Industrial Aggregates and Clay

There are no extensive, economically significant aggregate or clay resources at the study site.

3.3.3.10 The Coastline and Offshore Environment

The Coastline

The coastline of Port Simpson Bay consists largely of bedrock with limited beach zones (Clague and Bornhold in McCann, 1980). A partially exposed shoreline with offshore reefs and a moderately narrow bedrock intertidal zone is the most common shoreform. The mainland provides some protection from the prevailing south-east winds, while Birnie and Finlayson Islands and offshore reefs provide some protection from westerly winds and swell from westerly winds and swell from Chatham Sound. North and north-west winds may be more prevalent here than at locations measuring wind in the Prince Rupert area, due to greater exposure to Portland Inlet and Dixon Entrance. More protected locations are found in Port Simpson Harbour and Stumaun Bay.

The coast is dominated by erosional bedrock shorelines with extensive abrasion platforms veneered by boulders and cobbles. Narrow shingle beaches are found at the back of the abrasion platforms. Rocky headlands and bedrock outcrops along the foreshore are sources for the large debris. The platform shows a strong north-northwest trending lineation, controlled by the bedrock structure. (This structure is not present on Birnie Island.)

More extensive beaches repose on extensive abrasion platforms in sheltered locations. Beaches are generally narrow with a flat or gently sloping profile and are composed of shingle. Some beach material is probably supplied by the attrition of boulders and cobbles, other material is probably derived from erosion of the surficial cover of headlands or from offshore. Fine-grained beaches (sands and mud) occur in proximity to estuaries and in very sheltered locations, such as Stumaun Bay. Pocket beaches are common along the coast.

Rocky headlands segregate the coast and act as effective barriers to longshore sediment transport, except during high magnitude storm events. Some beach nourishment takes place by offshore-nearshore sediment transport mechanisms. No significant transport of material by littoral drift is evident.

Material segregation is the dominant beach process. Beach materials are sorted by wave and tidal action. Coarse material forms a wedge towards the back of beaches. The bedrock platform is exposed at middle zone and finer material is found at or near low water mark.

The Offshore Environment of Port Simpson Bay

The offshore zone shelves gently towards the coast in the southern part of Port Simpson Bay. The submarine slope is in the order to 40 m in 1.3 km. The slope is steeper on the eastern side of the bay adjacent to the proposed terminal site. The submarine slope is in the order of 40 m in 0.25 km off Grassy Point. Rushbrook Passage between Birnie Island and the mainland reaches a depth of 20-30 m at its deepest point, but is generally shallower than 18 m.

The substrate of Port Simpson Bay is mantled with mud below the 40 m submarine contour. Isolated areas of gravel and shell are associated with isolated slight submarine rises closer inshore (between 20 and 40 m submarine contours). Sand and shell bodies veneer bedrock in the south of the bay between the 10 and 20 m submarine contours. Patches of sand and mud occur over bedrock above the 10 m submarine contour. Much of the bottom material is probably reworked morainal deposits submerged by the postglacial rise in sea level. No depth of material over bedrock could be discerned.

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3.4.0 FISH RESOURCES

Commercial fish species prevalent along the marine approaches include Pacific salmon (5 species), herring, and groundfish. Other fish of social or ecological importance include eulachon and numerous inshore species. The geographic locations of resources along the marine approaches have been discussed mainly in relation to Statistical Areas of Canada Department of Fisheries, which include Areas 1-7 and 30 (Map 3-4.1).

The following subsections have been prepared to provide background information and references on the fishery resource as it exists to date. Section 4.1.3 Environmental Specifications and Section 4.1.4 Alternate Human Uses and Activities describe possible project-related effects on the Fish Resources and on those people who rely on the fishery for food and livelihood.

3.4.1 Marine Approaches

3.4.1.1 Salmon

Salmon are the most important commercial fish species in British Columbia, and all five species (chinook, coho, chum, pink and sockeye) are prevalent in the North Coast waters adjacent to and within the northern and southern marine approaches to Port Simpson. All species have similar life history patterns in that they spawn and die in freshwater habitats ranging from small streams to large rivers, and they migrate to sea while young to mature in the marine environment. While adults at sea, all salmon species are widely distributed in the pelagic environment as far as the central north Pacific Ocean or the Gulf of Alaska. However,

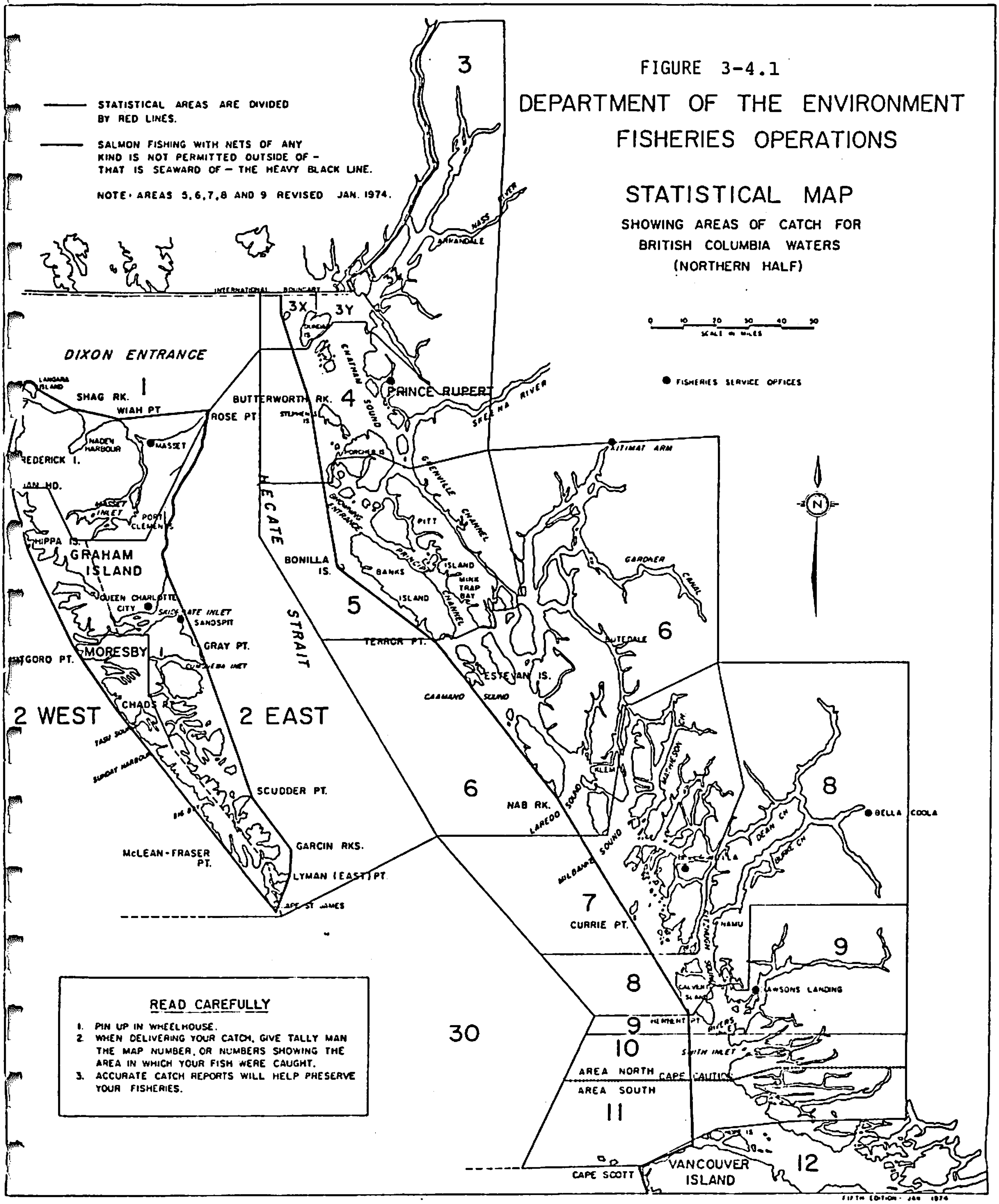
DEPARTMENT OF THE ENVIRONMENT
FISHERIES OPERATIONS
STATISTICAL MAP
SHOWING AREAS OF CATCH FOR
BRITISH COLUMBIA WATERS
(NORTHERN HALF)
STATISTICAL AREAS ARE DIVIDED BY RED LINES.
SALMON FISHING WITH NETS OF ANY KIND IS NOT PERMITTED OUTSIDE OF - THAT IS SEAWARD OF - THE HEAVY BLACK LINE.
NOTE: AREAS 5, 6, 7, 8 AND 9 REVISED JAN. 1974.
FISHERIES SERVICE OFFICES
READ CAREFULLY
1. PIN UP IN WHEELHOUSE.
2. WHEN DELIVERING YOUR CATCH, GIVE TALLY MAN THE MAP NUMBER, OR NUMBERS SHOWING THE AREA IN WHICH YOUR FISH WERE CAUGHT.
3. ACCURATE CATCH REPORTS WILL HELP PRESERVE YOUR FISHERIES.
INTERNATIONAL BOUNDARY
DIXON ENTRANCE
HECATE STRAIT
PRINCE RUPERT
SKEENA RIVER
NASS RIVER
GRAHAM ISLAND
MORESBY
VANCOUVER ISLAND
BELLA COOLA
2 WEST
2 EAST
1
3
3X
3Y
4
5
6
7
8
9
10
AREA NORTH
AREA SOUTH
11
12
30
SHAG RK.
WIAH PT
ROSE PT
MASSET
BUTTERWORTH RK.
BONILLA IS.
TERROR PT.
ESTEVAN IS.
SCUDDER PT.
GARCIN RKS.
LYMAN (EAST) PT.
McLEAN-FRASER PT.
GRAY PT.
SANDSPIT
QUEEN CHARLOTTE CITY
PORT CLEMENTS
HIPPA IS.
NAB RK.
CURRIE PT.
CAPE CAUTION
CAPE SCOTT
LAWSONS LANDING
NAMU
KITIMAT ARM
GARDNER CANAL
GRENVILLE CHANNEL
CHATHAM SOUND
BANKS ISLAND
PITT ISLAND
CAAMANO SOUND
LAREDO SOUND
MILBANKE SOUND
DEAN CH
SMITH INLET
FIFTH EDITION - JAN 1974

FIGURE 3-4.1

during certain life history periods, salmon populations in the marine environment may become more vulnerable to disturbances, particularly when concentrations of mature adults approach their natal spawning watercourses or when, as juveniles, most species remain in surface waters in nearshore coastal environments for extended periods. Although the timing of these events depends on the seasonal factors and varies with species, adults usually enter rivers in the late summer and fall (August-November), and young fish enter the marine environment in the spring, usually during freshet periods. While some species leave their freshwater environments soon after hatching (chum, pink, chinook), other species (coho, sockeye) remain in freshwater to rear for one year or longer and enter the sea as juvenile fish. Both fry and juveniles tend to remain near estuaries and coastal beaches for the first summer before migrating further offshore. They feed primarily on planktonic animals, such as copepods.

In the marine approach waters, streams and rivers having historically recorded runs for one or more species designated as "significant" or "major" occur primarily on the east coast of Moresby Island (Queen Charlotte Islands), the Nass and Skeena Rivers, and some coastal streams along the north coast of Graham Island and the mainland coast, south of Prince Rupert. There are few significant or major watercourses in Chatham Sound or Port Simpson Bay (Dept. of Fisheries and the Environment 1978).

Chinook salmon spawning populations are not prevalent in coastal watercourses along the marine approaches. The largest escapements (40,000 fish) occur in Area 4 (the Skeena River), while only modest runs (about 15,000) occur in Areas 3 (Lower Nass) and 7 (Bella Bella). There are very few chinook spawning in streams on the Queen Charlottes Aro et al 1977).

Coho salmon are more common and occur in more streams than Chinook salmon. The major runs (>70,000) occur to the Skeena River (Area 4), while significant numbers (>60,000) occur in streams in the Queen Charlottes (Area 2) and Butedale (Area 6). Other areas support less than 50,000 fish (Aro et al 1977).

Pink salmon are numerically the most abundant salmon species in British Columbia streams, and they are widespread in their distribution. They are distinguished from other species by the regularity of their life cycle, and they consistently return to spawn two years after entering the sea. Therefore, most populations returning to spawn are all of the same generation (genetically distinct from other runs). Although many streams possess both even and odd year runs, the North Coast areas generally support even year runs, particularly in the Queen Charlotte Islands.

In the marine approach waters, the Skeena River runs (Area 4) are the most abundant with over one million fish, on average, recorded from 1965 to 1975 during both even and odd eyars. Area 6 (Butedale) and Area 2 (Southern Queen Charlottes) follow with total runs over 900 thousand, but only during even years. In Area 3 (Lower Nass), which includes Port Simpson Bay, the major producing system is the Nass River. Escapements to Area 3 are also greater during even years, averaging just over 200 thousand fish (Aro et al 1977).

Chum salmon are also widely distributed in streams in the North Coast. Unlike most of the other species, chum salmon usually spawn in the lower reaches of streams, often intertidally, and therefore are subject to marine and near-shore influences. The largest average escapements (200-300 thousand fish) are reported to occur to streams in Area 2 (Southern Queen Charlottes), Area 6 (Butedale) and Area 7 (Bella Bella). Area 3 (Lower Nass) and Area 1 (Northern Queen Charlottes) support about 50,000 fish each, while Areas 4 and 5 (Lower Skeena River, Grenville-Principe) support less than 50,000 fish combined (Aro et al 1977).

Sockeye salmon, like chinook salmon, spawn in relatively few streams, and usually require watercourses with adjacent nursery lakes. Major runs in the North Coast occur in the Nass and Skeena river systems, from which a total of about 10% of all British Columbia Sockeye landings originate. While Area 4 (Skeena) and Area 3 (Nass) support average runs of over 800 and 100 thousand fish respectively, the remaining Areas all support runs of less than 50 thousand fish each (Aro et al 1977).

Apart from Pacific salmon species, other anadromous fish (steelhead trout, coastal cutthroat trout, Dolly Varden char) occur in waters of the marine approaches. However, with the possible exception of steelhead, which is a highly prized recreational fish, these species are minor resources in the marine approach waters. Steelhead are the anadromous form of rainbow trout, and the largest runs originate from the Skeena River. They usually spend two to three years rearing in freshwater before entering the sea, and usually return to spawn after another two to three years. Like salmon, they may range far offshore as adults. However, when smolts first arrive in the sea, they probably spend several months or longer in coastal areas, such as Chatham Sound (Hart 1973). Coastal cutthroat trout and Dolly Varden char are much less prevalent in the marine environment. There is little documentation of their distribution at sea, but they are probably restricted to the immediate estuarine environments near their native streams (Scott and Crossman 1973, Hart 1973).

The Salmonid Enhancement Program (SEP) is a long-term federal and provincial plan designed to preserve, rehabilitate and enhance the natural salmon stocks of British Columbia in order to increase production of this resource for the commercial, sport and native food fisheries. The number of different techniques employed to enhance fish production include man-made facilities and structures such as hatcheries, spawning and rearing channels, incubation boxes and fishways. In addition, 'natural' enhancement strategies include headwater stocking, small stream clearance and improvements and lake enrichment programs. The main SEP projects within the coastal areas of the marine approaches include major hatcheries and large-scale production operations located near Cumshewa Inlet at Pallant Creek (chum, coho) and Mathers Creek (chum) on the Queen Charlotte Islands. In addition, a small chum hatchery is located on McLaughlin Bay creek near Bella Bella. Reconnaissance surveys are underway in Rennel Sound on Graham Island to delineate areas suitable for enhancement of pink salmon stocks, while enrichment programs are planned for Bonilla, Devon and Lowe Lakes on the mainland east of Hecate Strait and in Masset Inlet on Graham Island. Minor production facilities are located near Skidegate (Sachs Creek) and Masset inlets (Yakoun River), on the Kloiya River near Prince Rupert, and the Kainet River in Statistical Area 7. Fishways have been installed in the Indian River (Statistical Area 6), in Kadjusdis River near Bella Bella and in the Naden River on Graham Island.

3.4.1.2 Herring

At the present time, herring is one of the most valued fish species in British Columbia. They have historically been harvested on a large scale for fish reduction plants, but since 1971, herring have been increasingly utilized for the valuable roe (egg) fishery, which has largely developed in response to the Japanese market demand. Herring are widely distributed along the Pacific coast, but are most abundant between Puget Sound and Dixon Entrance. Two main stocks of British Columbia herring have been identified; these rear at depths greater than 100 m in Hecate Strait and Juan de Fuca Strait, respectively. Both stocks remain relatively discreet, and utilize distinct clusters of spawning areas (Hourston and Haegele 1980).

The abundance of herring stocks has been a subject of considerble concern since overfishing reduced many stocks by the late 1960's, and the economic incentives to continue high harvest levels have remained. Although many populations have now returned to their former levels, the abundance of some stocks, particularly in North Coast areas, have not substantially recovered from their earlier decline (Hourston 1980a).

Herring spawn during early spring, and spawning grounds along the northern approach to the proposed LNG Terminal site in Port Simpson Bay include Naden Harbour, Skidegate, Porcher Island and Port Simpson Bay-Finlayson Island-Big Bay. Along the southern approach, spawning areas occur in inlets and bays on both side of Hecate Strait and the west coast of the Queen Charlotte Islands. Generally, North Coast populations spawn later than southern populations, and 50% of the spawning is usually completed from March 14 - April 7 depending on the site (Hourston 1980b).

The areas of completed spawn may be extensive, and several kilometres of beach may be covered.

Eggs are deposited on substrates such as kelp (Macrocystis), rockweed (Fucus), eelgrass (Zostera) and other seaweeds, as well as on rocks or pilings, and may, at times, be thickly deposited with several layers of eggs. The eggs are deposited largely just below the intertidal zone, with heaviest concentrations occurring at water depths less than -1.5 m datum (about 6 m below high water). After 10-21 days, larval herring emerge from the spawning grounds and drift with the current in surface waters. At this time, larval mortality is usually heavy and may approach 99% if strong offshore currents move the populations out of nursery areas (Hourston and Haegele 1980). After about one week, the larvae are able to swim and begin to move vertically in the water column, feeding at dusk on small zooplankton species (mainly copepods). About 10 weeks after hatching (July), the larvae metamorphose into juvenile stages, and gather in large schools in protected waters in the region of spawning grounds. They remain inshore for the remainder of the summer, but by September they form large schools, disappear from surface waters and move to their respective offshore areas. Herring remain in water deeper than 100 m and feed mainly on copepods and euphausiids. Most herring reach maturity after three years, and spawning may take place during one day, or over a period of several days. After spawning, adult herring move back to their deep offshore habitats.

In addition to their commercial importance, herring are a dominant element in the marine food web. Both larvae and adults are an important prey species to other fish, particularly salmon and some groundfish species.

3.4.1.3. Groundfish

Groundfish are a diverse group of marine fish which are found in near-bottom habitats usually in deeper waters (>100 m). At least 38 common species of groundfish, representing seven families, occur in northern British Columbia, but the most prevalent commercial species are Pacific cod, Pacific halibut, soles and flounders, and rockfish.

Pacific cod in the North Coast largely inhabit the waters of Hecate Strait. Spawning occurs in deeper water (>100 m) in the winter, and the major spawning area is in the "white rocks" ground in N.E. Hecate Strait. Peak spawning occurs in February and the eggs remain near bottom habitats. Larval cod feed on copepods, but the depth distribution of larval cod is not well documented (Ketchen 1961). After spawning and throughout the summer, adult cod move into shallower water 30-75 m, and feed on a variety of invertebrates and fish (Hart 1973).

Pacific halibut is the most valuable groundfish resource on the Pacific coast. Adult halibut spawn from November to July (usually between 275 and 412 m) principally in waters off the west coast of Graham Island and areas surrounding Cape St. James. The eggs remain near the bottom, but larval halibut rise in the water column to about 100 m where they grow for a period of months until settling to the bottom. Prior to settling juveniles may be swept into nearshore bottom habitats for the summer. Halibut feed primarily on fish, crabs, squid, and other invertebrates (Hart 1973).

In addition to halibut, other commercially harvested flounders include petrale sole, rex sole, butter sole, rock sole, lemon sole, Dover sole, starry flounder, and turbot. The life histories and distributions of all of these species differ somewhat. However, they are all bottom flatfishes which inhabit various areas of Hecate Strait. They all spawn at some time during late winter or early spring (January-March). Most spawn in various locations in Hecate Strait, except the petrale sole which migrates south to the west coast of Vancouver Island to spawn.

The eggs of petrale sole and lemon sole are bouyant for a short period and float near the surface, but eggs of the other species usually sink to bottom habitats. These eggs, however, may drift near shore. Juveniles of one species, lemon sole, may occur intertidally for 6 to 10 weeks. There is a general pattern of adult movements, also, from deep to shallow waters during the spring and summer. Food items vary with species and life history phase. Juveniles, when pelagic, usually consume various planktonic animals but adults usually rely on various benthic invertebrates (clams, clam siphons, polychaetes, crabs, and shrimp) or fish (herring, sand lance, and others).

There are numerous rockfish species which occur in British Columbia, however the most important commercial species are the Pacific ocean perch, yellowtail rockfish, yellowmouth rockfish, and redstripe rockfish. Most of these species are widely distributed in B.C. In the North Coast, major areas include southern Hecate Strait, Queen Charlotte Sound, and the west coast of the Queen Charlotte Islands. Most species occur from the surface to several hundred metres. Spawning for these species occurs during late winter or early spring (January-March).

Other groundfish species which are significant include lingcod, walleye pollock, and sablefish. Lingcod are widely distributed along the B.C. coast, and occur from the surface to 100 m. Spawning occurs from December to March, and eggs are deposited in large masses on the bottom. Pelagic juveniles hatch during the spring and are abundant in coastal waters through June feeding on copepods. Lingcod are piscivorous, consuming herring, sand lance, flounders, and many other species. Walleye pollock is fairly common in B.C. waters and occur from the surface to about 400 m. They have pelagic eggs and probably spawn in late March to April. Juvenile pollock prey on late developing eggs and copepods, while adults feed on shrimp, sand lance and herring. Adult sablefish (black cod) are most abundant in waters deeper than 500 m. Spawning occurs during January and February, and eggs and larvae are pelagic. Larvae and juveniles of black cod are commonly encountered in shallow areas. As in the case of many of the soles, this species moves to very deep waters during the winter. Foods include crustaceans, polychaetes and small fish.

3.4.1.4 Eulachon

The eulachon is a member of the smelt family (Osmeridae), and is of relatively low importance to commercial fisheries. However, it has a long history of importance to the native culture in B.C. The two major B.C. populations of eulachon originate from the Nass and Fraser Rivers, and at present, commercial harvesting is only allowed in the Fraser River.

Eulachon usually migrate into the Nass River to spawn during March. In this river, they may move up to 32 km upstream, but as weak swimmers, they only extend as far as tidal influences allow. Eggs are deposited freely and sink to the bottom, primarily on sand substrates. Larvae hatch during May and are carried downstream into the marine environment. The eulachon is thought to remain at moderate depths not far from shore during their period of growth, however, their distribution in northern waters is largely unknown.

In waters along the marine approach, eulachons inhabit deep water environments and are not reported to appear in surface waters until approaching their spawning rivers.

3.4.1.5 Inshore Fishes

There are numerous other fish species which inhabit the relatively shallow coastal habitats along the marine approaches to the proposed terminal near Grassy Point. The types of fish inhabiting these waters largely depends upon the physical characteristics of the habitat, as well as other biological features (e.g., vegetation and invertebrate communities). The most prevalent nearshore habitats along the marine approaches are rock-kelp bed associated shores, while estuaries and sand and mud bays are less abundant.

Nearshore habitats are important to many commercial species. Estuaries and adjacent waters are important for spawning and rearing of some salmon species, as well as herring. In addition, the early life history stages of groundfish utilize many shallow (even intertidal) areas. Most juvenile fish rely on the abundant food sources (mainly zooplankton) which appear to be especially abundant in these habitats during the summer months.

The other species present in these habitats include largely demersal forms (e.g., gobies, sand lances, snailfish, poachers and alligator fish, and sculpins) and reef-dwelling species (e.g., lingcod and dogfish). Most of these inshore fish species are associated with rocky shores and kelp beds.

The life histories of these various inshore species differ, covering a range of spawning times, locations and types of egg incubation (brood sacs, demersal eggs). All consume a variety of foods, but mainly planktonic or benthic invertebrates (e.g., copepods, tunicates, amphipods, shrimp). The species composition in these habitats varies with season and habitat types. More species occur in environments with greater physical relief and those with large kelp beds. Also, species numbers and diversity usually declines during the winter months as a result of increased wave action, reduced food supplies and vegetative cover.

3.4.1.6 Fish Resource Utilization

The principal commercial fisheries in British Columbia are for salmon, herring, rockfish, and halibut, while smaller fisheries exist for other groundfish (e.g., cod, soles, flounders) as well as shellfish. The North Coast harvests of fish (Statistical Areas 1-10) represent a substantial contribution to the total B.C. harvest (42% in 1979). Groundfish, salmon and herring, respectively, are the most important species harvested in the North Coast.

Salmon

All five species of salmon are harvested in the marine approach waters, as well as incidental catches of steelhead trout. Based on information from B.C. catch statistics since 1975, chinook salmon are harvested most intensively from Dixon Entrance (Area 1), Bella Bella (Area 7) and the East Coast of the Queen Charlotte Islands (Area 2E). Most chinook are harvested by trollers which can operate from March to November, however the most intensive fishing occurs between June and August. The most important fishing areas are McIntyre Bay, north of Langara Island in Dixon Entrance, along the northeast coasts of Graham Island, and in isolated locations within and outside of Chatham Sound.

Sockeye salmon are usually most heavily harvested from the Lower Nass (Area 3) and Skeena (Area 4) river areas. Harvests from Area 4 usually are greater and have accounted for up to 28% of the total B.C. landings. The majority of sockeye are taken by gillnets (78%) or seiners (21%), and these net fisheries are more strictly controlled than trollers. The net fishing season usually occurs during July and August in Areas 3 and 4, and is usually only open for several days each week. Primary harvest areas include Chatham Sound, the Skeena River estuary, Porcher Island, and Dundas Island. Minor catches occur in the Queen Charlotte Islands and other North Coast areas south of the Skeena River.

Coho are not a major species harvested in the North Coast, although some large harvests have occurred from Area 1 (Dixon Entrance) in some years. All types of gear participate in the coho fishery, however, the proportion taken by seiners and trollers has progressively increased since 1975. Most landings occur from July to September.

Chum salmon landings in the North Coast usually represent a major portion of the B.C. harvest, particularly Areas 6 and 7 adjacent to the southern marine approach. In 1979 these areas produced 36% of the total B.C. harvest. Substantial harvests have occurred during some years from Areas 2E (East Coast Queen Charlotte Islands/Hecate Strait), and 3 (Nass). Most landings are made by gillnetters (50%) and seiners(49%) during July to October.

Pink salmon landings in the North Coast (and all of B.C.) exceed all of the other salmon species. Although runs in North Coast waters are usually greater during even years, this is not clearly reflected in the catch statistics. The Skeena (Area 4), Nass (Area 3), and Butedale (Area 6) have reported the largest harvests, and in 1978 Areas 3 and 6 handled over 50% of the total B.C. harvest. Virtually all North Coast pinks are taken by seiners (68%) or gillnetters (25%). Most are taken from July to September.

Although a minor species, steelhead trout are taken mainly during salmon net fishing in Area 4 (Skeena) in July and August.

Herring

Herring is one of the most important fish species presently harvested, and is second only to the combined salmon harvest in North Coast waters in terms of landed weight and dollar value. Prior to 1972 the herring were used primarily for reduction to fish meal and oil, and after heavy fishing during this period, stocks were seriously depleted. Severe restrictions on the fishery occurred between 1967 and 1971. After 1971, major fishing again resumed, but herring were primarily harvested to supply the more valuable roe fishery for Japanese markets.

The herring harvest areas are closely associated with spawning grounds, and the fishery usually only occurs during a portion of the brief period of spawning (one to several days). In North Coast waters this usually occurs during March and April, depending on the site. Several North Coast populations began to decline during the roe fishery and some of these areas, particularly Chatham Sound (Area 4), the Nass, including Port Simpson (Area 3), and Butedale (Area 6) were closed during recent harvests. Since 1975 the largest harvests in the North Coast were from Areas 2E (East Coast

Queen Charlotte Islands/Hecate Strait), 5 (Grenville-Principe) and 7 (Bella Bella). Both gillnetters and seiners participate in the catch; and despite the larger number of gillnetters usually present, most of the landed weight is captured by the seiners.

In addition to the roe fishery, roe-on-kelp fisheries also occur in the North Coast, where kelp and the attached herring eggs are collected and supplied as a delicacy to Japan. These fisheries are individually lucrative, but only occur in a few areas. In the North Coast roe-on-kelp ponds are located in Skidegate and Atli Inlets (Queen Charlotte Islands), Kitkatla Inlet (Porcher Island), and Big Bay (on the mainland coast in Area 4).

Ground Fish

Groundfish represent a relatively small harvest in comparison to the salmon and herring fisheries, but the North Coast represents the most important region for this fishery in B.C. The dominant fishing method for most species, except halibut, is in bottom trawls, and the areas fished are relatively shallow banks or gullies in Hecate Strait and Queen Charlotte Sound (Areas 2E, 4, 5) and for some species, the west coast of the Queen Charlotte Islands (Area 2W). Trawling occurs thoroughout the year, but is usually most active from spring (April) to fall (October). Halibut are mainly harvested by longline gear in various locations throughout Hecate Strait (Area 2E) and Dixon Entrance (Area 1). The halibut season is strictly regulated by catch quotas and the open season occurs between May and August.

Native Food Fishery

Native harvests of fish represent a relatively small but socially important, use of fish resources in marine approach waters. Salmon, particularly sockeye, are the prevalent fish species taken, but domestic food catches of shellfish, eulachon, groundfish, herring roe, mussels, abalone, and crabs are also traditionally harvested. Most of the harvests in domestic fisheries are not recorded, and no accurate data exist documenting fishing areas or landings. The salmon for domestic use is usually obtained from the commercial gillnet catch, however, other gear such as set nets and purse seines are sometimes employed. The Queen Charlotte bands (Masset and Skidegate) harvest sockeye and chum salmon as well as abalone, razor clams, butter clams, chitons, halibut and other groundfish species. The lower Nass bands (Kincolith and Port Simpson) fish for sockeye in the Nass and Skeena estuaries and harvest crab and eulachon from the Nass River. The Port Simpson Band also harvest some herring spawn from Port Simpson Bay. Both bands utilize other shellfish and groundfish species (mainly halibut). Other native food fisheries exist for bands south of Port Simpson Bay, and most obtain their fish from nearby river mouths and inlets. These include the Metlakatla (Area 4) and Kitkatla bands (Area 5), which also participate in the lower Skeena fishery, the Hartley Bay (Area 6) and Kitasoo bands (Areas 6 and 7) as well as the Bella Bella band (Area 7).

3.4.2 Terminal

3.4.2.1 Marine Environment

The marine environment of Port Simpson Bay includes the waters of the main bay east of Inskip Passage including the tip of the Tsimpsean Peninsula and Stumaun Bay (Figure 1-5.2), and has been described separately by McDonald (1981). The bay is relatively shallow (20 m), with a sand and mud bottom. Salinities are brackish about 27°/oo in November. Intertidal areas except Stumaun Bay at the southern end of the Port Simpson study area are largely characterized by gently sloping bedrock outcrops with pockets of sand or coarser materials. Stumaun Bay is a sand and mud estuary draining the Stumaun Creek watershed.

Salmon

Site specific data on the distribution and seasonal abundance of salmon species in Port Simpson is generally lacking. Stumaun Creek supports about 7,000 pink and 20 coho salmon in 1980 (Fisheries and Oceans Canada unpubl. records); the highest pink salmon spawning density since 1950 reached 11,000 fish in 1978.

Also, the small creek draining Neaxtoalk Lake is locally reported to support some salmon spawners. The specific timing of migrations into these creeks probably varies, but pink salmon spawning migrations to Stumaun Creek probably occur from August to October with some spawning possibly occurring in portions of the intertidal areas of Stumaun Creek. It is also probable based on general life history data, that juvenile salmon from these drainages occur in surface waters of the bay from June through August; however no site specific data exists confirming their presence.

Herring

Pacific herring represent the most dominant fish resource in Port Simpson, and the life history of this species and important spawning areas have already been summarized for the marine approaches. Historically Port Simpson has been an important spawning area for herring and almost anywhere from Flewyn Point to south of Big Bay have been heavily ustilized in the past. Large populations in the Port Simpson-Big Bay area were harvested prior to 1978, when about 20,000 metric tons of fish existed. However, since the late 1960's and again in 1978, stocks drastically declined to less than 6,000 metric tons and fishing has been closed in both areas (Haegele and Miller 1979). In addition to the roe fishery, the Port Simpson band has a permit for retrieving spawn-on-kelp from the bay but commercial harvesting of this resource is suspended until stocks increase.

Spawning in Port Simpson occurs in early April and the average date of 50% spawning completions is April 7, ±14 days (Table 3.4.2.1-1). However, eggs may be deposited anytime from late March to late April.

TABLE 3.4-1
SPAWNING TIMES IN PORT SIMPSON
(from: Hourston 1980)

First Spawn	50% Completion	100% Completion	Duration Days
April 3, ±5	April 7, ±14	April 13, ±18	10 (1-53)

There are reports, also, that a late spawning population sometimes arrives in April or May, but there is little documentation of its timing or extent (Haegele and Miller 1979; B.A. Huber pers. comm.). Egg deposition in Port Simpson-Big Bay occurs on a variety of substrates, but eelgrass (Zostera sp.) is the preferred substrate, and occupied 44% of the spawn area in 1979 (Haegele and Miller 1979).

Other sites were kelp (Macrocystis sp.) (28%), filamentous red algae (10%), other brown algae (10%), foliose red algae (4%) and rockweek (Fucus sp.) (4%). The distribution of various algal substrates in Port Simpson, documented by Beak (1981), indicates that eelgrass is prevalent in Stumaun Bay and other shallow subtidal areas, while kelp is most prevalent in the reef areas near Inskip Passage and Birnie Island. Rockweed and red algal species are abundant along the mid to lower tidal zone of the rocky shores all along the bay. In 1981, a heavy spawn was recorded by March 25 in both Port Simpson Bay, Finlayson Island and Big Bay areas, and during this period almost all spawning substrates were heavily utilized (B.A. Huber, pers. comm.).

Depths of major egg depositions have been measured from the lower intertidal (+3.4 m above 0 datum) to shallow subtidal zones (-7.5 m) (Haegele and Miller 1979). In 1979, the heaviest areas of spawn deposition in Port Simpson were on the north shore between Grassy Point and Stumaun Bay to beyond Village Island.

Larval herring distribution has not been documented in the Port Simpson area. Based on general life history data (Hourston and Haegele 1979), larval herring would hatch after 10-20 days, suggesting peak emergence between April 17-27 in Port Simpson Bay. After hatching, the larval herring are reported to drift in the surface currents nearshore, however the areal distribution and depths where larval herring occur have not been thoroughly documented (R. Humphries, pers. comm.). Juvenile herring (10 weeks old) also are reported to remain inshore, but by September, juvenile herring form large schools and move towards their deeper (>100 m) offshore habitats in Hecate Strait (Hourston and Haegele 1980). Adult herring are usually only present inshore during their relatively brief period of spawning in the spring.

Other Species

Although detailed fish surveys have not been conducted in Port Simpson Bay, SCUBA investigations of several North Coast areas reported by Peden and Wilson (1976) and beach seining by Anderson (1975) provide some information on inshore species which have been observed in Port Simpson or near Dudevoir Passage, Parkin Islets, and Birnie Island. A list of species found in these areas is provided in Table 3-4.2.

At the time of these studies (mid-July 1979 and early November 1974), the dominant fish observed in the area of Port Simpson Bay were rockfish (Scorpaenidae), soles (Pleuronectidae) and sculpins (Cottidae). Some of these species are commercially harvested in North Coast B.C. waters. Pacific halibut are also apparently harvested to a certain extent by the Port Simpson band in areas north of Birnie Island. Apart from salmon, Dolly Varden char is the only other anadromous species documented in the bay. However, coastal cutthroat and steelhead trout are reported from local freshwater tributaries and these anadromous species may occasionally enter the bay.

The larval stages of some groundfish, herring and salmon are undoubtedly present in Port Simpson Bay at some times of the year, particularly May through August. Groundfish species with pelagic larvae that have been documented in sheltered inshore areas include Pacific halibut, some soles and flounders, and possibly rockfishes. The larval stages of sablefish and Pacific pollock also inhabit inshore areas, and may be present in Port Simpson Bay from March to July.

TABLE 3-4.2 INSHORE AND GROUNDFISH SPECIES OBSERVED WITHIN AND ADJACENT TO PORT SIMPSON BAY (From: Peden and Wilson 1976; Anderson 1975)

Family	Species	Common Name
Salmonidae	Salvelinus malma	Dolly Varden char
Chimaeridae	Hydrolagus colliei	Ratfish
Osmeridae	Hypomesus pretiousus	Surf Smelt
Gobiidae	Corphopterus nicholsi	Blackeye goby
Gadidae	Gadus macrocephalus	Pacific cod
	Theragra chalocogramma	Walleye pollock
Trichodontidae	Trichodon trichodon	(Pacific) sandfish
Bathymasteridae	Bathymaster caeruleofasciatus	Alaskan ronquil
	Ronquilis jordani	Northern ronquil
Embiotocidae	Dymatogaster aggregata	Shiner perch
Hexagrammidae	Oxylebius pictus	Painted greenling
Ammodytidae	Ammodytes hexapterus	Pacific sand lance
Scorpaenidae	Sebastes brevispinis	Silvergray rockfish
	Sebastes caurinus	Copper rockfish
	Sebastes ciliatus	Dusky rockfish
	Sebastes emphaeus	Puget Sound rockfish
	Sebastes flavidus	Yellowtail rockfish
Cottidae	Artedius harringtoni	Scalyhead sculpin
	Artedius meanyi	Puget Sound sculpin
	Enophrys lucasi	Leister sculpin
	Gilbertidia sigulates	Soft sculpin
	Hemilepidotus hemilepidotus	Red Irish lord
	Icelinus borealis	Northern sculpin
	Jordania zonope	Longfin sculpin
	Enophrys bison	Buffalo sculpin
	Leptocottus armatus	Pacific staghorn sculpin
	Myoxocephalus polyacanthocephalus	Great sculpin
	Nautichthys oculofasciatus	Sailfin sculpin
	Radulinus taylori	Spinynose sculpin
	Rhamphocottus richardsoni	Grunt sculpin

TABLE 3-4.2 - Cont'd.

Family	Species	Common Name
Agonidae	Agonus acipenserinus	Sturgeon poacher
Stichaeidae	Anoplarchus insignis	Slender coxcomb
	Chirolophis decoratus	Decorated warbonnet
	Chirolophis nugator	Mosshead warbonnet
Philidae	Pholis clemensi	Longfin gunnel
Pleuronectidae	Inopsetta ischyra	(Hybrid) sole
	Lepidopsetta bilineata	Rock sole
	Parophrys vetulus	English sole
	Platichthys stellatus	Starry founder*
	Psettichthys melanostictus	Sand sole

3.4.2.2 Freshwater Environments

Freshwater habitats either adjacent to the proposed terminal site or identified as potential freshwater sources for the LNG processing facility include Stumaun Creek, Neaxtoalk Lake, and three unnamed drainages at the north end of the Tsimpsean Peninsula (Figure 3.4.2-2). These have been rated for priority by Swan Wooster Engineering (1981). Georgetown Creek draining into Big Bay (south of Port Simpson) has been added as another potential source. Available information on fishes and fish habitats in these waterbodies is limited to Stumaun and Georgetown creeks, evaluated in 1975 for the Northcoast Environmental Analysis Team (Lee Doran Associates Ltd. 1975).

Stumaun Creek

Stumaun Creek drains a fairly large watershed east of Port Simpson village (Figure 3-4.3). It branches above the high tide line; the east fork is steep (5-10% gradient) and possesses several rapids and small falls. A water control structure in its upper reaches supplies the Port Simpson village and fish-processing facility located there. The west fork of Stumaun Creek, particularly the lower intertidal reach, has a more gentle gradient (about 2%) and contains gravel substrates suitable for salmon spawning (Lee Doran Associates Ltd. 1975).

Fish populations in the creek are reported to include pink and coho salmon, as well as sea-run cutthroat trout, Dolly Varden char and steelhead (Lee Doran Associates Ltd. 1975; Fisheries and Environment Canada 1978). However, no seasonal field surveys have documented the distribution of these species, except for historical records of salmon spawning (Fisheries and Oceans, unpublished data). Historical

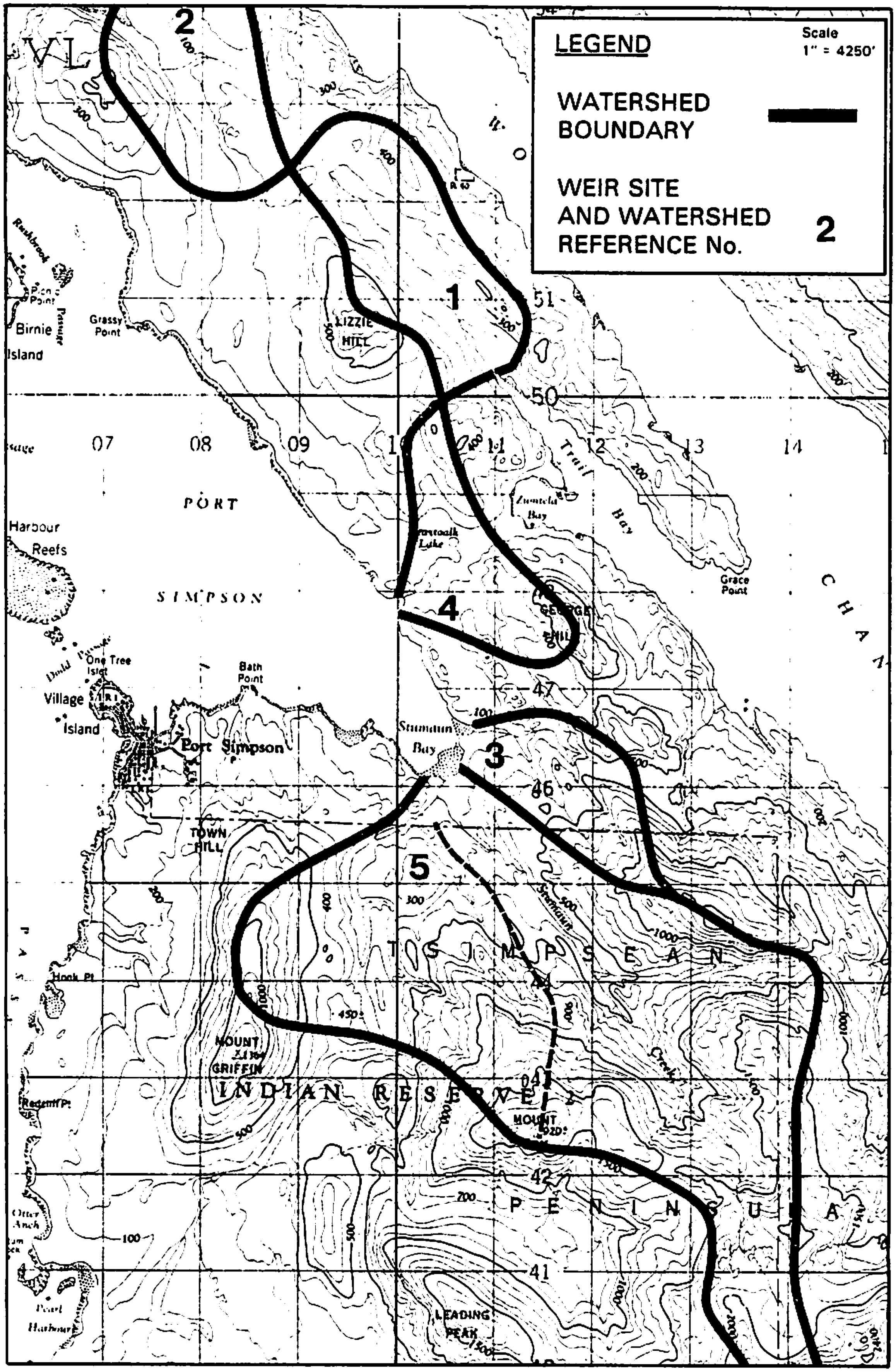

FIGURE 3-4.3 WATERSHEDS NEAR THE PROPOSED TERMINAL RANKED BY PRIORITY FOR USE AS WATER SUPPLIES.

escapements from 1950 suggest that the creek is used predominantly by pink salmon for spawning in the lower reaches (Fisheries and Oceans Canada unpubl. records). The timing of spawning migrations is not well documented but may occur from September to October with fry emergence probable in April to May. Pink fry would migrate to sea soon after emergence. Coho are reported in small numbers in the creek, and if present, juveniles would probably spend at least one year in the creek before migrating to sea. All five of the salmonid species which utilize the creek are anadromous.

Neaxtoalk Lake and Creek

Neaxtoalk Lake and Creek drain a small watershed north of Stumaun Bay (Figure 3-4.3). The lake is just below high tide levels and therefore is subjected to some tidal influences (Lee Doran Associates Ltd. 1975). Brackish conditions are therefore probably evident in the lake, particularly in the bottom layers. No sampling of fish populations in these waterbodies has been reported. Lee Doran Associates Ltd. (1975) suggested that only a "small trout population" exists in the lake, and no suitable spawning habitat for salmonids exists in the outlet creek. However, residents in Port Simpson have indicated that cutthroat trout and some salmon do spawn in the outlet creek and are periodically caught in the lake.

Georgetown Creek

The only reported fisheries evaluation of Georgetown Creek is contained in Lee Doran Associates Ltd. (1975). Georgetown Creek is one of the larger drainages on the Tsimpsean Peninsula, about 10 km south of Port Simpson village. The stream has low gradient habitats suitable for salmon and trout spawning and rearing for over 8 km, but a dam built for a lumber mill at the creek mouth has prevented any use of the creek by anadromous species for many years. A lake at the head of the creek apparently possesses cutthroat trout and once supported coho and steelhead trout runs.

Unnamed Creeks on the Tsimpsean Peninsula

Three unnamed drainages on the north end of the Tsimpsean Peninsula may also be utilized for water supplies (Figure 3-4.3). These creeks all drain watersheds smaller than Stumaun Creek. No information exists on fish or fish habitats in these creeks; however, if sufficient habitats and streamflows exist, they probably support small resident populations of cutthroat trout and possibly Dolly Varden. These streams have not been identified as salmon bearing streams (Fisheries and Environment Canada 1978).

3.4.2.3 Fish Resource Utilization

Commercial fishing activities in Port Simpson are largely limited to the herring roe fishery and periodic salmon trolling and gillnetting activities in the bay. Most commercial salmon fishing occurs outside of the bay, and only occasional halibut fishing (with long lines) is locally reported to occur north of Birnie Island. Major areas of fishing activities in and near the terminal sites are shown in Map 3-4.2

There are no data which summarize fish harvests from the Port Simpson Bay except for the herring fishery. Salmon harvests are reported for all of the Lower Nass areas (Area 3) and have been summarized for the marine approaches. The herring fishery in Port Simpson has been closed since 1978 because of a decline in stocks, but prior to the closure harvests from the Chatham Sound catch, which includes Port

Simpson Bay and the Pearl Harbour (Big Bay) area to the south, totalled 3363 metric tons in 1978 representing 11% of the total North Coast harvest (Hourston 1979). As indicated earlier, the timing of the herring fishery varies with the precise dates of spawning, but usually occurs in Port Simpson Bay for a brief period during late March to mid-April. Fishing activities occur only just prior to and during spawning, and may extend from a period of several hours to only a few days. The fishery is intensive with up to 20 seiners and over one hundred gillnetters possibly participating in the area of Port Simpson Bay and Cunningham passage (T. Panko pers. comm.).

Domestic food and recreational fishing undoubtedly occurs in Port Simpson Bay, but information on the extent on areas utilized are not presently available. The terminal site is relatively far from Prince Rupert, and non-commercial fishing is probably limited to local residents in Port Simpson.

3.5.0 INVERTEBRATE COMMUNITIES

3.5.1 Marine Approaches

3.5.1.1 Intertidal and Shallow Subtidal Communities

Marine invertebrates along the northern British Columbia coastline are generally distributed according to the degree of wave exposure and the physical nature of bottom substrates. In addition, the large tidal range in the study area (approximately 7 m) permits a vertical zonation of organisms according to their various preferences and adaptations. Other factors, such as dessication, freshwater inflow, and currents also determine the species composition at particular sites.

Shorelines along the northern marine approach through Dixon Entrance include the northern portion of Graham Island, Dundas Island group and Chatham Sound north of Porcher Island. The northwest corner of Graham Island (west of Masset Inlet and south of Langara Island) is mainly characterized by steeply sloping wave exposed bedrock shores with small pockets of sand beaches (north coast) or stretches of gravel/cobble and boulders (west coast). East of Masset Inlet (from Entry Point to Rose Spit and south to Lawn Point) is an extensive area of uninterrupted exposed sand beach. Shorelines of the Dundas Island group, Stephens Island, northern Porcher Island and the mainland coast are largely bedrock shores with varying degrees of wave exposure from exposed (western coast of Dundas Island) to partially exposed (Chatham Sound) conditions. Small areas of semi-protected to protected shores occur only in inside waters of inlets such as Masset and Naden Harbour, and Kitkatla Inlet (south Porcher Island).

The southern marine approach includes shores of the west coast Queen Charlotte Islands, and both east and west shores of Hecate Strait to Chatham Sound. While the west coast of the Queen Charlottes is mainly steeply sloping wave-exposed bedrock shore, both shorelines of Hecate Strait (east coast of Moresby Island and the mainland shores) are a complex assemblage of almost all habital types. Wave exposed bedrock shores border Hecate Strait, and numerous semi- protected to protected inlets and passages, some with sand or gravel beaches occur behind these exposed shorelines.

Bedrock and Boulder Substrates

The fauna inhabiting exposed bedrock shorelines of the approaches are probably typical of rocky headland fauna along the Pacific coast. Dominant organisms include an upper intertidal barnacle zone, a mid-intertidal community of open coast mussels, goose-neck barnacles, and starfish, and a diverse lower intertidal zone of anemones, snails, small crabs and other crustaceans, as well as numerous smaller organisms inhabiting microhabitats created by sedentary invertebrates and algal species. Subtidally, exposed rocky shores usually support some commercially important invertebrates such as the red sea urchin and abalone.

As wave exposure decreases, shorelines may become more densely populated, but still possess a pattern of zonation similar to exposed shores. However, some species common to exposed shores are absent. The open coast mussel, goose-neck barnacles, as well as the red sea urchin usually disappear. Abalone, also become absent when wave exposure and currents reduce subtidal flushing. Partially wave exposed habitats possess groups important in nearshore food webs, particularly numerous are amphipods and isopods which are food sources for fish and some birds. If wave exposure diminishes entirely, the intertidal fauna may substantially decrease if tidal flushing decreases while freshwater influences increase.

Cobble and Gravel Substrates

Cobble and gravel substrates represent a small portion of the shores along the marine approach and in wave exposed situations possess relatively few organisms. In more protected habitats, however, a large standing stock of organisms may be present including some crustaceans and molluscs which are important in food webs or in commercial fisheries, such as butter clams and littleneck clams.

Sand and Mud Substrates

Exposed sand beaches are most prominent on the north and east coast of Graham Island. Although relatively few organisms can tolerate the abrasive conditions of this habitat, one commercially important bivalve, the razor clam, does populate these habitats, and subtidally the commercial crab (Dungeness crab) may also be abundant. In more protected environments, amphipods, bivalves, and crabs may become more numerous, and the community in general becomes more diverse. In completely wave-protected areas, mud or mud and sand communities become predominant and the communities become even more diverse while standing stock also increases. The presence of eelgrass beds which are almost always present in these habitats contributes signficantly to the abundance of invertebrates. These habitats possess numerous small crustaceans, mud-shrimp, commercial and non-commercial crabs, and bivalves both intertidally and subtidally.

3.5.1.2 Commercial Invertebrate Species

Invertebrate species harvested commercially along the main approaches include crabs, clams, abalone, shrimp and prawns, and recently, octopus. Other invertebrates, not presently taken commercially are domestic food sources for natives or represent potential commercial species, such as mussels, red sea urchins, squid scallops, gooseneck barnacles and sea cucumbers.

Crab

The commercial Dungeness crab occurs in shallow coastal areas of sand substrates throughout British Columbia. The subtidal areas of McIntyre Bay and northern Hecate Strait off the east coast of Graham Island support large crab populations and are the most important crab harvesting areas in British Columbia. Landings occur mainly during September to November. The life history of crab includes a period (July-August) when crab larvae are abundant in the surface waters of shallow sandy bays. Juvenile crabs are also abundant in shallow water (<10 m).

Clams

There are five commercially important species of clams along the British Columbia coast (butter and razor clams, geoducks and two species of littlenecks). In the area of the marine approaches the most important commercial species have been the razor clam and the butter clam. Geoducks have only recently become important.

The butter clam is the most important clam species in British Columbia, and occurs in sand to gravel beaches from the lower intertidal to about 10 m. Planktonic larvae of butter clams occur in surface waters from May to August. In the North Coast it may take 8 or 9 years for a clam to reach commercial size. The most important harvest areas for butter clam are Area 4 (Skeena) and Area 5 (Grenville-Principe). Specific locations occur in the area of Dundas Island, Melville Island, Stephens Island, Metlakatla Bay, Porcher Island, northern Banks Island and Anger Island.

Razor clams occur only on sandy surf-swept beaches from the mid-intertidal to depths of 20 m. The most important concentrations of this species in British Columbia occur in McIntyre Bay (Queen Charlotte Islands) and in southern British Columbia (Long Beach, Vancouver Island). The McIntyre Bay population has produced the major razor clam harvest in B.C. since 1924, and harvests occur mainly from April to June on North Beach. Razor clams have a planktonic larval stage which lasts for approximately one year.

Geoducks are the largest of the clam species and occur subtidally in substrates of fine sand to sand/gravel mixtures along the entire B.C. coast. Planktonic larval stages occur during the spring and summer. These clams are long lived (100 years or longer) and reach harvestable sizes in about six years. Harvests of geoducks mainly occur in southern British Columbia, but recently some harvests have occurred in the North Coast from Chatham Sound (Area 4) and Cumshewa Inlet on the Southern Queen Charlotte Islands (Area 2E). Commercial harvesting may expand to other areas in the North Coast.

Littleneck clams do not represent an important commercial clam species at present. They are small clams occurring intertidally to 12 m. Planktonic larvae are present during the summer. Occasional landings have been reported from Areas 1, 4, 5, and 6, but only minor catches (<2 metric tons) have been reported.

Abalone

Abalone are widely distributed along rocky exposed areas of the marine approaches, usually subtidally to 10 m depths. Most of the harvests have been from locations in Area 2E (east coast Queen Charlotte Islands). Recently Areas 5 and 6 (Grenville-Principe, Butedale) have also been important. Small harvests have been reported from Area 1 (Dixon Entrance) and 4 (Skeena; Chatham Sound), and no harvests have occurred in Area 3 (Nass, including Port Simpson). Planktonic larvae of abalone are present primarily during the spring (April-June). As a result of intensive fishing many areas in the marine approaches are now closed to commercial fishing.

Shrimp and Prawn

Shrimp and prawn species harvested along the British Columbia coast include six separate species, all of which inhabit overlapping areas of the marine bottom. Some occur in deep inlets and bays, while others occupy various depths (usually below 25 m) on sand or mud bottoms in larger waterbodies. Although they are predominantly associated with bottom habitats, adults of some species migrate off the bottom and also occur at mid-water depths. Larval stages of shrimp are usually present in the water column during the spring and summer, often inhabiting shallow waters relative to adult habitats.

Generally, the North Coast and, in particular, the areas of the marine approaches (Areas 1-7) do not contribute a major portion of the shrimp and prawn harvests in British Columbia. Only Area 7 (Bella Bella) has consistently reported a moderate percentage (7-12%) of the B.C. landing of prawns. Fishing for prawns in Area 7 is concentrated in mainland inlets well east of the shores adjacent to the southern marine approach. Minor harvests are reported from Area 1 (Dixon Entrance), Area 5 (Grenville-Principe) and Area 6 (Butedale). Shrimp are also of minor importance in North Coast fisheries, and over the past six years Areas 4 and 5 have reported the only landings greater than one percent of the total British Columbia harvest. Chatham Sound (Area 4) has produced the largest harvests, and has produced as much as 9% of the British Columbia harvest in one year.

Octopus

Octopus is not a target species in the North Coast shellfish harvest, but they are taken incidentally from other fisheries (primarily by trawlers and in shrimp and prawn traps). Most of the British Columbia harvest is taken from Dixon Entrance (Area 1) and northern Hecate Strait (Areas 2E, 4 and 5). Octopus occur between 4 and 8 m below datum usually in bedrock crevices or under boulders. Larval octopus are planktonic, but remain in surface waters for only a few days in the fall (September). Octopus are an important subtidal predator, consuming crab, bivalves, gastropods and abalone.

Other Commercial Species

Other invertebrate species common in marine approach waters which are of potential commercial significance include mussels, red sea urchins, squid, scallops, gooseneck barnacles, and sea cucumbers. At present few of these species are harvested for commercial use but mussels, red sea urchins and squid have been harvested at low levels in some areas of British Columbia and fisheries for these resources may expand in the future. Mussels and red sea urchins are widely distributed along the British Columbia coast in partially exposed to protected (mussels) habitats of rocky shores. Squid are only concentrated in nearshore waters during spawning (September to December) where they form large, dense schools in near bottom habitats (below 30 m) of sheltered bays with sand or mud substrates such as Virago Sound, Naden Harbour and Rennell Sound (Queen Charlotte Islands), Malacca Passage, Anger Island and Milbanke Sound (mainland coast).

3.5.2 Terminal

The following sections summarize existing information on the intertidal and shallow subtidal invertebrate resources in the Port Simpson Bay area, and separately describes the presence of harvested species and their utilization for commercial and domestic fisheries. Marine vegetation is a dominant and important feature of these communities, and have been reported separately by Beak (1981).

3.5.2.1 Intertidal and Shallow Subtidal Invertebrate Communities

There is little direct documentation of invertebrate communities in Port Simpson Bay, and descriptions of most of the fauna have to be based on habitat characteristics of substrate and wave exposure described by Tera Environmental Consultants Ltd. (1981). The only reported survey of invertebrates in the area (Lee Doran Associates Ltd. 1975) examined two habitats relatively close to the proposed terminal facility at one site south of Grassy Point and at four sites in Port Simpson Bay and Stumaun Bay. These data have been incorporated into the descriptions of habitats which follow.

Bedrock and Boulder Substrate

Rock and boulders occur in the supralittoral and intertidal zones along almost all of the shorelines in the area of Port Simpson Bay. However, continuous bedrock and boulder substrates only occur on the shores of Birnie Island and the coastline north of Flewin Point. In other areas, rock and boulder outcrops are interspersed with sand, mud, or gravel/cobble substrates. The majority of the rocky shores in Port Simpson Bay are partially wave exposed or semi-protected while the coastline north of Flewin Point is exposed to the full force of sea swell and waves from Dixon Entrance. Therefore the invertebrate community north of Flewin Point is probably different than that typical of the more protected shores in Port Simpson Bay. There is no information on these more exposed sites in Port Simpson Bay. However the general characteristics of invertebrate communities in exposed rocky habitats have been described earlier and probably apply generally to the habitats north of Flewin Point.

The communities south of Flewin Point in more protected waters of Port Simpson Bay have only been described by the samples collected by Lee Doran Associates Ltd. (1975) on a partially exposed bedrock and boulder beach south of Grassy Point in November, 1974 (Table 3.5.1). In general, the rocky intertidal was inhabited by relatively few species compared to the numerous and diverse fauna which may occur on other partially exposed shores. Although he found some species which are typical also in exposed coastlines, such as Katarine tunicata and Thais emarginata, the presence of the mussel Mytilus edulis (rather than Mytilus californianus) and the abundance of littorine snails are suggestive of the wave-protected environment. Littorine snails were the most abundant herbivore and the hermit crab Pagurus spp. was the most common scavenger occuring in all but the uppermost zone.

TABLE 3-5.1

INTERTIDAL FAUNA ON A BEDROCK AND BOULDER BEACH NEAR GRASSY POINT, NOVEMBER 1974

(From Lee Doran Associates Ltd. 1975)

Zone (0 m = datum tide)	# Quadrats Studied	Species	Total Animals	# Quadrats With Animals	Animals/m²
Lower (below 2 m)	5	Balanus spp.	73	3	146.0
		Katarina tunicata	1	1	2.0
		Acmea scutum	6	3	12.0
		Pagurus sp.	82	3	164.0
		Tonicela lineata	1	1	2.0
		Hemigrapsis sp.	2	1	4.0
		Isopod (Ligia?)	1	1	2.0
		Littorina spp.	16	2	32.0
		Amphipods (Orchestia sp?)	2	1	4.0
Mid (-2 to +4 m)	10	A. Scutum	14	4	14.0
		Balanus spp.		7	17.1% av.cov.
		Littorina spp.	786	9	786.0
		Pagurus sp.	97	6	97.0
		Amphipods (Orchestia sp?)	20	2	20.0
		Mytilus edulis	86	6	86.0
		A. digitalis	21	5	21.0
		Goby	1	1	1.0
		Hemigrapsis sp.	1	1	1.0
		Thais emarginata	1	1	1.0
		A. persona	2	1	1.0
		Isopod (Ligia?)	1	1	1.0
Upper (above +4 m)	10	A. persona	30	8	30.0
		Littorina spp.	596	8	596.0
		Balanus spp.		9	5%
		Pagurus sp.	7	1	7.0
		Mytilus edulis	4	1	4.0
		Goby	1	1	1.0
		Amphipods (Orchestia sp?)	1	1	1.0

Barnacles, (Balanus spp.) accounted for an average of 17 percent of the cover in the mid-intertidal zone, and were present in 76 percent of the quadrats sampled over the entire intertidal zone.

As a result of the limitations imposed by only one sample, many other animals are likely to be represented in the lower zones, in addition to those collected by Lee Doran Associates (1975). These include a wide variety of crabs (Cancer oregonensis, and Hemigrapsus nudus), amphipods (Amphithoe spp.), and isopods (Idotea wosnesenskii and Gnorimosphaeroma sp.), snails (Searlesia dira and Lacuna Sp.), and chitons (Mopalia sp. and Tonicella sp.), as well as other less abundant groups such as encrusting sponges (Haliclona permollis and Ophlitspongia pennata), bryozoans, nudibrachs, polychaetes (both sedentary filter feeders such as Spirorbis and errant forms such as Nereis sp.), small asteroids, and holothuroids Cucumaria miniata and Eupentacta quinquesemita. There are no commercially important invertebrate species associated with these intertidal habitats, however, these communities do play a role in nearshore food webs within the bay by supplying prey species (e.g., amphipods, larval planktonic organisms) to fish species within the Bay (Simenstad et al. 1979).

Subtidal areas of rocks and boulders in the waters of Port Simpson Bay are probably limited to minor areas which occur in Rushbrook Passage and in offshore reefs in Inskip Passage. No information exists documenting the invertebrate resources of these areas. However, these areas generally support kelp communities (Macrocystis or Nereocystis) which provide additional habitats for a relatively rich community of invertebrates. The major grazers in this community are likely to be sea urchins, particularly the commercial red urchin Strongylocentrotus franciscanus, as well as the other harvested species (abalone and octopus) known to occur in other rocky subtidal areas (Section 3.5.1.2). Other grazers in the community are likely to be chitons, limpets (Acmeamitra), snails (Calliostoma sp. and Lirularia sp.) and the spider crab, Pugettia gracilis (Nyblade 1978).

Cobble-Gravel Substrate

Cobble and gravel are not major components of the shoreline materials in Port Simpson Bay, however, small pockets of these substrates occur in the intertidal and supralittoral zones predominantly on bedrock and boulder shorelines. Most of these areas of cobble and gravel are partially exposed, however, a few locations such as the east shore of Birnie Island are semi-protected. Subtidally only one small deposit of gravel has been identified in Port Simpson Bay approximately 1 km offshore of Bath Point.

Partially were exposed and semi-protected gravel and cobble substrates are an unfavourable habitat for marine invertebrates because of their instability and abrasiveness during wave activity and tidal changes. Zonation, if it occurs, is likely to be less distinct than it is on rock shorelines. Nevertheless Simenstad et al. (1979) suggest that the abundant habitats beneath the rock surfaces make this one of the most productive habitats in terms of the invertebrate numbers.

The invertebrate species composition of cobble-gravel substrates in Port Simpson Bay has not been investigated. However, Smith and Webber (1978) have completed surveys of these habitats in northern Puget Sound and report that the most common groups are gastropods (Littorina sp.), limpets isopods, amphipods, polychaetes and opportunistic crabs (Pagurus sp. and Hemigrapsus sp.). The ubiquitous barnacles and mussels are also likely to be present. The commercial butter clam prefers a porous gravel substrate and occurs in some of these substrates in the area of Port Simpson.

The small area of gravel-cobble substrate which occurs subtidally in Port Simpson Bay may support a variety of crustaceans, primarily mysids and amphipod species, sea cucumbers and perhaps shrimp (Lee and Bourne 1977; Cross et al. 1978). This area was not sampled by Lee Doran Associates Ltd. (1975) during their survey, and it represents a very minor subtidal habitat in Port Simpson Bay.

Sand and Mud Substrates

Sand forms a major portion of the intertidal and supralittoral substrate materials from Grassy Point to Stumaun Bay. Between Flewin Point and Grassy Point and on Birnie Island these substrates occur less frequently, usually in small pockets in the intertidal upper zones. Exposure of these sand substrates is approximately equally divided between partially wave-exposed and semi-protected environments.

Stumaun Bay, a semi-protected environment, represents an area of intertidal mixed sand and mud habitat. Subtidally, fine grained sediments ranging from silt to sand are also the predominant substrate within Port Simpson Bay.

In general, invertebrate communities of partially exposed and semi-protected sand habitats are characterized by low species diversity and low total biomass (Nyblade 1978). Beach erosion and limited food availability are considered the major factors restricing the fauna in this habitat. Little or no zonation occurs in the invertebrate community, and most of the species that are successful in this habitat occupy the lower shoreline zone.

The intertidal sand habitats of Port Simpson Bay have not been surveyed, and the general features of these communities have already been addressed for the marine approaches. Species typical of this habitat include amphipods (Orchestia traskiana), nemerteans, as well as several bivalve species (Tellini sp., Mysella tumida, and Transenella tantilla, Macoma sp. and Mya sp.) and detrital-deposit feeding polychaetes (Cerebratulus sp., Nephtys sp., Paronella sp., and Exosphaeroma sp.) Kozloff 1973; Smith and Webber 1978).

The fine grain habitats (sand and mud) in the semi-protected waters of Stumaun Bay are largely characterized by the presence of eelgrass. The importance of eelgrass has been discussed earlier, and it generally supports a unique and diverse group of invertebrate species. Lee Doran Associates Ltd. (1975) report abundant eelgrass in Stumaun Bay form colour air photos taken in September, 1974. Although these researchers only sampled the subtidal areas of Stumaun Bay they reported finding numbers of juvenile crabs, which they suspected were the commercial species, Cancer magister. Other species which Doran et al. (1975) reported for subtidal areas, and which may also occur intertidally, were the polychaete Nereis sp. and the commercial clam Protothaca staminea. Amphipods, isopods and nudibrachs are also typically abundant in eelgrass beds and represent an important food source for most fish which occur in the Bay, including juvenile salmon, groundfish and other inshore species.

Subtidal surveys in Port Simpson Bay are limited to a few Ponar grab samples taken at four stations in the main bay and Stumaun Bay (Table 3-5.2) at depths ranging from

TABLE 3-5.2 BENTHIC INVERTEBRATES COLLECTEC BY PONAR GRAB SAMPLER NEAR PORT SIMPSON, NOVEMBER 1974 (From Lee Doran Associates Ltd. 1975)

SPECIES	Station No:	S1-1	S2-2	S3-2	St-1
	Depth (m):	128	48	45	7
	Substrate:	Very Fine Silt	Fine Silt	Medium Silt	Medium Sand
BIVALVIA					
Yoldia amygdalea			4	8	
Compsomyas subdiaphana			6	7	
Nucula tenuis			2		
Axinopsida serricata					11
Tellina nuculoides			3	3	1
Cardiomya pectinata			1		
Protothaca staminea var. *ruderata*					7
GASTROPODA					
Mitrella gouldii				2	
SCAPHOPODA					
Dentaliium sp. *(rectius?)*			2		
POLYCHAETA (errant)					
Phyllodoce sp.				1	
Goniada brunnea		2	3		2
Nereis sp. 1					5
Polynoid B					3
Lumbrineris sp.					2
Nephtys sp. 2		1			
Onuphius sp.					6

TABLE 3-5.2 - Cont'd.

SPECIES	S1-1	S2-2	S3-2	St-1
Station No:	S1-1	S2-2	S3-2	St-1
Depth (m):	128	48	45	7
Substrate:	Very Fine Silt	Fine Silt	Medium Silt	Medium Sand
POLYCHAETA (sedentary)				
Sternaspis fossor		2	1	
Artacama conifera			1	
Stylarioides papillata				1
Praxillella affinis var. *pacifica*		1		
Ammochares fusiformis				11
Terebellides stroemi	1	17	2	
Melinna cristata		1		
Arenicola pusilla				1
Prionospio malmgreni				11
ECHINDERMATA				
Asteriodea				
Ophiura lutkeni	5		4	
Holothuroidea				
Molpadia intermedia	1	1		
Eupentacta pseudoquingesemita		1		
Crustacea				
Pagurus sp. 2 (juveniles)				8
Cancer sp. (juveniles)				6
Pentidotea resecata				5
Mpithoe sp.				1
Ampelisca sp.				7
Total Animals	10	44	29	88
Total Species	5	13	9	17
Total Weight gm	34.09	195.02	186.24	5.11
Diversity	0.418	0.738	0.712	1.003

7-128 m. These samples usually collect the smaller evenly distributed epibenthic and infaunal organisms. The deepest station, a fine silt bottom, had the fewest species, dominated by polychaetes, brittle stars and the small sea cucumber (Molpadia intermedia). Species diversity and biomass increased at the two medium depth stations, 45 and 48 m. These were silt (mud) substrates, and were characterized by polychaetes, non-commercial bivalves and a few gastropods. The most abundant and diverse fauna was associated with the shallow (7 m) sample in a sandy substrate of Stumaun Bay. Numerous polychaetes, bivalves, and crustaceans, including the commercial Cancer genus, dominated these samples.

The subtidal species reported by Lee Doran Associates Ltd. (1975) are similar to those described by Ellis (1971) as typical of sand and silt substrates in the Strait of Georgia. Ellis (1971) identified a group of nine species which he feels are the most ecologically significant in the invertebrate community of fine grained substrates, and seven of these genera were reported from samples in Port Simpson Bay. Also consistent with Ellis's (1969 and 1971) results is the fact that the deeper areas (greater than 70 m) tend to be impoverished in species and in biomass, and that the shallower stations have rich standing crops.

It should be stressed however, that the shallow subtidal areas in Port Simpson Bay remain poorly documented, and numerous other species may occur, particularly larger, more scattered sedentary species, as well as mobile species, such as crabs or shrimp.

3.5.2.2 Commercial Species and Resource Utilization

There is little available information regarding the commercial, native domestic or recreational utilization of invertebrate resources in Port Simpson Bay. Personal communications from government management biologists (P. Harvey and P. Sprout) indicate that Port Simpson Bay is not an important commercial harvesting area for any of the major shellfish species regularly reported in catch statistics for Area 3. The B.C. Ministry of Environment, Marine Resources Branch (unpubl.) report a bed of geoducks offshore of Port Simpson, which extends south, on the outside of Finlayson Island (Map 3-5.1). This bed is not currently harvested, although there is a possibility of an increase in the importance of the geoduck fishery on the North Coast in the future (P. Sprout, pers. comm.). Quayle and Bourne (1972) report concentrations of butter clams in the Port Simpson area, but presently they are only recreationally taken and in areas north and south of Port Simpson Bay, Maskelyne Island and Cunningham Passage, respectively. There is no information available regarding the size of this recreational fishery, however, daily bag limits of 75 clams apply (Fisheries and Oceans 1980).

Lee Doran Associates Ltd. (1975) found the commercial crab Cancer magister in Port Simpson Bay during beach seines near the proposed dock site and reported the littleneck clam in subtidal benthic samples from Stumaun Bay. The mussels, Mytilus edulis, although not of great significance either commercially or recreationally on the North Coast, also occurs in widely scattered areas on shores thoughout Port Simpson Bay. It is possible that other species of some commercial or domestic importance may also occur in some areas of Port Simpson Bay; particularly sea urchins and octopus.

There is no available information regarding the abundance or domestic utilization of these species in Port Simpson.

3.6.0 PLANKTONIC COMMUNITIES

3.6.1 Marine Approaches

Plankton are a diverse group of small organisms found primarily in the upper layers of the water column, and unable to maintain their distribution against the movement of water masses. Included in this community are the bacterioplankton, phytoplankton and zooplankton, with the latter group also including the larval stages of many intertidal and benthic invertebrates, as well as the larval stages (ichthyoplankton) of some fish species. A dominant feature of planktonic communities is their pronounced seasonal and spatial differences in abundance and species composition. Spatial variability occurs both with depth in the water column and between different areas. Many macroinvertebrate and fish species feed extensively on some members of planktonic communities at some stage in their life history. As a result, planktonic organisms represent a fundamental trophic link between the primary producers and dominant carnivores in marine food webs.

3.6.1.1 Phytoplankton

Phytoplankton are microscopic plants responsible for a significant portion of the primary production in coastal marine environments through the photosynthetic conversion of low-energy inorganic substrates (carbonate ion) into high-energy organic carbon molecules. The predominant role of phytoplankton as primary producers in marine food webs is only surpassed in some nearshore estuarine environments where much of the organic carbon entering the food web is derived from detrital vegetation (e.g., peat), or in other shallow nearshore environments where benthic algae are the dominant site of photosynthetic production. Phytoplankton include unicellular algae ranging in size from <5 µ to 100 µ in diameter, as well as chains and clusters of algal cells.

There are substantial seasonal and regional differences in the species composition, abundance and productivity of phytoplankton communities in North Coast British Columbia waters, although the description of phytoplankton from some areas is limited by the nature and extensiveness of the available data base.

In general, phytoplankton communities are dominated by flagellates as opposed to diatoms, but diatoms increase in importance in Hecate Strait, Chatham Sound and protected waters of the inside mainland coast.

The standing crop of phytoplankton in North Coast waters is usually highest between April and August with secondary fall blooms occuring during September or October in at least some Areas. The maximum abundance of phytoplankton occurs at the surface or at depths from 5 to 10 m depending on the area and time of year. Overall phytoplankton abundance is greatest in Hecate Strait, Chatham Sound, and protected waters of the mainland coast, while lowest abundance appears to be in waters off the west coast of the Queen Charlotte Islands.

3.6.1.2 Zooplankton

Zooplankton are a complex assemblage of fauna ranging in size from microscopic rotifers (<100 µ) to relatively large carnivorous copepods, ctenophores and euphausiids (10-15 mm). Some zooplankton are herbivorous and graze on phytoplankton (filter feeders), while others are omnivorous or carnivorous at one or more stages in their life cycle. Zooplankton are the dominant primary consumers in marine food webs, and in turn support members of higher trophic levels including fish, birds and marine mammals. As indicated earlier, the zooplankton community also includes the larval stages of shellfish, eggs and larvae of fish, and other forms which are planktonic for periods ranging from several days to several months.

Zooplankton may occur at various depths in the water column depending on the area, season, and time of day, but their vertical distribution in the waters of the marine approach is not well documented. In the surface waters (3 m) of the marine approach areas, copepods tend to dominate the zooplankton community throughout most of the year. The areas where copepods are the least dominant are Hecate Strait and the "inside" waters of the mainland coast. In these areas, other crustaceans and other invertebrate species including barnacle larvae, cladocerans, siphonophores, and polychaetes occur at some time during the year. The abundance of zooplankton changes with season, and generally all areas showed lowest standing crops during the winter months and higher values during the spring, summer or fall. Interpretation of seasonal changes is generally limited by the lack of data. The species diversity of zooplankton communities appears to be affected by the dominance of a few copepod species. Thus whenever standing crop values are relatively high ($>500/m^3$), diversity tends to be lowest due to the abundance of one or a few copepod species. Nevertheless, during peak periods of abundance, particularly spring and summer, other zooplankton organisms such as fish larvae and invertebrate larvae are probably also present. The data base is presently insufficient to adequately describe differences in zooplankton abundance between different geographic areas of the North Coast.

3.6.1.3 Other Components

Many marine species, including groundfish, pelagic fishes and shellfish have planktonic life history stages and at certain times of the year these ephemeral zooplankton may account for a considerable proportion of the community biomass. The duration of the planktonic phase of these forms ranges from a few days, as in the case of the eggs of lemon sole to over 100 days such as the zoea stage of Dungeness crab. In many cases, these relatively short-lived planktonic stages represent critical or sensitive periods in the life of economically important fish or shellfish resources. Usually, the presence of these larval stages of ephemeral invertebrates and fish coincides with the spring and summer blooms of phytoplankton and zooplankton.

Brachyuran (true crabs) zoea can represent a significant proportion of zooplankton communities in the spring when their density may approach $15,000/m^2$, particularly in areas such as Rose Spit and McIntyre Bay where relatively shallow open waters occur over sand substrates. Much lower numbers of zoea ($0-100/m^2$) are found at the heads of protected inlets. Other decapod larvae and zoea are more common ($1-40/m^2$) during winter months within the outer channels (e.g., Principe Channel) near the eastern part of Hecate Strait. Barnacle larvae have been measured in concentrations up to $3000/m^2$ in the spring, and are widespread in their distribution throughout the North Coast. Unidentified crustacean larvae were also one of the most numerous constituents of spring and fall zooplankton samples particularly in the waters of the "Inside Passage" of the mainland coast.

Relatively few fish eggs have been recorded in near surface samples collected in waters of the marine approaches, however they have been observed in almost all areas. Fish larvae have generally not been collected in zooplankton samples along the marine approaches largely as a result of sampling methods. In southeastern Alaska, higher densities of eggs and larvae have been measured, particularly during the spring, and in waters of the marine approach where herring spawning is known to occur, such as portions of Chatham Sound, herring larvae probably become an important species in the zooplankton community in nearshore waters from late April to June.

3.6.2 Terminal

Information describing planktonic communities within Port Simpson Bay is extremely limited. Lee Doran Associates Ltd. (1975) collected three zooplankton samples during November 1974, two within Port Simpson Bay itself and the third just west of Birnie Island. Phytoplankton samples were not obtained during this study. The most relevant data regarding probable phytoplankton and zooplankton species composition and abundance in the area of the proposed LNG facility are those of Dilke et al. (1979). These samples were taken approximately 6.4 km west of Port Simpson in Chatham Sound during late fall. Data describing seasonal trends in phytoplankton and zooplankton populations within Port Simpson Bay are not available, and probable trends can only be estimated based on observations from other similar coastal areas of British Columbia (Dilke et al. 1979; ESL Ltd. unpub. data). Seasonal and spatial differences in the productivity of waters adjacent to the proposed LNG terminal, as well as the relative productivity of these waters compared to other coastal areas of B.C. are also unknown.

3.6.2.1 Phytoplankton

Table 3-6.1 shows the species composition and abundance of phytoplankton collected from a depth of 3 m in fall and early winter at stations in Chatham Sound immediately adjacent to Port Simpson Bay (Dilke et al. 1979). Unidentified flagellates ranging in size from less than 5 to 15 microns comprised 94 and 98% of the September and October phytoplankton standing stock respectively, with the remainder of the phytoplankton community consisting of centric and pennate diatoms and dinoflagellates. The loss of most of the pennate diatoms and the reduction in the number of centric diatoms observed in the October sample may be associated with the decrease in salinity from 30.0 to 27.5 $^{o}/oo$ due to increased precipitation and freshwater runoff, or a natural successional change in community structure due to changing light regimes, nutrient availability and other physio-chemical changes occurring at this time of year. Despite the increase in flagellates by October, chlorophyll a levels were reduced from 1.29 mg/m^3 to 0.51 mg/m^3, demonstrating the overriding effect of the larger diatoms (in this case Chaetoceros and Nitzschia) on chlorophyll concentration. The species composition, abundance and chlorophyll a concentrations observed in this portion of Chatham Sound were consistent with other North Coast stations sampled during the late fall-early winter. For example, mean September and October chlorophyll a concentrations measured in other B.C. coastal waters were 1.40 ± 1.31 and 1.11 ± 1.53 mg/m^3, respectively (Dilke et al. 1979).

There are no available data describing the seasonal trends in phytoplankton species composition and abundance within Port Simpson Bay. However, from trends observed in similar areas of the B.C. coast, together with existing knowledge regarding the influence of the Skeena and Nass Rivers

TABLE 3-6.1 PHYTOPLANKTON SPECIES COMPOSITION AND ABUNDANCE (cells/L) NEAR PROT SIMPSON, SEPTEMBER AND OCTOBER 1978* (From Dilke et al. 1979)

SPECIES	STATION 005-13	STATION 006-10
CENTRIC DIATOMS		
Chaetoceros (4-15)	784	-
" (16-25)	3,660	838
" (36-45)	1,050	-
Coscinodiscus (<50)	-	1,120
" (<50)	784	60
Ditylum brightwellii	-	10
Rhizosolenia setigera	1,310	-
R. stolterfothii	522	-
Skeletonema costatum	209	2,240
Thalassiosira (21-40)	261	1,120
" (41-60)	522	559
Total	9,102	5,947
PENNATE DIATOMS		
Licmophora abbriviata	261	-
Nivicula spp.	-	10
Nitzschia closterium	522	-
N. pungens	2,880	-
Nitzschia spp.	261	-
Pleurosigma spp.	261	-
Thalassiothrix spp.	261	-
unid. pennates (21-40)	522	-
Total	4,968	10
FLAGELLATES		
Ceratium lineatum	-	600
Dinophysis spp.	2,090	90
Peridinium spp.	-	30
Unid. dinoflaggelates (<5)	-	559
Dictyocha fibula	-	10
Distephanus speculum	-	279
Ebria spp.	-	279
Unid. flaggelates (<5)	179,000	205,000
" " (6-15)	160,000	142,000
Total	289,180	348,847

* Samples taken from a depth of 3 m.

on water quality in the vicinity of Port Simpson Bay, certain general seasonal changes in phytoplankton community structure and abundance are probable. Only minor changes in the species composition and abundance observed in October are likely to occur during the period from November to February. While overall standing stock may decrease slightly to 1.0 - 2.0 x 10^5 cells/L, the phytoplankton community should still be dominated by large numbers of microflagellates. Centric and pennate diatoms will likely occur in low numbers throughout the winter.

With the increase in water temperature and development of a new thermocline in the spring, conditions favourable for a net increase in photosynthesis (Parsons 1965) will again enable the larger diatoms to develop into a signficant proportion of the phytoplankton community. However, spring phytoplankton data from Chatham Sound (Dilke et al. 1979) suggest that the major blooms of diatoms in Port Simpson Bay will likely occur after the late May-June freshet of the Skeena and Nass Rivers (Hoos, 1975), once the initial increase in water turbidity from suspended sediment loads associated with freshet disappear. If productivity in this area is under constraints similar to those involved in the Strait of Georgia (Parsons et al. 1967), then phytoplankton production within the estuarine environment in Port Simpson Bay can be expecred to be generally lower than in the boundary waters immediately outside Chatham Sound.

3.6.2.2 Zooplankton

The limited data describing zooplankton in Port Simpson Bay (Lee Doran Associates Ltd. 1975) suggests that winter zooplankton communities differ only slightly from other inshore coastal areas of B.C. The standing stock of zooplankton in three samples collected during October and

November 1974 was 77.5, 88.8 and 100.2 organisms/m^3. Table 3-6.2 shows the species composition of these Port Simpson Bay samples, as well as a late winter sample obtained from Fin Island, B.C., approximately 170 km south of Port Simpson (ESL Ltd. unpub. data). Both areas were numerically dominated by the copepods Acartia longerimis and Pseudocalanus minutus. Siphonophores (Class Hydrozoa), Oikopleura (Class Larvacea) and ephemeral zooplankton such as barnacle cyprids and nauplii, decapod zoea, and the larvae of other invertebrate groups typically comprise a relatively large proportion of the winter zooplankton community in North Coast waters (ESL Ltd. unpub. data). A much larger proportion of zooplankton taxa other than copepods (>70%) was present in near surface (3 m) samples collected from Chatham Sound west of Port Simpson in September 1978 compared to October (Dilke et al. 1979) (Table 3-6.3) when the species composition of the zooplankton community was more similar to that described by Lee Doran Associates Ltd. (1975). However, many of the differences between the results of the September and October surveys completed by Dilke et al. (1979) may be attributable to the time of day when the samples were collected (September, midday; October, after dusk) since many species of zooplankton undergo extensive diel vertical migrations.

As in the case of phytoplankton there are no data describing seasonal changes in zooplankton communities near Port Simpson. The over-wintering juveniles of Acartia and Pseudocalanus probably dominate the winter zooplankton community, feeding primarily on the abundant micro-flagellates. On the basis of studies completed elsewhere, surface zooplankton densities could range from 50 to 200 zooplankton/m^2 (Dilke et al. 1979). The calanoid copepod Centropages abdominalis and the cyclopoid copepods of the genus Oithona could also be relatively abundant, particularly in early

TABLE 3-6.2 A COMPARISON BETWEEN WINTER ZOOPLANKTON SPECIES COMPOSITION IN PORT SIMPSON BAY AND FIN ISLAND* WATERS, BRITISH COLUMBIA

		Taxanomic Group	Port Simpson: 10-11/1974 (Lee Doran Assoc. 1975)** % composition	Fin Island: 02-03/1977 (ESL Ltd. unpub. data)*** % composition
Ctenophora	:	Pluerobrachia bachei	0.07	0.7
Mollusca	:	Unknown Gastropods	-	0.23
Crustacea	:	Acartia	51.20	49.88
	:	Psduedocalanus	32.06	31.09
	:	Metridea	7.64	0.23
	:	Calanus	3.05	0.70
	:	Other copepods	3.78	7.66
	:	Euphausia	0.29	-
	:	Mysidacea	0.07	-
	:	Amphipoda	0.51	-
	:	Decapoda (larvae & zoea)	-	0.46
	:	Cirripedia (Cyprid stage)	-	1.62
Urochordata	:	Oikopleura	-	5.80
Chaetognatha	:	Sagitta elegans	1.34	1.62

* Fin Island is located west of the entrance to Douglas Channel.
** Samples were oblique hauls of unknown distance mean of 3 samples.
*** Samples were vertical hauls from 50 m.

TABLE 3-6.3

ZOOPLANKTON SPECIES COMPOSITION AND ABUNDANCE NEAR PORT SIMPSON, SEPTEMBER AND OCTOBER 1978
(From Dilke et al. 1979)

SPECIES	STATION 005-13* (09:78)	STATION 006-10* (10:78)
ZOOPLANKTON (excluding Crustaceans)		
Echinopluteus larvae	1.0	0.1
Limachina helicina	0.2	-
Phialidum sp.	3.5	-
Pluerobachia pileus	13.0	0.5
Doliolum sp. *(Tunicata)*	6.5	-
Sagitta elegans	-	0.1
unid. anthomedusae	0.5	-
unid. bivalve larvae	1.5	-
unid. larvaceans	0.2	0.1
unid. lepto medusae	1.8	-
unid. polychaetes	3.3	-
unid. polychaete larvae	14.0	-
unid. prosobranchs	6.3	3.5
unid. prosobranch larvae	7.0	-
unid. siphonophores	66.2	-
Sub-Total:	125.0	4.3
CRUSTACEANS (excluding Copepods)		
barnacle nauplii	2.0	-
Euphausia pacifica	-	2.8
Thysanoessa raschii	-	1.0
unid. euphausiid larvae	26.1	-
Parathemisto sp.	0.8	-
Podon sp.	0.2	-
Sub-Total:	29.1	3.8

TABLE 3-6.3 - Cont'd.

COPEPODS

Arcatia spp.	5.0	1.8
Calanus marshallae	-	0.2
C. pacificus	0.8	61.4
C. plumchrus	1.5	-
Centropages mcmurrchi	0.2	0.6
Corycaeus anglicus	4.5	0.6
Epilabidocera amphitrites	1.5	0.1
Metridia pacifica	-	0.6
Paracalanus parvus	3.3	0.1
Pseudocalanus minutus	0.2	1.0
Tortanus discaudatus	1.0	1.9
Unid. harpacticoids	0.2	-
Sub-Total:	18.2	68.1
TOTAL ZOOPLANKTON/m3**	172.3	76.2

* These two stations are located at 54° 32'N, 130° 32'W, approximately 6 km west of Port Simpson.

** 11.3 cm diameter Miller net towed for 10 min. at 5 knots at approximately 3 m depth.

winter (ESL Ltd. unpub. data). The planktivorous ctenophores such as *Pleurobrachia* which are common in summer and fall open-water surface samples, will likely become less important during winter (Fulton 1968; Table 3-6.3), although considerable numbers of *Pleurobrachia* were observed during a winter survey of deep water inlets near Kitimat, B.C. in 1977 (ESL Ltd. unpub. data). Various invertebrate larval forms (polychaetes, bivalves, and others) may also form a significant portion of the zooplankton community near Port Simpson during winter.

During spring, the release of large numbers of copepod eggs, and the subsequent emergence of copepod nauplii, will probably lead to an almost complete numerical dominance of the zooplankton community by various copepods in different stages of development. Due to the probable initial delay in phytoplankton growth in inshore waters affected by the freshet cycle of the Skeena and Nass Rivers, the major increases in zooplankton abundance within Port Simpson Bay will not likely occur until late June or July. Surface zooplankton densities during late spring and summer may exceed $1500/m^3$. However, as in the case of phytoplankton, maximum zooplankton densities will probably be limited to a certain extent by the estuarine nature of the Port Simpson Bay environment. By August, total zooplankton densities, still dominated by copepods, may be considerably reduced from the summer maximums, and fall species like *Oithona helgolandica* will probably dominate for a short time (ESL Ltd. unpub. data).

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3.80 VEGETATION

3.8.1 Marine Approaches

3.8.1.1 Aquatic Vegetation

3.8.1.1.1 Algal Communities

Inventory

The marine algal resources of northwestern British Columbia are extremely diverse. The best documented algal communities are the most conspicuous and most abundant, namely, bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis integrifolia*).

Bull kelp is whip-like in appearance. A long unbranched stripe or stalk extends from a holdfast at the bottom up to 25 m, to a single large blade supporting gas bladder. This arrangement suspends the photosynthetic blades, which may be up to 5 m long, as close as possible to teh surface for maximum light exposure. This plant is essentially an annual, although occasional plants may survive to the next season.

Giant kelp may have as many as 13 stipes rising up to 30 m from a single holdfast. Blade supporting gas bladders occur singly at numerous points along the stipe. This plant is a perennial and will regrow if not shorn back to the bare stipe.

Bull kelp and giant kelp have substantially different habitat requirements even though they occasionally occur in mixed beds. Bull kelp may grow in waters up to 18 m deep but is usually found from 7 - 9 m below zero tide level. Giant kelp is usually found in shallower waters from slightly above to 6 m below zero tide level. Bull kelp is able to tolerate strong currents and exposure to surf, therefore, where the two species occur together, bull kelp tends to form a protective ring around the deeper and more exposed perimeter of giant kelp. Both species grow in areas of rocky bottoms. Individual plants of bull kelp may weigh up to 12 kg; giant kelp may weight up to 45 kg. Hence the rocks to which these plants attach their holdfasts must be sufficiently large to withstand the stresses which waves can impose on such large structures.

Initial surveys of kelp beds on the B.C. coast were undertaken by Cameron in 1916. Following this only sporadic surveys were conducted. The Marine Plants Section of the Marine Resources Branch has conducted systematic surveys since 1975 to quantify the standing stocks of kelp at selected locations along the B.C. coast (Figure 3-8.1). Areas of high and low density kelp beds are mapped for those areas which have been surveyed in the marine approaches of the study area, namely the Goschen Island to Tree Knob Group, the Dundas Island Group, the Estevan Group and the north and west coasts of Graham Island (Map 3-8.1). A summary of the kelp bed areas and standing crops (derived from Coon et al. 1979, 1980; Field & Clark 1978; Field et al 1977) is presented in Table 3-8.1. Of the above-mentioned areas, the greatest harvestable density of kelp beds (tonnes/ha) occurs in the Goschen Island to Tree Knob Group; however, the Dundas Group has the largest area of kelp beds for the distance of coastline surveyed.

Stability and Sensitivity

Kelp beds are usually persistent features in locations where habitat conditions are suitable. Once plants are removed by storm action, man made disturbance or by predation from sea urchins, the area will recolonize provided the character of the habitat remains the same, and the disrupting influence is removed. An example of the stability of these kelp beds is the presence of kelp beds in the Porcher group in 1916 (Cameron, 1916). B.C. Research found they were still there in 1946 (Anon, 1948). Areas surveyed in 1976 (Coon et al., 1980) overlapped sufficiently with the 1946 survey to indicate that these beds had occupied the same area for at least 30 years and likely for 60 years or more. However, bull kelp does not always occur in equal abundance in the same location year after year. Occasionally bull kelp beds which occur in a particular location one year, disappear by the following year (Scagel 1947).

Kelp beds do not suffer permanent damage when harvested properly. Since bull kelp is an annual it can be cut at any depth and harvested whenever the plants are large enough to be of commercial value. This kelp depends on its spore producing ability to survive in the same location year after year. By the time the plants are large enough to harvest, sufficient spore production has taken place to ensure reproduction (Scagel 1947). Giant kelp, because it is a perennial can be harvested up to two times during one season provided the cutting is not low enough to damage an individual plant's ability to regrow.

Harvesting of these plants can take place at any time during the summer season in calm water.

Habitat Values

Marine algae provide a number of different habitats for marine organisms. Kelp beds may be looked upon as forests as they tend to provide a similar sort of environment in the sea as trees do on land. A number of fish species use kelp beds as escape cover from predatory fish. The kelps also act as substrates for a number of epiphytic organisms and therefore provide a local complement of flora and fauna which serve as a food source for resident fishes.

Intertidal and subtidal algae other than the kelps also provide cover for invertebrates and small fish. These algae in addition to the kelps provide spawning substrates for a number of fish, the most notable of which is the herring.

Commercial Value

Kelps (Nereocystis and Macrocystis) are primarily harvested for their content of algin, a versatile colloid which is used for emulsifying, stabilizing and suspending food, pharmaceutical and other commercial products. Harvesting takes place by cutting the kelp fronds below water by means of a barge carried mowing machine; the fronds are then forwarded to a factory for processing.

A recent commercial venture which has been gaining importance in the coastal economy has been the roe-on-kelp fishery. Kelp fronds are harvested immediately following herring spawning. The fronds with their complement of herring roe are marketed as a delicacy in Japan.

Other commercially important kelp species which are occasionally harvested on the British Columbia coast are Laminaria spp. and Porphyra spp. Much of this harvesting is done manually and is an important source of income for a few native communities along the B.C. coast.

The values of kelp products vary according to the market. However, in order to provide an estimate of the commercial value of kelp stocks, the value of kelp meal is considered to be $235 per wet tonne or $2,000 tonne of dry meal (M. Coon, pers. comm.).

The standing corps for the surveyed portions of the Northwest coast (Map 1) are presented in Table 3-8.1.

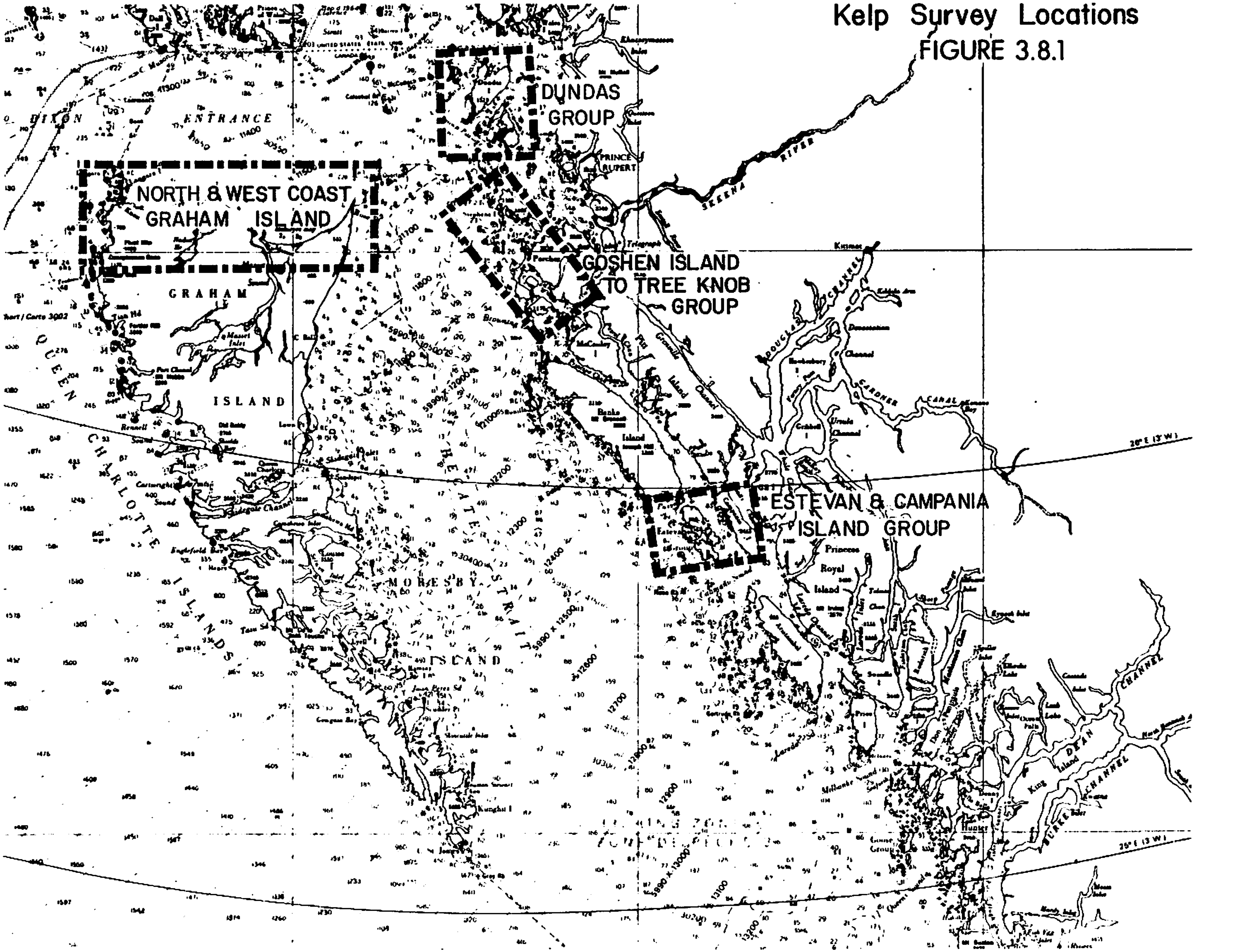
3.8.1.1.2 Vascular Plants

SUBMERGENT

Inventory

Two species of marine vascular plants or sea-grasses, are ubiquitous along the shoreline of northwestern British Columbia wherever appropriate substrates are found. *Zostera marina*, or eelgrass, is found subtidally along protected sand beaches and mudflats. Surfgrass (*Phyllospadix scouleri*), on the other hand, inhabits the rocky intertidal zone along the exposed shoreline. Habitat requirements for the two species are sufficiently different that they do not occur together. The distribution and abundance of these species on the British Columbia coast has not been mapped.

Eelgrass is an eurythermal (0° to 30°C), euryhaline (10 to 40%) member of the Potamogetonaceae, subfamily Zosteroideae (den Hartog, 1979). It is unable to tolerate exposure to wave shock, hence its preference for protected shorelines with sand or mud bottoms. Phillips (1972) working in Puget Sound, Washington found that the lower limit of growth was controlled by low light levels which exist at depth. Moody (1978) postulated that the upper limit of growth on Roberts Bank in Southern B.C. was controlled by dessication and coincided with the one percent exposure level; that is, eelgrass did not occur above the beach level which was exposed for only a few hours during the year.



Kelp Survey Locations
FIGURE 3.8.1

TABLE 3.8.1

Summary of Kelp Bed Areas & Standing Crops for Surveyed Locations Adjacent to LNG Marine Approaches

Inventory Area	Length of Coastline Inventoried (km)	Bed Area (ha)	Total Standing Crop (wet tonnes)	Harvestable Standing Crop (MWL[1] + .6 m) (wet tonnes)	Harvestable Density (tonnes/ha)
Estevan Group & Campania Island	82	1,470	77,618	47,934	33
Dundas Group	61	1,527	74,351	53,947	35
North & West Coast Graham Island	162	2,375	77,410	61,528	26
Goschen Island to Tree Knob Group	122	1,741	113,575	82,420	47

[1]MWL - mean water level

Distribution in the study area appears to be quite consistent with available information regarding habitat requirements of, and the ecological niche occupied by, eelgrass in other areas. The upper limit of growth is probably governed by the height of MLLW (mean lower low water) in the area. The lower limit of growth is likely controlled by light attenuation at depth. Hence the width of an eelgrass bed at any specific location bears a direct relationship to the slope on which it occurs. As expected, narrow linear beds are found along steeply sloping sandy shores in the study area. Almost nothing is known about the habitat requirements of surfgrass, however, it exists on open rocky shorelines which are subject to severe wave climates. It is attached to the rock substrates by its creeping rhizomes.

Stability and Sensitivity

Seagrasses form stable climax communities in nearshore marine ecosystems, and as such, normally constitute very persistent features of their environment. Population dynamics within eelgrass beds are only poorly understood. Long term trends have to be viewed in light of the pronounced annual cycles which are apparent in eelgrass beds. In the north Pacific, leaf numbers, turion (stem) densities, and biomass decline throughout the winter from their mid-summer peaks. Fluctuations in the boundaries of eelgrass beds in response to causeway and port development have been documented for Roberts Bank, B.C. (NHB, 1977).

Human activities deleterious or beneficial to seagrass meadows may be of a temporary or permanent nature. Odum (1963) observed a decrease in seagrass productivity in response to diminished light penetration during dredging and an increase in plant production the following growing season in response to a redistribution of mineral nutrients in the dredge spoil. Detrimental effects of a more permenant nature are usually the result of direct removal of habitat through burial or excavation. Erosion surrounding a borrow pit established in an eelgrass meadow on Roberts Bank resulted in a devegetated area 2.5 times its original size within 7 years of excavation (NHB, 1977). After the removal or disappearance of eelgrass, subsequent changes in the substrate often make re-colonization impossible (Wood, 1959; Rasmussen, 1973). Port developments may also enhance seagrass production, for example, the Roberts Bank Superport causeway deflected the turbid outflow of the Fraser River away from the shoreline. The waters south of the causeway are significantly clearer than those to the north and the eelgrass meadows are considerably more luxuriant in the area having clearer water (NHB, 1977). There is no information available on the effects of toxic pollutants on eelgrass.

Natural declines in eelgrass abundance have had serious ecological consequences. Man's destruction of seagrass beds has produced similar effects. Thayer et al (1973) report that the destruction of 1,100 metric tons of seagrass due to dredging resulted in the immediate loss of approximately 1,800 tons of infauna. A further 73 tons of fishery products and 1,000 tons of macroinvertebrate infauna were lost annually as a result of the dredging.

Habitat Values

Eelgrass meadows form complex ecosystems which function chiefly through intricate detrital food webs. The true importance of seagrass meadows to coastal marine and estuarine ecosystems is generally underestimated (Thayer et al, 1973). Eelgrass is highly productive in terms of its own growth and that of the epiphytic flora and fauna it supports.

Eelgrass also prevents substrate erosion and increases sedimentation around its base. Furthermore, eelgrass serves as a nutrient pump in transferring nutrients from the sediment to the water column. Thus eelgrass meadows function as the very foundation of complex ecosystems, whose constituents, at all levels, find their basic requirements for food and shelter within and adjacent to the seagrass meadows.

The importance of eelgrass to invertebrate herbivores and detritivores is well documented (Kita and Harada, 1962; Kikuchi, 1966; Orth, 1973; and Burke and Mann, 1974). Outram (1957, 1961) describes the importance of eelgrass as an attachment substrate for herring spawn in British Columbia coastal waters. Outram and Humphreys (1974) identified Port Simpson and Big Bay as important herring spawning grounds on the Tsimpsean Peninsula. In 1979 the herring spawning for these same areas was identified as occurring 44% on eelgrass, and 28% on kelp (Haegele and Miller, 1979). Other relationships between Pacific fisheries and the eelgrass resource are described in Kikuchi (1966, 1974). Eelgrass is also of considerable importance to certain waterfowl (Einarsen 1965; Ranwell and Downing, 1959). Cottam (1934) attributed massive reductions in black brant (*Branta bernicula*) populations to the disappearance of eelgrass along the North Atlantic flyway.

Commercial Values

Eelgrass is not harvested commercially in British Columbia and is therefore not of direct importance to local or regional economics. However, in view of its key position in many complex and valuable food webs, eelgrass must be considered an important biological resource which contributes directly, albeit to an unknown extent, to commercial fisheries resources in adjacent waters.

EMERGENT

Inventory

The marshes of the Pacific coast of North America are considered to be relatively uniform from Alaska to northern California (MacDonald and Barbour 1974). The characteristic species of these marshes are the sedges and rushes (Carex Iyngbyei, Scirpus americanus, and Scirpus maritimus), saltwort (Salicornia virginiana), seaside arrowgrass (Triglochin maritima), and salt grass (Distichlis stricta). The number of species in these marshes is not great and succession is considered to be very simple in comparison with other salt marshes in various coastal areas of the world (Chapman 1960).

The distribution of marshes in coastal British Columbia is extremely restricted. Most of the coast is extremely rugged with deep fjords and steep forested slopes which plunge directly into the sea; little exists between the forests and the sea but a rocky intertidal zone inhabited by a varied fauna and algal flora. Marshes can only occur on protected gently sloping, sand or mud bottoms. Along the northwest coast these conditions usually occur only at the heads of inlets or the mouths of rivers (estuaries).

Saline and brackish marshes occur in various locations on the Queen Charlotte Islands (Calder and Taylor, 1968), and in appropriate locations on the other coastal island and the mainland. Brackish marshes occur primarily on the intertidal zone of muddy estuaries such as the Tlell River on Graham Island. The characteristic species tend to be various rushes, sedges and grasses. Salt marshes may occur anywhere along coastal areas where substrates, slopes, and the energy regime permit; sheltered bays and the heads of inlets are appropriate locations. The salt marsh species are usually quite different from those on brackish marshes. Halophytic or salt-tolerant plants such as saltwort (Salicornia virginia), seaside plantain (Plantago maritima) and arrowgrass (Triglochin maritima) are common in these marshes. (Additional descriptions of salt and brackish marsh species on the northwest coast are forthcoming.)

The distribution of marshes on the northwest coast is poorly known. Apart from those on the Queen Charlotte Islands (Calder and Taylor, 1968) or in the vicinity of the Skeena and Kitimat River estuaries, virtually no published information exists.

Stability and Sensitivity

Marshes are dynamic systems in a constant state of flux with their environments. In a stable environment a marsh may remain stable for centuries. However, estuaries and coastlines are usually in the process of change and therefore affect succession in marshes. The simplest form of change in a marsh is from one community type to another. This may come about as a result of substrate aggradation, as in an estuary which is gradually extending, or simply due to organic matter built up by the plants themselves. As the plant environment is changed, the species change. Succession in marshes ultimately results in a terrestrial community.

The sensitivity of marshes to environmental disturbance is well known. British marshes have been the subjects of intensive research as a result of oil tanker mishaps. In general marshes seem to be fairly resilient to damage; the plants may be eliminated for a season, but manage to regrow. Some sensitive species may be eliminated in the case of toxic spills.

Habitat Values

Marshes are acknowledged to be among the most productive ecosystems in the temperate zone. They function as habitat for a wide variety of organisms including invertebrates, fish and birds. Because marshes are subject to daily tidal fluctuations they also receive the benefit of continual nutrient input and tidal flushing. The vascular plant growth that occurs in these marshes every year is enhanced by tidal action. When the plant remains decompose, the detritus feeds organisms both in the marsh and in the adjacent waters to which the detritus is flushed.

3.8.1.2 Terrestrial Vegetation

Inventory

The terrestrial vegetation of the northern British Columbia coast is quite uniform from one area to another. North of Vancouver Island the coastal vegetation, from sea level to an elevation of approximately 400 m, falls within the Coastal Cedars - Pine - Hemlock Biogeoclimatic Zone (Pojar, 1980). The dominant trees of this zone are western red cedar (*Thuja plicata*), yellow cedar (*Chamaecyparis nootkatensis*), western hemlock (*Tsuga heterophylla*), shore pine (*Pinus contorta*), Sitka spruce (*Picea sitchensis*) and red alder (*Alnus rubra*). The forests of this zone are of relatively low productivity and contain numerous bogs and bog-forest transition zones. These zones are described in greater detail in Section 3.4.

In exposed locations the most characteristic plant community is a Sitka spruce forest fringe, up to 100 m wide bordering the shoreline. The environmental variables governing this community have been intensively investigated (Cordes, 1968). The major influence governing the distribution and depth of this community is the intensity of sea spray; the greater the amount of salt spray the greater the width of Sitka spruce forest. In areas where the salt spray is diminished the dominance of Sitka spruce fades and western hemlock and western red cedar become more important. The Sitka spruce forests are very well developed in the coastal areas of the Queen Charlotte Islands both as a beach fringe community and also as an inland forest.

B.C. Forest Service forest cover maps are available for all the coastal areas if detailed forest composition of these stands is required.

Successional Stages and Development

The coastal forests may all be considered mature unless they have been logged or subject to avalanches or fires. Fires in the coastal forests tend not to be intensive because of abundant moisture. Trees may be fire-scarred but are usually not burned. Avalanches occur sporadically in areas which have unstable substrates. Succession on these areas usually begins with red alder but quickly progresses to coniferous species once the substrate has stabilized. Logged areas also tend to begin secondary succession with red alder and progress to a mixed hemlock - cedar forest.

Habitat Values

Wildlife use of the coastal lowlands of northwestern British Columbia is poorly understood. In similar forests in southeast Alaska, Taylor (1932) recognized six habitat types: beach fringe, muskegs, pioneer communities, avalanche areas, open stream banks and meadows, and climax forest. Only black-tailed deer use the beach fringe to any major extent; however brown bears use beach and sedge flats for food in spring. Black and brown bears, moose, grouse, mountain goat and deer all use a number of plant species in the climax forest (Meehan, 1974). Deciduous shrubs such as found in pioneer communities, avalanche areas and stream banks are considered important for moose.

Forestry Concerns

The area of forested land bordering the marine approaches is so large that it is difficult to make generalizations regarding forestry concerns. In general the forest cover is mature, but in relation to other forested areas not very productive. Pockets of highly productive timber occur in sites with good soils and drainage but these are rare.

3.8.2 Terminal

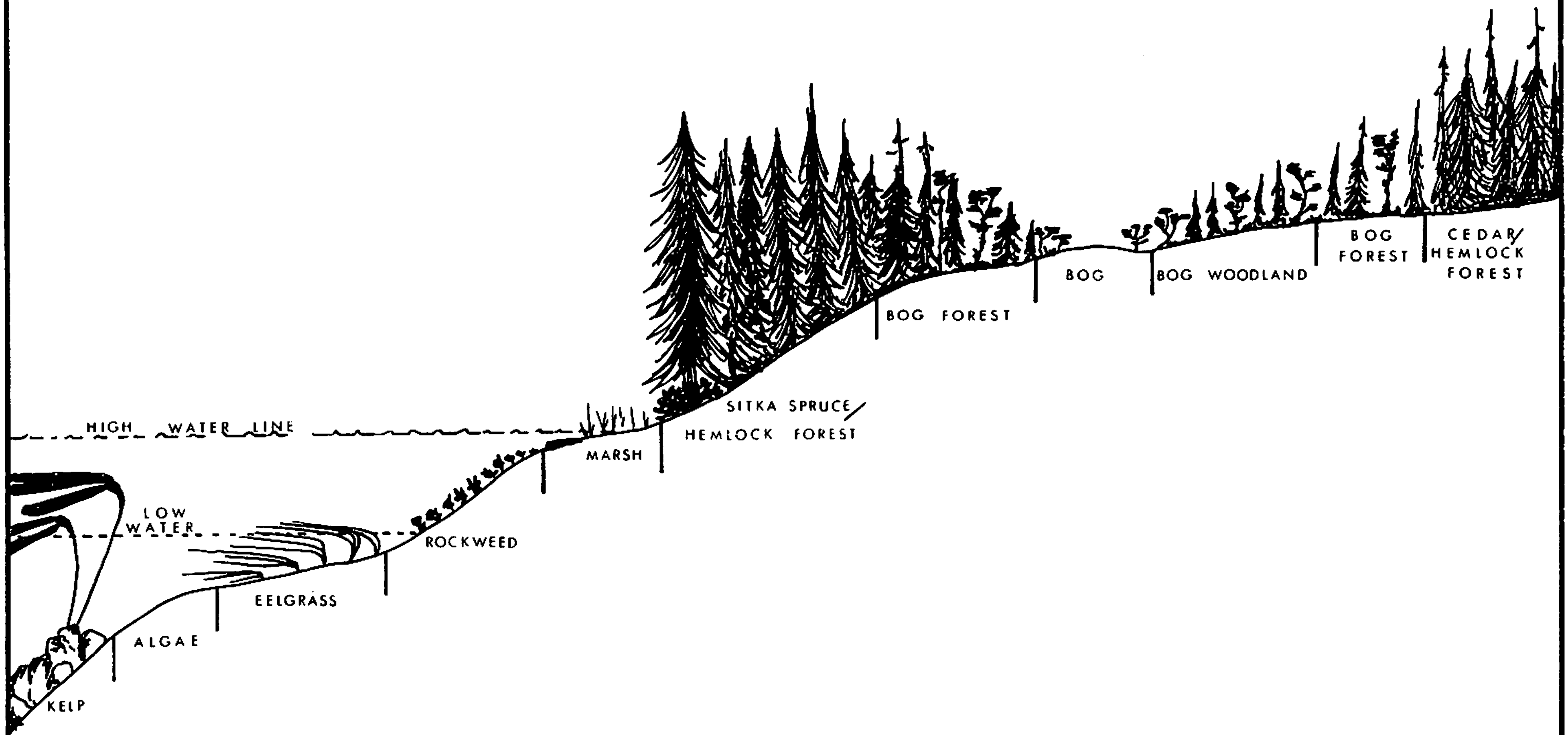
3.8.2.1 Aquatic Vegetation

3.8.2.1.1 Algal Communities

The algal communities at the site are controlled primarily by exposure and substrate type. In the sheltered coastline southeast of Grassy Point the rocky headlands are occupied intertidally by a *Fucus gardneri* zone and subtidally by *Laminaria saccharina*. Numerous brown and red algae occur in small quantities scattered among the above species. The headlands shelter crescent beaches which contain eelgrass and its associated epiphytic algae. A cross-sectional diagram of community distributions is presented in Figure 3-8.2

Generalized scheme of plant community distributions at the terminal site

FIGURE 3.8.2



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Northwest of Grassy Point the shoreline becomes much more exposed and the algal communities change. The shoreline becomes steeper and lacks the pocket beaches found in the more sheltered areas. The algal communities on the rock faces appear to be predominantly red algae. The community distributions observed in July, 1981 are shown on Map 3-8.2.

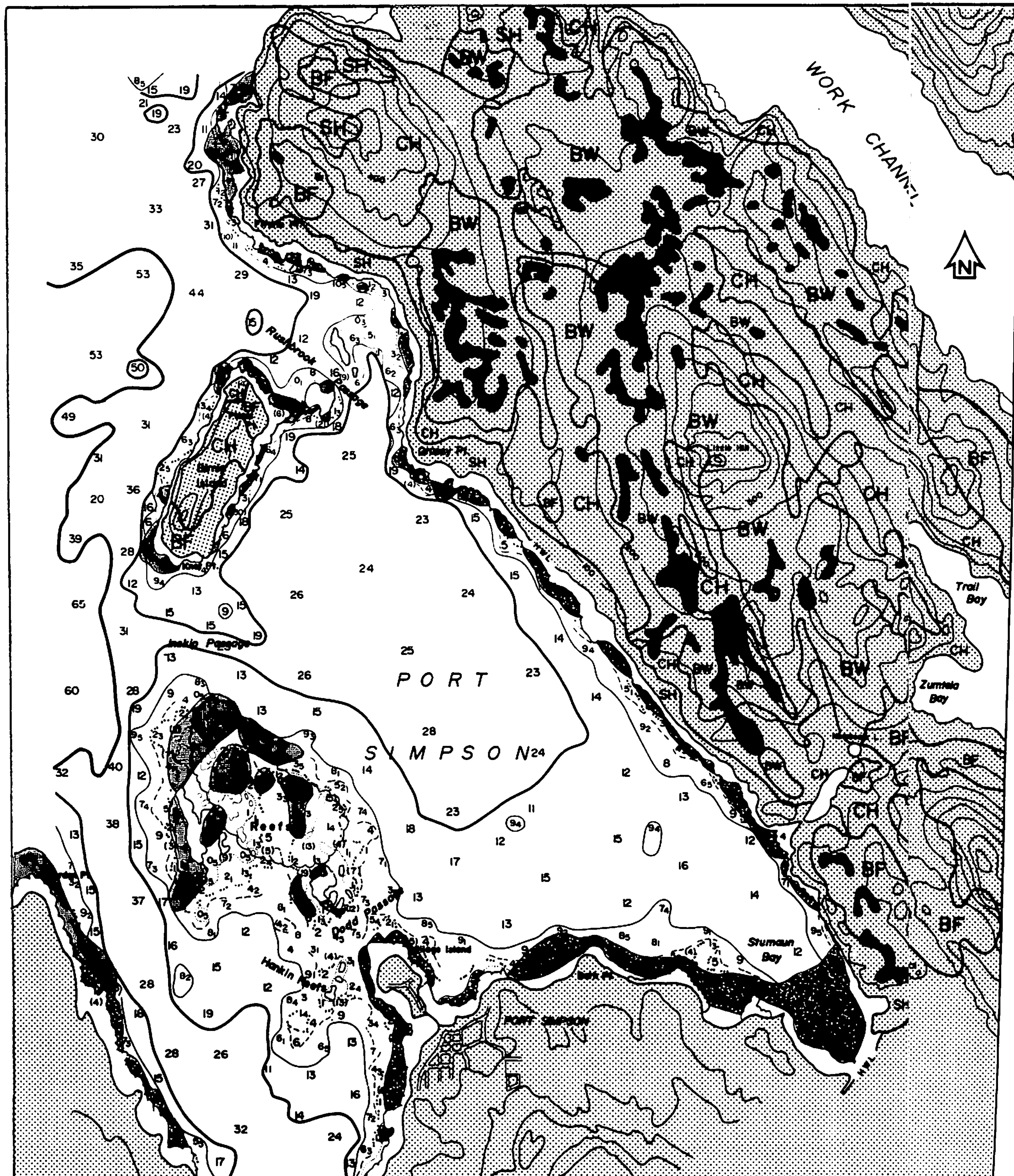
A few bull kelp fronds were observed on Harbour Reefs during the March 1981 survey. This was the only indication of bull kelp in the study area. It is generally accepted that kelp beds vary in species composition, density and area annually as well as seasonally. The abundance of bull kelp increases considerably during the spring and summer; the lack of kelp during the site visit was primarily a result of winter storms destroying last year's remaining kelp fronds.

Vascular Plants

SUBMERGENT

Two species of marine vascular plants, or seagrasses, occur along the shoreline of the study area (NEAT, 1975; Martin, 1978). Eelgrass is found subtidally along protected sand beaches and mudflats in the area. Surfgrass on the other hand, inhabits the rocky intertidal zone along the exposed shoreline. Habitat requirements for the two species are sufficiently different that they do not occur together.

In terms of areal coverage (Map 3-8.2) and hence biomass, eelgrass is by far the most abundant of the two seagrasses of the study area. Surfgrass only occurs sporadically in small clumps on the more exposed locations within the terminal study area. Eelgrass occurs along those beaches of



WESTERN L.N.G. PROJECT

DOME PETROLEUM LIMITED

PLANT COMMUNITIES AT TERMINAL SITE

BEAK CONSULTANTS LIMITED JULY 1981

SH	Sitka spruce/hemlock
CH	cedar/hemlock forest
BW	bog woodland
BF	bog forest
	bog (or muskeg)
	eelgrass
	kelp bed locations (approximate)

DEPTH COUNTOURS*

- 50 fathoms
- 20 fathoms
- 10 famthoms
- 6 fathoms
- 3 fathoms
- 1 fathom
- —LWL— Low Water Line **
- —HWL— High Water Line

*depths are reduced to Lowest Normal Tide, which at Port Simpson is 3.7 metres below Mean Water Level

**figures above Low Water Line represent feet above chart datum

SOURCE: Canadian Hydrographic Service — Chart #3993 @ 1:40,000 (1980)

Map 3-8.2

the Tsimpsean Peninsula and adjacent areas where suitable substrate and wave shock conditions exist. Generally the eelgrass beds are confined to a narrow fringe (10 to 20 m in width) parallel to the beach. The most extensive eelgrass meadow in the study area is at Stumaun Bay, east of Port Simpson. The areal extent of this bed could not be determined even at low tide as the seaward edge of the bed, extended into deep water. As described in Section 3.1.2, eelgrass plays an important role as fish and invertebrate habitat and is the most important substrate for herring spawn in the Port Simpson area (Haegele and Miller 1979).

EMERGENT

The emergent vegetation in the vicinity of the site is extremely limited in distribution. Small marshes were observed at the head of Stumaun Bay, the mouth of Neaxtoalk Lake and in small pockets along the upper beach zone. Individual marshes were only a few square metres in size. During the field survey, individual plant species could not be recognized in the marshes as the current year's growth had not yet emerged. The marsh areas were also very limited in extent and were therefore not mapped. Previous studies in the general area (NEAT, 1975) had recognized three different marsh communities. The communities and their associated species were:

Alkaligrass - Sea Plantain Zone (Puccinellia spp. - Plantago maritima)

This zone is usually inundated by high tides and in addition to the above species is characterized by scurvy grass (Cochlearia officinalis), seablite (Suaeda maritima), sea spurry (Spergularia marina), pickleweed (Salicornia pacifica), orache (Atriplex patula) and sea arrowgrass (Triglochin maritimum).

Hairgrass - Sedge Zone (*Deschampsia caespitosa* - *Carex lyngbyei*)

This zone is occasionally inundated by high tides. In addition to the above species, red fescue (*Festuca rubra*), bentgrass (*Agrostis exarata*), sea barley (*Hordeum brachyantherum*) and Baltic rush (*Juncus baltica*) make up the species complement of this community.

Grass - Forb Meadow

This zone is infrequently inundated. Its characteristic species are limegrass (*Elymus mollis*), Nootka bluejoint (*Calamagrostis nutkaensis*), hairgrass, bluegrass (*Poa* spp.), holygrass (*Hierochloe adorata*), Pacific brome (*Bromus pacificus*), Lyngbye's sedge (*Carex lyngbyei*) , chocolate lily (*Fritillaria camschatcensis*), silverweed (*Potentilla pacifica*), yarrow (*Achillea millefolium*), bedstraw (*Galium trifidum*), yellow paintbrush (*Castilleja unalascheensis*), water hemlock (*Circuta douglasii*), beach lovage (*Lingustichum scoticum*), sea watch (*Angelica lucida*), aster (*Aster subspicatus*) and Pacific clover (*Trifolium wormskjoldii*).

These marsh fringes are used primarily during the spring by Sitka black-tailed deer and bears.

3.8.2.2 Terrestrial Vegetation

Inventory

The vegetation of the Tsimpsean Peninsula is typical of the coastal lowland forests of northern British Columbia and southeast Alaska. This vegetation type has been considered part of the Coastal Western Hemlock Biogeoclimatic zone (wet subzone, Krajina, 1969), however it fits more closely into the proposed Coastal Cedars - Pine - Hemlock Biogeoclimatic zone (Pojar, 1980).

The vegetation of this zone is characterized by abundant bogs, coniferous forests and transition zones between the two. Transition from bog through bog woodland and bog forest to forest was usually though not invariably associated with increasing slope and decreasing peat depth (Neiland, 1971) in southeast Alaska for all except the Sitka spruce sea-spray type and the transitional shrub zone which were described in the NEAT report (1975). The vegetation community distributions observed in early July 1981 are presented on Map 3-8.2.

Sitka Spruce - Sea Spray Forest

Sitka spruce occurs in the study area mainly as a narrow fringe along the shore from north of Flewin Point to south of Neaxtoalk Lake. The presence and width of this Sitka spruce fringe has been related to the intensity of salt spray (Cordes, 1968). Sitka spruce is tolerant of high sodium ion concentrations on its needles and of moderate salt concentrations in the soil. Western hemlock is a codominant in this forest type, and the occasional red cedar is also present. The seaward edge of this forest is dominanted by a dense growth of salal which has been pruned by salt spray. The interior of the forest is quite dark and virtually devoid of undergrowth. Salmonberry (Rubus spectabilis) and red huckleberry (Vaccinium parvifolium) were present in small quantities. The bryophyte layer was well developed; the main species were Rytidiadelphus loreus and Hylocomium splendens. False lily-of-the-valley (Maianthemum dialatatum) and Nootka bluejoint (Calamagrostis nutkaensis) were identified as being characteristic of the herb layer in this forest type (NEAT, 1975).

Transitional Shrub Zone

This community (originally identified by NEAT, 1975) occurs only sporadically in the study area between the seaward forest edge and the foreshore in sheltered locations. It was characterized as follows:

> "Typical shrubs are false azalea, salal, red huckleberry, western crabapple, red alder, Sitka alder, salmonberry, thimbleberry, blueberry, black twinberry, blue current, red elderberry, Sitka mountain ash and devil's club. Associated species in the herb layer are false lily-of-the-valley, beach lovage, hemlock-parsley, sea-watch, Nootka bluejoint, giant vetch, yarrow, lime-grass, buttercup, chocolate lily, holygrass, sea barley, hairgrass, aster, yellow paintbrush, skunk cabbage, red fescue and bentgrass" (NEAT, 1975).

Cedar/Hemlock Forest

The most abundant forest type in the study area is dominated by red and yellow cedar with lesser amounts of western hemlock an shore pine (Map 3-8.2). Pojar (1980) considers this to be the zonal plant association. The understory composition is variable depending largely upon canopy closure; typical shrubs include blueberry (Vaccinium alaskaense), red huckleberry, false azalea (Menziesia ferruginea) and salal (Gaultheria shallon).

Ferns such as deer fern (Blechnum spicant) and forbs such as false lily-of-the-valley, foam flower (Tiarella trifoliata), dwarf dogwood (Cornus canadensis), and twayblade orchid (Listera cordata) complete the bulk of the forb layer in the forest (NEAT, 1975). In similar forests in southeast

Alaska the shrub frequency tended to be low while the herb frequency was high. The total number of species for this type of community was 67 (Neiland, 1971).

Bog Forest

This forested community is very similar to the coniferous forest above, but is characterized primarily by shorter trees and different dominants. Yellow cedar often forms dense stands of 7-10 m high (Neiland, 1971). In such a situation there is very little vascular plant undergrowth. Western hemlock usually dominates in the regenerating layer, however it is rarely a dominant in the upper canopy. Instead shore pine often appears as the tallest component of this community.

Bog Woodland

This community represents a further step from the coniferous forest toward the open bog. This open forest is usually dominated by scattered pines ranging from 1.5 to 6 m in height. The understory is generally sparse and dominated by a few small trees and some large shrubs such as Labrador tea (*Ledum groenlandicum*), false azalea, spreading juniper (*Juniperus communis*) and blueberry. The general appearance and species composition of the ground flora is the same as that of the bog.

Bog

Bogs are abundant in the study area and occur on either flat of gently sloping land. They may be either blanket bogs, covering the terrain as a thin peat layer, or raised bogs which have a raised center and slope toward the edges. The latter may have started in basins which once held lakes. Peat deposits in such areas can be very deep.

The surface of the bog may contain open pools with aquatic vegetation surrounded by a hummocky surface formed by sphagnum moss. Bogs usually contain a large number of different plant species. In southeast Alaska, Neiland (1971) observed 114 different species. The tree species occurring in the bogs are usually stunted and twisted "bonsai" forms of predominantly shore pine but also yelelow cedar, western hemlock and red cedar. Shrubs are abundant, some of the more common ones are Labrador tea, dwarf azalea, bog blueberry, spreading juniper, bog rosemary (*Andromeda polifolia*) lingonberry (*Vaccinium vitis idaea*), sweet gale (*Myrica gale*) and crowberry (*Empetrum nigrum*). Characteristic forbs according to NEAT (1975) were clouldberry (*Rubus chamaemorus*), sundew (*Dorsera rotundifolia*), burnet (*Sanguisorba officinalis*), goldthread (*Coptis trifolia*), white gentian (*Gentiana douglasiana*), starflower (*Trientalis arctica*), skunk cabbage (*Lysichitum americanum*) and deer cabbage (*Fauria crista-galli*). In addition to these forbs, several sedge species, cotton grass (*Eriophorum angustifolium*) and some grasses occur commonly in the bogs. The bryophyte layer consists overwhelmingly of *Sphagnum* species but other mosses such as *Dicranum* sp. and *Polystichum* spp. do occur. Occasional *Cladonia* and *Cladina lichens* are also found in raised hummocks in the bog.

Numerous ponds with fragments of last year's aquatic plants were observed during the field visit. These fragments could not be identifed, however, NEAT (1975) mentions the presence of yellow water lily (*Nuphar polysepalum*), pond week (*Potamogeton natans*), bur reed (*Sparganium* spp.), bog bean (*Menyanthes trifoliata*) and marsh marigold (*Caltha biflora*) in such areas.

Successional Stages and Development

The forests within the study area are all mature forests. The B.C. Forest Service mapping one in 1965 identified the bulk of the forests on the Tsimpsean Peninsula as being greater than 250 years old. These ages were confirmed during the field visit when tree rings of various species were counted from recently felled trees along cut lines in the study area. In general tree heights were less than 20 m, and the diameters averaged about 20 cm. These sizes confirmed the poor and low site* classifications for most of the northwestern tip of the Tsimpsean Peninsula which falls within forest management Region 64, compartment 60.

* Four site classifications exist for assessing the productivity of timber resources; in order of increasing productivity these are low, poor, medium, and good. In addition there is a non-productive (NP) category which is not assigned a site classification.

All of the cut trees examined showed repeated burn scars which had been enclosed by further growth. One tree which was greater than 230 years old showed 9 separate burn scars, two of which were only three years apart. It appears that low intensity fires have been a persistent feature of this area for a very long time. The past history of fires may be partially responsible for the large number of "spike top" trees. These are old trees with dead tops; however, the rest of the tree is relatively healthy and standing. Neiland (1971) reports on other studies which conclude that fire may play a role in the abundance of red cedar in some areas. Although western hemlock regenerates easily it is very susceptible to fire damage (Fowells, 1965) and thus in frequently burned areas cedar may be more successful.

The climax forest of the Coastal - Cedars - Pine - Hemlock zone is considered to be dominated by red and yellow cedar with lesser amounts of western hemlock, shore pine and occasionally mountain hemlock (Pojar, 1980). In the poorest soil types with the most oceanic climates, bog forests tend to be the climax zonal vegetation. However, there is also a tendency for bog expansion or forest expansion to occur, depending upon minor climatic and hydrologic changes (Neiland, 1971). Shore pine appears to be best suited to the bog woodlands and to the cedar - hemlock forest substrates, but cannot compete because of shade intolerance (Banner, 1980). Major disturbances such as fire or logging could allow pines to become established in an area as a seral stage (secondary succession) however the regeneration by the cedars and western hemlock would eventually return the forest to the zonal type.

Habitat Values

Habitat utilization by large mammals is dealt with in greater depth in the BEAK (1981) Dome LNG Wildlife Report. To briefly summarize, there are four major habitat types in the study area.

Sitka Spruce/Hemlock Forest

This area is considered of value to Sitka Black-tailed Deer due to its dense canopy closure which provides protection from heavy snowfalls. The edge of salal on the seaward side also provides a steady food supply as does an abundance of arboreal lichens in a similar forest type further inland. This forest also provides access to the narrow marsh fringes which deer and bears tend to use.

Forest/Bog Fringe

This area provides an "edge effect" where light penetration around bog areas permits abundant understory growth for wildlife forage. It also provides wildlife access to bog areas for deer and bears while providing nearby dense cover.

Bog

Bogs provide a diversity of highly nutritious plant species for food. Open water areas contain aquatic maprophytes which may be used by deer, bears and perhaps waterfowl.

Cedar/Hemlock Forest

This has the lowest wildlife value in the area. The understory is sparse in terms of preferred forage species and the overstory is not dense enough to provide good winter shelter.

FORESTRY CONCERNS

The purpose of this section is to provide an estimate of merchantable vs. non-merchantable timber resources at the LNG plant site. The area and volume data are based solely on existing Forest Service Maps and area - volume statements.

Discussions with Forest Service personnel in Prince Rupert revealed that very few concerns existed for forestry values at the terminal site.

Most of the area is low in yield and has severe silvicultural limitations (Don Thompson, pers. comm.). Most of the compartment 60 has been identified as part of the proposed Hecate Provincial Forest (Figure 3-8.3) which is expected to become a legal entity in 1981 (B.T. Sieffert, pers. comm.). Additional information concerning the Hecate Provincial Forest is forthcoming.

The study area is encompassed by region 64, compartment 60 (Figure 3-8.4). Of the total 2,966 ha within this compartment only 232 fall into a medium site category, 910 ha are considered poor and the remaining 1,823 are considered low. Low site stands are generally low in volume, have poor form and are therefore not considered merchantable.

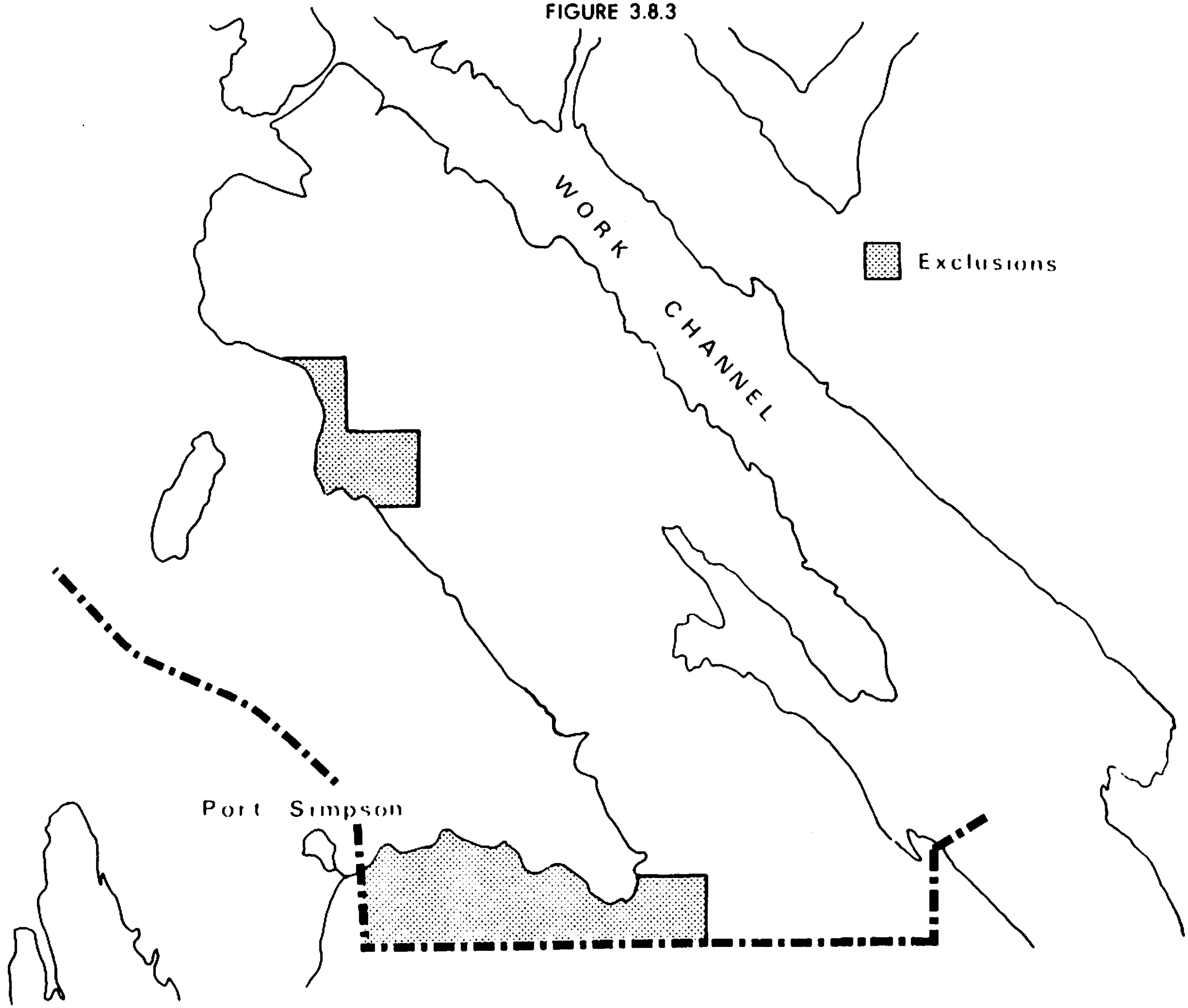
The major tree species in the study area area western red cedar, yellow cedar, western hemlock, Sitka spruce and shore pine. All of the area except 125 ha for falls within age classes 8 and 9 which are over 140 years old; the cedars and hemlock tend to be quite decadent by that age.

The most common forest type in compartment 60 is the red cedar, yellow cedar, hemlock, shore pine type. The trees are greater than 250 years old in this type, yet less than 20 m tall. It is therefore not surprising that this type occupies 32% of the total area in the compartment, yet produces only 18% of the volume.

In contrast, the hemlock, red cedar, spruce, yellow cedar fringe along the shore occupies approximately 3% of the area of compartment 60, but produces 4% of the volume. The trees are much larger in this area, up to 30 m tall, and the calculated volumes make it the fourth most productive type within compartment 60. It is likely that a portion of this type will be removed form the area of the LNG terminal as it is located in a strip along the shore from Grassy Point to Neaxtoalk Lake and beyond.

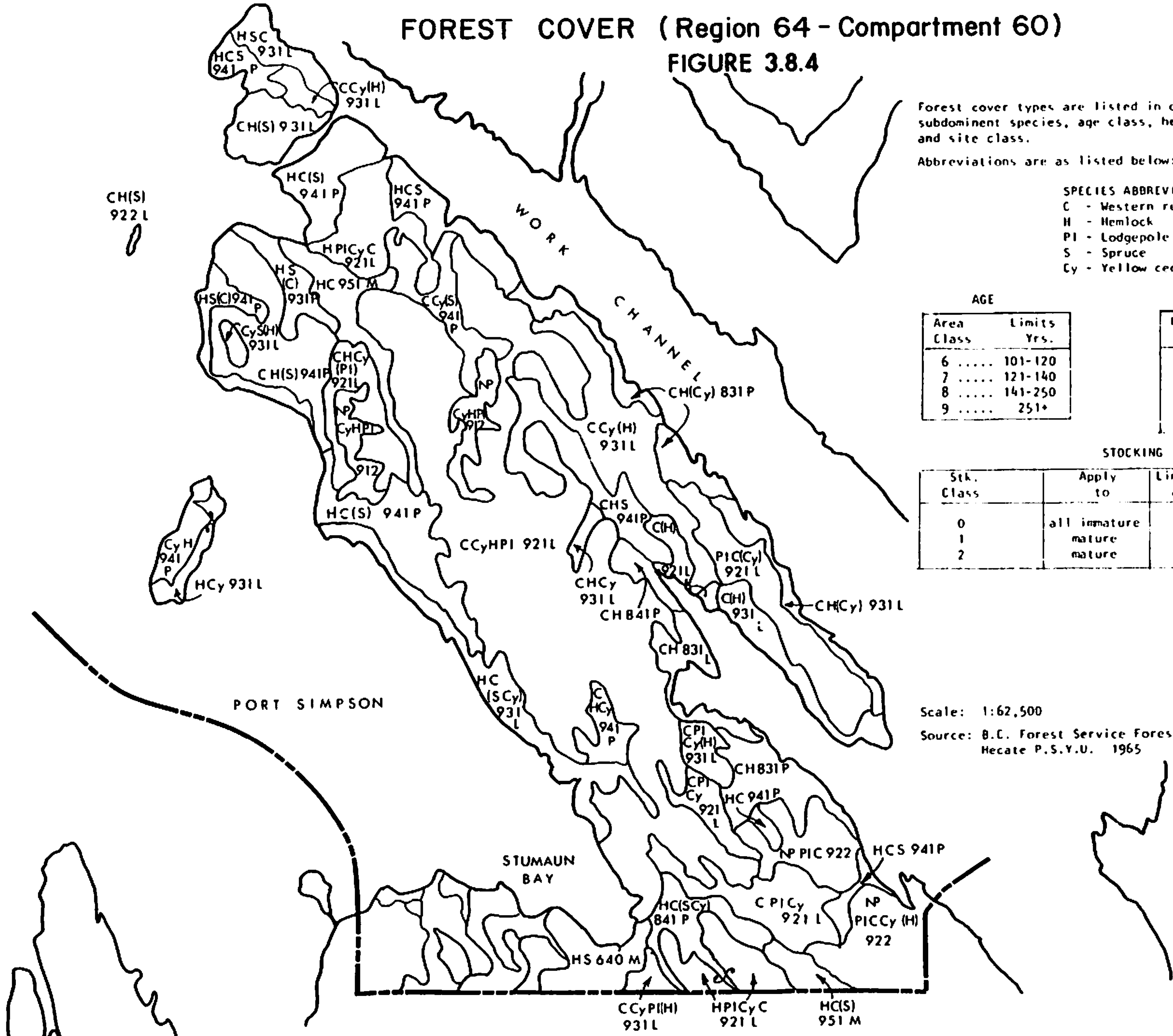
PROPOSED HECATE PROVINCIAL FOREST (COMP 60)

FIGURE 3.8.3



FOREST COVER (Region 64 - Compartment 60)

FIGURE 3.8.4



Forest cover types are listed in order of dominant species, subdominant species, age class, height class, stocking class and site class.

Abbreviations are as listed below:

SPECIES ABBREVIATIONS
C - Western red cedar
H - Hemlock
PI - Lodgepole pine
S - Spruce
Cy - Yellow cedar

AGE

Area Class	Limits Yrs.
6	101-120
7	121-140
8	141-250
9	251+

HEIGHT

Height Class	Limits Ft.
1	1- 35
2	36- 65
3	66- 95
4	96-125
5	126-155

STOCKING

Stk. Class	Apply to	Limits - No. of trees per acre 11.1" + d.b.h.
0	all immature	N.A.
1	mature	31+
2	mature	1-30

SITE
G - Good
M - Medium
P - Poor
L - Low
NP - Non-productive

Scale: 1:62,500

Source: B.C. Forest Service Forest Cover Map 103-J-9-W Hecate P.S.Y.U. 1965

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For the purposes of making initial estimations of timber volume at the site, we have assumed a location between Neaxtoalk Lake and Lizzie Hill and an area of 259 ha. Once the ultimate site selection is made these estimates can be refined. Given these constraints there are four species groupings which could be affected. The two major ones have been discussed above. Two other areas may be affected depending on the ultimate location of the terminal. Both are considerably more productive than the former two areas. A summary of the pertinent characteristics of the above- mentioned four types is presented in Table 3-8.2.

The area occupied by the site described above represents 8.7% of the area of compartment 60, but the calculated volume of 9824 cubic metres represents only 6.5% of the volume of the compartment. It appears, therefore, that this particular site, is low in productivity even in terms of the overall low production of compartment 60.

3.8.2.3 Endangered or Protected Species

A summer site visit conducted in early July, 1981 for the collection of plant species to complete the community information listed in earlier sections. This data forms an appendix to this section of the report. The terrestrial plant communities examined did not indicate the presence of any endangered or rare species in the proposed development site.

TABLE 3.8.2

Summary of Area Characteristics & Volume of Mature Timber Types at the Proposed LNG Terminal Site

Major Species[1]	Minor Species	Age Class	Height Class	Stocking Class[2]	Site Class[3]	Area in Comp. 60 Ha.	% of Comp 60	Average Volume/ Ha Cu M/ha	% of Total Vol. in Comp. 60	Ha. on Site	% of Type on Site	Volume on Site Cu m.
C Cy H Pl		9	2	1	L	953	32	27	18	207	80	5589
H C	S Cy	9	3	1	L	93	3	75	4	39	15	2925
C H	Cy	9	4	1	P	34	1	110	2	8	3	880
H C	S	9	4	1	P	135	4	86	7	5	2	430
TOTAL						2966		56		259[4]		9824

1 C - Red Cedar
Cy - Yellow Cedar
H - Western Hemlock
Pl - Lodgepole Pine
S - Sitka Spruce

2 Stocking Class - No. of trees per acre 11.1" + d.b.h. 1 = mature, 31 +

3 Site Class - relationship of tree height to age of stand G - good; M - medium; P - poor; L - low

4 Totals for all of Compartment 60

3.8.3 APPENDIX I

PLANT SPECIES IDENTIFIED AT TERMINAL SITE, JULY 1981

SCIENTIFIC NAME	COMMON NAME	COMMUNITY: Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
TREE CANOPY								
CUPRESSACAEA								
Chamaecyparis nootkatensis (D.Don) Spach	Yellow Cedar					x	x	
Thuja plicata Donn.	Western Red Cedar			x	x	x	x	
PINACEAE								
Picea sitchensis (Bong.) Carr	Sitka Spruce			x				
Pinus contorta var. contorta Dougl.	Shore Pine					x	x	x
Tsuga heterophylla (Raf.) Sarg.	Western Hemlock			x	x	x	x	
BETULACEAE								
Alnus rubra Bong.	Red Alder		x					
SHRUB LAYER								
CUPRESSACEAE								
Juniperus communis L.	Spreading Juniper						x	x
MYRICACEAE								
Myrica gale L.	Sweet Gale						x	x
EMPETRACEAE								
Empetrum nigrum L.	Crowberry						x	x
ARALIACEAE								
Oplopanax horridum (Smith) Mig.	Devil's Club				x			

APPENDIX I - Continued

SCIENTIFIC NAME	COMMON NAME	Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
ERICACEAE								
Andromeda polifolia L.	Bog-Rosemary						x	x
Gaultheria shallon Pursh.	Salal				x	x	x	x
Ledum groenlandicum Oeder	Labrador Tea					x	x	x
Menziesia ferruginea Smith	Rusty Menziesia					x	x	x
Vaccinium alaskaense Howell	Alaska Blueberry				x	x		
V. ovatum Pursh.	Evergreen Blueberry			x	x	x	x	
V. oxycoccus L.	Wild Cranberry						x	x
V. parvifolium Smith	Red Huckleberry		x	x	x	x	x	
V. uliginosum L.	Bog Blueberry							x
V. vitis-idaea L.	Lingonberry							x
CAPRIFOLIACEAE								
Linnaea Borealis L.	Twinflower			x	x			
Sambucus racemosa L.	Red Elderberry		x					
HERB LAYER								
LYCOPODIACEAE								
Lycopodium annotinum L.	Club-Moss			x	x			
EQUISETACEAE								
Equisetum fluviatile L.	Horsetail			x	x	x	x	
POLYPODIACEAE								
Adiantum pedatum L.	Maidenhair Fern		x					
Athyrium felix-femina (L.) Roth	Lady Fern				x	x		
Blechnum spicant L.	Deer Fern			x	x	x	x	
Cryptogramma crispa (L.) R.Br.	Rock Brake			x	x	x	x	

APPENDIX I - Continued

SCIENTIFIC NAME	COMMON NAME	Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
		COMMUNITY						
Dryopteris austriaca Jacq. Woynar	Wood Fern			x	x	x		
Gymnocarpium dryopteris (L.) Newm.	Oak Fern			x	x	x		
Polypodium glycyrrhiza D.C. Eat.	Licorice Fern			x	x	x	x	
Polystichum munitum (Kaulf) Presl.	Sword Fern			x	x	x		
PORTULACACEAE								
Montia sibirica (L.) Howell	Siberian Miner's-Lettuce			x	x	x		
CERATOPHYLLACEAE								
Nuphar polysepalum Engelm.	Indian Pond Lily							x
RANUNCULACEAE								
Caltha asarifolia DC.	Yellow Marsh Marigold							x
Coptis trifolia)L.) Salisb.	Gold Thread			x	x	x		
DROSERACEAE								
Drosera rotundifolia L.	Sundew							x
SAXIFRAGACEAE								
Tiarella trifoliata L.	Foamflower			x	x			
ROSACEAE								
Potentilla palustris (L.) Scop.	Marsh Cingue-Foil					x	x	x
Rubus chamaemorus L.	Cloudberry							x
Rubus pedatus J.E. Smith	Five-Leaved Bramble				x	x	x	
Rubus spectabilis Pursh.	Salmonberry		x					
Sanguisorba officinalis L.	Garden Burnet					x	x	x
CORNACEAE								
Cornus canadensis L.	Bunchberry			x	x	x	x	

APPENDIX I - Continued

SCIENTIFIC NAME	COMMON NAME	Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
ERICACEAE								
Monotropa uniflora L.	Indian-Pipe			x	x	x	x	
PRIMULACEAE								
Glaux maritima L.	Saltwort	x						
GENTIANACEAE								
Gentiana douglasiana Bong.	Swamp Gentian							x
MENYANTHACEAE								
Menyanthes trifoliataL.	Bogbean							x
Neoprophyllidium crista-galli (Menzies) Gilg.	Deer Cabbage					x	x	x
PLANTAGINACEAE								
Plantago maritima	Seaside Plantain	x						
JUNCAGINACEAE								
Triglochin maritimum L.	Seaside Arrowgrass	x						
POTAMOGETONACEAE								
Potamogeton natans L.	Floating-Leaved Pondweed							x
JUNCACEAE								
Juncus effusus L.	Rush							x
Luzula parviflora (Ehrh) Desv.	Woodrush				x	x	x	
CYPERACEAE								
Carex livida (Wahl.) Willd.	Sedge							x
C. lyngbyei Hornem.	Sedge	x						
C. obnupta. L.H. Bailey	Sedge				x	x	x	
C. pauciflora Lightf.	Sedge						x	x
C. pluriflora Hulten	Sedge					x	x	x
C. sitchensis Prescott	Sedge					x	x	

SCIENTIFIC NAME	COMMON NAME	Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
Eriophorum polystachion L.	Cottongrass							x
Rhyncospora alba (L.) Vahl.	Beakrush							x
GRAMINEAE								
Agrostis aequivalvis (Trin.) Trin	Bentgrass							x
Calamagrostis canadensis (Michx) Beauv.	Reedgrass				x	x		
Deschampsia caespitosa (L.) Beauv.	Hairgrass	x						
Glyceria occidentalis (Pipe) Nels	Mannagrass				x	x		
ARACEAE								
Lysichitum americanum Hulten and St. John	Skunk Cabbage		x	x	x	x	x	x
LILIACEAE								
Maianthemum dilatatum (Wood) Nels. & Macbr.	False Lily-of-the-Valley		x	x				
Streptopus amplexifolius (L.) DC.	Twisted Stalk		x	x	x	x		
Tofieldia glutinosa var. brevistyla Hitch.	Tofieldia						x	x
Veratum viride Ait.	False Hellebore					x	x	
ORCHIDACEAE								
Habenaria sacata Greene	Bog Orchid							x
H. dilatata (Pursh) Hook.	Bog Candle							x
Listera cordata (L.) R.Br.					x	x		
MOSSES								
Dicranum strictum				x	x	x	x	
Eurhynchium oreganum (Sull.) Jaeg. & Squerb.				x	x	x		
Hylocomium splendens (Hedw.) B.S.G.				x	x	x		
Mnium glabrescns Kindb.				x	x	x	x	

APPENDIX I - Continued

SCIENTIFIC NAME	COMMON NAME	Marsh	Transitional Shrub Zone	Sitka Spruce/Hemlock	Cedar/Hemlock	Bog Forest	Bog Woodlands	Bog
Pleurozium schreberi (Brid.) Mitt.				x	x			
Sphagnum spp.						x	x	x
LICHENS								
Cladina spp.								x
Cladonia spp.								x

Nomenclature according to Hitchcock and Cronquist, 1976

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3.9.0 WILDLIFE RESOURCES

3.9.1 MARINE APPROACHES

3.9.1.1 Marine Mammals

A variety of marine mammals inhabit the area encompassing the marine approaches to Port Simpson. Some species are common to the area only during specific time periods governed by migratory, breeding, or feeding behaviour and are considered seasonal residents or migrants. A few species are common throughout the area year round while others can only be considered visitors (Table 3-9.1).

All of the species that have been recorded in this study area are discussed below. Some of the pelagic species of whales are omitted as their ranges are offshore and current knowledge of these species indicate they are unlikely to use inshore waters.

Marine mammals are easily missed and surveys of their distribution and abundance have only been conducted along the north coast for selected groups, such as the sea lions. In general, the strength of the inventory information reflects the relative importance of the various species.

Order Cetacea

Baird's Beaked Whale (*Berardius bairdi*)

This species is known to occur from Alaska to Washington (Pike and MacAskie, 1969), and may be present occasionally in Dixon Entrance and Hecate Strait. These whales have been recorded in British Columbia off the west coast of Vancouver Island from May to September (Pike and

TABLE 3-9.1

STATUS AND RELATIVE ABUNDANCE OF MARINE MAMMALS ALONG THE MARINE APPROACHES

SPECIES	SCIENTIFIC NAME	STATUS	RELATIVE ABUNDANCE IN MARINE APPROACHES
Order Cetacea			
Bairds's Beaked Whale	Berardius bairdi	non-resident	rare
Cuvier's Beaked Whale	Ziphius cavirostris	non-resident	rare
Other Beaked Whales	Mesoplodon spp.	non-resident	rare
Sperm Whale	Physeter catodon	offshore resident	rare
Dall Porpoise	Phocoenoides dalli	resident	common
Pacific Harbour Porpoise	Phocoena phocoena	year-round resident	common
Killer Whale	Orcinus orca	resident	common
Pacific Pilot Whale	Globicephola macrorhyncha	non-resident	rare
Gray Whale	Eschrichtius gibbosus	migrant, summer resident	common
Right Whale	Balaena glacialis	resident	rare
Fin Whale	Balaenoptera physalus	migrant, some summer residents	uncommon
Minke Whale	Balaenoptera acutorostrata	resident	uncommon
Blue Whale	Balaenoptera musculus	offshore resident	rare
Order Pinnipedia			
Pacific Harbour Seal	Phoca vitulina	year-round resident	common
Northern Elephant Seal	Mirounga angustirostris	April-November resident	rare
Northern Fur Seal	Callorhinus ursinus	migrant and some year-round residents	common
Northern Sea Lion	Eumetopias jubatus	year-round resident	common
Order Carnivora			
Sea Otter	Enhydra lutris	year-round resident	rare

Sources: Pike and MacAskie (1969), Leatherwood and Reeves (1978), Cowan and Guiguet (1965), Bigg (1969), Spalding (1964), Bigg and MacAskie (1978).

MacAskie, 1969). Stomachs of this species contained mostly squid, as well as rays, deep water fish, octopus and crustaceans (Rice, 1978).

No direct sightings of Baird's Beaked Whales have been reported in Dixon Entrance and Hecate Strait, but because their range encompasses these marine approaches they could be considered occasional visitors.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

This species is known to inhabit the west coast of North America from Alaska to California and specimens have been recorded at Tow Hill and Sandspit on the Queen Charlotte Islands (Pike and MacAskie, 1969).

Cuvier's Beaked Whale is another relatively rare inhabitant of the north coast. Most of the recorded sightings have been on the west coast of Vancouver Island.

Other Beaked Whales (*Mesoplodon* spp.)

The only record of a Mesoplodon specimen recorded on the north coast was a dead juvenile male which drifted ashore at Prince Rupert Harbour in 1962 (Pike and MacAskie, 1969). The other records of this species in British Columbia were two separate reports from Vancouver Island (Pike and MacAskie, 1969).

Since only a single record of Mesoplodon exists this group can only be considered rare on the north coast.

Sperm Whale (Physeter catodon)

Sperm whales concentrate in the open ocean, up to 200 miles offshore, in late spring, summer and early fall. The stomach contents are mainly squid, ragfish and rockfish (Pike and MacAskie, 1969).

Occasionally, Sperm Whales are found in Dixon entrance, Hecate Strait and Queen Charlotte Sound but not in large schools (Pike and MacAskie, 1969). Male Sperm Whales may range as far north as the Bering Sea but females do not migrate into water with a temperature of less than 10°C which is south of the study area (Nishiwaki, 1967) except in late summer.

The sperm whale comprised 62% of the catch of the Queen Charlotte Islands whaling stations while they were in operation which provides some indication of their abundance relative to the other harvestable whales.

Due to the pelagic nature of Sperm Whales, sightings are rare in inshore waters. Their presence in the marine approaches is considered rare.

Dall Porpoise (Phocoenoides dalli)

The range of the Dall Porpoise extends from Ballenas Bay in Baja California to the Pribilof Islands in the Bering Sea. Based on the accounts of Pike and MacAskie (1969) and Cowan and Guiguet (1965) Dall porpoise are common on the B.C. coast throughout the year. There is some indication that they frequent more inshore waters, such as the marine approaches in the June to October period and move offshore in the winter months.

Dall Porpoises are sighted regularly in Queen Charlotte Strait, Hecate Strait, Dixon Entrance and Fitzhugh Sound. Schools of 30 to 100 have been recorded in inshore waters in spring and fall while very few sightings have been recorded in summer months (Pike and MacAskie, 1969). They have been seen frequently in Chatham Sound and are probably intermittent visitors to the terminal area (NEAT, 1975).

Pacific Harbour Porpoise (*Phocoena phocoena*)

The Pacific Harbour Porpoise is found all along the British Columbia coast in bays, harbours and inshore waters up to 20 miles offshore (Cowan and Guiguet, 1965). There are some seasonal concentrations of this species but no obvious migrations (Leatherwood and Reeves, 1978).

Harbour Porpoises are occasionally seen off Ridley Island (Figure 3-9.1) and a small pod of five was seen during winter surveys of 1977-78 in Chismore Passage (Martin, 1978). This species feeds primarily on small fishes such as herring and squid (Cowan and Guiguet, 1965; Leatherwood and Reeves, 1978).

Harbour Porpoise are considered one of the more common cetacea present in the marine approaches. They are probably widespread throughout Dixon Entrance, Hecate Strait, Queen Charlotte Sound and along the mainland coast.

Killer Whale (*Orcinus orca*)

The Killer Whale is widespread and conspicuous in coastal waters off British Columbia and throughout the north Pacific waters (Pike and MacAskie, 1969). There is one record of a mass stranding of Killer Whales near Masset in January 1941 (Pike and MacAskie, 1969). A recent and extensive study was conducted enumerating and identifying the pods that inhabit Georgia Strait (Bigg et al, 1976). No comparable data on north coast Killer Whales are available. Killer Whales are not known to be frequent visitors to the Port Simpson/Prince Rupert area but have been sighted in Prince Rupert Harbour in winter months (NEAT, 1975) and one pod was observed in Chearnley Passage (Martin, 1978).

Killer Whales have been known to feed on smaller whales, porpoises, sea birds, squid, seals and sea lions and many kinds of fish including salmon (Pike and MacAskie, 1969).

<u>Pacific Pilot Whale</u> (<u>Globicephela</u> <u>macrorhyncha</u>)

Pilot Whales are rarely sighted north of California, but records do exist of strandings as far north as Alaska. Three juveniles were caught in June 1957 approximately 400 miles west of Dixon Entrance (Pike and MacAskie, 1969). Pilot Whales primarily feed on squid.

Because of the singular record of these whales off the B.C. coast this species is considered incidental in the marine approaches area.

<u>Gray Whale</u> (<u>Eschrichtius</u> <u>gibbosus</u>)

Gray Whales are present along the British Columbia coast during their migrations between winter calving grounds off Baja California and Mexico and summer feeding grounds in the Bering Sea (Pike and MacAskie, 1969). They migrate along the west coast in relatively shallow water, except when crossing long channels or straits. Their southward migration begins in late September and October and ends in late January with the peak in late December (Pike, 1962). Hatler and

Darling (1974) found that sightings of Gray Whales along the west coast of Vancouver Island on their southward migration were confined to a 5-6 week period including all of December and early January. The northward migration begins in February and ends in May or June, peaking in early April (Pike and MacAskie, 1969).

Gray Whales generally spend the summer feeding in the Bering and Chukchi Seas where they utilize benthic and near benthic organisms, primarily amphipods. However, small numbers have been observed in summer along the west coasts of Vancouver Island and the Queen Charlotte Islands. Several were reported during the summer months at Langara Island (Pike and MacAskie, 1969). However, the greatest numbers of Gray Whales occur in Dixon Entrance, Hecate Strait and the west coast during the peak migratory periods in December and April (Map 3-9.1).

<u>Right Whale</u> (<u>Balaena glacialis</u>)

The Right Whale is considered rare in the northeast Pacific now, although it was once abundant. The present population in the north Pacific is estimated to be between 100 and 200 animals. The traditional summer feeding grounds of the Right Whale are in the Gulf of Alaska from the Queen Charlotte Islands to the Aleutian Islands (Gilmore, 1978) and Pike and MacAskie (1969) suggest that wintering grounds probably were the waters off British Columbia, Washington and Oregon.

Right Whale wintering and calving areas are unknown. There are three records of Right Whale catches at Queen Charlotte Islands whaling stations, two in 1924 and one in 1926 (Pike and MacAskie, 1969).

This species is equipped with baleen plates and feeds on zooplankton, primarily copepods. These whales may also feed on larger prey such as larval crustacea, euphausids, shrimp, small mollusca and small fish (Gilmore, 1978).

Because this species was depleted due to whaling, it is no longer considered common in the marine approaches area.

Fin Whale (*Balaenoptera physalus*)

This is the most abundant of the baleen whales to be found off the British Columbia coast. It is generally found offshore in open ocean but will occasionally enter Hecate Strait, Queen Charlotte Sound and the Strait of Georgia (Pike and MacAskie, 1969).

Most of the Fin Whales occurring off British Columbia are migrants travelling between northern feeding grounds in the Bering Sea and breeding grounds in lower southern latitudes. However, some are considered residents throughout the summer. Their primary food source are euphausids or small fish concentrated in groups (Mitchell, 1978).

Fin Whales may occasionally be encountered in Hecate Strait and Queen Charlotte Sound but they generally occupy offshore waters.

Minke Whale (*Balaenoptera acutorostrata*)

Minke Whales are not found in large numbers along the British Columbia coast, but when they have been observed it has been generally in protected areas (Trans-Mountain, Vol. XVI, 1980). Since they were not a valuable commercial species, few were caught by the whaling industry. Only two were recorded from the Queen Charlotte Islands and these were the only recorded catches off the west coast of North America. They are known to occur from Baja California as far north as the Chukchi Sea (Pike and MacAskie, 1969).

The Minke Whale feeds on small fish such as sand-lance and anchovy and may also utilize euphausids and other invertebrates (Mitchell, 1978). While these whales have a preference for protected waters, they are not considered common to the north coast.

Blue Whale (*Balaenoptera musculus*)

Traditonally, the Blue Whale was generally found well offshore either singly or in groups of two or three (Pike and MacAskie, 1969). They tended to congregate off the coast of Baja California from February to June and during the summer ranged in offshore waters from Central California to the Aleutian Islands (Rice, 1978). The Blue Whales in the North Pacific feed on specific species of krill, the primary one being *Euphausia pacifica* while *Thysanoessa* sp. is also utilized (Rice, 1978).

The pelagic nature of the Blue Whale would indicate that it is unlikely to occur along the marine approaches.

Order Pinnipedia

Pacific Harbour Seal (*Phoca vitulina*)

The Pacific Harbour Seal is a non-migratory species and its preferred habitat consists of tidal mud flats, sand bars, estuaries and reefs throughout the length of the British Columbia coast. While it is not a migratory species its local movements are known to be associated with tides, food, reproduction and season (Bigg, 1969).

Bigg (1969) estimated that the total Harbour Seal population of B.C. is approximately 35,000. The population in the Prince Rupert/Port Simpson area is approximately 200-300 (NEAT, 1975). Martin (1978) stated that groups of up to 60 Harbour Seals were seen hauled-out on bars near DeHorsey Island, Croasdaile Island and Genn Islands (Figure 3-9.1) and groups in excess of 200 were observed up the Skeena River near Kwinitsa (Map 3-9.1). Smith and Tugwell Islands are also favoured haul-out areas (NEAT, 1975). Martin (1978) mentioned a variety of winter observations of smaller groups at Big Bay, Hudson Bay Passage, the Gnarled Islands, Hodgson Reef, Jap Point and Galloway Rapids in Morse Basin (Figure 3-9.1). Historically Harbour Seals were much more abundant in the Prince Rupert/Port Simpson area than at present. However, because they were considered detrimental to the salmon populations in the Skeena, a control program was instituted from 1944-1960 allowing 200 seals to be killed annually. Some commercial hunting was continued from 1960-1965, but now the Harbour Seal has full protection under the Federal Fisheries Act (NEAT, 1975). To what degree these populations have recovered thus earlier abundance has not been confirmed quantitatively.

While Harbour Seals are present all along the coast of the mainland and the Queen Charlotte Islands, those sightings mentioned in the previous paragraph are the only documented reports specific to the study area. A known Harbour Seal colony is present on the southern tip of the Queen Charlotte Islands year round (Trans-Mountain Vol. XVII, 1980).

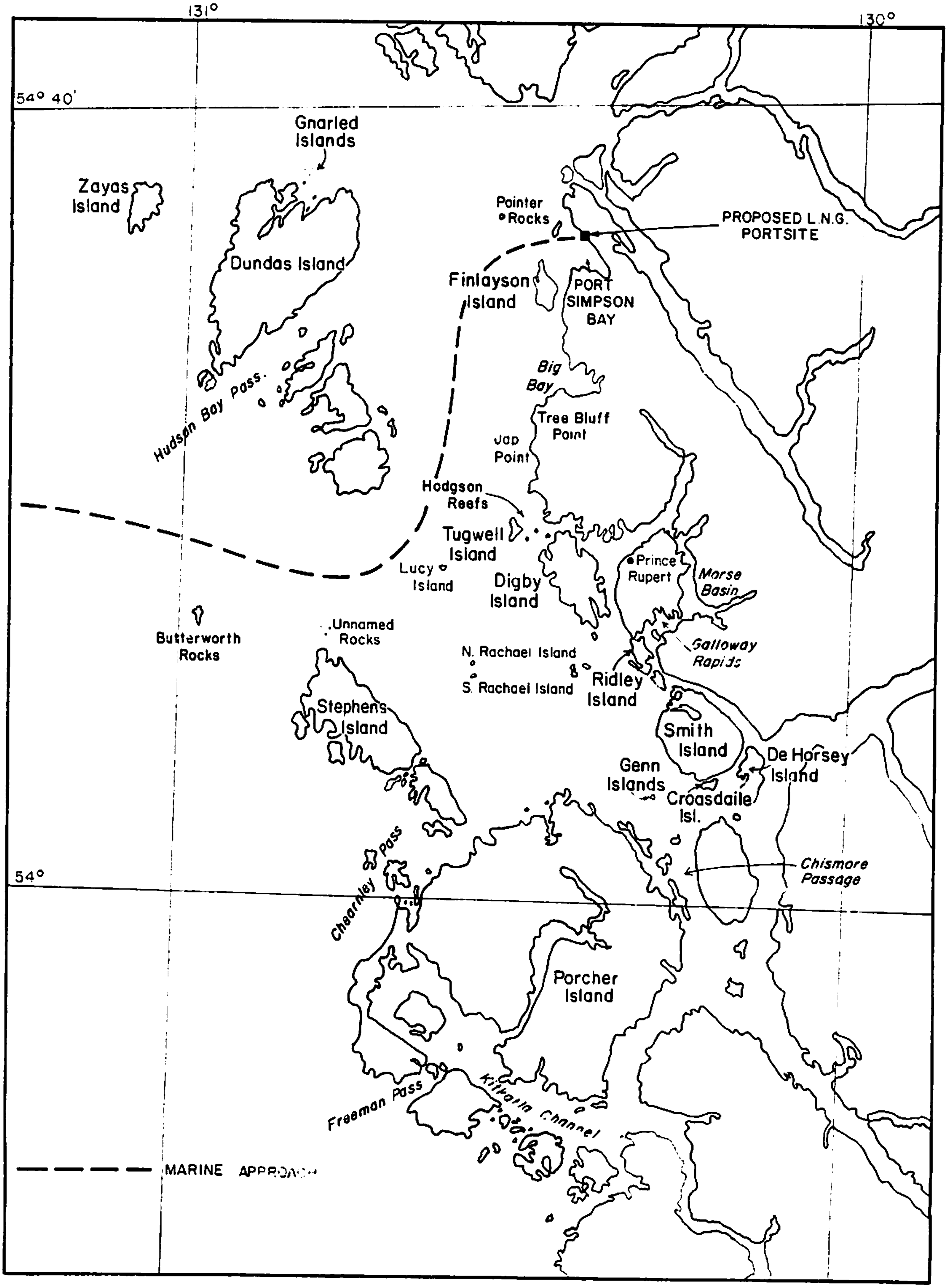


FIGURE 3.9.1
Some Locations in Chatham Sound
referred to in the text.

During the summer food consists primarily of octopus, rockfish and salmon. During the fall, salmon has been found to constitute one-third of the food catch in seal stomachs (Spalding, 1964). Fisher (1952) indicated that seals congregate at Port Essington during the eulachon run and then continue upstream with salmon runs. Spalding (1964) also found that in inlets eulachon may be an important food source during the winter.

While the Harbour Seals do feed on salmon in the Skeena, Spalding (1964) also found examples of seals that were utilizing octopus in one particular inlet, while salmon were moving up another. There was no obvious movement by the seals to take advantage of these salmon runs.

Harbour Seals are common throughout the north coast and the Queen Charlotte Islands in variable types of coastal habitats. Because they are quite abundant as well as diverse in their habitat preferences, they are probably one of the most common marine mammals in the marine approaches area.

Northern Elephant Seal (*Mirounga angustirostris*)

The Northern Elephant Seal is considered to be a rare species along the British Columbia coast. Elephant Seals have been documented as far north as Prince of Wales Island in southeastern Alaska (Willet, 1943) and a single specimen washed up on a beach on Langara Island, Queen Charlotte Islands (Guiguet, 1971a). Other records indicate that in British Columbia waters they are seen most often in Hecate Strait (Pike and MacAskie, 1969).

Elephant Seals are usually seen in British Columbia waters from April to November, their non-breeding season.

Their winter breeding area is along Baja and southern California (DeLong, 1978).

While food habits of the Elephant Seal are not well known, present knowledge suggests that Elephant Seals feed on bottomfish such as ratfish, sharks, spiny dogfish, eels, various rockfish and squid (DeLong, 1978).

In summary, Elephant Seals may be present in Hecate Strait from April through November in very small numbers.

Northern Fur Seal (*Callorhinus ursinus*)

Northern Fur Seals are a migratory species and move along the west coast of the Queen Charlotte Islands and Vancouver Island, enroute from their winter feeding grounds off California to their summer breeding grounds in the Bering Sea. Once the breeding season is over, the seals disperse over the north Pacific, but usually not into waters warmer than 20°C (Nishiwaki, 1967). Mature cows move as far south as Baja California (Spalding, 1964). Seals aged 1, 2 and 3 years remain along the coast in relatively high concentrations and yearlings are found in Hecate Strait, Queen Charlotte Sound and the inside channels and inlets of northern B.C. from January to April (Spalding, 1964). During the spring most seals return to the Pribilof Islands. The heaviest concentration of seals along the B.C. coast are found between mid-April and mid-May (Spalding, 1964).

Herring is an important food source for Fur Seals in Hecate Strait and off Vancouver Island, but squid are also taken frequently. Fur Seals in inside waters (inlets and channels) feed mainly on squid, ratfish and sablefish (Spalding, 1964).

The major numbers of migratory Fur Seals that are recorded along the British Columbia coast are on the west coast of the Queen Charlotte Islands. However, some resident immature Fur Seals are present through Queen Charlotte Sound and Hecate Strait.

Northern Sea Lion (*Eumetopias jubata*)

The Northern Sea Lion is considered migratory in that the population congregates at various rookeries during the breeding season and disperses in the fall. However, many cows with pups remain on rookeries year-round. The major rookeries in the study area are located at Forrester Island, Alaska. Two separate rookeries exist in the vicinity of Forrester Island with breeding populations of 3,000 and 1,000 (Table 3-9.2). Other rookeries are on Kerouard Island situated off the southern tip of Moresby Island with a breeding population estimated at 900 animals and North Danger Rocks, situated off the northwest corner of Banks Island, with a breeding population of 350 (Fish and Wildlife Branch, 1977).

Throughout the study area there are sites where groups of sea lions haul-out during the winter and summer months (Map 3-9.1). Estimated numbers of Sea Lions that occupy these sites and their seasonal use are shown in Table 3-9.2. Some haul-out areas utilized in the summer during the breeding season may be bachelor colonies. These colonies are occupied by immature males that were unable to establish territories in the rookeries and by some non-breeding females (Harestad and Fisher, 1975). Additional sites in the area were former colonies. These include Butterworth Rocks, unnamed rocks north of Stephens Island, Boston Island and Shag Rocks (Map 3-9.1 and Figure 3-9.1).

TABLE 3-9.2

NORTHERN SEA LION ROOKERIES AND HAUL OUTS IN THE STUDY AREA

Location	Status	Occurrence	Approximate Total
Kerouard I.	R	S	900
	HO	W	30
Scudder Pt.	X		/
Ramsay I.	HO	W	150
Reef I.	HO	S	200
	HO	W	150
Skedans I.	HO	S	/
	HO	W	300
Old Masset	HO		/
Masset Sd.	HO	S	50
Shag Rks.	X		/
Langara I.	HO	S	25
	HO	W	75
Joseph Rks.	HO	S	/
	HO	W	300
Hippa I.	HO	S	/
	HO	W	200
Kunakun Pt.	X		/
Cone Hd.	HO	W	15
Kindakun Pt.	X		/
Marble I.	HO	W	35
Moresby Its.	HO	W	100
Cape Henry	X		/
Chads Pt.	X		/
Tasu	HO	S	/
	HO	W	150
Wells Cove	X		/
MacLean Frazer Pt.	HO	W	20
Nagas Pt.	HO	W	50
Cape St. James	HO	S	/
	HO	W	/
Blenheim I.	HO	W	100
Gosling Rks.	HO	S	/
	HO	W	200
Day Pt., Day I.	X		500
McInnes Rks.	HO	S	/
	HO	W	150
Laredo Inlet	HO	W	/
Morey Rk.	HO	W	130
Steele Rks.	HO	W	125
Isnor Rks.	HO	W	10
Ashdown I.	HO	W	120
Estevan Grp.	HO	W	/
Joseph I.	X		/
North Danger Rks.	R	S	350
	HO	W	80

TABLE 3-9.2 - Cont'd.

Location	Status	Occurrence	Approximate Total
Halibut Rks.	X		100
Bonilla Rks.	HO	W	200
White Rks.	X		/
Archibald I.	HO	S	75
Butterworth Rks.	X		200
Rks. N of Stevens I.	X		/
Boston I.	X		/
Dundas I.	HO	W	400
Zayas I.	HO	W	225
Forrester I., Alaska			
- Lowrie I.	R	S	1,000
- Cape Horn Rks. & Sea Lion Rks.	R	S	3,000

From: Northern B.C. Coastal Wildlife Resources Map, Fish & Wildlife Branch, 1977.

Alaska's Wildlife & Habitat, Alaska Department of Fish and Game, 1973.

R - rookery
HO - haul out
X - former haul out
S - summer
W - winter
/ - no estimate available

During a winter study in 1978-79, a number of individual Sea Lions were observed in the Chatham Sound area. All were adult males except one that was seen off Tree Bluff Point (Martin, 1978). The adult males were seen on Dundas Island, in Kitkatla Channel and off Freeman Pass (Figure 3-9.1).

During the winter or non-breeding season, Sea Lions may feed on whiting, herring and rockfish, while those animals congregating on rookeries feed primarily on octopus along with rockfish, dogfish and salmon. On the non-breeding haul-outs, whiting and dogfish are the predominant foods. During the fall, when a large portion of the animals on rookeries and other haul-outs disperse along the coast, rockfish, hake and salmon become important foods (Spalding, 1964). Some Sea Lions may travel to creek mouths and prey upon eulachon and salmon (Martin, 1978).

Sea Lions are one of the most plentiful and widespread marine mammal occupying the study area. They are found on coastlines bordering both marine approaches in both breeding and non-breeding colonies and on a large number of haul-out sites.

Order Carnivora

Sea Otter (*Enhydra lutris*)

At one time Sea Otter inhabited the entire British Columbia coast but they were hunted for their pelts to such an extent that they were almost obliterated by 1830. Their population remains small and the Sea Otter is considered an endangered species by the Committee on the Status of Endangered Wildlife in Canada.

Their previous range extended from Baja California to the Aleutian/Commander and Pribilof Islands. At present they are relatively numerous in Alaska west of Prince William Sound. Sea otters have been transplanted from these more plentiful colonies to the Chichagof Island in southeastern Alaska (Kenyon, 1969) and to the west coast of Vancouver Island (Anon, 1969).

Along the north coast an observation of a Sea Otter at the Cape St. James sea lion rookery (southern Queen Charlotte Islands) has been recorded by Edie (1973). Small colonies in the Queen Charlottes and along the northern mainland have probably become established, based on observations of Sea Otters in these areas (Bigg and MacAskie, 1978).

The habitats preferred by Sea Otters are offshore kelp beds, rocky islets and reefs. They occasionally haul-out, but as a rule spend most of their time in the water. Food items are primarily sea urchins and molluscs (Cowan and Guiguet, 1965).

The Sea Otter is still a rare species along the west coast of British Columbia. Recent sightings indicate some range extensions into the north coast as a result of transplants and emigration from other colonies, and this modest recovery shows no signs of reversal.

3.9.1.2 Marine Birds

The marine birds of coastal British Columbia constitute a remarkable marine resource. From small coastal estuaries up long protected inlets to the pelagic environments offshore, a diversity of marine birds are found in great abundance along the B.C. coast. The following general pattern of marine bird occurrence is described here, based on observations of Robertson (1974a), Martin (1978) and Savard (1979). In the marshy vegetation of these coastal estuaries, Trumpeter Swans, Canada Geese and various species of puddle ducks are found as migrants and winter residents. Puddle ducks are found on almost all such estuarine marshes, with decreasing frequencies of Canada Geese and Trumpeter Swans, respectively. From deeper waters at the mouth of estuaries proceeding down the deep fjords, diving ducks, divers and some alcids and gulls occur primarily from October to May. Concentrations tend to occur in shallow water, along tide lines and around local fish concentrations. Proceeding toward more exposed locations the fauna tends to exclude swans, geese and puddle ducks except in the presence of extensive estuarine marsh development, such as that at Big Bay, south of Port Simpson. Along exposed shorelines, diving ducks such as scoters, oldsquaw and harlequin ducks, gulls and divers (loons, grebes and cormorants) are the chief groups occurring. In the pelagic waters at the mouths of inlets and in Hecate Strait and Dixon Entrance a different avifauna occurs. It is chiefly composed of alcids (auklets, murrelets and puffins), shearwaters, fulmars, storm petrels, phalaropes and jaegers. Diving ducks, almost exclusively scoters and oldsquaw, may occur relatively far off the eastern shores of the Queen Charlotte Islands in shallow waters, but they are not truly birds of the pelagic zone. The pelagic birds occur year- round as a group though individual species have seasonal occurrence patterns. Gulls tend to be common in all these habitats, and at all seasons.

Recent attention to these resources has improved the available inventory information, and major marine bird breeding colonies and concentrations along the shores of Hecate Strait and Dixon Entrance have been plotted on resource maps and reproduced in Maps 3-9.2 and 3-9.3. The principal colonies and aggregations are highlighted, but a listing of all marine, marine associated and game birds along the approaches and at the terminal has been provided (Table 3-9.3).

Breeding Concentrations

On the Queen Charlotte Islands, recent compilations of sea bird colony data have estimated the number of breeding pairs at 422,958 (B.C. Provincial Museum, 1979). A further minimum estimate of 44,785 pairs breed on islets from Goose Island north to the Alaska border (Map 3-9.2) (Fish and Wildlife Branch, 1977). At the west end of Dixon Entrance the Forrester Island group in Alaska is the breeding site for a further 553,612 pairs (Sowls et al, 1978). The total thus exceeds one million breeding pairs in these waters, and a complete inventory has not yet been compiled.

Species composition is important for conservation interest and also because it helps to identify limitations in the data for sea bird aggregations away from breeding colonies. Storm Petrels (Leach's and Fork-tailed) account for almost half of the breeding sea birds in the above area. They forage offshore (K. Vermeer, Canadian Wildlife Service, pers. comm.), and are thus not likely to be encountered in large numbers within the Dixon Entrance and Hecate Strait marine approaches. The small alcids, Ancient Murrelet and Cassin's Auklet, represent over 40% of the total breeding sea birds along the marine approaches and represent the major conservation interest. Their colonies represent a high proportion of the world's population of these species. While nesting, these birds forage in adjacent waters including the marine approaches. The Rhinoceros Auklet and Tufted Puffin, while less numerous, still represent over 125,000 pairs. These species utilize deep waters for foraging and are likely to be encountered along the marine approaches. Other species listed in Table 3-9.4 occur in much smaller numbers. A fur-

TABLE 3-9.3

COMPARATIVE COUNTS OF MARINE BIRDS DURING FALL & WINTER IN CHATHAM SOUND AND ADJACENT NORTH COAST WATERS, 1977-1978

	Surveys Conducted in Chatham Sound*				Surveys Conducted in Dixon Entrance, Hecate Strait & Chatham Sound**				
	Sept. 14	Nov. 5	Jan. 14	Mar. 14	Sept. 22-24	Oct. 17,18	Nov. 14-16	Jan. 9-12	Feb. 13,14,16
Swans	-	-	4	-	-	-	-	-	-
Geese	176	600	750	127	251	220	271	610	464
Puddle Ducks	706	1,350	817	326	71	564	821	69	118
Diving Ducks	67	663	855	334	640	2,888	2,434	7,196	5,193
Divers	data not available				525	592	393	936	688
Gulls	data not available				6,619	4,858	3,158	3,536	3,699
Alcids	data not available				150	79	94	58	442

* Data from Canadian Wildlife Service (1980)
** Data from J. P. Savard (1979)

ther discussion on the distribution of these breeding species away from their breeding islands is undertaken below.

TABLE 3-9.4: Numbers and Species Composition of Sea Birds Breeding in Waters Adjacent to the Marine Approaches to Port Simpson (see text)

Fork-tailed Storm Petrel	95,958
Leach's Storm Petrel	401,510
Pelagic Cormorant	580
Glaucous-winged Gull	3,779
Common Murre	3,800
Pigeon Guillemot	1,323
Ancient Murrelet	240,880
Cassin's Auklet	192,462
Rhinoceros Auklet	82,965
Horned Puffin	435
Tufted Puffin	45,423

Source: B.C. Fish and Wildlife Branch (1977); B.C. Provincial Museum (1979); Sowls et al (1978).

Breeding by marine birds is not restricted to those species which nest colonially. The Marbled Murrelet is believed to nest in trees along the coast (Guiguet, 1971), and the only indications of numbers and distribution is the observation of pairs early in the season (April - June) and pairs and young (June - August). Unfortunately, though counts of Marbled Murrelets have been made during sea bird breeding colony censuses, these observations have yet to be analyzed (R.W. Campbell, B.C. Provincial Museum, pers. comm.). Their numbers likely extend into the thousands in water adjacent to the marine approaches, but better definition of numbers is not yet possible. Other species which are known to breed along the coast include Canada Geese, Mallards and Red-throated Loons. The numbers of breeding geese are not known, but inventory information indicates some concentration of breeding activity in the Chatham Sound area (Fish and Wildlife, 1977). There appears to be a further goose breeding area in the Milbanke Sound - Goose Island area. Red-throated Loons breed in muskeg ponds adjacent to the coast. These records have recently been plotted by the B.C. Provincial Museum, but have not yet been published. Numbers are small (R.W. Campbell, pers. comm.). Some breeding by Mallards takes place along the coast (Fish and Wildlife Branch, 1977), but its extent appears to be small.

In terms of the distribution of sea bird breeding colonies, some attention should be directed at those colonies nearest the proposed LNG port site. As indicated below ("Winter and Migratory Concentrations") there are no known sea bird breeding colonies in the immediate Port Simpson Bay area, but Chatham Sound is an important colonial sea bird breeding area, particularly the southern end (Figure 3-9.1; Map 3-9.2). Lucy Island is by far the most important, with a breeding population of 21,150 breeding pairs of Rhinoceros Auklets. The nearby islands, North Rachael and South Rachael Islands, have further colonies of Rhinoceros Auklets, numbering 1,500 and 2,000 respectively. In summary, this amount is almost 40% of the known breeding Rhinoceros Auklets on the British Columbia coast.

<u>Winter and Migratory Concentrations</u>

The distribution of marine birds in north coastal waters is incompletely known, but data to 1977 have been compiled by the Fish and Wildlife Branch (1977). The concentrations in excess of 100 individuals are indicated in Map 3-9.3

WESTERN L.N.G. PROJECT
DOME PETROLEUM LIMITED

SEABIRD COLONIES OF NORTHERN B.C. COAST

NUMBER OF BREEDING PAIRS BY COLONY

SPECIES

CODE

- FTSP - fork-tailed storm petrel
- LESP - Leache's storm petrel
- PECO - pelagic cormorant
- GWGU - glaucous-winged gull
- COMU - common murre
- PIGU - pigeon guillemot
- ANMU - ancient murrelet
- CAAU - Cassin's auklet
- RHAU - rhinoceros auklet
- TUPU - tufted puffin

NO.	COLONY	FTSP	LESP	PECO	GWGU	COMU	PIGU	ANMU	CAAU	RHAU	TUPU	OTHERS, SPECIFY	TOTAL
	Langara Island												
1	Langara Island			63	126		80	25,000	A				25,269
2	Cox Island			9							8		17
	West Coast Graham Island												
3	Lepas Bay Island*	3,500	4,500				50		200				8,250
4	Unnamed Islands				26		2						28
5	Frederick Island				5		20	30,000	60,000				90,025
6	Tian Islets			28	237		50						315
7	Solide Islands	800	800						950				2,550
8	Brock Island			18			3						21
9	Unnamed Islets	300	500		8				300				1,108
10	Barry Island	500	200	1					100				801
11	Hippa Island*	5,000	3,000	15	20		10	20,000	10,000				38,045
12	Sadler Island			19	67								86
13	Seal Point Rock	1,500	1,500										3,000
14	Stiu Rock			2	28		5						35
15	Gagi Rock				53								53
16	Marble Island			16	13		20	1,000	5,000	200	300		6,549
	West Coast Moresby Island												
17	Buck Channel Is.		250				A						250
18	Sauders Island						A	200+	40				240+
19	Willie Island	50	50						300	A			400
20	Helgesen Island						A	150	2,500				2,650
21	Carswell Island	A	A	5			5	A	900				910
22	Bone Point			10	A		5						15
23	Lihou Island		10,000	1			15	10,000	1,000		25		21,041
24	Luxmore Island								200+				200+
25	Rogers Island	9,000	9,000										18,000
26	Moresby Islets									25+			25+
27	Lomgon Islets				34		4+						38+
28	Unnamed Islet				6		2+		100				108+
29	Gowdas Islands				21		10						31
30	Adam Rocks				45		4+				6		55+
31	Anthony Islands	400	6,400	11	247		150	200	25,000	2,700	60		35,168
32	Flatrock Island			5	140		12+				4		161+
33	Gordon Islands				6		23		3,000	300	100		3,429
34	St. James Island			30	31				20+		1,500		1,581+
35	Kerouard Islands*			10	74	50	25+		22,000		1,500+		23,659+
	East Coast Moresby Island												
36	Lyman Point Islet										25		25
37	Gull-Marshall Is.				1		20						21
38	Rainy Islands				23								23
39	High Island							100		100+			200+
40	Rose Harbour Is.						25+		50				75+
41	Garcin Rocks				102		4+						106+
42	Langtry Island	4,000					15+		200				4,215
43	Rankine Islands*	3,500	7,500		6		25+	11,000+	5,000				27,031+
44	Joyce Rocks				94								94
45	Sea Pigeon Island						15+	5+					20+
46	Green Rock				7		10						17
47	Bolkus Islands	125+	500		2			4,500+	1,200+	100			6,427+
48	Slug Islet				54		3	10+					67+
	Rock Islet	3,000	3,000		1				25				6,026
	Skincuttle Is.		500+					500					1,000+
	George Island	A	1,500					7,500	750				9,750
	Jeffrey Island*						6	600+	2,000				2,606+
	East Copper Is.*	1,000	500					4,500	4,700				10,700
49	Howay Island			20+	5			15+	200				240+
50	Alder Island	10					12+	5,500	1,600				7,122+
51	Centre Island						15+						15+
52	Arichika Island	500	25+				8	500+	500				1,533+
53	Marco Rock				24		17						41
54	Hutton Islands						10						10
55	Hoskins Islets	2,000					5+						2,005+
56	Bischof Islands	5,000					10+	300					5,310+
57	Murchison Is.			75+	6		14+	800+	200+				1,095+
58	Hotspring Is.	100					50		500				650
59	Ramsay Rock				14								14
60	Tatsung Rock				43		6+						49+
61	Ramsay Island			20	24		20	1,000	7,500				8,564
62	House Island						5+	3,000+	50+				3,055+
63	Agglomerate Is.	A	1,000+		21			2,000+					3,021+
64	Kawas Islets	300			24		15+		250				589+
65	Tar Islets	15	15		24				100				154
66	Dodge Point							60,000					60,000
67	Kul Rocks				11		1+						12+
68	Gil Islet						10+						10+
69	Titul Island						10+		200				210+
70	Lost Island	100+			43		45+		45				233+
71	Kingsway Rock				70		9						79
72	Reef Island			45	9		10+	500+	500+	100			1,164+
73	South Low Island				20								20
74	Vertical Point			25									25
75	Limestone Islands						50	15,000					15,050
76	Low Island	A			70		15+		A				85+
77	Skedans Islands	10,000			35				500				10,535
78	Kingui Island	10+					2+						12+
79	Cumshewa Island				18		5+						23+
	Skidegate Inlet												
80	Gillatt Island				9		10						19
81	Flowery Islets				20		2						22
82	Bush Islands				7		17						24
83	Angle-Tree Is.				1		12						13
84	Maple Island				2+		10+						12+
85	Jewel Island						15+						15+
86	Torrens Island						25+						25+
	Masset Inlet & Juskatla Inlet												
87	Sloop Islet				12		3+						15+
88	Dawson Islets				10		10+						20+
89	Cowley Rock				8		2+						10+
90	Harrison Is.				1		9+						10+
	North Coast Graham Island												
91	Cape Naden				42		A						42
	Forrester Island, Alaska												
92	Petrel I.	44,350	344,250	75	175	1,000	16	B	11,660		6,700	35 Horned Puffin	408,255
93	Forrester I.			B	75	1,900	150	30,000	2,200	54,000	35,000	375 Horned Puffin	123,700
94	Sea Lion Rk.			21	50		B						71
95	Cape Horn Rks.				100	750	3				150	25 Horned Puffin	1,028
96	Lowrie I.		450				16	B	20,000	15	B		20,481

SEABIRD COLONIES OF NORTHERN B.C. COAST

NUMBER OF BREEDING PAIRS BY COLONY

SPECIES

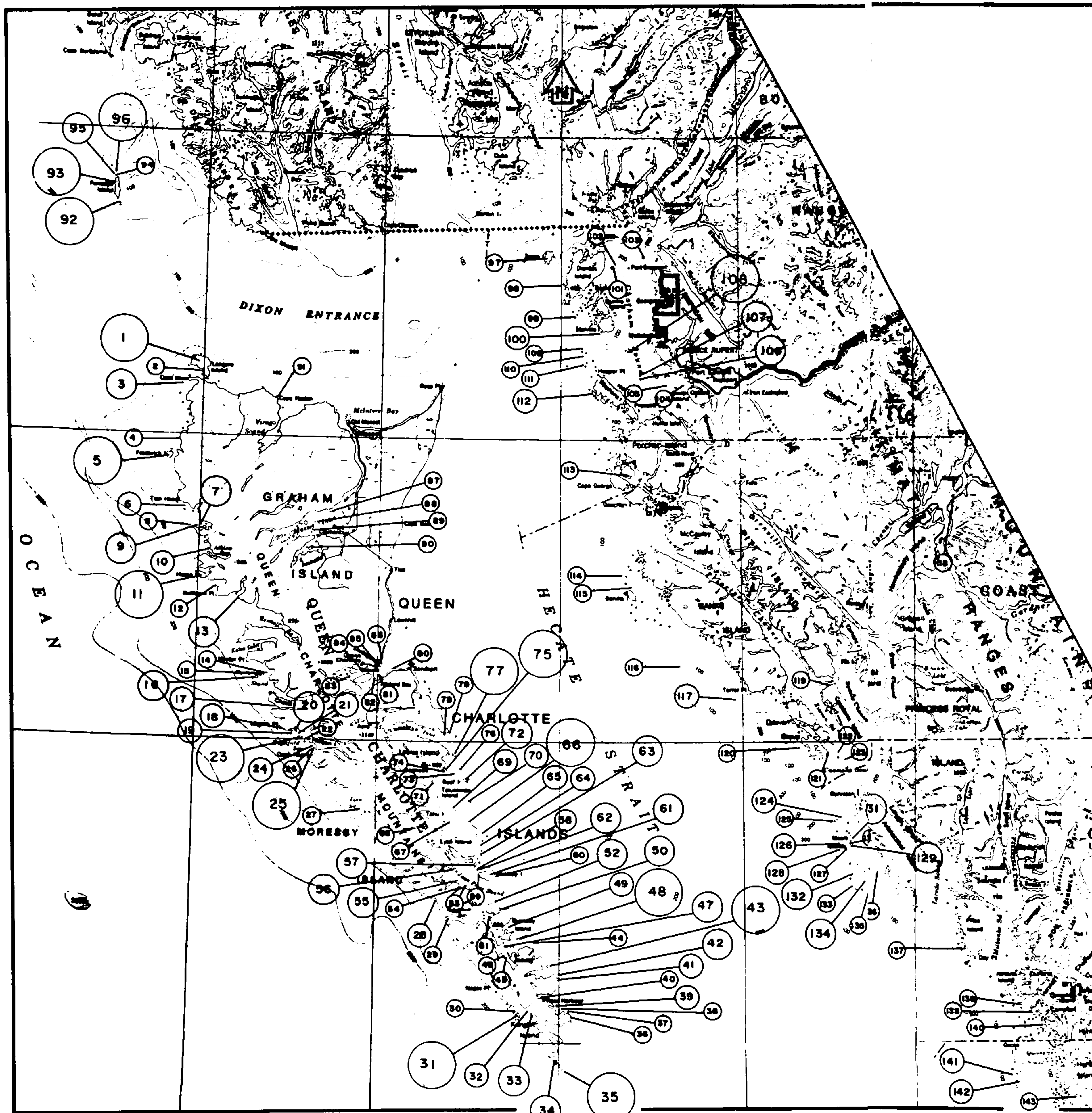
BEAK CONSULTANTS LIMITED JULY 1981

CODE

- A - suspected breeding
- B - known breeding - no estimate of numbers
- C - known breeding - small numbers but no accurate estimate
- D - known breeding - large numbers but no accurage estimate
- E - former colony
- + - minimum estimate
- * - ecological reserve

NO.	COLONY	FTSP	LESP	PECO	GWGU	COMU	PIGU	ANMU	CAAU	RHAU	TUPU	OTHERS, SPECIFY	TOTAL
	East Copper Is.*	1,000	500					4,500	4,700				10,700
49	Howay Island			20+	5			15+	200				240+
50	Alder Island	10					12+	5,500	1,600				7,122+
51	Centre Island						15+						15+
52	Arichika Island	500	25+				8	500+	500				1,533+
53	Marco Rock				24		17						41
54	Hutton Islands						10						10
55	Hoskins Islets	2,000					5+						2,005+
56	Bischof Islands	5,000					10+	300					5,310+
57	Murchison Is.			75+	6		14+	800+	200+				1,095+
58	Hotspring Is.	100					50		500				650
59	Ramsay Rock				14								14
60	Tatsung Rock				43		6+						49+
61	Ramsay Island			20	24		20	1,000	7,500				8,564
62	House Island						5+	3,000+	50+				3,055+
63	Agglomerate Is.	A	1,000+		21			2,000+					3,021+
64	Kawas Islets	300			24		15+		250				589+
65	Tar Islets	15	15		24				100				154
66	Dodge Point							60,000					60,000
67	Kul Rocks				11		1+						12+
68	Gil Islet						10+						10+
69	Titul Island						10+		200				210+
70	Lost Island	100+			43		45+		45				233+
71	Kingsway Rock				70		9						79
72	Reef Island			45	9		10+	500+	500+	100			1,164+
73	South Low Island				20								20
74	Vertical Point			25									25
75	Limestone Islands						50	15,000					15,050
76	Low Island	A			70		15+		A				85+
77	Skedans Islands	10,000			35				500				10,535
78	Kingui Island	10+					2+						12+
79	Cumshewa Island				18		5+						23+
	Skidegate Inlet												
80	Gillatt Island				9		10						19
81	Flowery Islets				20		2						22
82	Bush Islands				7		17						24
83	Angle-Tree Is.				1		12						13
84	Maple Island				2+		10+						12+
85	Jewel Island						15+						15+
86	Torrens Island						25+						25+
	Masset Inlet & Juskatla Inlet												
87	Sloop Islet				12		3+						15+
88	Dawson Islets				10		10+						20+
89	Cowley Rock				8		2+						10+
90	Harrison Is.				1		9+						10+
	North Coast Graham Island												
91	Cape Naden				42		A						42
	Forrester Island, Alaska												
92	Petrel I.	44,350	344,250	75	175	1,000	16	B	11,660		6,700	35 Horned Puffin	408,255
93	Forrester I.			B	75	1,900	150	30,000	2,200	54,000	35,000	375 Horned Puffin	123,700
94	Sea Lion Rk.			21	50		B						71
95	Cape Horn Rks.				100	750	3				150	25 Horned Puffin	1,028
96	Lowrie I.		450				16	B	20,000	15	B		20,481

NO.	COLONY	FTSP	LESP	PECO	GWGU	COMU	PIGU	ANMU	CAAU	RHAU	TUPU	OTHERS, SPECIFY	TOTAL
	Dixon Entrance & Chatham Sound												
97	Zayas I.				1								1
98	Unnamed Its. west of Dundas I.				67								67
99	Connel Is.				1		10			25			36
100	Rk. north of Simpson Rk.				155								155
101	Green I.				51								51
102	Grey It.				48		15						63
103	Pointer Rks.				A								A
104	Holland Rks.				C								C
105	Greentop It.				A		A						A
106	S. Rachael I.				16					2,000			2,016
107	N. Rachael I.									1,500			1,500
108	Lucy I.				47		4			21,150			21,201
109	Triple Is.			12	25			A					37
110	Lightstation Grp.			31	34								65
111	Tree Knob Grp.							A					A
112	Roland Rks.				112								112
113	Gurd Rk.				A								A
	West Coast of Banks Island and the Estevan Group												
114	Northwest Rks.				36		4						40
115	North Rk.				27		3						30
116	North Danger Rks.												A
117	Joseph I.			4	115		5						124
118	Coste Rks.			A	A								A
119	N. End Campania I.				C								C
120	McDonald I.				5								5
121	Unnamed Its. off Porter I.				15								15
122	Glide I.				11								11
123	Dupont I.									50			50
	West Coast of Aristazabal Island and Price Island												
124	Wells Rks.				139		1			100		20	260+
125	Isnor Rk.				4								4
126	Gander Grp.	63			35			C	25	C		C	123+
127	Its. S.W. of Moore Is.			9	4								13
128	McKenny Is.	100	50		59		1						210
129	Whitmore Is.	325	825		34		C		100				1,484+
130	Is. between McKenny and Whitmore Is.	B	25					A	33		25		83+
131	Moore Is.		4,500				5		100	2,000			6,605+
132	Byers Is.				69		10	7,000	64+	1,500			8,643
133	Conroy Is.								50	50			100
134	Sinnett Its.	500+	670		40		2		290				1,502
135	Harvey Is.				45		1		50				96
136	Bowden Is.				3								3
137	Its. S.W. of Price I.				36								36
	West Coast of Campbell Island and Hunter Island												
138	Its. of Limit I.				28								28
139	Fingal I.	B			55								55+
140	Guano Rks.				13								13
141	Gosling Rks.				150		500						650
142	Rogerson It.				38		2		150	25			215
143	Mosquito Its.				35		C						35+



WESTERN L.N.G. PROJECT

DOME PETROLEUM LIMITED

SEABIRD COLONIES OF NORTHERN B.C. COAST

BEAK CONSULTANTS LIMITED JULY 1981

SIZE OF SEABIRD COLONIES
(number of breeding pairs)

1—100

101—1,000

1,001—10,000

Colony Number ----- 000 — 10,001—500,000

Aggregate Total

SOURCES

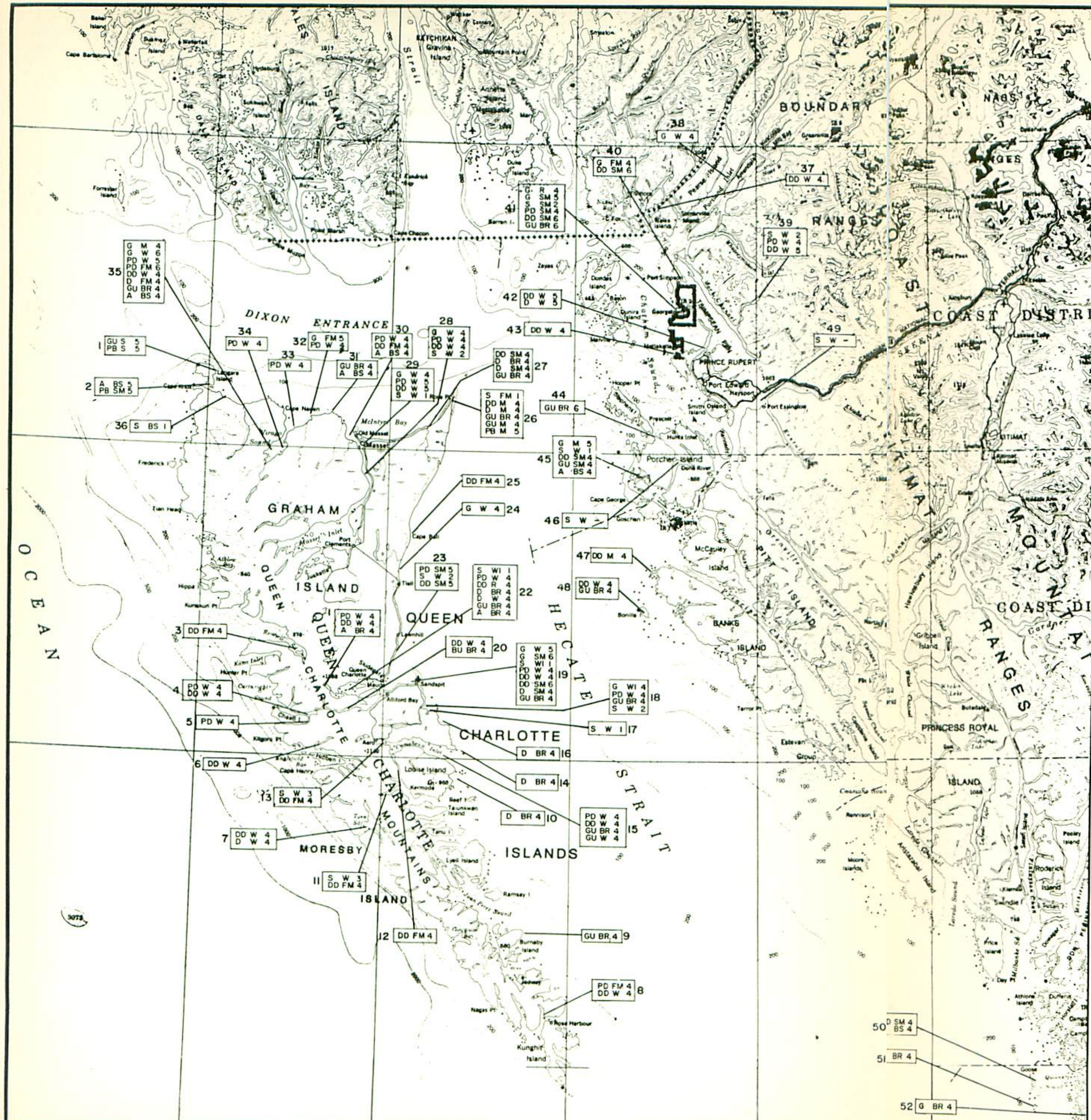
Campbell, R.W. and Garrioch, H.M., 1979. Seabird colonies of the Queen Charlotte Islands, B.C. Provincial Museum (Vertebrate Zoology Division), Victoria, B.C. V8V 1X4

Hotter, I. (compiler), 1977. Northern B.C. coastal wildlife resources map. B.C. Fish and Wildlife Branch

Sowls, A.L., S.A. Hatch and C.J. Lensink, 1978. Catalogue of Alaskan seabird colonies. Fish and Wildlife Service, U.S. Department of the Interior

20 0 20 40 60 80 Km

Map 3-9.2



WESTERN L.N.G. PROJECT

DOME PETROLEUM LIMITED

MARINE BIRD AGGREGATION

BEAK CONSULTANTS LIMITED JULY 1981

WATER BIRD GROUP

- G Geese
- S Swans
- PD Puddle Ducks
- DD Diving Ducks
- D Divers*
- GU Gulls
- A Alcids
- PB Pelagic Birds**

SEASONAL OCCURENCE***

- R Resident
- BR Breeding Resident
- FM Fall Migrant
- SM Spring Migrant
- M Migrant
- S Summer
- BS Breeding Summer
- W Winter
- I Intermittent

NUMBER OF INDIVIDUALS

- 1 1 - 5
- 2 6 - 50
- 3 351 - 100
- 4 101 - 500
- 5 501 - 1,000
- 6 More than 1,000

EXAMPLE

120 [G FM 2] ---- 6 - 50 Geese in Fall Migration
---------- Location Number

* Loons, Grebes and Cormorants
** Albatrosses, fulmars, shearwaters, petrels, phalaropes, jaegers and terns
*** **Resident** - birds present year round
Breeding Resident - always present, and breeds in the area
Fall Migrant - birds enroute from breeding grounds (primarily Sept. to Nov.)
Spring Migrant - enroute to the breeding grounds (primarily March to May)
Migrant - Both spring and fall (above) applicable, or seasonal pattern unknown
Summer - occuring mainly in June to August
Breeding Summer - as above, breeding in the area
Winter - occuring mainly Nov. to March
Intermittent - occasionally present, but not every year

LOCATION OF
WATER BIRD AGGREGATIONS

1	Langara I.	19	Sandspit	37	Pearse Canal (N. of Wales I.)
2	Parry Passage	20	Skidegate Narrows	38	Portland Inlet
3	Shields Ba	21	Long Inlet	39	Quottoon Inlet
4	Skidegate Chan	22	Skidegate Inlet	40	Stumann Bay
5	Chaati Narrows	23	Dead Tree Point	41	Big Bay
6	Security Cove	24	Tlell R.	42	Prince Rupert Hr. and Fern Passage
7	Tasu Sd.	25	Cape Ball	43	Metlakatla Bay
8	Rose Inlet	26	Rose Spit	44	Morrell Pt.
9	Scudder Pt.	27	Tow Hill	45	Kitkatla Inlet
10	Skedans Is.	28	Masset Sd.	46	Porcher Inlet
11	Sewell Inlet	29	Delkatla Slough	47	Larsen Hr.
12	Carmichael Passage	30	Masset Hr.	48	Bonilla I.
13	Gillatt Arm	31	Wiah Pt.	49	Skeena R. Estuary
14	Cumshewa I.	32	Cape Edenshaw	50	Goose I.
15	Cumshewa Inlet	33	Inskip Pt.	51	Gosling Rks.
16	Gray Bay	34	Craft Bay	52	Sea Otter Inlet
17	Sheldans Bay	35	Naden Hr.		
18	Copper Bay	36	Pillar Bay		

SOURCE:
Hatter, I (compiler), 1977, Northern B.C. coastal wildlife resources map. B.C. Fish and Wildlife Branch.

Note: Water bird aggregations less than 100 individuals have been omitted except for swans. Aggregations of water birds in Masset Inlet were excluded.

20 0 20 40 60 80 Km

Map 3-9.3

This map shows there are major concentrations along most of the coast. There are gaps, for example, adjacent to Banks Island and Aristazabal Island and it is difficult to conclude that adequate surveying has been done in these areas. The principal group observed was the diving ducks, with lower numbers of geese, puddle ducks, divers, gulls and alcids. Swans occur in small groups in suitable habitats along both sides of Hecate Strait, and are a resource of considerable conservation interest.

What is apparent in perusing these records is that most records refer to winter. Such an emphasis is realistic in view of the high numbers of northern breeding aquatic birds which utilize coastal B.C. during the period October to May. However, marine bird aggregation information for the spring and fall periods is much less complete. Another limitation is that the available records are restricted to shorelines and do not consider the open wates of Dixon Entrance and Hecate Strait. Some idea of bird use in these waters has been provided by Savard (1979).

During surveys conducted over the open waters of Dixon Entrance, Hecate Strait and Chatham Sound the density of birds encountered varied from 27 per 100 km flown to 1,011 per 100 km whereas densities of birds observed in inlets and along sandy and rocky shorelines averaged much higher (Table 3.9.5). Interpreting these data does not lead to the most obvious conclusions. For example, shoreline surveys can cover large proportions of the littoral (shoreline) habitats, whereas survey transects across Hecate Strait and Dixon Entrance represents a very small sampling of the available open water habitats. For this reason it would not be valid to conclude more birds are likely to occur along shoreline habitats compared to open water habitats in the marine approaches. A more realistic conclusion is that marine birds utilizing open water habitats can occur in large numbers, particularly in Hecate Strait in January and February. Among the groups observed, diving ducks (Scoters, Oldsquaws) were by far the most numerous, followed by gulls, alcids and divers.

TABLE 3-9.5: Comparative Density of Marine Birds (birds/ 100 km) along the Marine Approaches, 1978 Winter

A. Habitat Type	Inlets		Sandy Shoreline		Rocky Shoreline	
Date	Jan	Feb	Jan	Feb	Jan	Feb
Total	2639	3715	2600	2363	1566	1279

B. Habitat Type	Open Waters					
Area	Dixon Entrance		Hecate Strait		Chatham Sound	
Date	Jan	Feb	Jan	Feb	Jan	Feb
Total	67	27	573	1012	271	89

Data from Savard (1979). Numbers represent birds recorded per 100 km flown.

Certain bird groups recorded in low densities, particularly shearwaters and alcids, may reflect the biases associated with January and February sampling. Savard (1979) did encounter a large congregation of shearwaters in Chatham Sound near Dundas Island in November. He refers to a similar sighting one month later, and an earlier sighting by Guiguet in 1945. Shearwater numbers peak off the B.C. coast in summer and fall, and numbers in mid-winter are low (K. Vermeer, unpublished data). This would explain their low numbers in Savard's study. However, in summer and autumn their numbers along the B.C. coast are likely to exceed one million, and a certain proportion will occur regularly along the marine approaches. One member of this study team sighted large numbers (5,000+) of shearwaters south of Rose Spit, and a larger aggregation (25,000) off the mouth of Masset Inlet in mid-May 1971 (I. Robertson, unpublished data).

Ancient Murrelets and Cassin's Auklets were also observed by Robertson in large numbers in Hecate Strait in mid-May, 1971, though specific numbers are not available. Some 360,000+ pairs of these species nest in the Queen Charlotte Islands, thus such observations are not unlikely. No systematic series of surveys has documented such marine bird use of the marine approaches outside of the winter period.

Recreational Values

While hunting for ducks and geese does occur on the north coast, most of the marine birds mentioned above are not harvested. Nature watching is attracting a growing tourist trade to the Queen Charlotte Islands, and the large marine bird colonies are one of the principal attractions (M.P. Shepard, Swiftsure Tours, pers. comm.).

The relative low intensity of hunting immediately adjacent to the marine approaches reflects the relatively poor puddle duck and goose habitat. As quoted in the companion vegetation report (BEAK, 1981) the distribution of marshes is extremely restricted. As a consequence, puddle ducks and geese tend to occur in low numbers. Away from the approaches and up protected inlets the amount of favourable habitat and numbers of puddle ducks and geese tend to increase (B.C. Fish and Wildlife Branch, 1977).

Shorebirds

On the periphery of the approaches, shorelines adjacent to Dixon Entrance and Hecate Strait are utilized by large numbers of shorebirds (plovers and sandpipers primarily). The main shorebirds likely to be encountered and their status in the study area are shown in Table 3-9.3. Their importance to the present project is related to high numbers; the sensitivity of shoreline resources to the project is considered slight.

Though studies on shorebirds utilizing the north coast have only recently been initiated, G.W. Kaiser of the Canadian Wildlife Service has estimated that during the migration of western sandpipers, over 1,000,000 pass through the Fraser Estuary during the fall migration. Maximum instantaneous counts for specific days have exceeded 75,000 with large proportions passing through the Fraser estuary with each tidal cycle (G.W. Kaiser, pers. comm.). Certain shorelines along the north shore of the Queen Charlotte Islands appear to be particularly favourable to shorebirds, but quantification of such resources remains to be completed.

Raptors

Associated with the seabird colonies of the Queen Charlotte Islands are peregrine falcons. Ninety-seven known nesting sites have been identified in the Queen Charlotte Islands (Fish and Wildlife Branch, 1977). At least three active eyries have been reported on offshore islets in Chatham Sound in association with nesting colonies of alcids (NEAT, 1975). It is probable that the peregrine falcon is present in the marine approaches area during the winter months, in association with concentrations of shorebirds (NEAT, 1975). In spring and summer, the chief attraction of the area for peregrine falcons is the large number of alcids on which it feeds (Beebee, 1974). Their known nesting sites are located at considerable distances from the marine approaches.

Bald eagles are residents of the shorelines adjacent to the marine approaches, occurring in their greatest numbers in the October to March period. Osprey occur but in much smaller numbers (Beebee, 1974).

3.9.2 TERMINAL

3.9.2.1 Marine Mammals

The only known aggregation of marine mammals in the immediate vicinity of the Port Simpson proposed development is a Northern Sea Lion haul-out at the northern tip of the Tsimpsean Peninsula (Trans-Mountain Vol. XVII, 1980). However, due to the mobile nature of marine mammals it is probable that various other species that are common to the north coast also utilize the area.

Pacific Harbour Seals are undoubtedly found at the site as their preferred habitats are tidal flats, sand bars, estuaries and reefs (Bigg, 1969). The Northern Fur Seal is also a possible seasonal visitor as they are found in many of the inside channels and inlets of the north coast from January to April (Spalding, 1964). Sea Lions are likely to utilize the area after their dispersal from breeding colonies. In future, Sea Otters might also occur in this area as occasional observations of Sea Otters have been made along the north coast. The likelihood of such observations should increase as the Sea Otter slowly re-establishes itself along the B.C. coast.

The cetaceans that may be found in the Port Simpson area include Pacific Harbour Porpoise and Killer Whales. These species are common to the north coast and are known to frequent inshore waters.

Major aggregations of some marine mammals are present along both access routes to Port Simpson and have been discussed in Section 3.9.1.

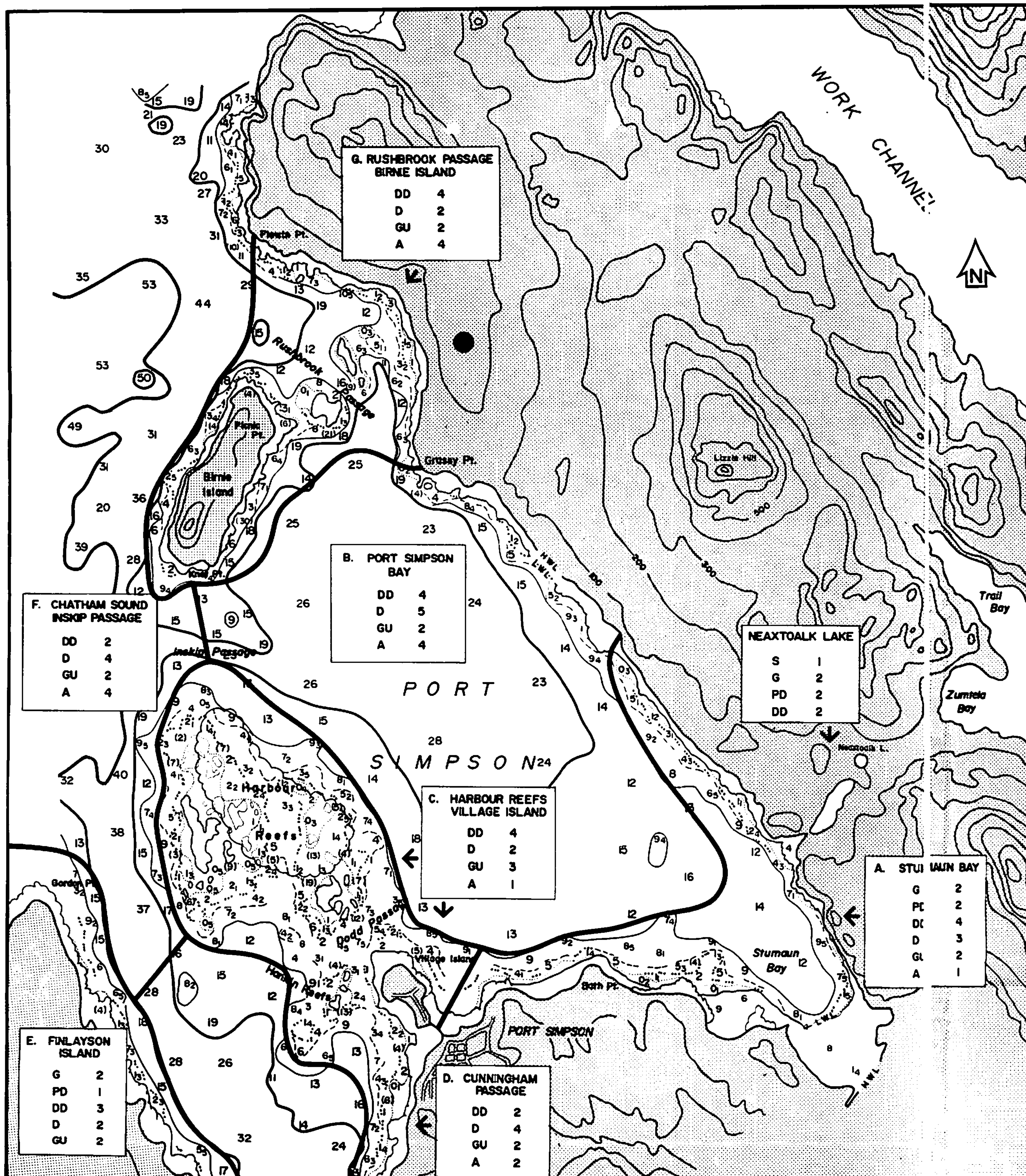
3.9.2.2 Marine Birds

Coastal British Columbia provides a variety of inshore and open water habitats used by marine birds. With very little winter freezing in these water, the provision of such habitats in winter makes the B.C. coast unique in Canada.

The general characteristics of the coastal marine avifauna have been described above under marine access (Section 3.9.1). These generalizations apply to the Port Simpson study site, except that open ocean habitats are not found here. Marine bird information for the Port Simpson area was obtained by a census conducted in these waters on March 10, 1981, from the Chatham Sound surveys of P.W. Martin (1978), Canadian Wildlife Service (1980), and from the B.C. Fish and Wildlife Branch (1977). These are the principal sources for the following site information. Specific site locations for the Port Simpson area are found on Map 3-9.4.

Distribution and Abundance

The marine bird fauna of the proposed development site (Port Simpson Bay) is composed primarily of diving ducks and divers (loons, grebes and cormorants), and to a lesser extent by geese, puddle ducks, gulls and alcids (Table 3-9.6)



WESTERN L.N.G. PROJECT

DOME PETROLEUM LIMITED

I) DISTRIBUTION AND ABUNDANCE OF MARINE BIRDS — PORT SIMPSON HARBOUR AREA
Censused March 10, 1981
II) AQUATIC BIRDS — NEAXTOALK LAKE
Observed March 10, 1981
III) BLACKTAILED DEER
Incidental sighting March 9, 1981

BEAK CONSULTANTS LIMITED JULY 1981

MARINE BIRD GROUP

G	geese
S	swans
PD	puddle ducks
DD	diving ducks
GU	gulls
A	alcids
D	divers (loons, grebes and cormorants)

NUMBER OF INDIVIDUALS

1	1—5
2	6—50
3	51—100
4	101—500
5	501—1,000
6	more than 1,000

Boundary of sub-area

Site of Black-tailed Deer observation — March 8, 1981

DEPTH COUNTOURS*

- 50 fathoms
- 20 fathoms
- 10 fathoms
- 6 fathoms
- 3 fathoms
- 1 fathom
- LWL — Low Water Line **
- HWL — High Water Line

* depths are reduced to Lowest Normal Tide, which at Port Simpson is 3.7 metres below Mean Water Level

**figures above Low Water Line represent feet above chart datum

SOURCE
Canadian Hydrographic Service — Chart #3993 @ 1:40,000 (1980)

Map 3-9.4

TABLE 3-9.6

BIRDS OBSERVED IN PORT SIMPSON AREA,
March 10, 1981 BY SUBAREA

Species	Subareas A	B	C	D	E	F	G	Total
Common Loon	7	-	1	1	-	-	2	11
Yellow-billed Loon	-	1	-	-	-	-	-	1
Red-throated Loon	50	-	-	-	-	-	-	50
Arctic Loon	-	415	4	-	-	241	3	663
Red-necked Grebe	5	3	2	1	-	-	2	13
Horned Grebe	3	1	4	2	6	1	-	17
Western Grebe	1	525	-	100	-	-	-	626
Pelagic Cormorant	6	1	11	-	1	9	17	45
Double-crested Cormorant	-	-	3	-	1	-	5	9
Swan sp.			(3 - Neaxtoalk Lake)					
Canada Goose	37	-	-	-	11	-	-	48
Mallard	10	-	-	-	3	-	-	13
Greater Scaup	-	-	4	-	-	-	-	4
Scaup sp.	7	-	10	-	7	-	2	26
Barrow's Goldeneye	12	-	-	-	-	-	-	12
Common Goldeneye	1	-	2	-	-	-	3	6
Bufflehead	2	-	-	-	4	-	-	6
Oldsquaw	6	-	30	-	3	-	-	39
Harlequin Duck	6	-	22	-	5	-	19	52
Black Scoter	-	-	87	7	1	-	1	96
White-winged Scoter	27	29	69	17	19	-	16	177
Surf Scoter	48	83	45	-	27	30	70	303
Red-breasted Merganser	5	-	2	-	3	-	1	11
Glaucous-winged Gull	36	7	71	8	7	23	10	162
Mew Gull	-	-	-	-	-	-	1	1
Common Murre	1	106	-	5	-	7	1	120
Pigeon Guillemot	-	-	5	2	-	2	1	10
American Coot	-	-	1	-	-	-	-	1
TOTAL	270	1171	373	143	98	313	154	2522

A - Stumaun Bay
B - Port Simpson Bay
C - Harbour Reefs - Village Island
D - Cunningham Passage
E - Finlayson Island
F - Chatham Sound - Inskip Passage
G - Rushbrook Passage - Birnie Island

This avifaunal composition is typical of most B.C. west coast protected waters (Robertson, 1974a, Vermeer and Vermeer, 1975). Within this general pattern, there is considerable ecological diversity. The census conducted by boat on March 10 indicated considerable differences in the avifauna in different parts of the Port Simpson Bay area (Map 3-9.4).

Stumaun Bay: Stumaun Bay and adjacent shorelines are largely protected and include at the mouth of Stumaun Creek the only significant area of estuarine marsh. Not surprisingly, this was the chief area for Canada Geese and Mallard in the study area (Table 3-9.6). Even so, numbers of these species, the only goose and puddle duck species identified in the study area were low. In their report on Chatham Sound, Martin (1978) and the Canadian Wildlife Service (1980) concluded that the Port Simpson Bay area, and Stumaun Bay in particular, had a high capability for dabbling ducks. This appears to be an estimate of capability that was not based on data provided in either report. The Fish and Wildlife Branch Wildlife Resource Map (1977) does not indicate any significant puddle duck concentrations in Port Simpson Bay.

The most common bird groups in Stumaun Bay were diving ducks and divers. The bathymetry of Stumaun Bay and, in fact, all other parts of Port Simpson Bay (Map 3-9.4) indicates that intertidal areas are very limited, and that deep water habitats are extensive. This helps explain relatively high numbers of diving ducks and divers. The most numerous species were Surf Scoter and White-winged Scoter among the diving ducks, and Red-throated Loon among the divers.

Port Simpson Bay: With the exception of the open shoreline from Grassy Point south to the LNG Port site, the Port Simpson Bay subarea was entirely composed of deep water habitats (Map 3-9.4). On March 10 when the census was conducted, there was a large concentration of divers (Arctic Loons, Western Grebes) and alcids (Common Murres) approximately halfway between the Harbour Reefs and Grassy Point, in an area of deep water (24-26 fathoms). These three species in this area comprised 1,046 individuals, or over 41% of all marine birds counted in the study area (Table 3-9.6). Over the entire study area these species accounted for 1,409 of the 2,522 birds observed, or 56%.

These numbers for divers and alcids are very high when compared to available information. For example, Martin recorded an average of only 815 loons, grebes and alcids over various parts of the Chatham Sound area in five surveys starting in September 1977 and extending to March 1978 (Canadian Wildlife Service, 1980). The emphasis of this earlier study was waterfowl (swans, geese and ducks) and it is likely that deep water environments were not surveyed in a representative fashion. Similarly the Northern B.C. Coastal Wildlife Resources map (Fish and Wildlife Branch, 1977) appears to concentrate on shorelines, thereby missing the open water areas and the divers which frequent them. Therefore, the larger numbers of loons, grebes and murres observed in Port Simpson may not be unusual.

One additional factor which is germane to this discussion is the timing of herring spawning in Port Simpson. As discussed below ("Trophic Considerations"), arctic loon, western grebe and common murre are known to be important predators of Pacific herring, Clupea harengus pallassii (Robertson, 1972; Ainley and Sanger, 1979). Herring spawning in Port Simpson has a median date of April 7± 14 days (ESL, 1981), and is usually preceded by increasing congregation near spawning sites. The high numbers of divers observed on March 10 in Port Simpson Bay were likely attracted to these pre-spawning concentrations, and soundings taken in Inskip

Passage at the same time as the marine bird census confirmed the presence of schooling fish in these waters.

Several smaller flocks of scoters were observed in the open waters of Port Simpson Bay, in waters greater than 10 fathoms (Table 3-9.6).

Harbour Reefs - Village Island: This area is largely composed of rocky shorelines adjacent to Port Simpson and the series of reefs (Harbour Reefs) which extend from Port Simpson to Inskip Passage (Map 3-9.4). The principal group of birds associated with this subarea were diving ducks, gulls and to a lesser extent divers. Certain of the species, Black Scoters, Oldsquaw and Harlequin Ducks, tended to frequent reef areas such as the Harbour Reefs, and were absent or much less numerous elsewhere in Port Simpson Bay. There is not yet sufficient food habits information on these species to identify their apparent preference for these habitats. Among the diving ducks, White-winged and Surf Scoters were quite numerous in these waters. The gulls were utilizing the reefs as a roosting site, which at the time of the survey was exposed at low tide.

Cunningham Passage: This body of water lies between the Tsimpsean Peninsula and Finlayson Island. In its deep waters, the prime species observed during the March 10 survey was the Western Grebe (Table 3-9.6). Deep waters here extend to over 30 fathoms and though no herring schoools were observed in echo soundings it is likely that they occasionally frequent this area and that divers feed on them here.

Finlayson Island: The northeast shore of Finlayson Island is mostly rocky, with a few pebble beaches. This subarea was quite small and the number of birds observed was correspondingly small. Few birds other than diving ducks were observed. The most common species were Surf and White-winged Scoters. Eleven Canada Geese were observed feeding on one of the beaches (Table 3-9.6).

Chatham Sound - Inskip Passage: As indicated in Map 4 this subarea includes those waters outside of Birnie Island and Harbour Reefs. It is largely a pelagic area, and divers were the most numerous marine bird group. By far the most common divers were Arctic Loons, attracted most likely by pre-spawning schools of herring (Table 3-9.6). In 1981 the first spawning occurred on March 25, just fifteen days subsequent to the bird census..

Rushbrook Passage - Birnie Island: This subarea includes those shallow waters surrounding Birnie Island and in Rushbrook Passage. The bathymetry is similar to that of the Harbour Reefs, except that it is considerably less exposed. Numbers of birds in this area were not high (Table 3-9.6). The chief group was composed of diving ducks; divers were also present but far less numerous. Principal species were Surf Scoters, Harlequin Ducks, Pelagic Cormorants and White-winged Scoters.

Neaxtoalk Lake: Neaxtoalk Lake is a small lake which discharges via a short stream to nearby Port Simpson Bay, just north of Stumaun Bay (Map 3-9.4). Although indicated on the map as two separated wetlands, on March 10 when it was surveyed by helicopter there appeared to be one continuous wetland. Observed were: three unidentified swans, believed to be Trumpeter Swans, about 20 Canada Geese and about 15 unidentified ducks.

Utilization of Neaxtoalk Lake by birds outside of the period of the observations is conjectural. However, as mentioned below breeding here by Red-throated Loons is likely and by ducks possible.

Migration

Compared to information available on seabird breeding colonies and wintering marine birds much less information is available on migration. This is particularly so in the case of the Port Simpson area, which while within the general Pacific Flyway for waterfowl and other marine birds is probably not on its most travelled corridors. Furthermore, it is doubtful if the Port Simpson area is an important stopping area along the flyway. Big Bay, some 12 km to the south is an important area in spring for swans, geese, puddle ducks and diving ducks (Fish and Wildlife Branch, 1977). From the same information source, Port Simpson is identified as important for equivalent numbers of diving ducks (1,000+ individuals) but no mention is made of other groups (Map 3-9.3). Thus, numbers of marine birds in the Port Simpson study area during spring migration are not likely to exceed those recorded in the March 10 census.

For fall migration, site specific information from Port Simpson is lacking other than a reference to numbers of geese (presumably mostly Canada Geese) ranging in numbers from 100 to 500 (Fish and Wildlife Branch, 1977). However, there is reliable information for the Chatham Sound area and adjacent waters (Savard, 1979, Canadian Wildlife Service, 1980). These data show that for ducks at least the main increase in numbers is after September (Table 3-9.7). In Chatham Sound the same pattern applies to geese, but data from a larger area including Hecate Strait and Dixon Entrance show geese numbers relatively stable during the September to November period. Neither do data from these latter areas indicate any fall migratory timetable for divers, gulls and alcids; no major increases take place in the September to November period, only decreases. A different picture for these groups is indicated by the Canadian Wildlife Service data for the Chatham Sound area above (Table 3-9.6). Though the area covered was not constant as indicated in the table, there is evidence of a major influx of divers and gulls. Most of the latter appear to pass through the area.

Table 3-9.7

Numbers of Divers, Gulls and Alcids Counted During the Fall and Winter Period, 1977-78, in Chatham Sound*

Month of Survey	Sep'77	Nov'77	Jan'78	Feb'78	Mar'78
Number of Transects	23	11	14	17	19
Lengh of Transect (km)	361	189	321	261	321
Divers	266	502	1,657	391	1,155
Gulls	5,087	28,000±	4,905	1,890	1,466
Alcids	131	68	309	424	252

* Data from P. W. Martin, 1978 and (Canadian Wildlife Service, 1980)

While these numbers are not strictly pertinent to the Port Simpson Bay area, and are somewhat contradictory, they do indicate that the census carried out in March in Port Simpson Bay may not have sampled the maximum numbers which might occur. Studies by Savard (1979) and Martin (Canadian Wildlife Servie, 1980) indicated high numbers for different groups during all months between September and March, excepting December when no surveys were conducted. For example, both studies agreed on the following timing of peak numbers: geese - January, puddle ducks - November, diving ducks -

January. Savard's (1979) surveys showed peak numbers for divers in January, gulls in September, and alcids in February. Numbers in September and October tended to be considerably lower than peak winter numbers. Comparing September and March figures, Canadian Wildlife Service (1980) results shows that numbers of geese, puddle ducks and gulls were greater in September, whereas numbers of diving ducks, divers, and alcids were higher in March (Tables 3-9.7 and 3-9.8).

Breeding Activity

There are no known sea bird colonies in the Port Simpson Bay area (Fish and Wildlife Branch, 1977). Just outside the harbour the Pointer Rocks in Chatham Sound is an area of suspected breeding by Glaucous-winged Gulls (Map 3-9.2).

Not all sea birds nest colonially, however, and there is a strong likelihood of breeding in the area by Canada Geese and Red-throated Loons. The Northern B.C. Coastal Wildlife Resources map (Fish and Wildlife Branch, 1977) lists geese as breeding residents in the Chatham Sound area, and residents of Big Bay. No permanent residency is listed for the Port Simpson Area. The lack of summer observations from this area leaves their breeding status doubtful in Port Simpson. Owing to the proximity of Big Bay and the availability of suitable muskeg and intertidal habitats small numbers of Canada Geese can be expected to breed here.

A small number of Red-throated Loons breed in the study area (Fish and Wildlife Branch, 1977). According to Martin (1978) this species is an "abundant breeder" in Chatham Sound, utilizing muskeg lakes for nesting and brood rearing, and foraging in adjacent salt water. In the study area, only Neaxtoalk Lake offers such habitat, and would likely be utilized by just one pair of Red-throated Loons.

TABLE 3-9.8

COMMON AND SCIENTIFIC NAMES OF BIRDS AND THEIR STATUS IN AND ADJACENT TO THE MARINE APPROACHES (A) AND IN THE ENVIRONS OF THE TERMINAL (T)

COMMON NAME	SCIENTIFIC NAME	STATUS
Gaviiformes		
Common Loon (A,T)	Gavia immer	Migrant; winter resident
Yellow-billed Loon (A,T)	Gavia adamsii	Migrant; winter resident, rare
Arctic Loon (A,T)	Gavia arctica	Migrant; winter resident
Red-throated Loon (A,T)	Gavia stellata	Migrant; winter resident, rare breeder
Podicipediformes		
Red-necked Grebe (A,T)	Podiceps grisegena	Migrant; winter resident
Horned Grebe (A,T)	Podiceps auritus	Migrant; winter resident
Western Grebe (A,T)	Aechmophorus occientalis	Migrant; witner resident
Procellariiformes		
Balck-footed Albatross (A)	Diomedea nigripes	Offshore migrant
Short-tailed Albatross (A)	Diomedea albatrus	Offshore migrant, rare
Northern Fulmar (A)	Fulmaris glacialis	Offshore migrant
Pink-footed Shearwater (A)	Puffinus creatopus	Offshore migrant
Pale-footed Shearwater (A)	Puffinus carneipes	Offshore migrant
New Zealand Shearwater (A)	Puffinus bulleri	Offshore migrant
Sooty Shearwater (A,T)	Puffinus griseus	Offshore migrant
Slender-billed Shearwater (A)	Puffinus tenuirostris	Offshore migrant
Manx Shearwater (A)	Puffinus puffinus	Offshore migrant, rare
Fork-tailed Storm Petrel (A)	Oceanodroma furcata	Breeding
Leach's Storm Petrel (A)	Oceanodroma leucorhoa	Breeding

TABLE 3-9.8 - Cont'd.

COMMON NAME	SCIENTIFIC NAME	STATUS
Pelecaniformes		
Double-crested Cormorant (A,T)	Phalacrocorax auritus	Winter resident
brandt's Cormorant (A)	Phalacrocorax penicillatus	Winter resident, rare
Pelagic Cormorant (A,T)	Phalacrocorax pelagicus	Breeder
Ciconiiformes		
Great Blue Heron (A,T)	Ardea herodias	Breeder
Anseriformes		
Whistling Swan (A,T)	Olor columbianus	Migrant; winter resident
Trumpeter Swan (A,T)	Olor buccinator	Migrant; winter resident
Canada Goose (A,T)	Branta canadensis	Breeder
Brant (A,T))	Branta bernicla	Migrant
White-fronted Goose (A,T)	Anser albifrons	Migrant
Snow Goose (A,T)	Chen caerulescens	Migrant
Mallard (A,T)	Anas platyrhynchos	Breeder
Gadwall (A,T)	Anas strepera	Migrant
Pintail (A,T)	Anas acuta	Migrant; winter resident
Green-winged Teal (A,T)	Anas carolinensis	Migrant; winter resident
Blue-winged Teal (A,T)	Anas discors	Migrant; winter resident
American Wigeon (A,T)	Anas americana	Migrant; winter resident
Shoveler (A,T)	Anas clypeata	Migrant; winter resident
Ring-necked Duck (A,T)	Aythya collaris	Migrant
Canvasback (A,T)	Aythya alisineria	Migrant
Greater Scaup (A,T)	Aythya marila	Migrant; winter resident
Lesser Scaup (A,T)	Aythya affinis	Migrant; winter resident
Common Goldeneye (A,T)	Bucephala clangula	Migrant; witner resident
Barrow's Goldeneye (A,T)	Bucephala islandica	Migrant; winter resident
Bufflehead (A,T)	Bucephala albeola	Migrant; winter resident
Oldsquaw (A,T)	Clangula hyemalis	Migrant; winter resident
Harlequin Duck (A,T)	Histrionicus histionicus	Migrant; winter resident

TABLE 3-9.8 - Cont'd.

COMMON NAME	SCIENTIFIC NAME	STATUS
White-winged Scoter (A,T)	Melanitta deglandi	Migrant; winter resident
Surf Scoter (A,T)	Melanitta perspicillata	Migrant; winter resident
Common Scoter (A,T)	Melanitta niger	Migrant; winter resident
Hooden Merganser (A,T)	Lophodytes cucullatus	Migrant; winter resident
Common Merganser (A,T)	Mergus merganser	Breeder
Red-breasted Merganser (A,T)	Mergus serrator	Migrant; winter resident
Falconiformes		
Golden Eagle (A,T)	Aquila chrysaetos	Migrant
Bald Eagle (A,T)	Haliaeetus leucocephalus	Breeder
Osprey (A,T)	Pandion haliaetus	Breeder, rare
Peregrine Falcon (A,T)	Falco peregrinus	Breeder
Gyrfalcon (A,T)	Falco rusticolus	Migrant
Merlin (A,T)	Falco columbarius	Migrant
Galiformes		
Blue Grouse (T)	Dendragapus obscurus	Breeder
Spruce Grouse (T)	Canachites canadensis	Breeder
Ruffed Grouse (T)	Bonasa umbellus	Breeder
Gruiformes		
Sandhill Crane (A,T)	Grus canadensis	Breeder
American Coot (A,T)	Fulica americana	Migrant; witner resident
Charadriiformes		
Black Oystercatcher (A,T)	Haematopus bachmani	Breeder
Semipalmated Plover (A,T)	Characruis semipalmatus	Breeder
Killdeer (A,T)	Characruis vociferus	Breeder
American Golden Plover (A,T)	Pluvialis dominica	Migrant
Black-bellied Plover (A,T)	Squatorola squatorola	Migrant

TABLE 3-9.8 - Cont'd.

COMMON NAME	SCIENTIFIC NAME	STATUS
Surfbird (A,T)	Aphriza virgata	Migrant; winter resident
Ruddy Turnstone (A,T)	Arenaria interpres	Migrant
Black Turnstone (A,T)	Arenaria melanocephala	Migrant; winter resident
Common Snipe (A,T)	Capella gallinago	Migrant
Whimbrel (A,T)	Numenius phaeopus	Migrant
Spotted Sandpiper (A,T)	Actitis macularia	Migrant
Solitary Sandpiper (A,T)	Tringa solitaria	Migrant
Wandering Tattler (A,T)	Heteroscelus incanus	Migrant
Greater Yellowlegs (A,T)	Totanus melanoleucus	Migrant
Lesser Yellowlegs (A,T)	Totanus flavipes	Migrant
Knot (A,T)	Calidris canutus	Migrant
Sharp-tailed Sandpiper (A,T)	Erolia acuminata	Migrant
Pectoral Sandpiper (A,T)	Erolia melanotos	Migrant
Baird's Sandpiper (A,T)	Erolia bairdii	Migrant
Least Sandpiper (A,T)	Erolia minutilla	Migrant
Dunlin (A,T)	Erolia alpina	Migrant; winter resident
Short-billed Dowitcher (A,T)	Limnodromus griseus	Migrant
Long-billed Dowitcher (A,T)	Limnodromus scolopaceus	Migrant
Semipalmated Sandpiper (A,T)	Ereunetes pusillus	Migrant
Western Sandpiper (A,T)	Ereunetes mauri	Migrant
Marbled Gotwit (A,T)	Limosa fedoa	Migrant
Sanderling (A,T)	Crocethia alba	Migrant
Red Phalarope (A,T)	Phalaropus fulicarius	Migrant
Northern Phalarope (A,T)	Lobipes lobatus	Migrant
Pomarine Jaeger (A)	Stercorarius pomarinus	Offshore migrant
Parasitic Jaeger (A,T)	Stercorarius parasiticus	Migrant
Long-tailed Jaeger (A)	Stercorarius longicaudus	Offshore migrant
Skua (A)	Catharacta skua	Offshore migrant, rare
Glaucous Gull (A,T)	Larus hyperboreus	Winter resident
Glaucous-winged Gull (A,T)	Larus glaucescens	Breeding
Herring Gull (A,T)	Larus argentatus	Winter resident
Thayer's Gull (A,T)	Larus thayeri	Winter resident
California Gull (A,T)	Larus californicus	Migrant
Mew Gull (A,T)	Larus canus	Breeding

TABLE 3-9.8 - Cont'd.

COMMON NAME	SCIENTIFIC NAME	STATUS
Bonaparte's Gull (A,T)	Larus canus	Migrant
Black-legged Kittiwake (A,T)	Rissa tridactyla	Winter resident
Sabine's Gull (A)	Xema sabini	Migrant
Common Term (A,T)	Sterna hirundo	Migrant
Arctic Term (A,T)	Sterna paradisaea	Migrant
Common Murre (A,T)	Uria aalge	Breeding
Pigeon Guillemot (A,T)	Cepphus columba	Breeding
Marbled Murrelet (A,T)	Brachyramphus marmoratus	Breeding
Ancient Murrelet (A,T)	Synthliboramphus antiuus	Breeding
Cassin's Auklet (A,T)	Ptychoramphus aleuticus	Breeding
Rhinoceros Auklet (A,T)	Cerorhinca monocerata	Breeding
Horned Puffin (A)	Fratercula corniculata	Breeding
Tufted Puffin (A)	Lunda cirrhata	Breeding
Columbiformes		
Band-tailed Pigeon (T)	Columba fasciata	Breeding

Sources: Godfrey (1966); Robertson (1974a); B.C. Fish and Wildlife Branch (1977); Martin (1978) Sowls et al (1978); and Savard (1979).

There is a further wetland some 2 km north of Lizzie Hill, which might also be utilized by loons for breeding. Such lakes could also be used by small numbers of puddle ducks and diving ducks for breeding. In an earlier study (NEAT, 1975) it was assumed that Mallards breed on the Tsimpsean Peninsula in small numbers. There is no other reference to this possibility.

The major unknown in addressing breeding activity by birds in the study area is the status of the Marbled Murrelet. This species nests in tree cavities (Guiguet, 1971b), and based on its summer distribution is believed to breed along the entire British Columbia coast. Very few nests have ever been found and it is only in the last two decades that its arboreal nesting has been confirmed. It is a likely breeder in the Port Simpson study area. Breeding pairs and recently fledged young would likely be encountered if observations were made between May and July.

Trophic Considerations

In considering distribution and abundance patterns in the Port Simpson Bay area, inferences were made that these patterns were related to habitat types. As is seen in Table 3-9.6 deep water habitats such as Port Simpson Bay, Cunningham Passage and Chatham Sound-Inskip Passage had a somewhat different marine bird fauna than the remaining subareas, whos habitats were primarily shoreline, intertidal and shallow water.

These habitats differences extend to more than the physical form (e.g. bathymetry) of the habitats themselves, and one important factor is food habits. Table 3-9.9 provides a summary of the principal food types of the mareine birds found in the terminal site area during the March visit.

TABLE 3-9.9

FOOD HABITS OF SELECTED MARINE BIRDS OCCURRING IN THE PORT SIMPSON BAY AREA

	Marine Plants	Molluscs	Crustacea	Polychaetes	Fish Benthic	Fish Mid-Water	Offal	Source
Arctic Loon						X		Ainley & Sanger, 1979
Western Grebe						X		Ainley & Sanger, 1979
Pelagic Cormorant					X			Robertson, 1974b
Swans	X							R. W. McKelvey*
Canada Goose	X							Ainley & Sanger, 1979
Mallard	X							Halladay, 1968; Burgess 1970
Scaup	X	O						Vermeer & Levings, 1977
Oldsquaw		X	O					Vermeer & Levings, 1977
Harlequin Duck		O	X					Ainley & Sanger, 1979
Black Scoter		X		O				Vermeer & Levings, 1977
White-winged Scoter		X						Vermeer & Levings, 1977
Surf Scoter		x						Vermeer & Levings, 1977
Glaucous-winged Gull						X	O	Ainley & Sanger, 1979
Common Murre						X		Ainley & Sanger, 1979

X - principal foods
O - minor foods

* Canadian Wildlife Service, personal communication

Rather than cite specific foods, the food types have been organized into habitat categories. For more detailed information on food habits, the source documents are listed.

The characterization of food habits points out these broad habitat types, excluding the use of offal (garbage, refuse) by the large gulls. Starting at the beaches, the first is the shoreline and intertidal zones, where marine plants are concentrated. Canada Goose and mallard foods are found in this zone, and the relative scarcity of these plants in ithe terminal site area (BEAK, 1981) helps explain low numbers of these species, as well as the absence of other puddle duck species. Scaup are also found at the lower part of this zone feeding on intertidal algal and invertebrates. Their relatively low numbers may indicate rather limited preferred habitats in the terminal site area. The second major zone extends from the low intertidal to the 10 fathom line, the latter boundary being an arbitrary limit: the maximum depth to which birds will customarily dive for food. This zone includes the preferred habitats for diving ducks and those divers which forage on benthis fish. The Harbour Reefs - Village Island sub-area provides typical characteristics for this habitat, and this sub-area had the highest total of diving ducks (Table 3-9.6).

On March 10, 1981 most birds (65%) censused were in the third zone, the deep water or pelagic zone, which comprised virtually all of sub-areas B, D and F (Table 3-9.6). Within this zone Arctic Loon, Western Grebe and Common Murre numbers amounted to 1399, or 55% of all birds observed. They prefer pelagic habitats, based on these and other observations, and on food habits (Table 3-9.9). In the Gulf Islands along the southern B.C. coast, the data show these species have a high proportion of herring in their diet (Robertson, 1972). This was mentioned above, and it is likely that concentrations of these fish-eating birds coincide with the occurrence of herring in the terminal site area.

Trophic and habitat considerations emphasize that the utilization of the terminal site area by marine birds is at least partly dependent upon the quality of the marine habitats. This review of the marine habitats has indicated that the shallow water (benthic) and deep water (pelagic) habitats support sizable populations of marine birds. Shoreline habitats, and specifically habitats with a well- developed marine plant algae zone are relatively sparse in the study area. This fact explains the relatively low numbers of geese and puddle ducks in the area.

Consumptive and Non-Consumptive Use

Consumptive use includes both the legal and illegal harvesting of marine birds. For game management purposes the terminal area is in management unit (M.U.) 6-14 of Region 6 (Skeena). Data on the legal harvest of ducks and geese in M.U. 6-14 is presented in Table 3-9.10. It should be kept in mind that the Tsimpsean Peninsula study area is atypical of most of the M.U. 6-14 of which it is part. A large proportion of the total harvest of waterfowl in M.U. 6-14 probably occurred in the study area. The average legal harvests for 1978 and 1979 in M.U. 6-14 were 837 ducks and 189 geese. This does not include waterfowl taken by members of the Port Simpson Indian Band.

Consumptive use of waterfowl in the Tsimpsean Peninsula area had been previously reported by NEAT in 1975. Based on 1972 Hunter Sample data and the judgement of the authors, it was estimated that 2,300 ducks and 125 geese were taken annually, both by recreational hunters and members of the Indian Band. These data compare quite favourably with recent information, although the number of ducks harvested could have been an over-estimate. The NEAT (1975) report also indicated that the ducks taken were primarily migrants, whereas the geese harvested were presumed to be part of the resident population. Hunting effort was estimated at 450 man-days per year for waterfowl (NEAT, 1975).

TABLE 3-9.10: Hunter Sample Data for Waterfowl in M.U. 6-14 in 1978 and 1979*

	1978		1979	
	Estimated Number of Hunters	Estimated Number Harvested	Estimated Number of Hunters	Estimated Number Harvested
Ducks	102	930	74	743
Geese	88	190	46	188

* Data from B.C. Fish and Wildlife Branch, Victoria

Non-consumptive use of marine birds includes nature study, viewing, photography and scientific study. The aesthetic appeal of marine birds in northern coastal B.C. can be considered high because of the tremendous diversity and abundance of species present. The emergence of natural history oriented tours operating in northern coastal B.C. might indicate an increase in non-consumptive use of marine birds.

The Tsimpsean Peninsula area supports large numbers of marine birds on tidal foreshores, reefs, roosting islets, and areas of tidal disturbance (NEAT, 1975). While it is assumed there is an appreciation of wildlife in the study area, the actual non-consumptive use is probably minimal due to limited access.

3.9.2.3 Big Game Mammals

To date no information has been published regarding large terrestrial mammals on the study area. Consequently, discussion of the distribution and abundance of big game animals for the study area draws heavily upon both the results of conversations with locally knowledgeable individuals as well as more generalized published accounts (Banfield, 1974; Cowan and Guiguet, 1965) which include the study area. Similaryly, treatment of the issues of habitat utilization by big game is based almost entirely upon a comprehensive survey of the available literature of similar habitats in other areas.

Distribution and Abundance

Coastal blacktail Deer (*Odocoileus hemionus*) and Black Bear (*Ursus americanus*) represent the most common species of big game animals on the Tsimpsean Peninsula (A. Edie and B. van Drimmelen, B.C. Fish and Wildlife Branch, pers. comm. 1981). Wolves (*Canis lupus*), Grizzly Bears (*Ursus arctos horribilis*) and Moose (*Alces alces*) are probably occasional visitors to the study area (R. Escott, B.C. Fish and Wildlife Branch, pers. comm. 1981).

Blacktail Deer on the Tsimpsean Peninsula and adjacent islands are probably of the Sitka race (*Odocoileus hemionus sitkensis* Merriam). Cowan and Guiguet (1965) describes the geographic range of the Sitka Deer as coastal southeastern Alaska and British Columbia "to the general vicinity of Port Simpson where gradual merging with the southern race takes place". The southern race referred to is

Columbia Blacktail Deer (Odocoileus hemionus columbianus Richardson) which occurs along a narrow fringe of the Pacific coast as far south as California. Of the two races of Coastal Blacktail Deer considerably more is known about the Columbian Blacktail, however, neither race has been studied on the coastal lowland habitats typical of the study area.

The deer population of the Tsimpsean Peninsula is thought to be low in numbers in comparison to insular populations elsewhere on the British Columbia coast, most notably Columbian Blacktail Deer on portions of Vancouver Island and Sitka Deer on the Queen Charlotte Islands. However, information is not available for other mainland deer populations along the coast and direct comparisons cannot be made to the study area. Low deer populations in the Port Simpson area are thought to be the result of a number of factors including the intermittent and highly variable nature of snowfall throughout the winter period (A. Edie, pers. comm. 1981) as well as wolf predation and the quantity and quality of winter range (NEAT, 1975).

Black Bears are reported to be common on the study area (NEAT, 1975). Although the taxonomic nuances of the various subspecies of the black bear in North America are in need of revision, it appears that the greatest variety of subspecies ocurs in northwestern British Columbia. Cowan and Guiguet (1965) recognize the subspecies occuring on the study area as Ursus americanus kermodei (Hornaday). The white colour phase of the Kermode Black Bear and the Blue (Glacier) Bear are protected in northwestern British Columbia. Detailed information regarding population dynamics and the geographical distributions of the various races of the Black bear in northern British Columbia is almost totally lacking. As a result we are unable to relate the "commonness" of the Black Bear on the Tsimpsean Peninsula in any meaningful way to Black Bear populations of other geographical areas in the interior or along the coast of the province.

Wolves are indigenous to southeast Alaska (Meehan, 1974) and coastal British Columbia (Cowan and Guiguet, 1965). Martin (1978) reported that wolves are present on all the larger islands in the Chatham Sound region except the Dundas Group; tracks were observed at Big Bay on the Tsimpsean Peninsula during his study. Population levels of wolves on the study area are completely unknown. It has been postulated that the winter distribution of wolves on the study area approximates that of their principal prey species, the Blacktail Deer (NEAT, 1975).

Moose and Grizzly Bears occur along the British Columbia coast at the head of most coastal inlets (Cowan and Guiget, 1965) and may be infrequent visitors to the Tsimpsean Peninsula. No authenticated sightings were found for the study area, and it is highly unlikely that these species could be of more than peripheral interest with regard to potential impacts.

In early March 1981 representative wildlife habitats were searched for big game animals during an aerial reconnaissance of the study area. Only faint game trails were observed in open bog communities and no wildlife sign was noted in other habitat types. On March 9, 1981, five Black-tailed Deer were sighted on the fringe of a bog north of Grassy Point (Map 3-9.4) by TERA personnel (personal communication, 1981). During a ground reconnaissance for the vegetation study performed by BEAK evidence of old browsing activity by deer was found along the edge of a bog south of Lizzie Hill. Other habitats visited showed no evidence of recent use by big game. It appears that the study area receives only very light use by big game animals and supports only low to moderate populations of resident Sitka Deer and Black Bear. Wolves also use the area to an unknown extent.

Habitat Utilization

Wildlife habitat requirements are basically food and shelter. On occasion a single plant community type may provide both but more commonly a mixture of plant communities is necessary to meet all of an animal's needs. In general, for ungulates, early successional stages provide food needs; they contain a diversity of plant species which have high nutrient values. In areas of high snowfall, mature or climax forests have been identified as being vital for deer in winter as snow accumulation is less in dense forests than it is in open areas.

Overall the Tsimpsean Peninsula seems to provide a favourable mixture of mature forest for cover and open bog area for a diversity of browse and forage species. A site visit indicated that the area contained many browse species which were not being used by deer; therfore, the tentative conclusion is that deer distribution is not limited by food availability. Heavy, unpredictable snowfalls and unknown predation levels (both by man and wolves) may be factors limiting the population of deer on the Tsimpsean Peninsula.

The study area falls within the Cedar - Pine - Hemlock biogeoclimatic zone which occurs along the lowlands and lower slopes of the coastal mountains from approximately Cape Caution north into southeastern Alaska (Pojar, 1980). The tree species characteristic of this zone are western red cedar (Thuja plicata), yellow cedar (Chamaecyparis nootkatensis), western hemlock (Tsuga heterophylla), shore pine (Pinus contorta), Sitka spruce (Picea sitchensis) and red alder (Alnus rubra). These species form several discreet form habitats within the study area. The habitats are described below in ascending order of estimated wildlife value.

Cedar/Hemlock Forest

The most abundant forest community is the red cedar - yellow cedar zonal association. In addition to the cedars, shore pine and western hemlock are components of this association. In the study area the maximum heights of these trees were in the order of 30 meters and ages were in excess of 200 years. This aging forest was characterized by the presence of dead "spike tops", particularly on red cedar. The canopy closure was variable and hence the understory was subject to varying light penetration; however, the undergrowth was usually dominated by regenerating conifers leaving the shrub layer poorly developed. Although western hemlock grows poorly in this association (Pojar, 1980), it usually dominates the regeneration.

The poorly developed shrub layer consisted of varying amounts of huckleberry and blueberry species (Vaccinium alaskaense, V. parvifolium, V. ovalifolium), salal (Gaultheria shallon), and false azalea (Menziesia ferruginea). In terms of food value, all of the above species with exception of false azalea are considered to be highly palatable for Columbian Blacktail Deer (Harestad, 1979). In locations where deer populations are high and browse availability is limited, deer are reported to use conifers during the winter period (Klein, 1965; Harestad, 1979; Jones, 1975). During BEAK's site visit in March, 1981, no sign of browsing on either shrub species or regenerating conifers was harvested in this habitat type.

The herb layer could be only partially assessed due to the season of the field visit. However, the herb layer in the same forest type has been previously described as being comprised of "... various ferns and forbs such as false lily-of-the-valley, foam flower, dwarf dogwood and tway blade orchid" (NEAT, 1975). During the time of BEAK's visit, deer fern (Blechnum spicant) was the only herb present; no evidence of deer use of deer fern was observed even though it is a palatable species in other areas (Harestad, 1979).

Bog

The Tsimpsean Peninsula is also characterized by a preponderance of bog areas, which occur both on level substrates and on slopes. The bogs contain various densities of shore pine and shrub and herb species diversity is great. The most common species were Labrador tea (Ledum Groenlandicum), juniper (Juniperus communis), swamp laurel (Kalmia microphylla), sweet gale (Myrica gale), and salal. Of these species only the last two are considered deer browse species (Harestad, 1979).

The herb layer could not be assessed adequately because of the season of the field visit; however, Pojar (1980) has described a similar association as being characterized by (Trichophoron caespitosum), deer cabbage (Fauria crista galli), crowberry (Empetrum nigrum), bog rosemary (Andromeda polifolia), bog blueberry (Vaccinium uliginosum) and a sedge (Carex livida).

The ground cover was dominated by species of Sphagnum as well as other mosses such as Rhacomitrium spp., Dicranum spp., and Rhytidiadelphus loreus. Lichens (Cladina spp. and Cladonia spp.) occurred commonly on the raised hummocks. It has not been reported whether deer are able to make use of these lichens.

On March 9 and 10, 1981 the centres of the bogs had numerous open water ponds which contained remnants of last season's aquatic macrophytes but no fresh emergents for the current season.

Sitka deer have been reported to use succulent forbs such as deer cabbage, marsh marigolds (Caltha biflora) and skunk cabbage (Lysichitum americanum) in southeast Alaskan bogs (Klein, 1965). The vegetation sampled from these bogs in general was of higher nutritive value than that from forests. Klein (1965) attributed these differences to the much higher light availability for forbs in bogs.

Although some game trails were observed passing through and around the edges of bogs in the study area, virtually no evidence of deer browse or pellet groups was found in the bogs visited in early March 1981. Trails through bogs tend to remain as a semi-permanent feature. Because of high precipitation levels and mild tempertures it is likely that pellet groups degenerate rapidly; however, any recent droppings should have been apparent. The lack of browse and fresh droppings indicate that deer use the bogs primarily during the spring and summer period when forbs are present. Bogs tend to be favoured by bears in spring when young sedge and forb shoots are emerging and also during the fall when berries are ripe. No indications of bear use (droppings) were found, however, it is unlikely that any sign would have remained from the previous fall.

Forest/Bog Fringe

The forest/bog fringe occurs as a transition zone between bog and forest species. Because of good light penetration there is an abundance of shrub species in the understory. The tree species are red cedar, yellow cedar, shore pine and western hemlock in varying proportions according to distance from the bog. The game trails observed in the bogs usually occurred around the edges and sometimes moved in and out of the forested fringe. Although an abundance of browse species occurred here, in the area visited there was little indication of their having been used.

The Black Bear occurs in all forest types but tends to prefer semi-open forested areas (Herrero, 1972). It is therefore likely that the forest/bog fringe receives considerable use by Black Bears on the study area.

Sitka Spruce/Hemlock Forest

This habitat type has two floristic components. One is the Sitka spruce - hemlock beach fringe; the other is the dense inland hemlock - spruce forest. The Sitka spruce - hemlock forest occurs primarily as a narrow fringe 30-60 m wide along the exposed shoreline of the Tsimpsean Peninsula. The shoreline understory is dominated by dense salal which diminishes with distance from the forest edge. The dense canopy permits little light penetration, and hence, the understory is restricted to a well-developed moss layer dominated by Rhytidiadelphus loreius and Hylocomium splendens.

This habitat type is an important one for deer as it provides the dense forest cover needed to prevent deep snow accumulation and also contains a preferred food source, salal. The forest is usually fronted by a narrow marsh fringe dominated by a sedge, Carex lyngbyei which is also a valued food source for deer. During the site visit, little indication of browse was observed on the salal; however, because of spray and storm damage to the plants the effects of browsing were difficult to assess.

Although peripheral to the immediate study area, pockets of dense hemlock - spruce forest occurred along Stumaun Creek at the head of Stumaun Bay. Here the dominant species was western hemlock, although considerable quantities of Sitka spruce were interspersed. For the purposes of evaluating wildlife habitat, these two areas: the beach Sitka spruce fringe and the inland hemlock - spruce forest have been combined as their wildlife function is essentially the same.

In the hemlock - spruce forest the canopy was as dense as the Sitka spruce fringe although the trees on the former type were taller, up to 40 m in height. This may be a response to more favourable soil condition and less exposure in the inland site. A notable feature of the hemlock - spruce site was the preponderance of arboreal lichens in the upper canopy. Arboreal lichens have been determined to be important in the winter diets of Columbian Blacktail Deer on Vancouver Island (Harestad, 1979). The ground flora of this site was not assessed; however, it can be considered as important for deer as is the Sitka spruce fringe in providing a dense canopy for shelter form heavy snowfall and also in providing a winter food source. The Stumaun Bay area has been assessed and mapped as valuable wildlife habitat by the B.C. Forest Service (North Coast Timber Supply Area).

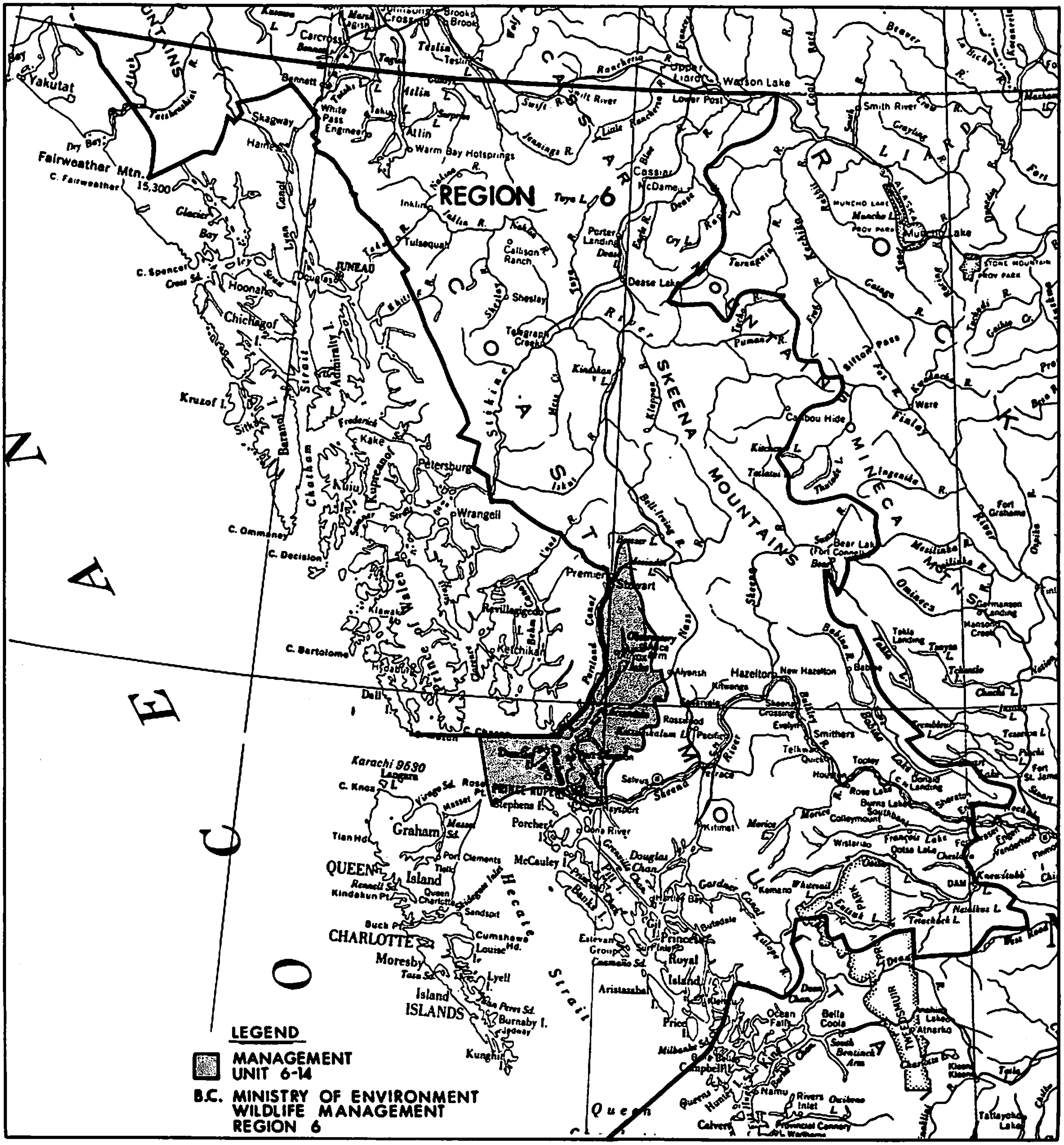
Consumptive and Non-consumptive Uses

The consumptive uses of big game animals encompass legal and illegal harvesting for both sport and food purposes. Non-consumptive uses are generally considered to include nature study, photography and viewing. Given the limited access to the study area and the serious constraints to ease of observation, most notably topography and plant cover, it is unlikely that non-consumptive uses of the big game resources of the study area are of any consequence.

For game management purposes the study area is in Management Unit 6-14 of Region 6 (Skeena - See Map 3-9.5). In British Columbia game harvest information is collected at the Management Unit level and published records do not contain reliable data at any more detailed level than this. Consequently, discussion of harvest records must necessarily encompass the entire Management Unit (M.U.). The Tsimpsean Peninsula represents less than five percent of the land area of M.U. 6-14. In addition the Tsimpsean Peninsula constitutes virtually all of the coastal lowland landform in M.U. 6-14. In short, the Tsimpsean Peninsula is atypical of the remainder of the Management Unit and caution should be exercised in interpolating game harvest information for the entire Unit to the study area.

Recent game harvest and hunting effort data for M.U. 6-14 and Region 6 as a whole are presented in Table 3-9.11. This information was obtained from the Region 6 headquarters in Smithers. From 1976 to 1979 inclusive, an average of 1.75 Grizzly Bear, 6.5 Black Bear, 4.0 Moose and 0.75 Deer were harvested each year in M.U. 6-14. Table 3-9.12 compares hunting effort and success in M.U. 6-14 in terms of percentages of Region 6 hunting effort and harvest.

Hunting effort for any species in M.U. 6-14 has never amounted to more than a very small portion (maximum = 6.6%) of the total hunting effort in Region 6 for that species. M.U. 6-14 has accounted for a disproportionate amount of the total harvest for certain species on occasion (to a maximum of 11.5% of the total Region 6 grizzly bear kill in 1978). In general it appears that M.U. 6-14 accounts for a disproportionately large amount, in terms of harvest


REGION 6
SKEENA MOUNTAINS
LEGEND
MANAGEMENT UNIT 6-14
B.C. MINISTRY OF ENVIRONMENT
WIDLIFE MANAGEMENT
REGION 6
Yakutat
Fairweather Mtn.
15,300
C. Fairweather
Skagway
Haines
JUNEAU
Hoonah
Chichagof I.
Kruzof I.
Sitka
Baranof I.
Admiralty I.
Kake
Petersburg
Wrangell
C. Ommaney
C. Decision
C. Bartolome
Ketchikan
Stewart
Hyder
Prince Rupert
Stephens I.
Porcher I.
McCauley I.
Graham Island
QUEEN CHARLOTTE ISLANDS
Moresby Island
Lyell I.
Burnaby I.
Karachi 9630
Masset
Port Clements
Sandspit
Hecate Strait
Princess Royal Island
Aristazabal I.
Kitimat
Terrace
Hazelton
New Hazelton
Smithers
Houston
Bella Coola
Ocean Falls
Namu
Rivers Inlet
Dease Lake
Cassiar
Watson Lake
Lower Post
Atlin
Telegraph Creek
Sheslay
Tulsequah
Carcross
Teslin
Bennett
White Pass
Warm Bay Hotsprings
Muncho Lake
Smith River
Ware
Caribou Hide
Fort Grahame
Germansen Landing
Manson Creek
Burns Lake
François Lake
Vanderhoof
Fort St. James

MAP 3-9.5

TABLE 3-9.11

HARVEST INFORMATION FOR SELECTED BIG GAME SPECIES IN M.U. 6-14 and Region 6, 1976-79

	1976	1977	1978	1979
Grizzly Bear				
M.U. 6-14	1/21*	1/14	3/57	2/38
Region 6	23/824	20/770	26/1167	21/662
Black Bear				
M.U. 6-14	10/51	4/24	4/37	8/81
Region 6	142/1810	68/1169	75/1253	93/1234
Moose				
M.U. 6-14	1/34	4/97	6/58	5/166
Region 6	597/13819	508/10751	648/11850	622/15154
Deer				
M.U. 6-14	1/62	0/46	2/52	0/22
Region 6	87/1910	83/1436	247/3451	251/3179

* The numerator is the number of animals harvested; the denominateor is the number of hunter days expended for that species. Therefore 1/21 indicates that one animal was harvested in a total of 21 days of hunting.

Data from B.C. Fish and Wildlife Branch, Smithers

TABLE 3-9.12

HARVEST AND HUNTING EFFORT IN M.U. 6-14 AS PERCENTAGES OF REGION 6 HARVEST & EFFORT

	1976	1977	1978	1979
Grizzly bear	4.4/2.6*	5.0/1.8	11.5/4.9	9.5/5.7
Black bear	7.0/2.8	5.9/2.1	5.3/2.9	8.6/6.6
Moose	.17/.25	.79/.90	.93/.49	.80/1.1
Deer	1.2/3.6	0/3.2	.8/1.5	0/.69

* The numerator is the percentage of Region 6 kill harvested in M.U. 6-14; the demoninator is the percentage of Region 6 hunter days in M.U. 6-14.

Data from B.C. Fish and Wildlife Branch, Smithers versus effort compared to the entire region, of the annual Grizzly and Black Bear harvest of Region 6. In contrast, both Moose and Deer are under represented in the Management Unit harvest. These relationships are shown more clearly in Table 3-9.13 which expresses the ratio of percentage effort for M.U. 6-14 in relation to Region 6 as a whole.

Table 3-9.13

Ratio of Percentage of Harvest to Percentage of Hunting Effort Occuring in M.U. 6-14

	1976	1977	1978	1979
Grizzly Bear	1.7	2.7	2.4	1.7
Black Bear	2.5	2.9	1.8	1.3
Moose	0.7	0.9	1.9	0.7
Deer	0.4	no kill	0.5	no kill

Data from B.C. Fish and Wildlife Branch, Smithers

Values greater than 1.0 indicate that less effort was required to harvest an animal in M.U. 6-14 than in the rest of Region 6. Similarly, values of less than 1.0 indicate that more effort (i.e., hunter days) was required to make a kill. Table 3-9.13 can therefore be viewed as a table of relative success for M.U. 6-14 compared to all of Region 6.

When the harvest information for M.U. 6-14 (Tables 3-9.11 to 3-9.13) is reviewed in light of the earlier discussion of big game distribution and abundance on the study area several points warrant further investigation. The Grizzly Bear is more of a coastal animal than the Moose, hence the heavy harvest of Grizzly Bear and the light Moose kill in M.U. 6-14. As these species occur only infrequently in the study area, it is unlikely that they constitute any more than a negligible portion of the game harvest in the study area.

Porportionately, there is a relatively high harvest of Black Bears in M.U. 6-14. As the Black Bear is spread throughout the forested region of M.U. 6-14, it is likely that only a few Black Bears are harvested annually in the vicinity of the study area.

The annual Deer harvest in M.U. 6-14 is surprisingly small (average of 0.75 deer/year) given the size and human population of the area.

It is quite probable that the unreported deer harvest due to poaching and native subsistence hunting is considerbaly greater than the official licensed harvest figures indicate. No attempt has been made to estimate the magnitude of unreported harvesting of any of the big game animals of the study area or surrounding regions.

3.9.2.4 Furbearers

Distribution and Abundance

Information on the furbearers of the proposed site has similar limitations to those outlined in the section on big game. Furbearer resources are most easily assessed by analyzing data on their exploitation by trapping, however, no records are kept of the harvest by Port Simpson Indian Band members. As an alternative indication of furbearer resources in the region, trapline records for more southern parts of the Tsimpsean Peninsula and the Prince Rupert area were analyzed, realizing that inferences to the proposed port site must be made with caution. Discussions with band members provided some confidence with this approach.

Furbearing animals common to the Tsimpsean Peninsula listed in Table 3-9.14 were taken from the annual harvest statistics for registered trapline holders. From the available data and personal communications with non-registered trapline holders, mink appears to be the dominant furbearer in the low elevation coastal areas surrounding Port Simpson Harbour, Iverness Passage and the Skeena River. Interior traplines reveal that marten is the most common species, followed by mink, beaver, river otter, squirrel, wolverine, weasel, fox, fisher, and muskrat. Although annual harvest statistics are not required from traplines operated by Port Simpson Indian Band members, information obtained from two members of the Port Simpson Band Council on March 10, 1981, indicate mink, marten, otter and beaver to be the chief species trapped (J. Bryant and J. Lawson, pers. comm.).

Relative abundance of the species in the study area can be examined form the annual harvest statics shows in Table 3-9.15. During the trapping season (October-February) the harvest of marten is greater within the coastal forest area, whereas increased numbers of mink are found to inhabit the surrounding shorelines. These abundance figures tend to confirm information from the local Band Council members.

Proposed Site

Based on the above harvest records and geographical location of the proposed site the shoreline along Stumaun Bay appears to be a suitable environment for mink, with marten inhabiting the area surrounding Stumaun Creek.

TABLE 3-9.14

COMMON FURBEARERS OF THE TSIMPSEAN PENINSULA

Wolverine	Gulo luscus
Red Fox	Vulpes fulva
Mink	Mustela vison
Fisher	Martes pennanti
River Otter	Lutra canadensis
Muskrat	Ondatra zibethica
Marten	Martes americana
Beaver	Castor canadensis
Red Squirrel	Tamiasciurus hudsonicus
Weasel	Mustela erminea

Data from B.C. Fish and Wildlife Branch, Prince Rupert

TABLE 3-9.15

ANNUAL FURBEARER HARVEST STATISTICS FOR THE TSIMPSEAN PENINSULA

Beaver		5	2	4			1	3	3	2	7	27
Marten	12	60	24	102	51	2	79	55	59	65	93	602
Muskrat											1	1
River Otter				2			2	4	4	4	5	21
Wolverine				1						5	6	12
Fox				1						2		3
Fisher							1					1
Mink		30	18	10	2	22	27	2	15	18	14	158
Weasel							1		3			4
Squirrel										1	20	21

Data from B.C. Fish and Wildlife Branch, Prince Rupert

Trapping Activity

Trapping activity in the Tsimpsean Peninsula is conducted by 14 trapline holders plus an unreported number within the Indian reserve lands. Seven of the traplines are registered with the Fish and Wildlife Branch in Prince Rupert and are the basis of the annual harvest statistics summarized in Table 3-9.15. Within the Indian reserve lands trapping activity is concentrated north of Big Bay to Grassy Point (J. Bryant, J. Lawson, pers. comm.). Annual traping activity for each registered trapline is shown in Table 3-9.16. A significant proportion of the active traplines recorded no furs taken. The majority of these areas are located on the coastal islands west of the peninsula. Annual fluctuations in harvest may be attributable to changes in trapping effort or techniques or to changes in animal populations on the islands. A significant proportion of inactive traplines are also recorded throughout the years. These results may reflect the relative importance of the trapping industry in the area, value of furs sold for auction, species density and/or management techniques of the trappers.

J. Bryant and J. Lawson of the Port Simpson band indicated that due to the increased price of furs, trapping within the Reserve has also increased recently. Trapping activity appears to be relatively constant on the non-reserve portions of the study area.

Table 3-9.16
Trapping Activity for Registered Trapline Holders

Year	Active Trap Lines	Active Trap Lines (with no furs recorded)	Inactive Traplines
1969/70	1	0	6
1970/71	6	1	1
1971/72	5	2	2
1972/73	7	3	0
1973/74	6	4	1
1974/75	4	2	3
1975/76	6	2	1
1976/77	5	2	2
1977/78	6	2	1
1978/79	5	2	2
1979/80	4	1	3

Data from B.C. Fish and Wildlife Branch, Prince Rupert

Most of the animal pelts are sold through the Ontario Fur Traders Association in Prince George; however, catches of fewer than five specimen are usually kept by the trappers for their own use. Fur prices vary depending on the species and quality of the pelt. The two dominant species in the study area, marten and mink, are classified as the northern coastal inlet type and regarded by some fur buyers as a poor quality pelt (Western Canadian Raw Fur Auction Sales Ltd., pers. comm. 1981). The 1979/80 provincial price lists rate mink and marten at $34.49 and $31.96 per skin respectively. River otter and beaver furs in the area are considered to be good quality furs and bring as much as $75.00 per skin. Over the past five years the fur price for mink and marten has increased (pers. comm., Barry Saunders, 1981). From examining the harvest statistics in the area, registered fur trapping does not appear to be a major resource. However, this conclusion may not apply to native trapping, and in fact the economic and social importance of trapping has been identified by the Port Simpson Band Council. The extent of this value awaits more detailed study of trapping activities by band members.

3.9.2.5 Upland Game Birds

Hunter harvest data for M.U. 6-14 indicate that 306 grouse of three species were harvested in 1978 (Table 3-9.17). The grouse harvest on the Tsimpsean Peninsula probably accounts for but a fraction of the total for M.U. 6-14. NEAT (1975) estimated the grouse harvest for Tsimpsean Peninsula at 100 birds per year. Franklin's Grouse though harvested in M.U. 6-14 is more characteristically a subalpine species and no doubt occurs in parts of the sampling area other than the Port Simpson Bay area. Though not encountered in this study both Blue Grouse and Ruffed Grouse are likely to occur in the terminal area.

Table 3-9.17
Hunter Sample Data for Upland Game Birds in M.U. 6-14 in 1978 and 1979

	1978		1979	
	Estimated Number of Hunters	Estimated Number Harvested	Estimated Number of Hunters	Estimated Number Harvested
Ruffed Grouse	61	156	9	53
Franklin's Grouse	27	136	unavailable	unavailable
Blue Grouse	27	14	21	83
Total	115	306	N/A	N/A

3.9.2.6 Raptors

Bald eagles are present in large concentrations during the fall and winter months in several locations on

Tsimpsean Peninsula including Port Simpson (NEAT, 1975). A BEAK survey on March 10, 1981 observed 21 bald eagles distributed throughout the Port Simpson area and a concentration of 52 bald eagles just north of Rushbrook Passage. The potential for public enjoyment from the observation of bald eagles is great in the Port Simpson study area. Other raptors occur in the terminal area and these are indicated in Table 3-9.8.

3.9.2.7 Other Birds

The relative scarcity of intertidal flats and beaches would indicate shorebird utilization of the terminal site area is limited. Certain shorebirds such as Black Turnstones and Surfbirds which are found in rocky habitats are likely to occur in areas such as the Harbour Reefs and rocks in Rushbrook Passage. No shorebirds were observed during the March 10 census. However, Martin (1978) recorded late autumn and winter concentrations of shorebirds numbering over 1,000 individuals in Pearl Harbour and Big Bay, immediately to the south. He did not report any large concentrations in the Port Simpson Bay area, although it was part of his study area.

3.9.2.8 Endangered Species

Peregrine Falcons nest along the north coast in association with seabird colonies primarily in the Queen Charlotte Islands. In Chatham Sound three known eyries have been reported on offshore islets in association with nesting colonies of alcids (NEAT, 1975). Breeding sites are not reported in public documents as a means of protecting these sites, but they do not occur in or near the terminal area.

Another uncommon species found along the north coast is the Sandhill Crane. This species utilizes open habitats (bog, meadow) near the coast for breeding. South of Prince Rupert they are relatively conspicuous (W. Munro, B.C. Fish and Wildlife Branch, pers. comm.), and they can be expected to occur in small numbers in the Tsimpsean Peninsula (NEAT, 1975).

While Sea Otters were once abundant on the west coast they are now considered an endangered species. Recent transplants in British Columbia and southern Alaska have been undertaken and occasional sightings indicate that the Sea Otter is re-establishing itself on the north coast.

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3.10.0 SURFACE WATER

3.10.1 Marine Approaches

Along the marine approaches to Port Simpson Bay many small rivers and streams affect near shore waters, but only two major rivers, the Skeena and the Nass, are large enough to affect the water quality and currents in Chatham Sound.

The Skeena, which is the second largest river entering the coastal waters of British Columbia, drains the Skeena Mountains and part of the interior plateau with a drainage area of about 52,000 km^2. As recorded over a 30 year period at Usk (150 km upstream), the average mean monthly flow is 923 m^3/s (Water Survey of Canada 1973) ranging from a minimum of 52 m^3/s to over 9,345 m^3/s with a median spring flood of 4,730 m^3/s (Figures 3.10.1 and 3.10.2, Lee Doran Associates 1975). Two maxima occur every year, the largest in late spring as a result of snow-melt from higher elevations, and a smaller peak in autumn or early winter due to runoff caused by direct precipitation. Individual rainstorms can cause smaller distinct peaks.

Precipitation amounts and intensities are greatly dependent on geographical locations and the ruggedness of the terrain. Variations occur because of elevation, aspect, exposure and orientation of the site. Figure 3.10.3 shows the geographical distribution of annual precipitation (in inches) for the north coast of B.C. (B.C. Natural Resources Conference, 1956). It can be seen that exposed seaward slopes receive the heaviest precipitation while lowlying and protected areas receive the least.

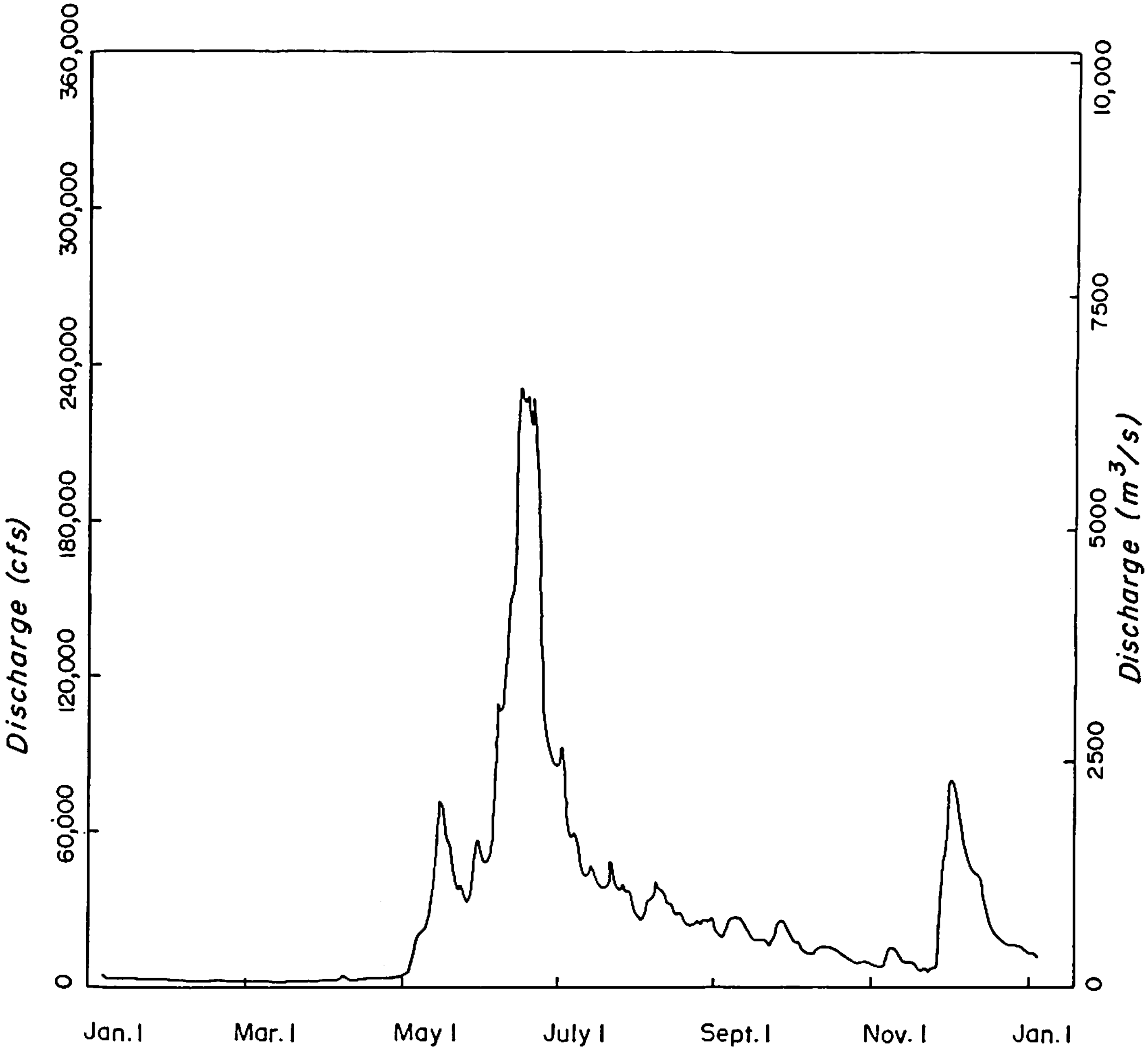


Figure 3.10.1 Skeena River hydrograph, typical flow year, 1950 (from NEAT, 1975)

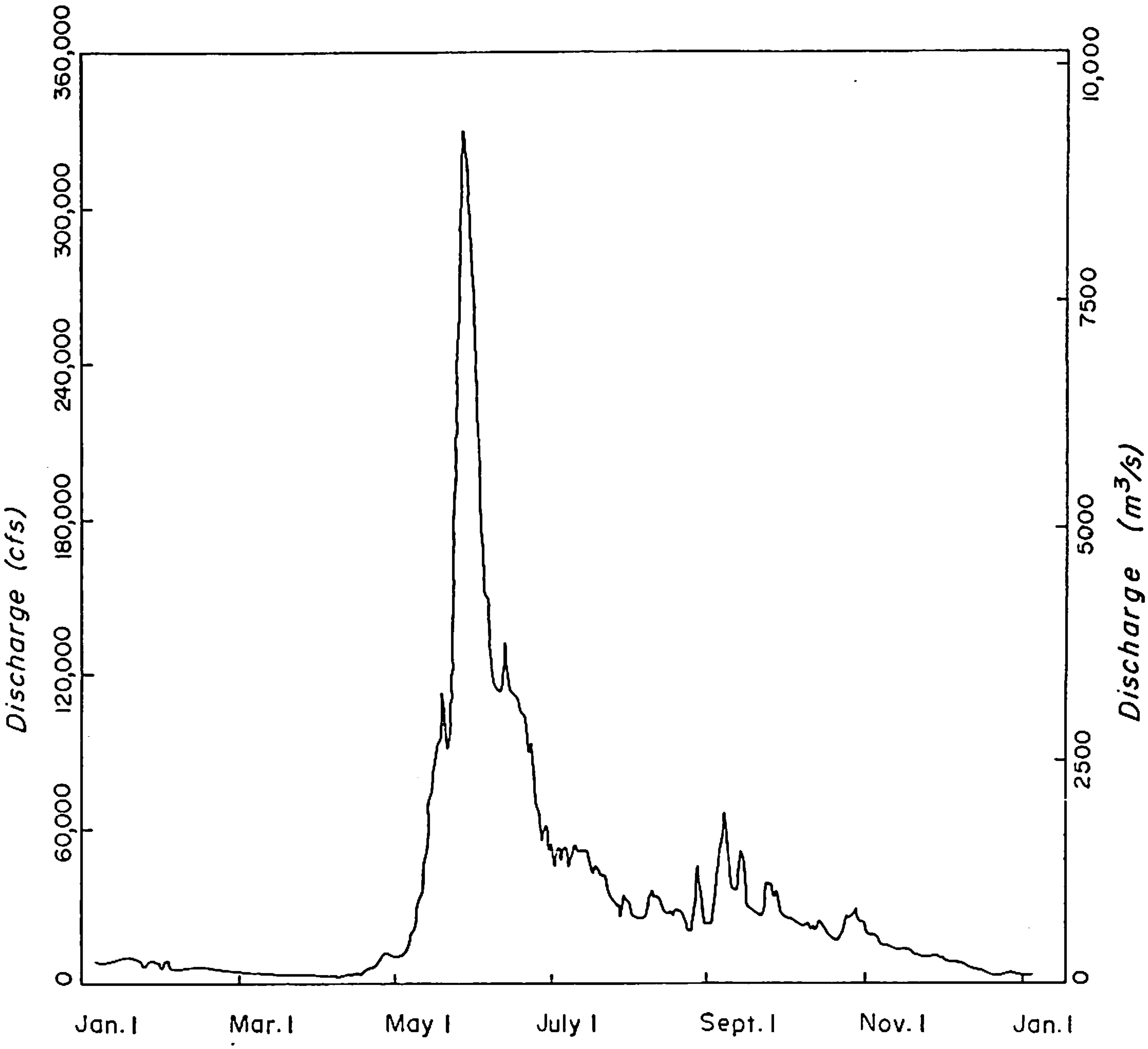


Figure 3.10.2 Skeena River hydrograph, maximum flow year, 1958 (from NEAT, 1975)

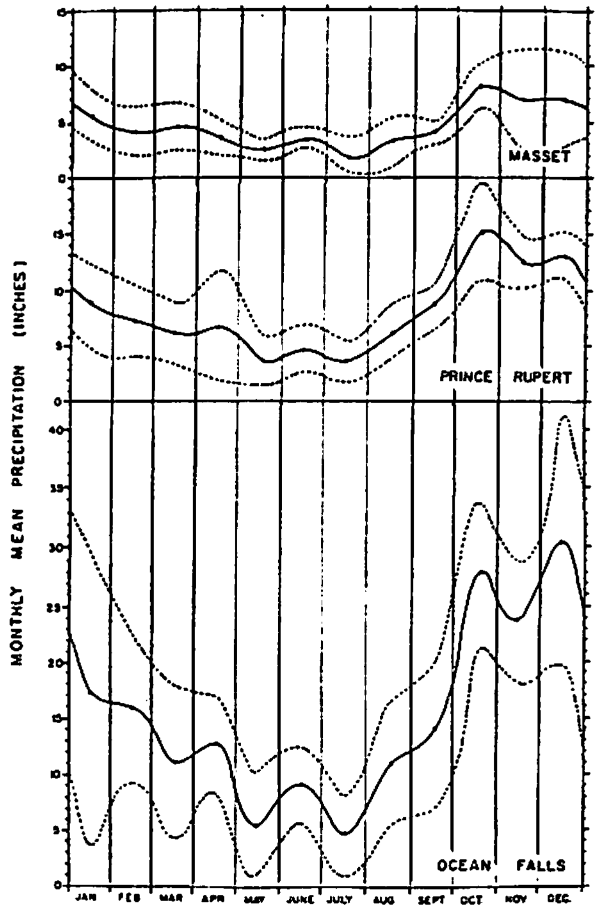


Figure 3.10.3 The annual cycle of precipitation (inches) for Prince Rupert and Masset, 1956 – 1963 (from Crean, 1967)

The Nass River drains a basin of only 20,500 km^2 in a region where the precipitation ranges from 100 cm per year in the highlands to 380 cm per year on the lower slopes. As can be seen from Figures 3.10.4 and 3.10.5 (NEAT 1975) which show the Nass River hydrographs for 1965, a typical flow year, and for 1961, a maximum flow year, the freshet maximum in June is smaller and much broader than that of the Skeena. Also, rain in the fall can produce peaks in flow that exceed the flow during spring runoff, e.g., Figure 3.10.5. Flood frequency curves for the Nass and Skeena Rivers are exhibited in Figures 3.10.6 and 3.10.7 (NEAT 1975)

Surface waters of Chatham Sound are strongly influenced by discharge from both the Nass and Skeena Rivers, especially during freshet. It has been shown (Trites 1956) that a large portion of Skeena water moves northward along the Tsimpsean Peninsula toward Dundas Passage with about 30% finding its way into Dixon Entrance and Hecate Strait through Ogden Channel and Brown Passage (Trites 1956). At certain times of the year Nass River water blocks the northern movement of Skeena River water. During freshet Nass water moves as far south as Melville Island (Trites 1956). the effects of Skeena and Nass River discharge on oceanography are further discussed in Chapter 3.1.1.

Like the Fraser and Squamish rivers, the Skeena water is very turbid, particularly during the spring freshet or heavy autumn rains. Part of the turbidity arises from glacial flour scoured from the glaciated regions of the river headwaters, while some of it is derived from suspended particulates (silt, etc.) from the lower sections of the drainage basin. Although no records of the exact quantity of sediment carried by the Skeena are available, photos of the estuary during the freshet show a greyish-brown plume extending many kilometres from the river mouth. Hoos (1975)

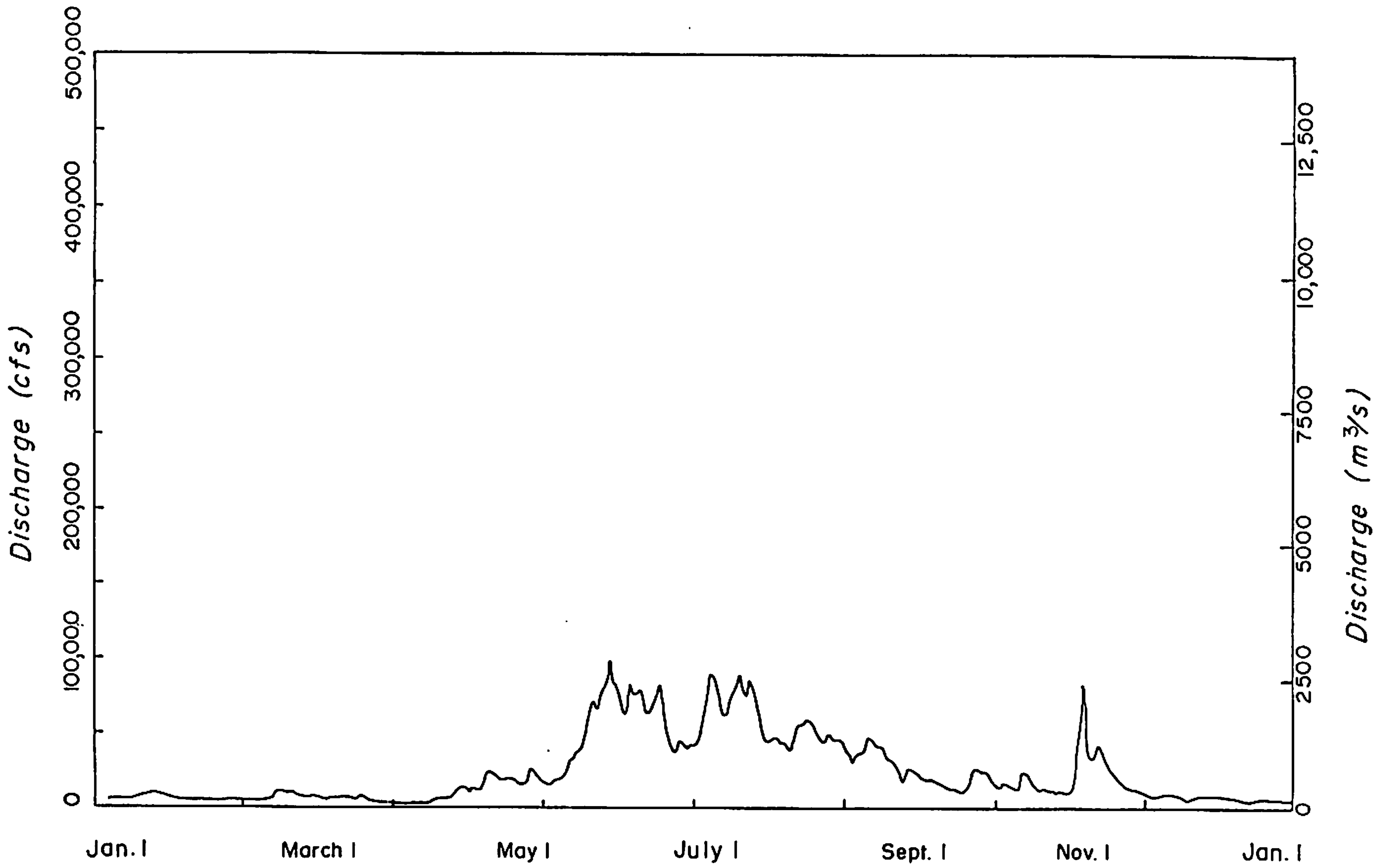


Figure 3.10.4 Nass River hydrograph, typical flow year, 1965 (from NEAT, 1975)

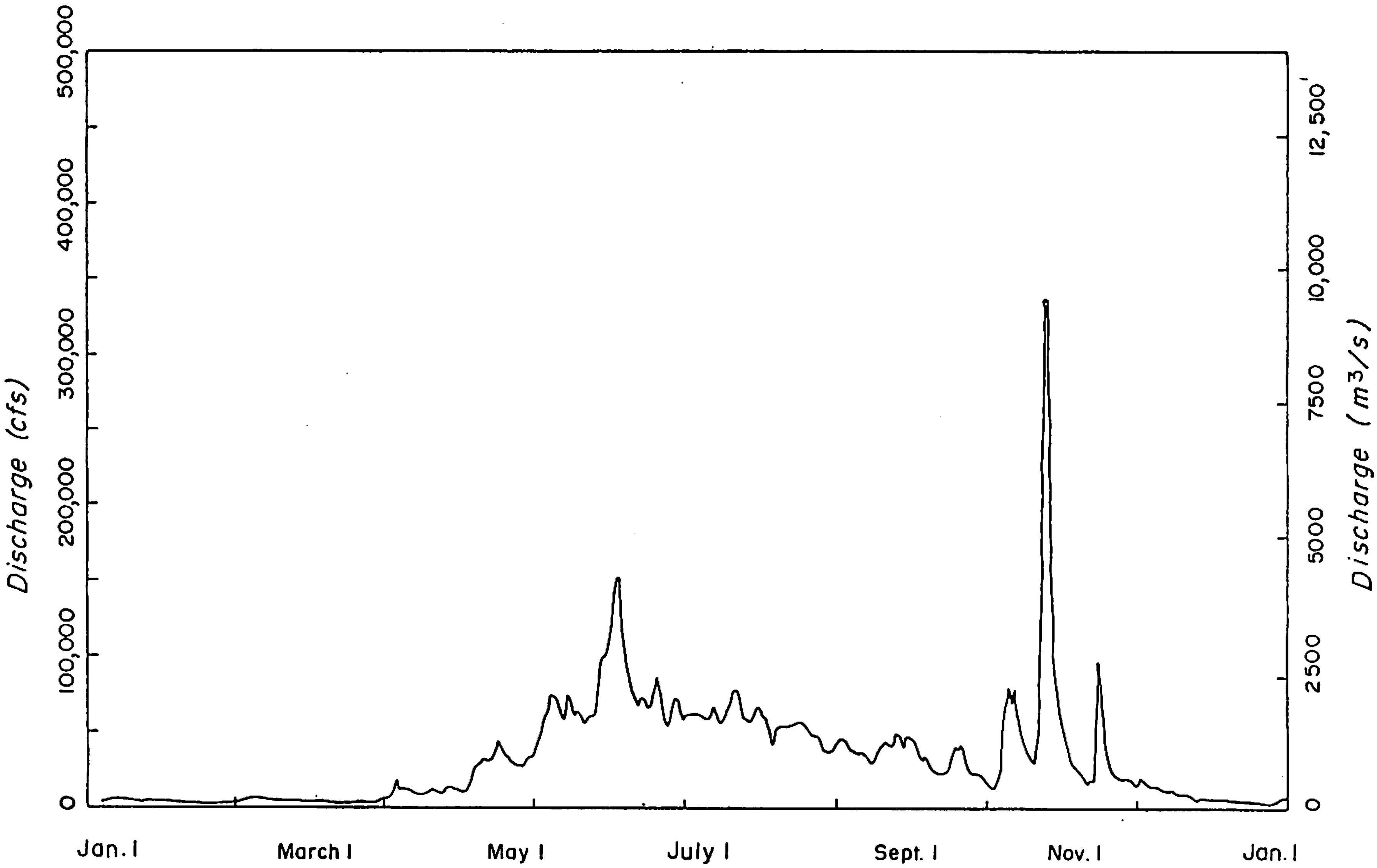


Figure 3.10.5 Nass River hydrograph, maximum flow year, 1961 (from NEAT, 1975)

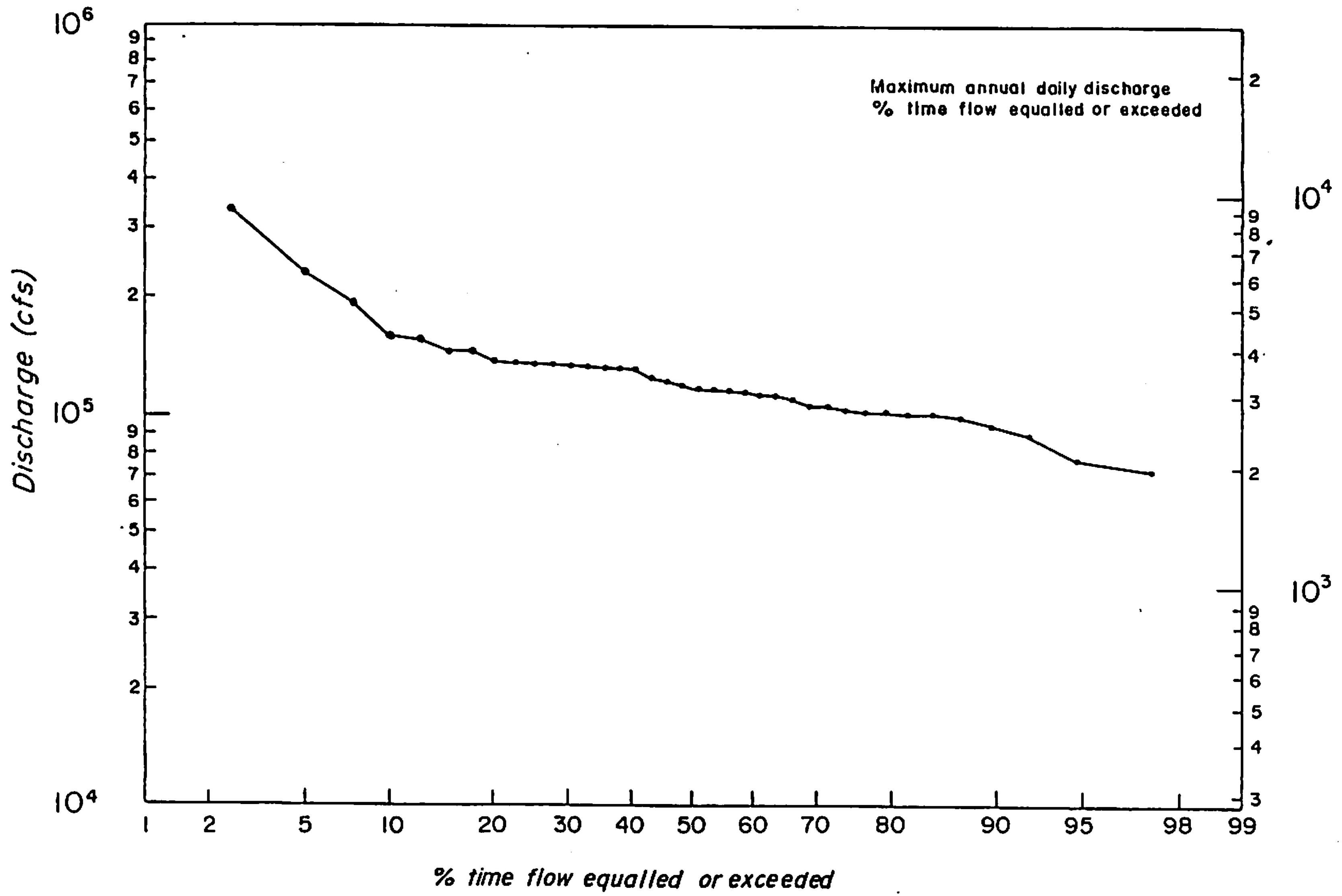


Figure 3.10.6 Flood frequency curve for the Nass River (from NEAT, 1975)

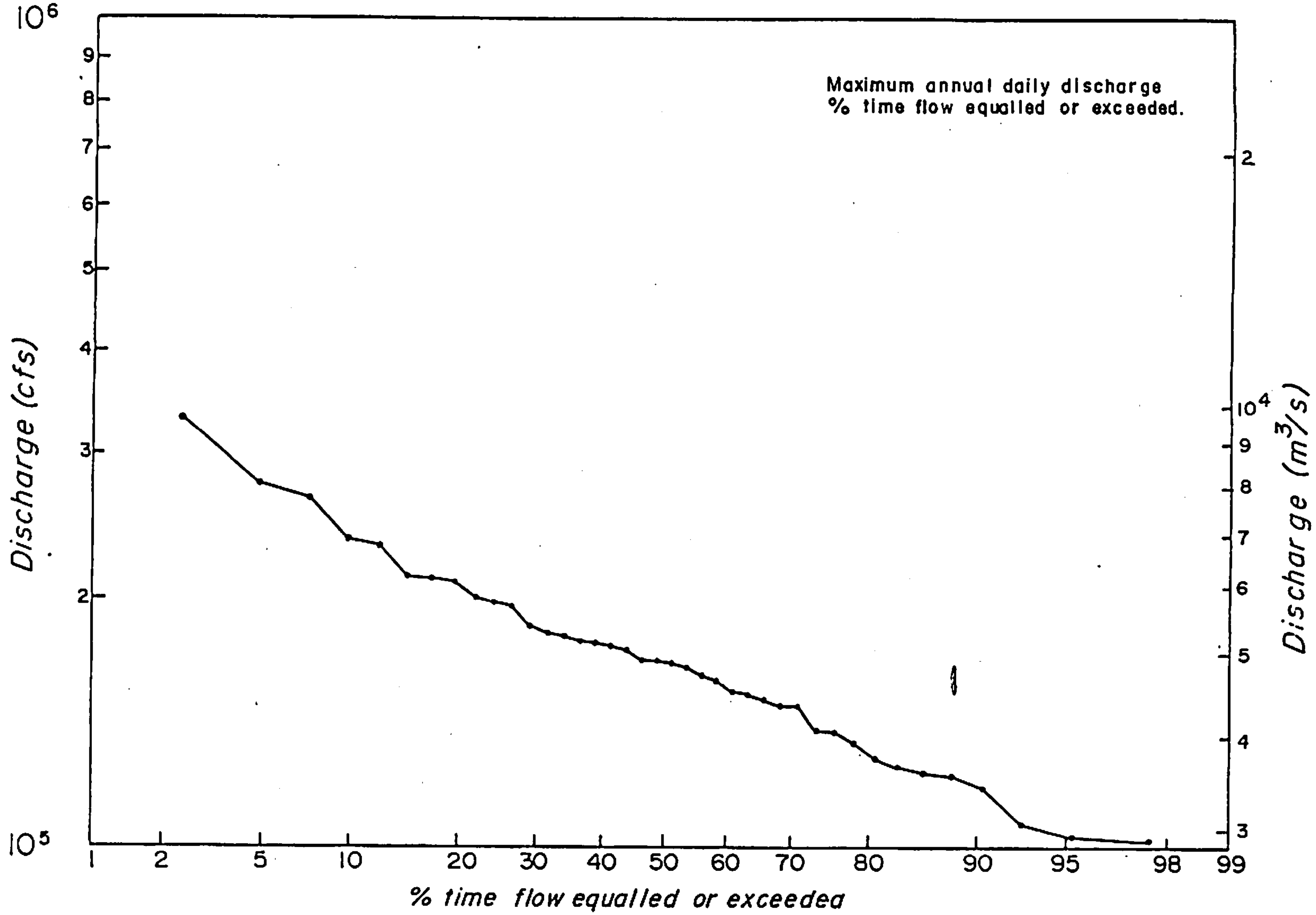


Figure 3.10.7 Flood frequency curve for the Skeena River
(from NEAT, 1975)

suggests that the load is at least as large as those of the Fraser and Squamish rivers. Because the Nass drainage basin contains glaciers, the quantity of bedload carried is also probably quite large.

3.10.2 Terminal

There is very little published surface water flow information for the Port Simpson area. At the head of Port Simpson Bay is Stumaun Bay exhibiting large areas of sand and mud flats overlying fluvial gravel (NEAT 1975, Vol. IV). Several streams flow into Stumaun Bay, the largest of which is the small intertidal estuary of Stumaun Creek. It is formed by the confluence of two branches at the high tide line (NEAT, 1975). The main fork is steeper and drains an entirely mountainous area, the west fork drains an area of rolling terrain and has more shallow gradients. Both forks show peak flows in fall due to rainfall with possible large flows over 8.5 m^3/s. Minimum flows on the main fork area are 0.056 m^3/s and on the west fork 0.028 m^3/s. The mean monthly runoff and calculated flood hydrographs for Stumaun Creek (Figures 3.10.8 and 3.10.9) were calculated by Northwest Hydraulic Consultants from available precipitation information for the Skeena and Nass rivers, the topography and the mean monthly evapotranspiration because no stream gauges had been operational on Stumaun Creek to that time (NEAT, 1975).

3.10.3 Proposed Fresh Water Supply Sources

A field investigation and office study have been completed as the first stage in assessing the feasibility of developing a fresh water supply for the proposed LNG terminal

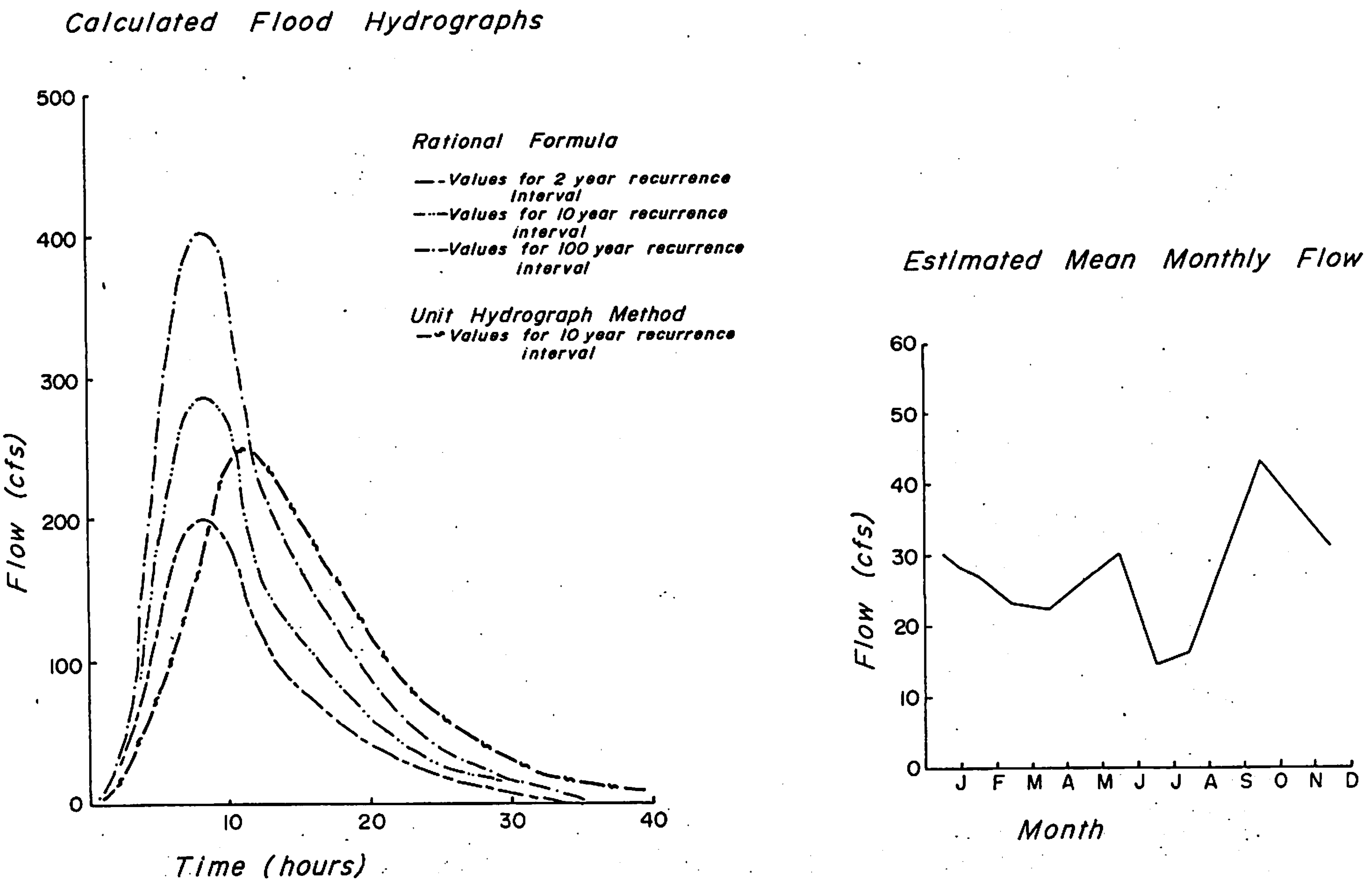


Figure 3.10.8 Hydrographs for the main fork of Stumaun Creek (from NEAT, 1975)

Runoff from small watersheds is primarily dependent on rainfall patterns and other hydrologic parameters and is difficult to predict on a daily basis. Over a longer monthly time basis however, average total runoff volumes can be estimated from readily available past monthly rainfall records. To assess how this monthly runoff volume could occur on a daily basis throughout the month will require predicting future rainfalls on a probability basis. However for the purposes of this report, consideration of average and drought situations is sufficient to evaluate watershed potentials.

For example, if monthly rainfall is considered to occur in a relatively uniform daily distribution, the resulting runoff would be expected to be fairly uniform. However, if the monthly rainfall occurs unevenly on isolated days with extended dry periods between, resulting runoff pattern would likely also be uneven. Runoff would also be expected to decrease or cease altogether depending on the elapsed time between rainfall events. As noted earlier existing rainfall records for Prince Rupert and Port Simpson indicate an average that rainfall can be expected on 16 days during a summer month.

Extended dry periods have occurred in past years in the Grassy Point area during which streamflows may have ceased temporarily.

Accordingly, the use of any small watershed in this area as a reliable water supply will require the storage of surface water for use during dry periods. Storage would be required regardless of the apparent adequate yield of the watershed during average conditions.

site. Development of a supply from both nearby surface water and groundwater sources were studied. Development of a more remote surface source from Georgetown Lake was also evaluated.

Table 3.10.1 provides a summary of projected water requirements for the LNG project.

TABLE 3.10.1

Summary of Projected Total Water Requirements

	USE	WATER REQUIREMENTS AVERAGE DAILY (or as shown)	MAXIMUM DAILY
A1	Plant using fresh water for once-through cooling.	284,000 l/min	284,000 l/min
A2	Plant using fresh water for cooling tower makeup	7,600 l/min	7,600 l/min
B	Plant Construction	250,000-375,000 l/day (174-260 l/min)	562,500-843,750 l/day (390-585 l/min)
C	Plant Operation	5700 l/day 4 l/min	12,825 l/day 9 l/min
	Ship makeup	100 m^3/week 69 l/min (24 hour supply time)	

The water demands outlined above assume that fire protection requirements will be met from sea water sources.

3.10.3.1 Surface Waters

In order to provide estimated runoff and recharge for the local streams the precipitation information detailed in Section 3.4.2.2 of this report were used.

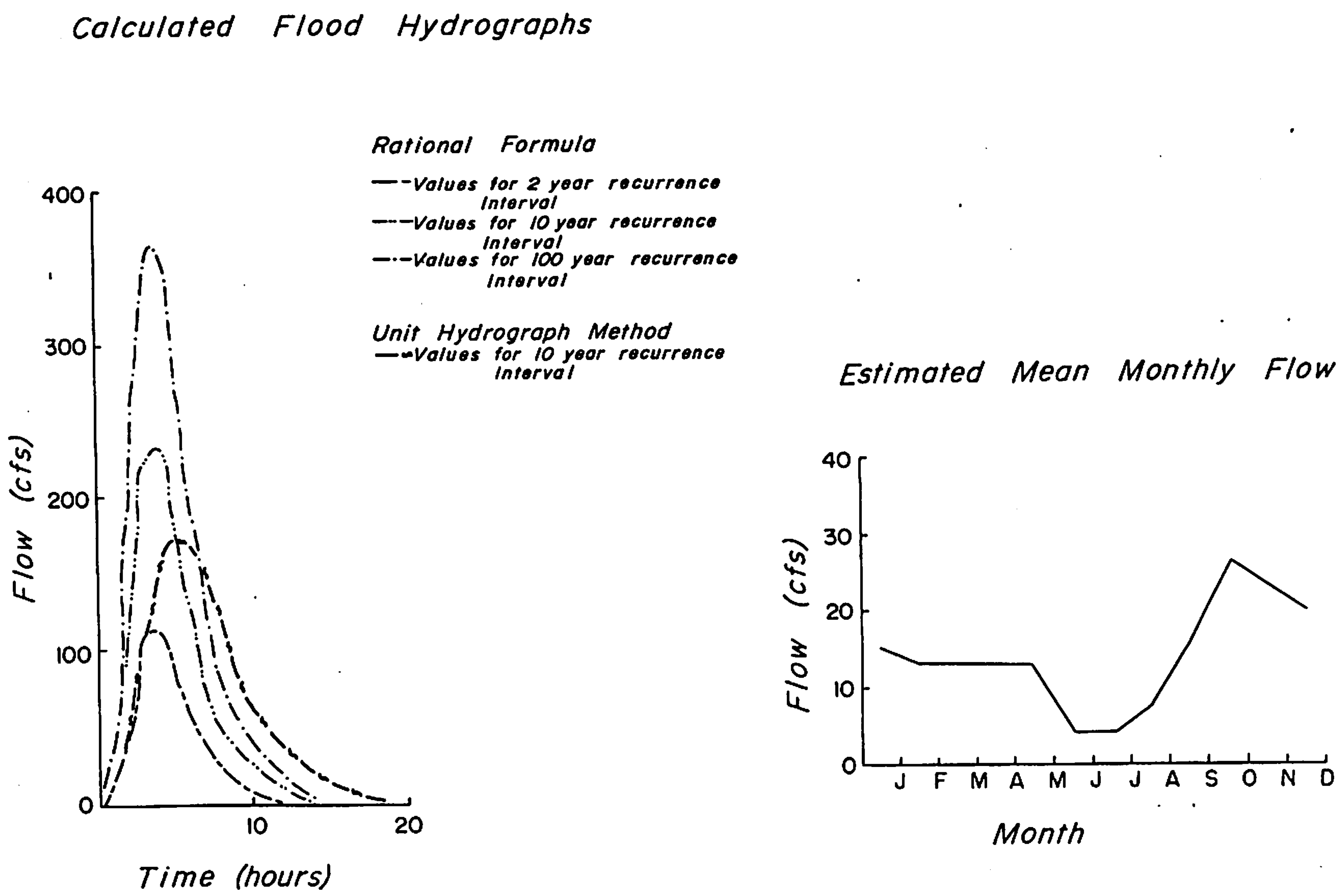


Figure 3.10.9 Hydrographs for the west fork of Stumaun Creek (from NEAT, 1975)

The portion of total precipitation effective in producing surface runoff depends on many watershed parameters including soil infiltration capacity, soil moisture, soil depth, evapotranspiration and surface depression storage.

Estimation of these individual parameters will require further site testing and investigation.

Typical published runoff coefficients for unimproved forested areas considered similar to the Grassy Point area vary from .05 to 0.35 with actual values depending primarily on soil infiltration capacity. The lower values would be applicable to relatively permeable type soils.

To estimate watershed runoff yields for water supply function, a conservative runoff coefficient of 0.15 has been selected as appropriate in view of the minimal site hydrologic data available. The value of the runoff coefficient may require adjustment later as more site hydrologic information is collected and evaluated.

The remainder of total rainfall is assumed to be lost to evapotranspiration, retained in surface storage depressions or infiltrated into watershed soils.

Average June/July Runoff

In order to calculate average June/July runoff an average monthly precipitation of 102 mm and a runoff coefficient of 0.15 a monthly net surface runoff volume of 15,300 m^3/sq.km is calculated. Assuming this volume was distributed uniformly throughout the month this volume represents an average daily flow of 354 l/min/sq.km.

Minimum June/July Runoff

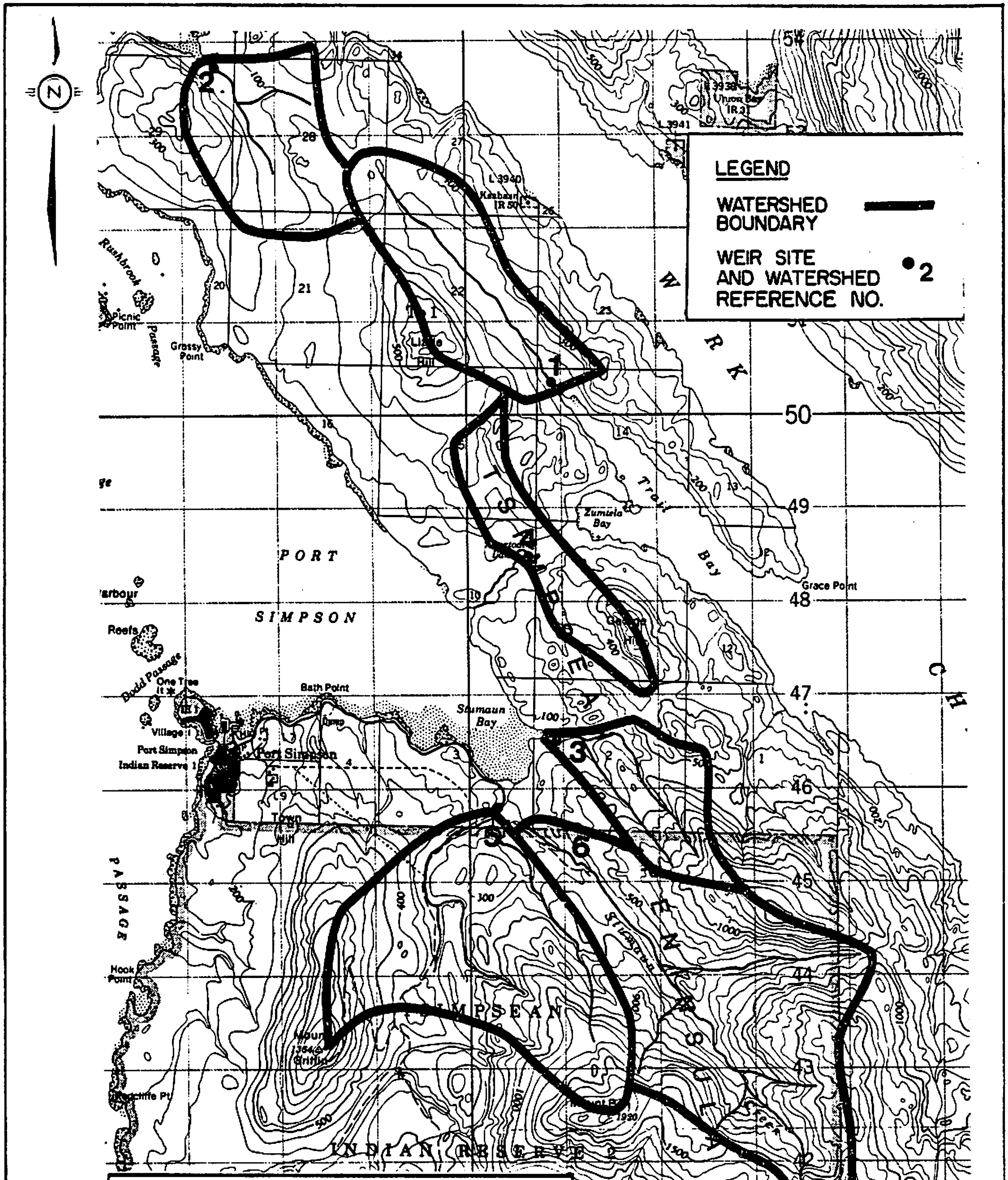
Considering a minimum monthly total rainfall of 7.6 mm as representative of an extremely dry period during June and July and assuming a runoff coefficient of 0.15 the monthly net surface runoff volume is reduced to 1140 m^3/sq. km. This represents an average daily flow of 26 l/min/sq. km for a uniform monthly rainfall distribution.

As discussed earlier it is possible that during such a dry month the rainfall will occur in isolated events with extended dry periods between. Streamflows could be substantially reduced or non-existent at the end of such a dry period, confirming the necessity of providing adequate back-up surface storage.

As a result of site inspecton and office study, various surface water sources have been selected as supply possibilities and are considered to warrant further investigation. These possible surface water supply sources are shown on Figure 3.10.10 and Figure 3.10.11 and are discussed in the order of their apparent ability to supply the site requirements.

It is noted that the site visit took place on a clear sunny day. An examination of precipitation records for the period prior to the visit indicates that rainfalls were generally low for the 10 days prior to March 18. Recorded precipitation from March 8 - 18/81 was 29 mm with no rain occurring on the 11, 12, 17, and 18 of the month.

The recorded precipitation amounts indicate that local evaluation took place during a dryer than normal period in March, possibly resulting in lower than normal flows being observed in local watercourses. The following sources were evaluated and are ranked in decreasing order of suitability:



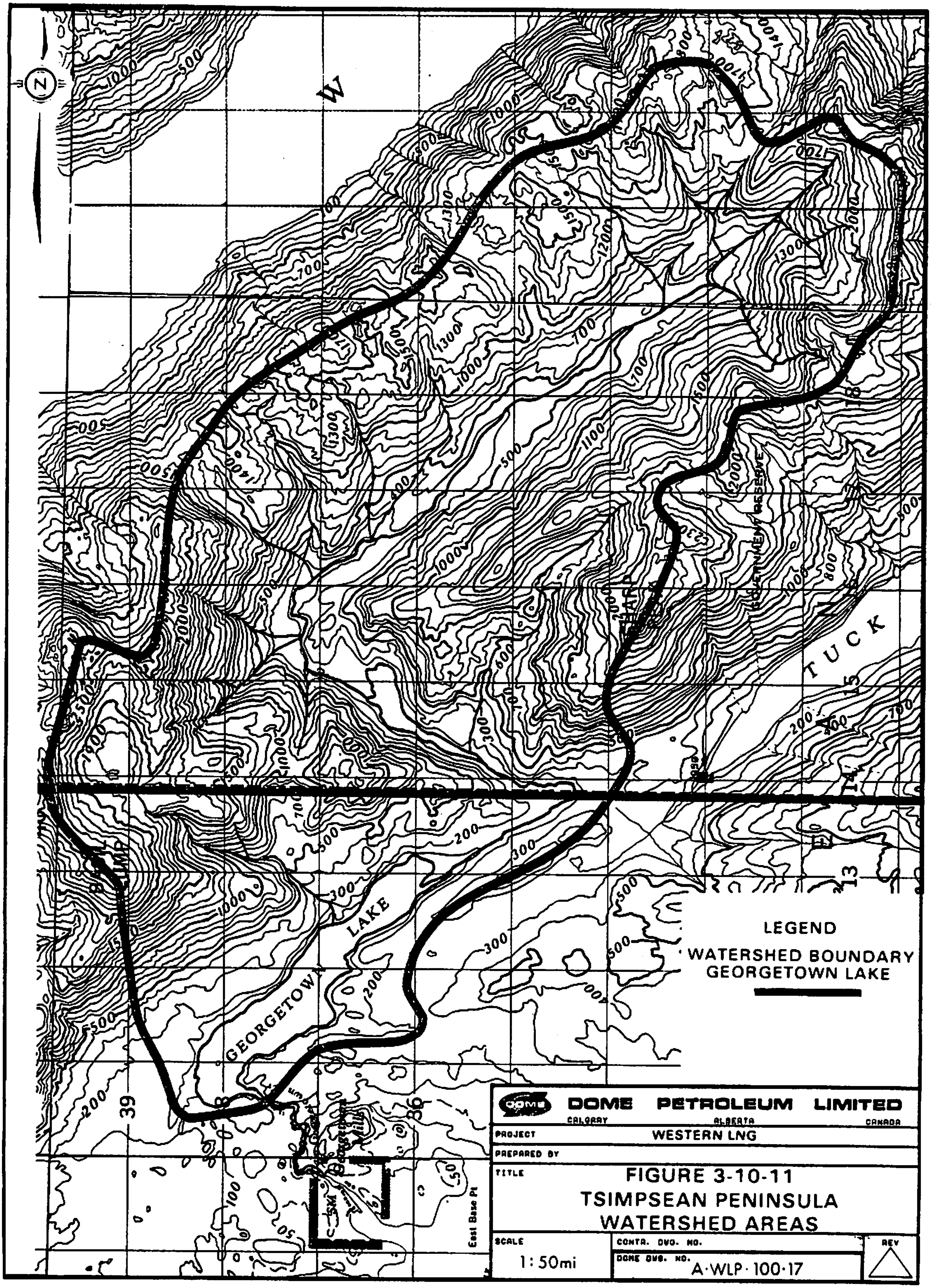
DOME PETROLEUM LIMITED
CALGARY ALBERTA CANADA

PROJECT: WESTERN LNG

PREPARED BY:

TITLE:
FIGURE 3-10-10
TSIMPSEAN PENINSULA
WATERSHED AREAS

SCALE	CONTR. DWG. NO.	REV
1:50 mi	DOME DWG. NO. A-WLP-100-18	



DOME PETROLEUM LIMITED
CALGARY ALBERTA CANADA

PROJECT: WESTERN LNG

PREPARED BY:

TITLE: FIGURE 3-10-11
TSIMPSEAN PENINSULA
WATERSHED AREAS

SCALE: 1:50mi

CONTR. DWG. NO.

DOME DWG. NO. A·WLP·100·17

REV

1. Unnamed Creek Draining into Trail Bay

This watercourse is over 3 km in length, has a catchment area of approximately 320 hectares and lies in a narrow gap bounded by Lizzie Hill on the west and low lying ridges bordering Work Channel to the east. The watershed area is heavily treed and the stream channel meanders along its length at an approximately average grade of less than 3%. Good storage sites should be available in this watershed. The peak elevation in the watershed is estimated at 245 metres above Mean Sea Level (MSL).

Bedrock outcroppings were noted at various locations within the watershed and may indicate low soil depths. The headwaters of this watershed were also observed to contain areas of coastal muskeg having a high capacity for water retention and possible saturation during wet periods.

Using the runoff yields outlined in the above, this watershed could produce a monthly net surface runoff volume of 49,000 m^3 during an average June/July month representing an average daily flow of 1135 l/min.

During a dry June/July month the runoff yield could fall to 3650 m^3 representing an average daily flow of 85 l/min.

Estimated storage in the amount of 25 days average daily consumption is required on this source.

2. Unnamed Creek North of Grassy Point, South of Dudevoir Passage

Approximately 225 ha are contained in the catchment of this watercourse lying at the north point of the Tsimpsean Peninsula. The exact boundaries of the watershed must be determined by ground inspection because the watershed divide is not well defined.

Channel slopes are low in the order of 3% over the main channel length providing good possible storage sites. Elevations in the watershed rise to approximately 245 metres above MSL on Lizzie Hill.

An estimate of runoff volume in this watershed for an average June/July month would be 34,000 m^3 or 790 l/min on an average daily basis.

For a dry June/July month, runoff volume is estimated at 2540 m^3 or 60 l/min on an average daily basis.

Storage requirements on the watercourse would be in the order of 30 days average daily consumption.

3. Unnamed Creek Draining into Stumaun Bay

The catchment area of this watercourse is estimated to be 175 ha. Ground elevations rise from sea-level to approximately 305 metres above MSL elevation on an average 10% slope. The catchment area is heavily treed providing heavy ground cover and shading.

Bedrock outcroppings were observed in this watershed and may indicate a general low soil depth cover. No significant muskeg areas were observed during the inspection which may reflect steeper slopes and better drainage conditions within this catchment.

The yield of this watershed during an average June/July month is estimated to be 27,000 m^3 or 651 l/min on an average daily basis.

A dry June/July month could reduce the watershed yield to 2000 m^3 or 45 l/min considered on an average daily basis.

It is estimated that storage in excess of 30 days average daily consumption would be required on this watershed for reliable use as a water supply source.

4. <u>Neaxtoalk Lake</u>

Neaxtoalk drains an area of approximately 180 ha stretching in a thin band from George Hill at the south to the slopes of Lizzie Hill at the north. Neaxtoalk Lake flows into a salt water lake which then discharges into Stumaun Bay.

At high tidal levels sea water flows into the salt water lake and the combination of salt water and fresh water from Neaxtoalk Lake drain back out into the ocean at low tidal levels.

It is not presently known how much salt water enters Neaxtoalk Lake or the effect on the quality of the fresh water in the lake.

The ground level in the catchment area rises from lake level to approximately 215 metres above MSL. The major tributary channels were not observed during the site visit although they are reported to discharge significant flows during wet periods.

The immediate area surrounding Neaxtoalk Lake is reported to be comprised of deposited organic material. Muskeg formation around the lake has apparently been prevented due to the fluctuating lake water levels which result from the interaction of tide levels and lake inflows.

The expected runoff from the Neaxtoalk Lake watershed is considered similar to that of the unnamed creek flowing into Stumaun Bay. Storage would therefore also be required within this watershed to cover extended dry summer periods. This storage volume may exist in Neaxtoalk lake at present lake levels could also require raising the lake level with a lake outlet structure. To determine the feasibility of utilizing this lake as a potable water source and storage site would require further on-site investigation.

5. West Tributaries of Stumaun Creek

The two westerly tributaries of Stumaun Creek known as West and East Salmon Creek flow into the main Stumaun Creek channel below the water intake for the Village of Port Simpson. Water from these tributaries would therefore be available for water extraction.

The drainage area of the two tributaries is approximately 570 ha and the watershed ground elevation rises to approximately 585 metres above MSL at the top of Mount Ben and is comprised of rolling and somewhat mountainous terrain. The most westerly tributary is paralleled by a road along some of its length and has also been partially cleared.

Channel slopes along the two tributaries are approximately 2% in the lower reaches but increase in their headwater areas on Mount Ben. Channel bottoms were observed to contain gravels in their lower reaches.

At the time of inspection the tributary channels were estimated to be discharging 380-470 l/min at their downstream confluence.

Watershed yield estimates indicate that on a monthly basis 87,000 m^3 of water could be available during an average June/July month which represents an average daily flow of 2000 l/min.

For June/July periods the monthly runoff volume is estimated to fall to 6450 m^3 or 150 l/min on an average daily basis.

Considering low flows possible during extended dry periods surface storage would be required in the amount of 20 days average daily consumption.

6. Stumaun Creek

The main channel of Stumaun Creek serves as the water supply to the Village of Port Simpson and the Port Simpson Cannery. The main channel is considered fully utilized by these licensed users and would therefore probably not be available as a water supply source for the site. Excess water is assumed to flow over their intake during wet periods of the year but probably ceases or drops significantly during dry summer periods.

The band is authorized to divert 375,000 imperial gallons per day from Stumaun Creek at their intake and store 5.52 ac.ft of water annually. The Band also holds permits for crossing Crown lands with their supply to the village.

The drainage area of Stumaun Creek down to the intake is approximately 970 ha and the ground elevation rises to approximately 735 metres above MSL in its headwaters. At the time of the site inspection water was observed spilling over the intake dam.

This watercourse drains a mountainous area and has steeper slopes than its westerly tributaries. Slopes along its lower reaches are in excess of 5%. The headwater area is relatively flat and contains several small ponds. Lengths of the channel observed contained primarily gravels and boulders. The mouth of Stumaun Creek below its confluence with its westerly tributaries was noted to be considerably wider than at upstream channel locations and contains an intertidal pool area of probable fisheries significance.

Watershed yield estimates indicate that on a monthly basis 148,000 m^3 (120 ac.ft.) of water would be available during an average June/July month which represents an average daily flow of 3425 l/min (905 US gpm).

For dry June/July periods the monthly runoff volume is estimated to drop to 11,000 m^3 or 250 l/min (65 US gpm) on an average daily basis.

7. Georgetown Lake

Georgetown Lake and Creek were not inspected during the site visit but have been examined from existing aerial photography and topographical mapping.

The drainage area of the lake is approximately 4790 ha to its outlet and represents one of the major drainage areas on the Tsimpsean Peninsula. The drainage area is bounded by the peak of Basil Lump to the north, Sharp Peak and the drainage of Silver Creek to the south.

Georgetown Creek rises to approximately 790 metres above MSL in its headwaters area. The gradient along the majority of the creek is less than 2% but rises to approximately 5% in its upper reaches.

The catchment slopes draining into Georgetown Creek above the lake are steep along most of its length indicating runoff and inflows to the lake may be fairly rapid during wet periods.

Watershed yield estimates for the lake indicate that on a monthly basis 730,000 m^3 of water would be available during an average June/July month which represents an average daily flow of 17,000 l/min. For a dry June/July month runoff volume is estimated to fall to 55,000 m^3 which represents an average daily flow of 1287 l/min.

This watershed could theoretically meet the water requirements at the site during construction, and for operations, plant cooling tower makeup water demand during average yearly runoff conditions. The watershed would not be able to meet the large once-through cooling demands of the operating plant.

For dry June/July periods the theoretical yield of the watershed would not be able to meet the cooling tower makeup requirements and would require providing storage on the lake or drawing the lake level down temporarily.

Georgetown Lake is contained within Indian Reserve #2 and its use would be subject to negotiation with the Port Simpson Indian Band and provincial and federal agencies.

Watershed Summary

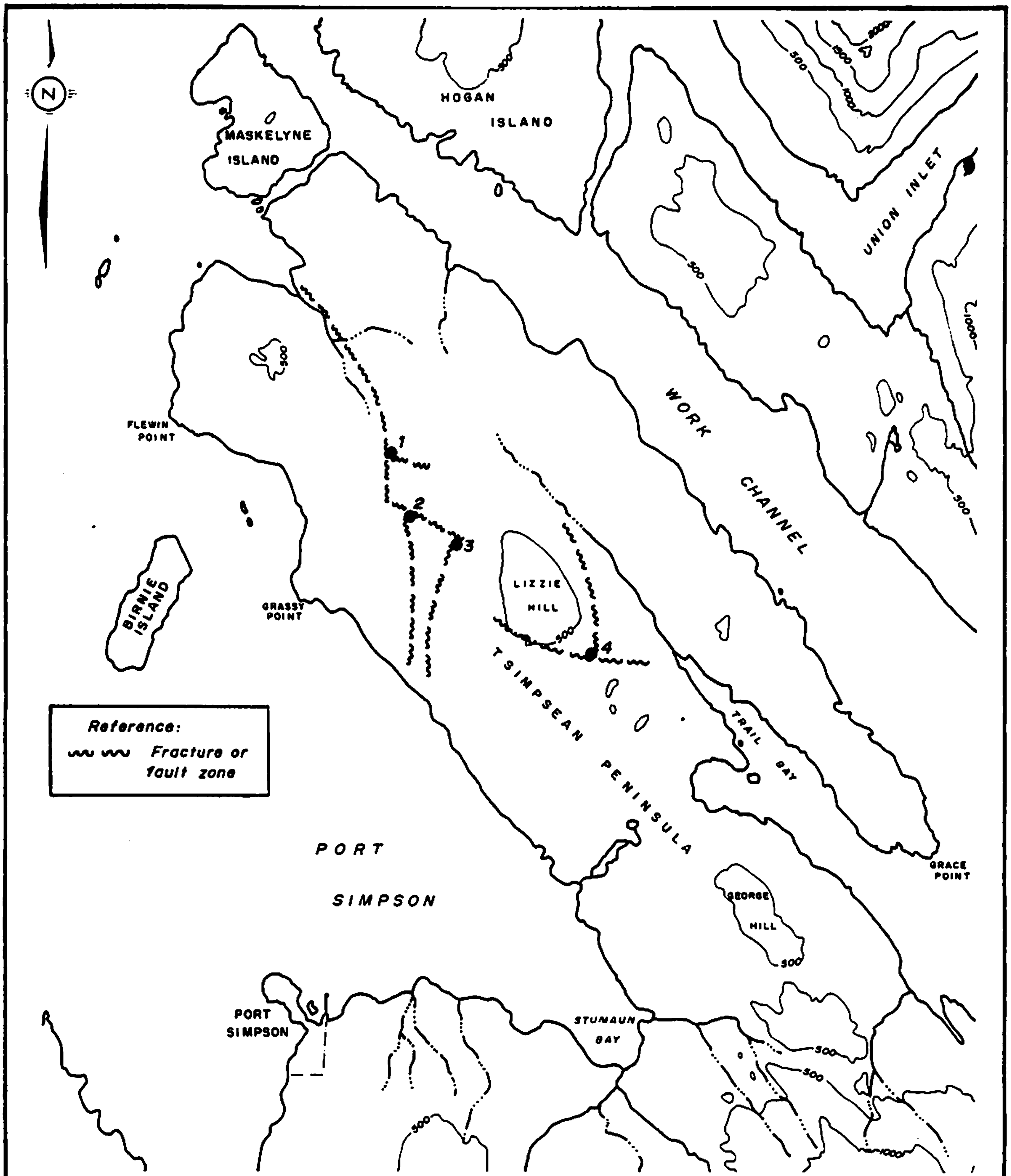
RANK	NAME	Size (ha)	Est. Ave. Monthly Runoff (M^3)	Est. Dry Monthly Runoff (M^3)	Est. Req'd Surface Storage (M^3)
1	Unnamed Creek Trail Bay	320	49,000	3,650	9,400
2	Unnamed Creek N. Grassy Point	225	34,000	2,540	11,250
3	Unnamed Creek Stumaun Bay	175	27,000	2,000	12,000
4	Neaxtoalk Lake	180	28,000	2,050	12,000
5	West Tributaries Stumaun Creek	570	87,000	6,450	7,500
6	Stumaun Creek	970	148,000	11,000	-
7	Georgetown Lake	4790	730,000	55,000	-

3.10.3.2 Groundwater

To assess the groundwater potential of the Grassy Point and Port Simpson area Brown, Erdman & Associates Ltd. were retained to provide specialist input.

The following are exerpts from their report submitted following the site inspection:

> "Groundwater will be present on the Tsimpsean Peninsula in fractured bedrock types with gneiss beneath the northeastern half of the peninsula and metamorphosed sediment beneath the southwestern part of the peninsula. Both types of rock appear to be hard and brittle and should fracture cleanly near faults zones. A major fault zone lies beneath Work Channel and numerous fault and fracture zones which are probably subsidiary to the major fault cut across the Peninsula. Please see the attached map (Figure 3.10.12) for the locations of prominent fault and fracture zones and preferred drilling locations at the intersections of these zones.
>
> Rainfall records from Prince Rupert indicate that approximately 250 mm of precipitation should fall on the Peninsula each year. If 5% of this water can be economically intercepted by wells 1140 l/min of water could be developed.
>
> However, we judge that there is a 90% chance of successfully developing a 260 l/min requirement for the construction camp which will also meet the makeup and potable water demand of the plant."



DOME PETROLEUM LIMITED CALGARY ALBERTA CANADA		
PROJECT	WESTERN LNG	
PREPARED BY		
TITLE	FIGURE 3-10-12 PORT SIMPSON AREA LOCATION SKETCH	
SCALE 1:50,000	CONTR. DWG. NO. DOME DWG. NO. A·WLP·100·16	REV

3.10.3.3 Water Licensing

No water licenses presently exist on the Tsimpsean Peninsula down to Georgetown Lake except for the main channel of Stumaun Creek as discussed above.

Water licenses existed on Georgetown Creek in past years but have been cancelled for non-use.

At the present time no licensing of groundwater exists in British Columbia and no permits are required for this type of water extraction.

3.10.3.4 Quality of Surface Waters

Surface waters in the Grassy Point area should be suitable for domestic consumption although the water would be expected to exhibit a brown colour from dissolved organic materials from the watershed. This brown coloration is reported present in the Port Simpson water supply from Stumaun Creek but does not appear to affect its suitability for consumption. Chlorination of surface water used for domestic consumption is recommended by the British Columbia Department of Health. The storage of surface water required for use during dry periods would serve to improve the quality of surface water by possible settlement of solids.

Results from chemical testing of Stumaun Creek are contained in Table 3.10.2 and describe the water supply as very soft and low in dissolved mineralization.

TABLE 3.10.2
Water Sample From Stumaun Creek
Collected June 15, 1978

Physical Test		RESULT	ACCEPTABLE LIMIT***
pH		6.55	6.3-8.5
Conductivity		20.0	- micromhos/cm
Turbidity		0.28	5. C.U.
Colour (Pt-Co Scale)		L 5.	15. J.T.U.
Total Suspended Solids*		0.5	- mg/L
Total Dissolved Solids		16.0	1000. mg/L
Dissolved Anions			
Alkalinity			
Biocarbonates	HCO3	4.98	- mg/L
Carbonates	CO3	Nil	- mg/L
Chlorides	Cl	L 0.050	250. mg/L
Snifates	SO4	6.2	500. mg/L
Nitrates	N	L 0.10	10.** mg/L
Nitrites	N	L 0.001	** mg/L
Fluoride	F	0.056	1.5 mg/L
Silicates	SiO2	1.2	- mg/L
Dissolved Cations			
Hardness	CaCO3	6.40	- mg/L
Calcium	Ca	2.02	200. mg/L
Magnesium	Mg	0.33	150. mg/L
Potassium	K	0.25	- mg/L
Sodium	Na	1.32	- mg/L
Iron	Fe	0.090	0.30 mg/L
Manganese	Mn	0.003	0.05 mg/L
Others			
Total Iron	Fe	0.18	- mg/L
Total Manganese	Mn	0.004	- mg/L

L Less than
mg/L Milligrams per litre (or parts per million for drinking water)
* Sample filtered on a 0.45 micron membrane
** Total Nitrate and Nitrite Nitrogen
*** As established by the Canadian Drinking Water Standards and Objectives, 1968.

SOURCE: Health and Welfare Canada

3.10.4 REFERENCES

B.C. Natural Resources Conference 1956. British Columbia Atlas of Resources, Smith Lithograph Co. Ltd., Vancouver, B.C.

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Hoos, L.M. 1975. The Skeena River Estuary. Status of Environmental Knowledge to 1975. Estuary Working Group, Regional Board. Pacific Region. Dept. Fish. and the Env. Fish. and Mar. Service. 418 pp.

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Northcoast Environmental Analysis Team (NEAT), 1975. Prince Rupert Bulk Loading Facility, Phase II Environmental Assessment of Alternatives Vol. 4, Appendix C. Aquatic Aspects. Vol. 5, Appendix D, Vol. I Main Report Federal-Provincial Joint Committee on Tsimpsean Peninsula Port Development.

Trites, R.W., 1956. The Oceanography of Chatham Sound British Columbia. J. Fish. Res. Bd. Can. 13(3):385-434.

3.11 HISTORIC AND ARCHAEOLOGICAL RESOURCES

3.11.1 Terminal

3.11.1.1 Recorded Heritage Resource Sites and Site Potential

Although no historic buildings or B.C. Provincial Government designated heritage resource sites have been recorded in or near the proposed Grassy Point LNG plant site one prehistoric site has been recorded.

During his preliminary survey of Port Simpson Harbour, Inglis (1974) recorded several archaeological sites along the harbor shores (Figure 3.11.1). Of these, site GdTo-23 occurs in the proposed plant site (Figure 3.11.2). Although reported as only a small partially disturbed campsite represented by a shell midden the site was not assessed and its significance is not known.

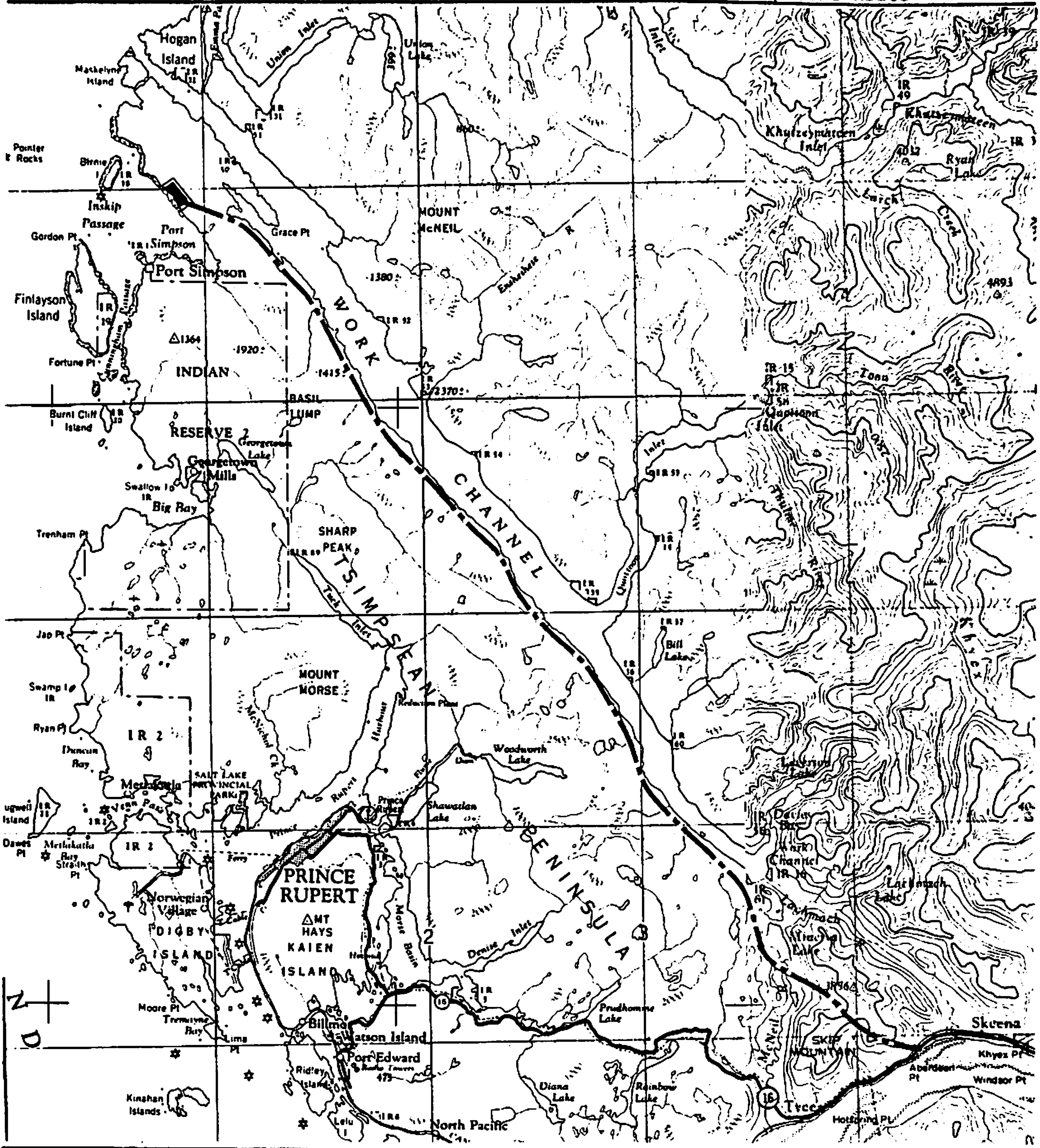
More generally, the proposed plant site has a relatively high heritage resource potential. This is demonstrable not only in terms of the presence of site GdTo-23 but by the presence of several sites in the surrounding vicinity. These include large prehistoric campsites (GdTo-52 and GdTo-2) and early historic period burials (GdTo-3).

On the other hand, although the area identified by Dome Petroleum Limited for the proposed Grassy Point LNG plant site is in an area of high heritage resource potential, the specific plantsite location will have the least potential impact on significant heritage resources.

3.11.1.2 Development Consideration

Although much of the Port Simpson area has been previously surveyed for archaeological sites the work was not intensive and any development along this shore would be

PROJECT	Dome Petroleum Limited Proposed Grassy Pt. LNG Plant	TITLE	Proposed Plant Site and Pipeline Route



LEGEND

Proposed Plant Site

Proposed Work Channel Pipeline Route

ARESCO Ltd.

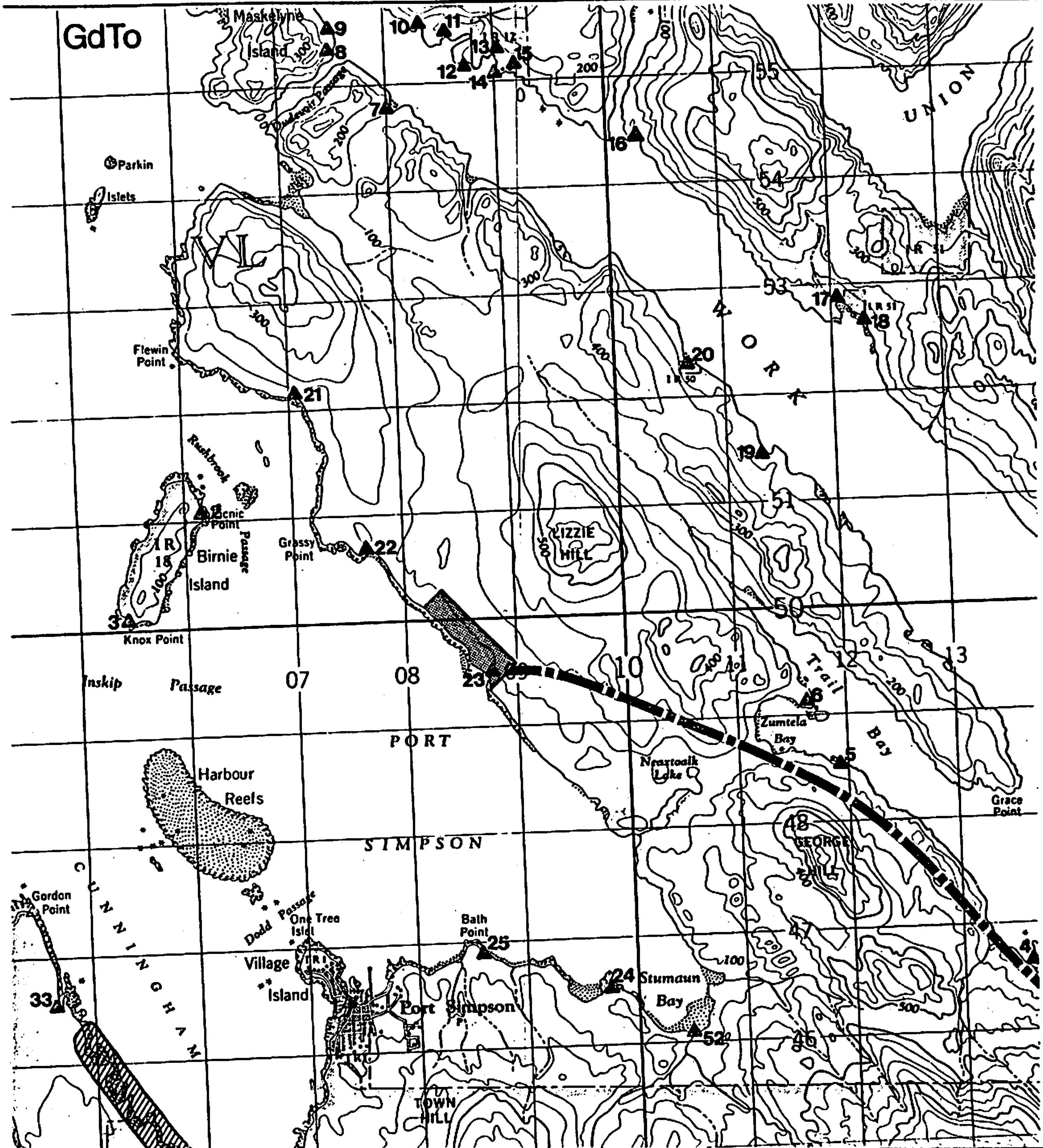
CALGARY ALBERTA

scale 1:250,000

FIGURE 3-11-1

PROJECT Dome Petroleum Limited
Proposed Grassy Pt. LNG Plant

TITLE Previously Recorded Archaeological
Sites: Plant Area Detail



LEGEND

▲8	Archaeological Site & Site Number
(hatched)	Numerous Archaeological Sites
GdTo	Borden Block Designation
(stippled)	Proposed Plant Site

ARESCO Ltd.
CALGARY ALBERTA

scale 1:50,000

figure 3-11-2

recommended for an in-field heritage resource impact assessment. With specific reference to the proposed Grassy Point plant site the following is suggested:

1. The heritage resource site potential is such that the proposed development area will be surveyed prior to construction;

2. Site GdTo-23 will be avoided if possible during plant construction and use. If this is not possible the site will be assessed with the B.C. Heritage Conservation Branch to determine its significance;

3. The proposed plant site location is among the least likely to contain significant heritage resources in the overall context of the Port Simpson Harbour area and is recommended for development planning from a heritage resource perspective.

4.0.0 ENVIRONMENTAL ASSESSMENT - WESTERN LNG PROJECT

SUMMARY

A detailed site specific physical and biological inventory of the natural resources in the Port Simpson Bay area of British Columbia was completed in the spring of 1981. A somewhat less intensive regional environmental inventory has been prepared for the marine approaches including Dixon Entrance, Hecate Strait, and Queen Charlotte Sound.

The environmental effects of the Western LNG Project terminal and its LNG carrier operation have been assessed and no significant environmental disruption identified. Environmental effects of minor significance include:

a) Alteration of Herring Spawning Habitat

A small percentage of herring spawning habitat in Port Simpson Bay will be altered by the construction of the service wharf. The riprapped north and south face will be similar to the rocky shoreline habitat typical of the area and will be recolonized by algae and invertebrates.

b) Cooling Water Discharge

A once-through-seawater-cooling system is proposed. The intake and discharge locations will be carefully selected in conjunction with the appropriate regulatory agencies to minimize any changes to the thermal regime near the discharge location. Provision of seawater intake screening and low approach water velocities acceptable to government will preclude fish being drawn into the system. The temperature of the cooling water at the outlet will be about 11°C higher than the temper-

ature of the inlet water. The government receiving water quality objective of a temperature change of less than 0.5°C, 100 metres from the discharge point will be met or bettered.

Any effect on the marine fauna will be small and localized, resulting possibly in slightly higher productivity due to the slight increase in receiving water temperature.

c) Temporary Removal of Intertidal Invertebrate Habitat

Intertidal and subtidal invertebrate habitat will be temporarily removed in the construction of the service wharf. The riprapped north and south faces will rapidly be recolonized by algae and invertebrates.

d) Topographic Changes and Removal of Terrestrial Vegetation for Terminal Site and Utility Corridors

Site preparation, excavation and peat disposal will permanently change the topography of the LNG terminal site. Recontouring, return of topsoils and revegetating will ensure that the land not used by terminal facilities will be stable and suitable for natural regrowth. Runoff during construction and operation will be controlled to minimize erosion and siltation.

e) Effects from Accidental Release of LNG, Fuel Oils and Process Chemicals

Accidental release of LNG, fuel oils (including bunkers) and process chemicals are a remote possibility. Design, monitoring and contingency plans will minimize the risk of an accidental spill or leak and maximize the clean up ability. Further description of these are found on page 4.1-15 storage of Bulk Fuel and Lubricants, and 4.1-9 Liquefied Natural Gas.

The Environmental Assessment itself also addresses naturally occurring phenomena that could affect the safety and operation of the LNG liquefication plant, storage tanks, loading systems and LNG transportation systems. Design considerations are incorporated for the following:

a) Forest Fire

While forest fires are not common along the north coast of B.C., the plant has been designed with sufficient setback and fire protection that a forest fire will not affect the safety of the plant. Plant shutdown will be evaluated depending on the seriousness of the fire. The setback and fire fighting protection provided at the plant will also protect surrounding forest should a fire occur at the plant or loading facilities.

b) Earthquake, Land Subsidence, Mud Flows

The LNG facilities will be built to Canadian Standards Association Z276 which, among other criteria, specifies siting and foundation requirements. This will assure that the plant can operate safely and, if necessary, be shut down safely and not be affected by minor or major earthquakes. Land subsidence and mud flows are unlikely due to the stable underlying geology of the site.

c) Hurricane or Tornado

Existing wind data for the north coast report strong winds but no hurricane or tornado type storms. Facilities will be designed using predicted wind loads using historical records. Weather forecasting for shipping along the marine approaches and terminal area will provide sufficient warning to undertake necessary precautions.

d) Tsunami

Oceanographic records from the early 1900's to date do not report Port Simpson Bay as having experienced any damage-causing tsunamis. The design of the plant and loading wharf are such that even a very large tsunami (3-4 metres) would not affect the operations unless an LNG carrier was moored to the wharf during the tsunami. The LNG carrier will be able to disconnect and leave the berth in less than 10 minutes should a tsunami warning be issued for the north coast of British Columbia by the existing international tsunami warning system.

e) Flood

The plant and shipping facilities are not located on or adjacent to any water body that is subject to flooding.

4.1.0 ENVIRONMENTAL DESIGN AND PROTECTION

4.1.1 Terminal Design and Siting Considerations

Evaluation and planning for the proposed LNG terminal progressed from a provincial scale with 26 sites to five sites to the preferred Grassy Point site in the Prince Rupert area. The reports "Environmental Considerations in LNG Terminal Selection" by TERA Environmental Consultants Ltd. and "Engineering Considerations in LNG Terminal Selection" by Swan Wooster Engineering Co. Ltd. outline the terminal selection process. The Grassy Point site at Port Simpson Bay emerged as the technically preferred site on both engineering and environmental grounds. Detailed engineering and environmental studies of the LNG terminal in Port Simpson Bay refined location and major facility process options such as a once-through cooling system. An explanation of some of the environmental rationale is discussed in the following paragraphs.

The initial LNG terminal site was chosen to be between Grassy Point and Barge Point on the northeastern shore of Port Simpson Bay. Subsequent detailed geotechnical examination of the foreshore and adjacent uplands showed that Barge Point was indeed the area which could best accommodate a barge service wharf using a minimum of intertidal and excavated upland area. In fact, this site would minimize the amount of fill needed and still provide almost 2 hectares of flat area.

The LNG plant site and loading pier were first proposed to be between Grassy Point and Barge Point. However, more detailed surveys and examination of the foreshore and upland areas suggested a better plant and loading pier location was south of Barge Point. Reference to Figure 1.5.1

shows the preferred terminal site in Port Simpson Bay. Other advantages which were taken into consideration for final siting were as follows:

a. The upland shelf at the southerly site shows less slope for the plant and, therefore, would lessen the need for extensive excavation and blasting of bedrock. Therefore, site disturbance would be minimized.

b. The extent of peat at the southerly site is less than for the northerly area, eliminating the need for as large a quantity of peat removal and peat disposal.

c. The location of the terminal south of Barge Point would not affect the Stumaun Creek estuary because of its distance from Stumaun Bay. The southerly site would be further from the productive shallow marine areas between Birnie Island and Grassy Point. The rocky shore and shingle beaches of Barge Point show only moderate biological productivity.

d. All project access facilities, such as the pipeline, powerline and access road, would be shorter to the southerly site and, therefore, would create less disruption.

e. Some land near Grassy Point consists of privately held land while the southerly site is unencumbered B.C. Crown land. Therefore, less potential for land use conflict would exist at the southern site.

Engineering design has been reviewed from an environmental perspective at the early stages of the project to eliminate or minimize potential environmental effects. Some of these design considerations to be implemented are:

- Development of a single fresh water supply for construction and operations minimizes disruption and construction in more than one water body;

- Development of terraces readily allows for control and settling of storm runoff water thus minimizing erosion and siltation;

- The barge service wharf area, as chosen, reduces the need for extensive filling and incorporates a coarse rip-rap surface on the north and south sides. The construction material would utilize waste rock from the site and result in a substrate similar to rocky shores on the coast.

- The design of the loading pier was chosen in order that as little disturbance of the intertidal area as possible would occur. A pile structure will avoid most disturbance to intertidal and sub-tidal areas during construction and retain the natural substrate. The pile structure reduces, as well, the likelihood of effecting currents in the bay and blockage of natural light;

- A peat disposal site for the LNG terminal has not been finalized at this time. However, studies have shown that suitable impervious depressions are available adjacent to the terminal site for peat disposal. The peat would be disposed in such a manner that no groundwater or surface water contamination would result. The disposal site would be located away from any drainage system utilized by fish.

- The LNG process utilizes the concept of methane cooling by refrigeration with heat rejection using cooling water. A once-through-seawater cooling system for heat rejection was chosen rather than a fresh water cooling system which might overtax the local freshwater systems. Studies are on-going to evaluate the feasibility and reliability of a seawater cooling tower recycle system.

- The access road to the plant would be integrated into a road system to be provided by the B.C. Ministry of Transportation and Highways. Dome Petroleum Limited would cooperate with all other government and crown corporations which are responsible for linear facilities such as roads, transmission lines and gas pipelines to develop common corridors and mutually beneficial construction schedules.

The location of any industrial facility on the coast of British Columbia must be completed in an environmentally safe fashion to protect the fisheries resource. The selection of the preferred location at Grassy Point was based on the fact that Port Simpson Bay is one of the best harbours on the coast; sheltered to all but westerly and northwesterly winds, low currents and relatively little traffic. An LNG facility is a very clean operation and requires straightforward pollution control technology to produce environmentally acceptable air and water discharges. It also does not require large quantities of bunker fuel or other petroleum products which might accidentally be spilled. Dome will provide spill detection, prevention and control facilities, develop and implement training of staff using operations manuals and will prepare contingency plans in cooperation with the appropriate regulatory agencies to deal with accidental spills of LNG or other materials used at the Terminal facilities.

4.1.2 Environmental Specifications

Liquefied Natural Gas

Liquefied Natural Gas (LNG) produced at the proposed project will be a very pure liquid methane with only trace amounts of ethane or other hydrocarbons. Virtually all sulphur and water will have been removed at gas plants located at the gas fields. Final water and CO_2 removal will be part of the facilities.

Methane gas itself is non-toxic to plants, animals and fish. Hann and Jenson (1974)* reviewed the average toxicity of natural gas components for a range of aquatic flora and fauna, and found that the lethal toxicity (TLm 96-h) of methane was greater than 1000 ppm, and Foothills Pipe Lines Ltd. (1975) and Beak Consultants Ltd. (1977) reported no mortality to rainbow trout when natural gas was saturated (20-30 ppm) in well oxygenated holding water after 8 hours. In earlier work, Schaut (1939) reported that minnows were not affected after two hours of exposure to a saturated methane solution (about 54 mg/L), and Shelford

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* Hann, R. W. and P. A. Jensen. 1974. Water quality characteristics of hazardous materials. Volumes 1 to 4 Environmental Engineering Div. Civil Engineering Department, Texas A&M University.

Beak Consultants Ltd. 1977. Toxicity tests of natural gas. Prepared for Foothills Pipe Lines (Yukon) Ltd., Calgary.

Foothills Pipe Lines (Yukon) Ltd. 1975. Bioassay on pipeline natural gas. Prepared by Western Research and Development Ltd.

Schaut, G.G. 1939. Fish catastrophes during drought. Journal A.W.W.A. 31:771.

Shelford, V.E. 1917. An experimental study of the effects of gas waste upon fish, with special reference to stream pollution. Bull. Ill. State Lab. Nat. Hist. II.

(1917) found that methane was not toxic to sunfish (both cited in Beak Consultants Ltd. 1977). However, even if the maximum solubility of the methane rich material was attained, levels of methane in the water column would probably not exceed 30 ppm at water temperatures between 5 and 10°C (Beak Consultants Ltd. 1977), suggesting that the toxic effects of methane to fish in the marine environment should not be a major concern, as its presence in the water column at these concentrations would be limited in the case of an accident. As any spill of LNG would likely be at or very near the surface, oxygen depletion due to methane stripping would be highly unlikely. The very cold nature of LNG (-162°C) has the potential to freeze plants or animals that come in direct contact with an accidental spill of LNG. LNG immediately vaporizes to a gas as it warms, therefore, the liquefied natural gas would not spread in the same fashion as oil, nor leave a residue if an accidental spill or leak occurred. Methane is not spontaneously combustible, a 5 to 15% methane-in-air proportion and an ignition source are both required to result in a fire.

The plant, storage and loading facilities will be designed to meet the CSA Z276 Standard for LNG. Each LNG storage tank will have a dyke suitable to contain the entire tank volume. Dyke floors will be provided with drainage channels and recovery sumps to minimize surface area affected by an accidental spill (and therefore minimize vapourization while allowing for control and recovery of LNG). The LNG loading wharf will have a spill collection and impoundment system. All storage vessels will have overfill protection systems. The LNG loading arms will have an inert gas purge system interlocked with the loading pumps to prevent an LNG spill in case the LNG carrier moves beyond prescribed limits while loading LNG. LNG loading lines can be purged and disconnected in less than ten minutes. The facilities will be designed to monitor and alarm for the presence of low levels of methane to preclude major spills or losses of LNG. The staff will also be trained to handle accident situations. Operating and maintenance procedures will be strictly followed to assure accidental leaks or spills are minimized.

The plant design, construction and operations will be such that small leaks or spills of LNG will not affect biological resources in the Terminal area.

The report "LNG Risk Analysis - Western LNG Project" prepared by Ecology and Environment, Inc., describes in detail the probability of a major spill of LNG and the potential effect of a vapour cloud or major fire that could result. The plant and loading facilities will be provided with fire fighting equipment and trained operators as required by the CSA codes.

Air Emissions

Air emissions from the project are primarily restricted to combustion products of pipeline grade natural gas. The refrigeration compressors for the liquefied natural gas facility on Port Simpson Bay will be designed for natural gas turbine drive. The compressor drivers will exhaust to the atmosphere. The volume of exhaust will contain some oxides of nitrogen emission but no sulphur dioxide as the gas is sulphur-free. Natural gas is one of the cleanest burning fuels available and no deterioration of ambient air quality will be expected.

NO_2 emissions will be at or better than the Waste Management Branch Level A Objective for Natural Gas Combustion from Stationary Industrial Combustion Sources of 200 lb NO_2 per million standard cubic feet through the use of low NO_x combustors. Ambient NO_2 levels will be less than the 0.21 ppm federal ground level concentration objective.

Other emission sources would be the flare stack which may be used for short periods during LNG carrier loading or cool down or in case of emergency upset in the plant.

No liquefied natural gas will be allowed to escape and vapourize during the plant process, storage, loading, and shipping. Vaporized gas produced during loading (boil off) will be used to replace storage tank volume and used as plant fuel. A flare will be provided to combust the gas in case of operational problems.

Liquefied natural gas carriers will normally be powered by "boil off" of liquefied natural gas, or with auxiliary bunker fuel, if necessary, while at sea. Bunker or diesel fuel will be used on board the carrier for auxiliary power while berthed and loading.

Liquid nitrogen (N_2) will be maintained on-site to be loaded on to carriers while in port. At times, liquefied nitrogen may be vapourized in a special vaporization vessel for purging in the plant. No air quality deterioration from this process is expected.

Other marine traffic associated with the shipping of LNG include tugs, coast guard vessels, pilot boats, and maintenance equipment at the loading dock. These vessels and vehicles will typically be powered by diesel engines. These vessels and vehicles are small and operate only periodically during each week. As such they will contribute little air emissions.

Solid Waste Handling

During construction, solid wastes will include skids, scrap metal, paper and plastics, welding rods and domestic waste consisting primarily of boxes, dry goods and food stuffs. Collection of garbage will be made frequently and disposed of at a solid waste landfill site located, designed and operated to meet the Pollution Control Objectives for Municipal Type Waste Discharges in British Columbia.

Operation of the plant will generate small volumes of office and maintenance area wastes and a small number of empty chemical containers. Empty chemical containers will be triple-rinsed prior to landfilling. These solid wastes will be disposed of a sanitary landfill site located, designed and operated in a manner approved by the Ministry of Environment Waste Management Branch.

Plant Cooling Water System

The liquefied natural gas plant requires cooling of the compressed refrigerant. A once-through sea water cooling system is proposed. The water intake has as yet not been designed. A suitable location will be determined with appropriate regulatory agencies on the basis of oceanographic and water temperature/salinity studies. This location will ensure that the water will be taken with minimum effect on flora and fauna of Port Simpson Bay. For example, the approach water velocity will be low enough to allow small fish to swim away from the water intake. Entrainment screening will be provided so as to prevent fish from accidentally being drawn into the intake.

The cooling water will increase in temperature about 11°C through the heat exchangers, then it will be discharged through a suitable diffuser at a location yet to be determined. Oceanographic and water temperature/salinity studies presently under way will ensure that a location is chosen to optimize dispersion and flushing of the discharge, so that the bay will not experience an increase in water temperature. The cooling water discharge will meet or better the Ministry of Environment receiving water quality objective which specifies that the water will not increase more than 0.5°C at a distance of 100 metres from the discharge.

The once-through cooling system requires chlorination using hypochlorite in order to prevent marine growth fouling the cooling system. Hypochlorite will be added to provide a continuous chlorine residual of about 0.25 ppm. The natural affinity of sea water for chlorine to form chloride and the decreasing solubility of chlorine with increased water temperature will assure that the cooling water discharge will not contain any free chlorine. The use of other additives may be required occasionally and will be reviewed with the appropriate regulatory agencies prior to treatment.

<u>Storage and Manufacture of Hypochlorite</u>

The chlorination of the once-through cooling system will utilize the manufacture and storage of hypochlorite on site. The volumes of hypochlorite required are relatively small (approximately 340 kg/day) and the same applies to storage volume (about 5,000 kg). Proper safeguards to prevent accidental loss of hypochlorite will be implemented. These include:

a) special storage facility designed to withstand corrosive material;
b) monitoring and alarm equipment on the hypochlorite system to detect leakage;
c) proper dyking of storage facilities and operating instructions and training of operators to deal with an accidental release of hypochlorite.

Storage of Mixed Refrigerants and Process Chemicals

Ethylene and propane are compounds used within the liquefaction process as refrigerants. These two compounds are shipped under pressure as liquids, but are gases at atmospheric pressure. One year's storage capacity of ethylene (estimated at 1500 cu. m.), and one month's storage capacity of propane (estimated at 450 cu. m.) will be provided on site. These compounds will be brought in by barge and will have transfer and storage requirements as established by the Canadian Standards Association to prevent loss to the environment.

MEA (monoethanolamine) is a process liquid chemical used to remove any remaining CO_2 not removed from the feed gas from the gas plants. Small amounts of MEA must be replaced after regeneration. Storage for one year's supply (estimated to be about 55 cu. m.) of MEA will be provided. Handling and transportation of the MEA have not been chosen, but the chemical is widely used in the gas processing industry without harm to the environment.

Hot Oil System

A closed loop, circulating system is used to transport hot oil to the process and offsite facilities for heating purposes. This system will employ a proprietary organic oil which is highly stable at elevated temperatures, 350°C (660°F). The oil is heated in waste heat exchangers installed in the refrigeration compressor driver. The heated oil is circulated through each of the process trains where it transfers heat to the feed gas and CO_2 on an "as-needed" basis. In addition, the process plant fuel gas will be heated continuously and buildings will be heated as needed by the hot oil system. For system start-up a single small furnace will be provided.

Storage of Bulk Fuel and Lubricants

Bulk fuel for tugs and other service equipment will be provided on site. This will include a bulk terminal for fueling of tugs, harbour requirements of LNG carriers, as well as plant maintenance equipment. Approximately 300 tonnes of diesel fuel storage will be on site and will have proper safeguards to prevent and minimize the effect of any potential spill of bulk fuels. These include:

a) a dyked area surrounding the fuel tanks to prevent escapement of fuel in the event of a leak from a storage tank;
b) fail-safe valve systems to prevent leakage of fuel from open valves;
c) designated fueling areas for tugs operated by trained personnel;
d) provision of a containment boom and a boat to put it in place immediately in case of a spill;
e) a means of removing any fuel from within the dyked or boomed areas to proper disposal.

Supplementary bunker fuel loading will normally occur at the LNG discharge terminal.

Lubricants on site will be stored in 45 gallon drums. These 45 gallon drums will be stored in suitable pits which would contain any lubricants spilled should a drum fail. The handling of fuel and lubricants in the plant will be done only by trained personnel using established procedures. Lubricants will be loaded either in 45 gallon drums or from truck tanker to the LNG carrier.

Process and Potable Water

Process and potable water make-up requirement for the LNG plant are small. The volumes of water anticipated are 150-250 m^3/day. The most likely source will be a small watershed adjacent to the plant. This water source will be developed by utilizing a reservoir and small water pipeline to the plant. The watershed will be selected on the basis of being able to support minimum flows during the dryer summer months downstream of the reservoir and still supply adequate quantities of potable water to the plant. None of the streams evaluated are reported as producing fisheries streams, probably due to their 'flashy' nature. The stream selected will be evaluated for its fisheries enhancement potential.

Sanitary Effluent

All sewage generated during the construction and operation of the LNG plant will be treated to meet B.C. Provincial objectives. The location of the treated effluent discharge will be in an area where any potential effect on intertidal and subtidal habitats of Port Simpson Bay will be minimized.

Prince Rupert - Port Simpson Roadway

The project will require construction and operation of a roadway from Prince Rupert to Port Simpson with a short lateral to the plant site. Reports prepared by Tera Environmental Resource Analyst Limited in association with John Moore and Associates* and others referenced therein, describe

* "Benefit-Cost Analysis of the Port Simpson - Prince Rupert Road and Ferry Link" prepared for the Port Simpson Band Council by Tera Environmental Resource Analyst Limited in association with John Moore and Associates May 1978.

environmental, socio-economic and engineering considerations for roadway route alternatives. These reports conclude that a roadway can be constructed with minimum environmental affects and major social and economic benefits. It is Dome's intention to work closely with the B.C. Ministry of Transportation and Highways to utilize and improve on the information in the reports to ensure the roadway is constructed to minimize environmental effects.

4.1.3 ENVIRONMENTAL MANAGEMENT

Construction scheduling will be an important part in the mitigation of potential environmental effects. A very small amount of construction is required in the sub and intertidal zone. Scheduling of this construction will be done to avoid the herring spawning and incubation period. Other biologically sensitive areas are recorded and their significance outlined in the respective resource sections. Construction of the Western LNG Terminal will be scheduled with the appropriate regulatory agencies at final design such that they have a minimal effect on sensitive significant natural resources.

All areas disturbed during construction and not occupied by the LNG plant and access routes will be restored to as natural a condition as possible. A buffer zone or set back around the plant will also be maintained to prevent a forest fire from affecting the plant. Restoration will include recontouring of the excavated area surrounding the plant, landscaping and replanting suitable ground cover species to avoid erosion and gullying. Utility corridors will be recontoured and road cuts seeded, development of proper ditches, culverts, and other road drainage facilities will be provided.

The rip-rap used for the service wharf will be clean and suitable for recolonization by algae and invertebrates. The side slopes of the service wharf will be similar to many rocky intertidal areas on the northcoast.

During construction, all personnel will abide by a no-gun no-hunting rule. In this manner, greater safety and the possibility of poaching is minimized. During operations no hunting will be encouraged and, in cooperation with the B.C. Fish and Wildlife Branch, wildlife and waterfowl protected wherever possible.

Environmental monitoring will be an integral part of the operational aspects which handle flammable and toxic substances. Elaborate monitoring to detect and warn of leakage of LNG at the storage facility and loading pier will be provided. Detectors and alarms to detect spills and leaks of fuel, lubricating oils, hypochlorite and nitrogen will be installed at the LNG terminal.

Environmental inspectors will be retained to inspect the construction of the LNG terminal and its utilities to provide on-site advice to further safeguard the environment. The inspector will work closely with the regulatory agencies and will have the benefit of "Good Environmental Practice Conditions" included in the contractors' agreements.

Contingency plans will be developed and implemented after review by the appropriate regulatory agencies for any spill of LNG, fuel, lubricating oils, hypochlorite or nitrogen.

Most road and parking areas at the Terminal will be black-topped to avoid dust or erosion problems. Drainage from the plant area will be channeled and allowed to collect in settling basins so as to avoid the introduction of sediments into Port Simpson Bay. Leachates from stored muskeg and overburden will not be allowed to flow into Port Simpson Bay or reach fish bearing streams such as Neaxtoalk Lake and Stumaun Creek.

4.1.4 Alternate Human Uses and Activities

Commercial, Recreational and Indian Food Fisheries

The marine approaches for the LNG carriers (Figure 4.1.1) pass through existing shipping and fishing vessel routes. Table 4.1 summarizes the projected commercial shipping traffic for the northcoast of B.C. Figure 4.1.2 provides monthly estimates of fishing vessels by gear type obtained from historic fishing statistics from the Department of Fisheries and Oceans. These data confirm that the coast has a relatively small number of vessels that will encounter LNG carriers. The Canadian Coast Guard plan to institute a Vessel Traffic Management (VTM) Traffic Zone in the Prince Rupert area in the near future.

The Terminal will also be providing on-going communication with the LNG carrier as it approaches and leaves the berth relaying information from the Coast Guard and the Department of Fisheries and Oceans as to other large vessel traffic and fisheries openings and closures. The need is not forseen for any special status for LNG carriers as vessels will follow existing rules of seamanship.

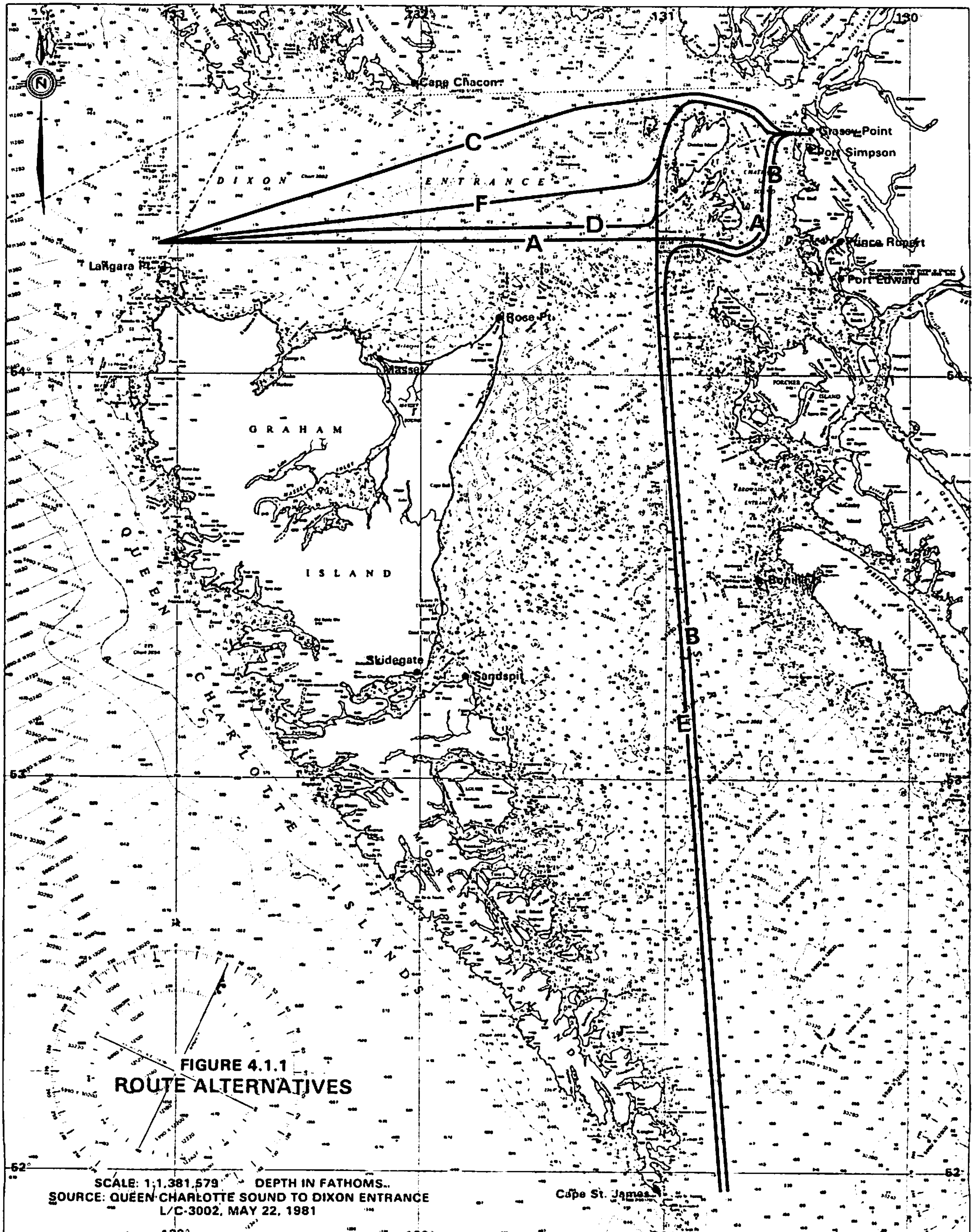


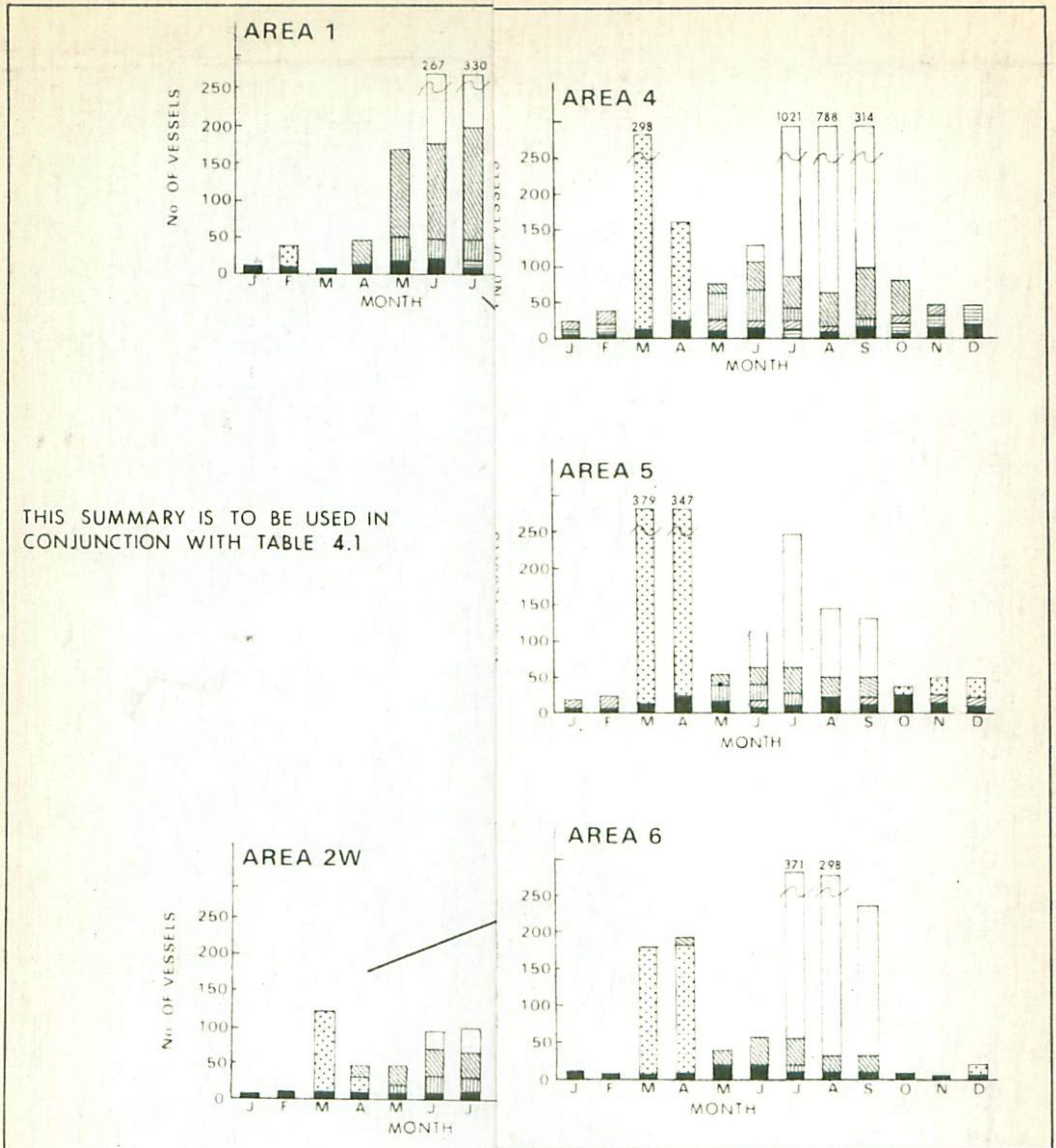
FIGURE 4.1.1
ROUTE ALTERNATIVES

SCALE: 1:1,381,579 DEPTH IN FATHOMS.
SOURCE: QUEEN CHARLOTTE SOUND TO DIXON ENTRANCE
L/C-3002, MAY 22, 1981

TABLE 4.1 - PROJECTED TRAFFIC DENSITIES

Route Segment	1978 (actual)	1980 (Est)	1985 PROJECTIONS Regular Traffic	Grain	Coal	LNG	Petro-chems.	Other	TOTAL	1990 PROJECTIONS Regular Traffic	Grain	Coal	LNG	Petro-Chems.	Other	TOTAL
1	1957	2036	2304	210	232	48	64	178	3036	2606	392	280	96	124	178	3676
2	1738	2016	2128	52	58	12	16	44	2310	2508	98	70	24	58	44	2802
3	2182	2270	2568	262	290	60	80	222	3482	2906	490	350	120	182	222	4270
4	1886	1962	2220	262	290	60	-	222	3054	2512	490	350	120	102	222	3796
5	666	692	782	-	-	60	-	-	842	886	-	-	120	-	-	1006

FIGURE 4-1.2 SUMMARY OE LNG
MARINE APPURS BRANCH)



LEGEND
······· PROPOSED ALTERNATIVE LNG CARRIER ROUTES
416 SUM OF WEEKLY MAXIMUM
SALMON NET VESSELS
SALMON TROLLERS
HERRING NET VESSELS
HALIBUT LONGLINERS
GROUNDFISH TRAWLERS
MISCELLANEOUS
ANY GEAR COMPRISING LESS THAN 10 VESSELS

Existing commercial, recreational and Indian food fisheries in the Port Simpson area are described in Section 3.4.0 Fish Resources. Fishing vessels, fish packers and recreational vessels utilize Dodd, Inskip and Rushbrook Passage depending on trip origin and destination. Carrier approaches to Inskip Passage will be advised through the Coast Guard VTM and carrier steaming speeds will allow time for small vessels to avoid the carrier. The effect of the project on the fish resource is described further in Section 4.6.0.

Fishing patterns in the approaches to Port Simpson Bay (shown in Figure 4.1.3 and Table 4.1) indicate that for a few days in March or April during the herring fishery and periods during June, July and August during the salmon seining and gillnetting fisheries, a significant number of fishing vessels could encounter a berthing or unberthing carrier. It is expected that liaison will be established between the Harbour Master, local fishery officers and the fishing community.

The construction and operation of the LNG facilities will be done such that minimal impact will occur off the Indian Food Fishery in Port Simpson Bay. The taking of shellfish in the area 125 m on either side of each wharf would be the only significant effect. Personal communication with members of the Port Simpson Band indicate these areas are not intensively used for the shellfish fishery.

Recreational Boating

At present there is no road access to Port Simpson which tends to limit the use of Port Simpson Bay as a harbour for recreational vessels. If the construction of a road from Prince Rupert to Port Simpson were to result in the construc-

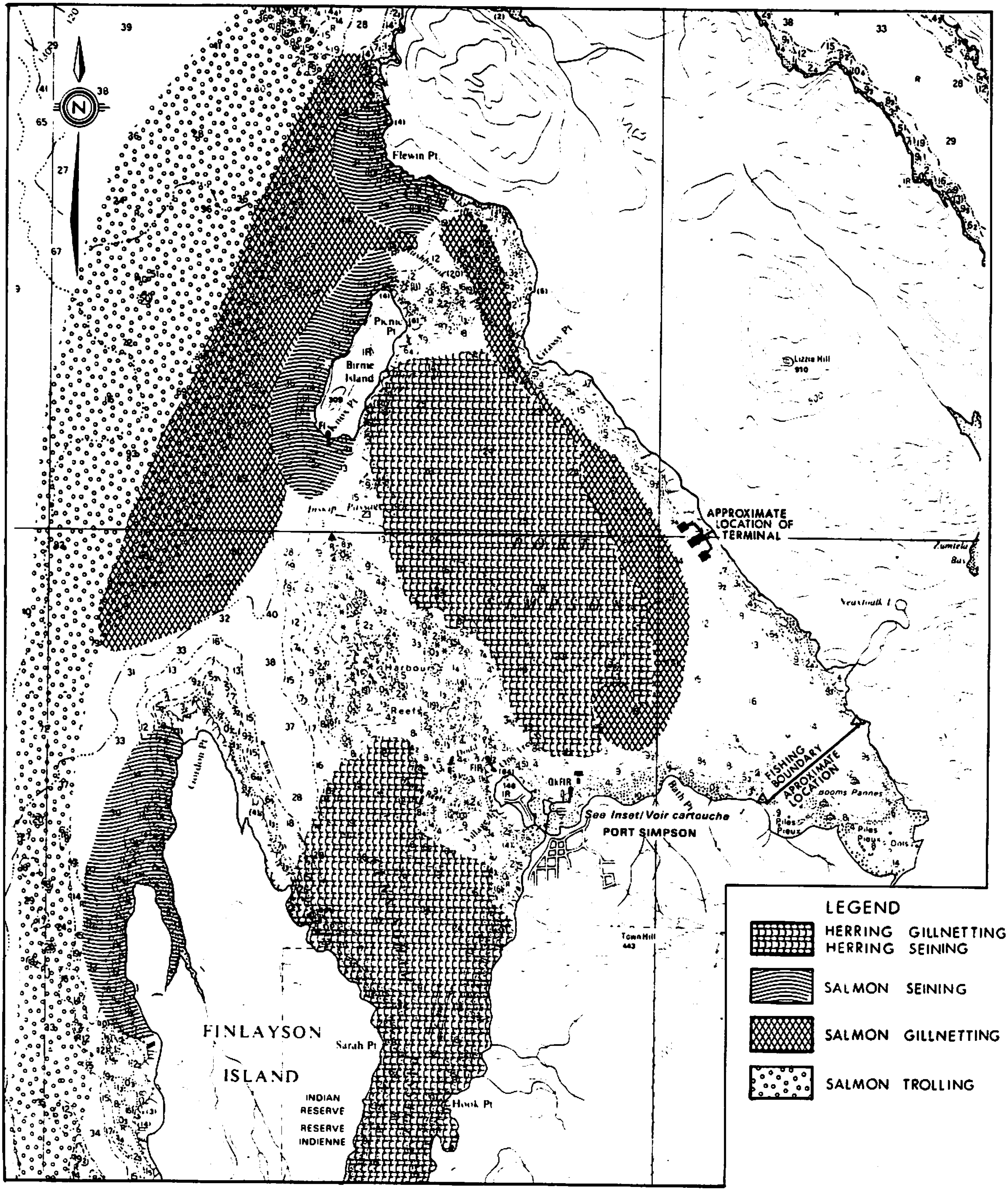
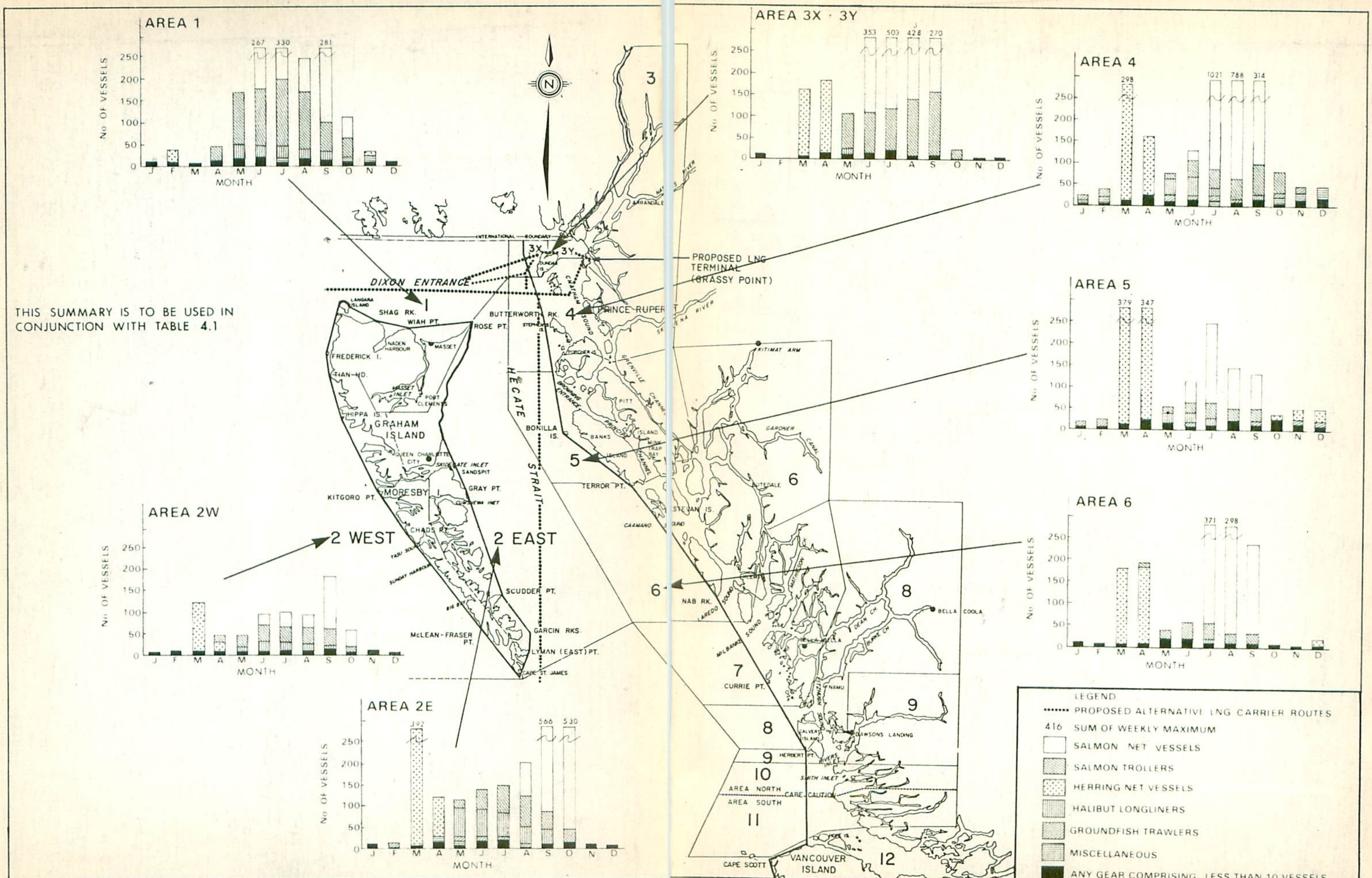


FIGURE 4.1-3

LOCATIONS OF MAJOR FISHING AREAS WITHIN THE VICINITY OF PORT SIMPSON

FIGURE 4-1.2 SUMMARY OF RECORDED WEEKLY MAXIMUM VESSEL NUMBERS FOR ALL GEAR TYPES IN AREAS WITHIN THE LNG MARINE APPROACHES, 1975-1980 (FROM: DEPARTMENT OF FISHERIES AND OCEANS, SMALL CRAFT HARBOURS BRANCH.)



tion of a new marina, the presence of any additional recreational vessels would not affect carrier operations.

Other Recreational or Tourism Activities

Recreational activities in Port Simpson are limited at present due to poor access. Tourism is almost non-existent for the same reason. Construction of a road from Prince Rupert to the area could increase recreational activities and tourism to the north end of the Tsimpsean Peninsula for use of beaches, shellfish, picnicking, camping, hunting, recreational sport fishing, and general tourism interest to see an LNG Terminal and an LNG carrier.

This will provide additional opportunities for employment while adding to the existing pressures to fish and wildlife resources to the area.

Other Renewable and Non-Renewable Resources

Construction of a road from Prince Rupert to Port Simpson Bay may allow harvesting of merchantable timber in presently inaccessable areas on the Tsimpsean Peninsula.

There are no commercial mineral or oil or gas resources identified on the Tsimpsean Peninsula. Construction of a road from Prince Rupert to Port Simpson may identify some new gravel resources in the Tsimpsean Peninsula.

4.2.0 CLIMATE

4.2.1 Marine Approaches

4.2.1.1 Air Quality

The LNG carriers are of sufficient size to accommodate most climatic conditions experienced on the northern B.C. coast. During periods of low visibility, navigational equipment will provide additional safety for the carriers as they approach through Dixon Entrance or Hecate Strait.

Other marine traffic such as terminal supply vessels, pilot and Coast Guard vessels, are somewhat more inconvenienced by wind and visibility factors. However, appropriate scheduling of the smaller and less time-critical vessels will make it possible to reduce potential adverse weather effects. Because of the small number and size of these vessels, effects on air quality will increase only slightly from existing levels.

Installation of navigational equipment in the marine approaches will have no adverse effects on climate. No channel alteration is necessary for the marine approaches.

The emissions from the LNG carriers will not affect the general air quality in the marine approaches. Along the marine approaches the LNG carriers will be fueled by natural gas, supplemented by bunker fuel.

4.2.1.2 Noise and Dust

Navigational equipment will be installed to fulfill the requirements of Transport Canada. Little noise or dust will be generated during the installation of this equipment.

The noise produced by the engine of an LNG carrier is of relatively low magnitude. No significant noise nor any dust emissions are expected from the LNG carriers.

Other marine traffic such as supply vessels, Coast Guard vessels, and pilot vessels also have noise levels similar to existing traffic in Port Simpson Bay and insignificant dust emissions. All vessels will be equipped with suitable muffler systems to reduce ambient noise levels.

4.2.2 TERMINAL SITE

4.2.2.1 Air Quality

Construction

During site preparation and construction of the LNG terminal at Grassy Point, some vehicular emissions will occur during site excavation, blasting, site leveling, peat disposal, and the development of road access. The installation of the LNG pier, service wharf, and the LNG facility will require heavy machinery. However, the low volume and low concentration of emissions will not be significant in relation to the good dispersion at the terminal site. Most construction equipment will be diesel powered with characteristic low emission levels. The low levels of NO_x and dust emitted will rapidly disperse into the atmosphere.

Operation

The LNG terminal will use compressors to refrigerate and liquefy the natural gas. These natural gas powered compressors will emit as combustion by-products, low levels of oxides of nitrogen (NO_x). Boil-off from the storage vessels will be returned to the system, refrigerated, and liquefied. Release of vaporised gas can be accomplished if necessary through a flare stack and this in turn may result in short-term emissions to the atmosphere. The potential effect of the occasional use of this flare is regarded as insignificant.

Emissions from diesel generators operating loading pumps on board the LNG carrier while docked are low and will not affect the local air quality.

Accidental spills or leaks of process chemicals such as hypochlorite, liquefied nitrogen or diesel fuel may cause temporary localized atmospheric effects.

All volatile and toxic substances which may vaporize and create either combustible or toxic gases will be stored in specially designated areas with proper safeguards as described in Section 4.1.0. Monitoring of these designated compounds by plant personnel will be continuous. Alarms which detect spills or leaks will also be provided.

4.2.2.2 Noise and Dust

Construction

Noise and dust emissions during site preparation and plant construction will have a localized effect on air quality. Blasting will result in sporadic high magnitude noise emission. Heavy machinery for excavation and site leveling will be sources of noise. However, this noise will be temporary, and confined to the hours 7:00 a.m. - 10:00 p.m. during the construction period.

Environmental protection against noise will include removal and/or protection of personnel from the blast sites, wearing of hearing protectors, noise-reducing mufflers on equipment, and scheduling of noisy operations (e.g. blasting) during daylight hours.

Dust would be generated during most of the earth-moving and excavation phases of the terminal construction. Handling and processing of construction aggregates is another source of dust.

Dust suppression with surface wetting of all open-cut surface areas will be conducted, if necessary. The construction aggregates will be provided with watering facilities to keep dust at acceptable levels.

Operation

Noise and dust are not significant factors during the operation of the LNG terminal. The noise level of the plant is low. The only dust which could be encountered would be associated with gravelled road surfaces.

Noise in the LNG plant would emanate from natural gas fired compressors. Suitable mufflers and shrouds surrounding the machinery will reduce the noise levels to the acceptable industry standard. Dust suppression during the operation of the plant will be completed through black-topping most road surfaces.

4.3.0 LANDFORM AND TOPOGRAPHY

4.3.1 MARINE APPROACHES

4.3.1.1 Terrain, Geology, and Mining

The installation of navigational equipment along the marine approaches will have a negligible effect on terrain, as construction activities will be on a small scale. Construction access will be from the sea and air.

The operation of LNG carriers and other ships will have no effect on terrain.

4.3.1.2 Seismicity

The operation of LNG carriers, other ships, and navigational aids could be affected by tsunamis associated with seismic events. Environmental effect of a tsunami in open water would be insignificant on the LNG carrier.

4.3.2 TERMINAL SITE

4.3.2.1 Terrain, Geology, and Mining

Construction

The effects of the project on terrain are associated with rock excavation, and the removal and disposal of organic deposits (peat or coastal muskeg) from the site area. Organic deposits are a minor component of the surficial geology at the site, but are more extensive to the east and south-east, in areas which will be crossed by road and pipeline access. As the organic deposits have poor foundation and seismic properties, they will be removed, or else structures will be built on pilings anchored to bedrock.

Considerable rock excavation will be necessary. Schists, which constitute part of the bedrock, could present localized stability problems in rock cuts, and may have poor foundation properties when used as fill. As slopes in the site area are not steep, no major slope stability problems will result from bedrock excavation. Quartzites and gneisses in the site area have good foundation and stability properties.

Bedrock and glacial till, which comprise most of the site area, will present no environmental problems when excavated. Saturated glaciomarine deposits could become unstable when disturbed but, since these deposits form only a thin veneer over bedrock, no major problems are expected.

The development of road access, and to a lesser extent pipeline construction, could affect slope stability where organic deposits or saturated glaciomarine deposits are found on steep slopes. Stability problems will be minimized by avoiding such deposits where possible, and by taking care not to disrupt surface and groundwater drainage.

Some erosion of fine-grained and organic deposits may result from construction; this is more likely to occur as a result of road and pipeline construction than from construction in the site area itself. Problems will be minimized by revegetation of disturbed soils, and by control of surface drainage in construction areas.

The project will not affect mining, as no mineral deposits are known in the site area. Gravel deposits suitable for construction aggregate are lacking, and most aggregate for the project will be imported.

Operation

No effects on terrain will result from operation of the project. Routine maintenance of access roads may require some disturbance of surficial materials at borrow sites.

4.3.2.2 Seismicity

Construction

The seismic risk factor will be considered in the design of all project facilities, and in road, pipeline, and power line access routes. The project will conform to CSA Standard Z276 for LNG facilities. Environmental effects related to pipeline and road access routes will be minimized wherever possible by avoiding steep slopes subject to slide or debris flow activity, and by avoiding surficial deposits of high seismic response, such as deep organic deposits.

Operation

The only significant environmental risk related to seismic activity is associated with the possibility of spills of LNG or other substances. The project will conform to CSA Standard Z276, which provides design requirements for seismicity to prevent failure of LNG storage tanks. Dykes surrounding the storage facilities will be designed to contain major LNG spills in the unlikely event of a rupture. Dykes will be constructed to contain major spills from storage facilities used for fuel or other chemicals.

The existing international tsunami warning system provides warning on tsunamis occurrence. LNG will not be held in loading lines during a tsunami warning at the LNG terminal, but retained in storage tanks. An LNG carrier would deberth the loading dock in the event a tsunami warning was issued.

4.3.2.3 Coastal Geomorphology

Construction

Excavation and leveling of the site, and construction of the service wharf and carrier pier will affect the shoreline and offshore zone in the immediate vicinity of the site. At the service wharf, the existing intertidal area will be replaced with rock fill. The effects of the carrier pier will be relatively minor because of its piling construction.

Construction in the shoreline and offshore area will result in the introduction of small amounts of sediment to the harbour in the form of fine material washed from rock fill, and the disturbance of bottom sediments. As longshore sediment movement in the harbour is light, this added sediment should have no significant effect on shoreline and intertidal morphology outside the immediate construction area.

Modifications to the approach channel in Inskip Passage, if required, will alter the subtidal and intertidal morphology in the one reef where blasting may be required. However, such effects will be localized, as the amount of channel blasting required is minimal. Air curtains or other devices approved by the Department of Fisheries and Oceans would be employed to minimize the effects of blasting on marine life.

Operation

Coastal morphology and the balance of sediment in the Port Simpson Bay area should not be affected by the operation of the facility. The open piling structure of the carrier pier will not cause interference with existing harbour circulation. The service wharf will not constitute a major barrier to circulation or sediment movement, and since longshore sediment movement in the area is minor, no noticeable change in the intertidal morphology of the area is expected. Maintenance dredging at the wharf and carrier pier will not be necessary.

The effect of waves (wash) from large ships in the harbour area will be insignificant, as the predominantly rock and cobble shoreline is not sensitive to such disturbance.

4.4.0 VEGETATION

4.4.1 MARINE APPROACHES

4.4.1.1 Aquatic Vegetation

a) Algal Communities

Construction

Kelp beds occur in shallow areas which are not within the navigation route. Only at the entrance to Port Simpson Bay does some kelp exist. Channel blasting, if required, may have a short-term effect but recovery time of kelp and other algal communities is rapid.

Operation

Spills would be the only effect on algal communities. Physical disruption caused by grounding of a vessel or fire in the event of an LNG spill will cause only temporary damage which will recover naturally. Damage to plants from fuel spills would be more severe; but localized depending on the type of spill and duration of exposure.

Marine safety procedures, minimal bunker fuel handling, low bunker fuel storage requirements on LNG carrier and the implementation of contingency plans to deal with spills will minimize effects on algal communities (Section 4.1.0).

b) Vascular Plant Communities

Construction

Eelgrass beds will not be affected by the construction phase of the marine approaches because they are distant from the navigation route.

Operation

Eelgrass beds, like the kelp beds are expected to be unaffected by normal traffic on the navigation routes because of their distance from the marine approaches. Similarly, marine accidents with physical disturbance will quickly recover but fuel spills could produce longer lasting effects.

General marine safety procedures, minimal bunker fuel handling and the implementation of contingency plans to deal with spills will minimize effects on algal communities (Section 4.1.0).

4.4.1.2 Terrestrial Vegetation

Construction

Terrestrial vegetation will not be affected by the installation of navigational aids at the marine approaches.

Operation

There will be no effect on the forests resulting from carrier traffic along the marine approaches.

4.4.2 TERMINAL SITE

4.4.2.1 Aquatic Vegetation

a) Algal Communities

Construction

Algal communities will be subject to localized physical removal or disturbance in the vicinity of the LNG terminal during construction of the loading and service wharves. The loss of such communities may have further implications in terms of marginally reduced herring spawning substrate in Port Simpson Bay. Accidental spills could cause localized short-term effects to kelp beds adjacent to the terminal area.

In order to reduce such effects, the area of direct disturbance will be kept to a minimum. Any foreshore filling will be carried out at construction times approved by resource agencies to minimize turbidity and siltation. Provision of a settling basin will prevent suspended solids from reaching saltwater from the peat disposal area (Section 4.1.0).

Operation

The same effects as outlined in the marine approaches section apply to the terminal site. Potential physical disturbance through grounding or fire may damage algal communities but they are likely to recover naturally. Other potential effects may be anticipated from spills of hypochlorite and lubricants in particular. Proper operation of storage facilities and contingency plans as outlined in

Section 4.1.0 will minimize the chance of spill and the resultant impact on algal communities.

Turbidity and siltation of algal communities will be minimal during construction activities, because settling basins will remove suspended solids.

b) Vascular Plant Communities

Construction

Disturbance to eelgrass habitat will be insignificant. Construction of the service wharf will require a small area of foreshore. More prolific eelgrass beds within Port Simpson Bay are found in Stumaun Bay and subtidal sandy areas which will not be disturbed as they are away from the site. Mitigation measures for vascular plant communities include avoidance of eelgrass habitat and minimizing turbidity and siltation during foreshore excavation and filling.

Operation

Disturbance to eelgrass communities in the subtidal area through fire from an LNG spill, or damage to plants from spills of hypochlorite or lubricants are potential effects on vascular plant communities anticipated from operation of the LNG terminal. While these type of accidents are highly unlikely because of the safe design and operation of the plant, recovery from physical disturbance is expected to occur rapidly. Careful operating and monitoring procedures are followed to reduce spill risks. A contingency plan as described in Section 4.1.0 for a fuel spill will be followed.

4.4.2.2 Terrestrial Vegetation

a) Habitat Values

Construction

The LNG liquefaction and storage facilities will occupy an area of 40 hectares and an access road is planned to link the site to a road between Port Simpson and Prince Rupert. Direct removal of vegetation in these locations will result in the loss of some plant communities and wildlife habitat. These effects will be minimized by keeping the right-of-way area of disturbance as small as possible and designing and constructing the access road using environmental inspectors. Revegetation of road cuts and borrow areas as described in Section 4.1.0 will be provided.

b) Forestry Concerns

Construction

Forestry values at the terminal site are generally low. Construction of the terminal facilities will involve clearing of decadent forest. Assessment of their timber value will be made prior to their removal. Reclamation of cleared areas will involve seeding of an intermediate plant cover for stabilization of the substrate.

Operation

The possibility of fire is the major concern to forest communities associated with operation of the LNG terminal. Proper control measures and safety procedures will be employed to minimize the risk of fire from LNG or leaks or spills of hypochlorite which might also affect the forest resource.

4.5.0 OCEANOGRAPHY

4.5.1 MARINE APPROACHES

4.5.1.1 Physical Oceanography

Construction

Channel blasting is not anticipated to be required to deepen the approach to Port Simpson through Inskip Passage. However, if requested by regulatory agencies, no more than about 3 m from a rock in the centre of the passage would be removed.

The change in the channel bathymetry will be minor, and will not result in any changes in circulation, wave patterns or water column chemistry or temperature.

Operation

Operation of LNG carriers and other ships will not affect the physical oceanography of the marine approaches.

4.5.1.2 Water Quality

Construction

Some local short term increase in turbidity may be associated if channel deepening is required in Inskip Passage. Otherwise, no water quality effects are associated with construction. Mitigation procedures removing suspended solids will follow those outlined in Section 4.1.0.

Operation

A general increase in marine traffic may have only a slight effect on water quality in northern Chatham Sound, due to domestic wastes and minor fuel spills or leaks. However, this effect is expected to be minimal.

4.5.2 TERMINAL SITE

4.5.2.1 Bathymetry and Circulation

Construction

Construction of the service wharf will locally alter the bathymetry of the harbour at the terminal site, as fill will be used for the wharf. The wharf, when completed, will form a projection from the shoreline of similar size to several natural existing shoals along the Port Simpson shoreline which are exposed to low tide. As such, it will not present a significant obstacle to currents and waves, and will not significantly alter the overall circulation pattern in Port Simpson Bay.

The carrier pier will have less effect on circulation and waves than the service wharf, because of its open piling design.

Operation

Operation of LNG carriers and other vessels will not affect circulation patterns in the harbour area. During calm conditions, waves generated by the carriers might be noticeable, but these should be minor compared to waves naturally occurring in windy weather.

4.5.2.2 Thermal Regime and Water Column Chemistry

Construction

The addition of rock fill for the service wharf, and the construction of the carrier pier, may result in some minor short term variation in the salinity regime of the waters of Port Simpson Bay.

Operation

The discharge of plant cooling water into Port Simpson Bay will have a minor affect on water temperature in the harbour area. This temperature change will be less than 0.5° Celcius. Oceanographic studies are presently underway to identify the most suitable location for discharge. Work is also being done to predict the effect on dissolved oxygen levels due to the cooling water discharge.

As sea water will be used for cooling, the salinity of the harbour water will not be affected by cooling water discharge. Other process and domestic water discharges will be minor, and will have no effect on temperature or water chemistry.

A major accidental spill of LNG into the harbour would result in pronounced localized cooling of the surface water. However, containment dykes around the storage tanks, and the safety precautions used in loading, will make the probability of a major spill extremely low.

4.5.2.3 Water Quality

Construction

Salt water quality during construction of the facility could be affected by:

- sediment released into the harbour as a result of the site excavation, rock fill used for the service wharf, and pier construction;
- leachate from peat cleared from the site;
- cement or aggregate spills;
- domestic effluent from the construction camp;
- the risk of spills or leaks of fuel or other chemicals from the construction site or support vessels.

Mitigation measures undertaken to minimize effects on salt water quality will include:

- peat will be disposed of in depressional areas inland from the site. These will be lined if necessary with till or glaciomarine clay material, to prevent leachates from reaching the harbour;
- domestic waste will be treated to British Columbia Waste Management Branch Level A Objective;
- fuel supplies and other chemicals will be contained in safe areas, and contingency measures as described in Section 4.1.0 will be implemented to clean up any accidental spills;

Operation

The only potential effect on water quality in the operations phase will be the risk of accidental spills of fuel, lubricants, or other chemicals. As process equipment will be powered by natural gas, the amounts of diesel fuel and gasoline used will be small. All reasonable safety precautions will be taken to ensure safe storage of fuels, lubricants, and chemicals, and to clean up any accidental spills which may occur.

The work force required for operation of the facility will be much smaller than that required for construction, so the amount of domestic effluent will be small. All effluent will be treated to Waste Management Branch Level A Objective. Water used for cooling will not be contaminated, and will not affect water quality.

4.6.0 FISHERIES

4.6.1 MARINE APPROACHES

4.6.1.1 Fish Resources

a) Pacific Salmon

The effect on pacific salmon from marine LNG carrier traffic is expected to be minimal. No direct effects are expected even for salmon stocks feeding in near-surface waters should an LNG spill occur as LNG rapidly vaporizes to methane gas and should not enter the water column. Methane is not toxic to fish (see section 4.1.2 Environmental Specifications). Localized cooling of near-surface waters may occur if a large spill of LNG were to occur, but fish could avoid the temperature change by swimming away from the spill. The remote possibility of a fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel could affect some estuarine spawning and rearing areas located along the marine approaches. If a fuel spill occurred during critical larval stages, April to October, when the larvae are in the inshore near surface waters, the effect could be more serious. However, carriers will keep well offshore and any spill would be small and be dispersed before reaching land.

b) Pacific Herring

The effect on pacific herring from marine LNG carrier traffic is expected to be minimal. No direct effects are expected since herring stocks typically remain below 100 metres along the marine approaches. The effect on herring in near-surface waters would be the same as described in a) above. The remote possibility of a fuel or lubricant oil spill resulting from a collision with a fixed object or another vessel close to shore could affect spawning areas located along the marine approaches. However, the fuel spill will have to occur during the critical spawning and larval stage, March to July, when the larvae are in the inshore near-surface waters to be significant. Carriers are well offshore and any spill would be small and be dispersed before reaching land.

c) Groundfish

Almost no effects on pacific groundfish from marine LNG carrier traffic are expected. No direct effects are expected since groundfish live in water in excess of 100 metres deep. The remote possibility of a fuel or lubricating oil spill resulting from collision with a fixed object or another vessel could affect only those species along inshore areas at a time when buoyant eggs are at the critical larval stages, December through February, and for rearing juvenile groundfish during March and April. However, carriers are well offshore and any spill will disperse before reaching inshore areas.

d) Other Fish

Other fish of cultural or sport importance are the eulachon and seagoing trout such as dolly varden char. Through most of its life cycle, the eulachon stays in deep water and only during its spawning runs in March do they reach near-surface waters. The hatched larvae are then swept into the shallow estuaries in May. There is a remote possibility of a fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel which could affect eulachon larvae when found in the shallow near-surface waters of the estuaries. However, LNG carriers will be well offshore and any spill will disperse before reaching inshore areas.

Sea-going trout, including dolly varden and steelhead, are not normally found in the marine approach study area. The effect on sea-going trout from marine LNG carrier traffic is expected to be miminal. Other inshore fishes found in relatively shallow water along the marine approaches to the proposed Port Simpson LNG terminal are numerous and constitute an important food source for the larger fish species discussed previously. However, the effect on these near-shore fish populations from marine LNG carrier traffic is expected to be minimal.

e) Commercial Fishing

A significant portion of B.C.'s salmon and groundfish fisheries occur in the northern B.C. waters. Specifically, most of the fisheries occur in Hecate Strait and Dixon Entrance where the marine approaches show wide navigable channels. The possibility exists that fishing vessels travelling from one fishing zone to another and LNG carriers may need to avoid each other. There is sufficient navigable water for the LNG carrier to avoid zones where fishing is occurring and other routes can be utilized at these times to avoid congested areas. The LNG carrier will be equipped with navigational aids and radar to identify and avoid fishing vessels. This subject is discussed in greater detail in section 4.1.4 Alternate Human Uses and Activities.

4.6.1.2 Invertebrates

a) Intertidal and Benthic Invertebrate Species

The effect on invertebrates from marine LNG carrier traffic along the marine approaches is expected to be small. Invertebrates are typically intertidal or benthic and, therefore, are well removed from the potential shipping lanes. Some of the more mobile invertebrates such as shrimp and prawn frequent water depths of more than 30 metres and, therefore, are out of the direct influence of the expected marine carrier traffic. The remote possibility of a fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel could affect invertebrate larvae in the inshore near- surface water. However, LNG carriers are well offshore and any spill would be small and be dispersed before reaching land.

The invertebrate communities are an important link in the food web of the marine ecosystem. In particular, the mid-intertidal zone of partially exposed and semi-protected bedrock and boulder intertidal habitat are the most densely populated. In the unlikely event of a fuel spill occurring and reaching the intertidal area, all invertebrates whether bivalves, gastropods, amphipods, or commercial arthropods at that site will be affected.

b) Commercial Invertebrate Species

The effect on commercial invertebrate species from marine LNG carrier traffic is expected to be minimal. Most commercial invertebrates such as clams, oysters, mussels, abalones, scallops, sea urchins, and dungeness crab occur in the intertidal and subtidal areas. These areas are well removed from LNG carrier approaches. The remote possibility of a marine fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel could affect these species in intertidal areas. The more free swimming forms such as squid, octopus, and shrimp are unlikely to be affected. No interference with the direct harvest of commercial invertebrate species along the marine approaches is expected.

4.6.1.3 Planktonic Communities

The effect on planktonic communities from marine LNG carrier traffic is expected to be minimal. Increased LNG carrier traffic and other boat movements will locally disturb the upper water column and affect plankton. However, this potential effect will be similar to that caused by other shipping in the area.

The remote possibility of a fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel can marginally affect plankton, if near or at the surface.

4.6.2 TERMINAL SITE

4.6.2.1 Fish Resources

a) Pacific Salmon

Construction

Salmon stocks can be affected by siltation, fuel spills, and water or chemical changes resulting from construction of the proposed LNG terminal. Salmon (principally pink salmon) utilize the Stumaun Creek estuary between August and October. Most of their spawning occurs in the creek channel proper with some spawning in portions of the inter-tidal area (well removed from construction activities). Juvenile salmon occur in the surface waters of the bay from June through August. Other salmon species reported in Port Simpson Bay are coho salmon. Neaxtoalk Lake has been recorded to support a few pink and coho salmon spawners. Adverse effects on salmon due to construction could affect the native food fishery in the Port Simpson area.

Alteration of a small area of rearing habitat will be necessary for construction of the service dock and LNG loading wharf. However this construction will be scheduled so as to have little effect on juvenile salmon during their rearing cycle in near-surface waters of the bay. Road construction will be closely controlled to prevent siltation which may otherwise affect spawning in Stumaun Creek or Neaxtoalk Lake, reducing spawning potential.

Siltation from construction of land and marine based facilities will be controlled so that there will be little, if any, affect on spawning salmon in fresh water or newly hatched larvae in the estuaries of Stumaun Creek and Neaxtoalk Lake. Run-off channelling, overburden and peat disposal will be properly managed to prevent changing the flow regime of some of the smaller streams on and adjacent to the site with resulting effects on water quality of Port Simpson Bay.

Use of good environmental control practices during the construction of access roads, gas pipeline, power lines, as well as water supply to prevent adverse effects on salmon spawning and rearing creeks. It can be emphasized that many of the streams within the terminal site study area are reported not to support salmon populations. Therefore, the potential effects will be insignificant on these streams.

The construction and operation of ancillary facilities such as the camp, service areas, and treated effluent from the construction camps will have only negligible impact on the salmon resource in the Port Simpson Bay study area. These effects will not be serious as siltation will be minimized as described in 4.1.0.

Freshwater habitats adjacent to the proposed terminal site have been identified as potential freshwater sources for the LNG processing facility. Of seven watersheds identified, only Stumaun Creek, Georgetown Creek, and to some extent Neaxtoalk Lake, have known salmon spawning and rearing populations. The other freshwater bodies are too small to show adequate flow for support of significant salmon populations. The evaluation of freshwater streams draining into Work Channel as potential water supply sources (Section 3.10.3.1) will include fisheries evaluation to assure that water supply and storage is accomplished without adversely effecting the stream and, if practical, enhancing fishery production.

Spills or leaks of fuel, lubricants, or other chemicals used for the construction of the LNG facilities may be detrimental to salmon alevins, fingerlings, and juveniles. Strict control of fuel storage and runoff water from overburden removal and storage areas will be provided as outlined in Section 4.1.0.

Operation

Possible changes in water quality due to LNG ship movements during operation will be negligible and therefore will be no impact on salmon populations.

Some feeding and rearing habitat of the newly hatched alevins and fingerlings feeding in the near-surface waters of Port Simpson Bay may be affected by ship movements. Accidental spills or leaks of process chemicals or LNG, should they occur, also will be detrimental to salmon. Contingency measures as outlined in Section 4.1.0 will be taken to avoid accidental release of chemicals or fuels to protect salmon occupying the near-surface waters of the bay.

Cooling water is required in the liquefaction process. Proper location of the water intake and discharge pipes will be accomplished to prevent damage to the fishery. The water intake structure will be designed as in Section 4.1.0 to prevent entrapment of fish and will be maintained and operated throughout operations.

The location of the water intake would be as deep as practical within Port Simpson Bay to take advantage of colder water observed at that depth. Proposed submarine discharge of cooling water is expected to marginally increase water temperatures in the immediate vicinity of the discharge pipe. The cooling water discharge pipe will be located in an area of good tidal flushing. Temperature increases will remain less than 0.5°C within 100 metres of the discharge pipe or diffuser and would have little impact on the local salmon populations.

Fuel spills during operations will be unlikely because of the use of natural gas as the main fuel for the LNG carriers, thus requiring only small amounts of Bunker fuel as a back-up. Spills of diesel fuel from other project-related vessel traffic in the area and the possibility of lubricating oil spills occurring as stores are being loaded on the LNG carrier cannot be entirely discounted. Consequently, care will be taken to prevent spills at all times.

Should a spill occur, a contingency plan will be implemented to minimize the spill and to clean it up as outlined in Section 4.1.3.

b) Pacific Herring

Construction

Herring utilize Port Simpson Bay as a spawning and rearing area during the spring and summer months. The herring resource is important to the local fishing industry and, consequently, adverse impacts to herring can affect the economy of the fishery of the area.

A small amount of direct habitat alteration will occur during the construction phase. Construction of the service wharf will result in an existing intertidal rock area being filled with rock as outlined in the previous section on Pacific Salmon. The effect of the change in spawning substratum will cause a very localized effect on herring. The LNG carrier loading wharf will have minimal impact because of its piling and sheet pile construction. The portion of Port Simpson Bay affected by the service wharf is a small portion of habitat available for herring spawning.

The construction of marine and land based facilities will cause minor water siltation that may affect spawning herring and newly hatched larvae. Construction of marine facilities will be scheduled with the appropriate regulatory agencies to minimize this impact. Water siltation from land-based construction will be avoided through settling basins as outlined in Section 4.1.0.

Chemical spills or loss of runoff water from peat or overburden storage sites will be strictly controlled to prevent detrimental affects to spawning herring and newly hatched larvae. Practices as described in Section 4.1.0 will be instituted to prevent these effects.

Operation

Direct spawning habitat loss is minimal in the operational phase. The impact ship movements may have on the newly hatched larvae which occupy the near-surface water layers is expected to be minimal.

Cooling water is required in the liquefaction process. Proper location of the water intake and discharge diffuser as described in Section 4.1.0 will be provided to protect herring.

Fuel spills during operations are expected to be unlikely because of the use of natural gas as the primary fuel for the LNG carrier, and minimal storage or loading of bunker fuel at Grassy Point. Spills of diesel fuel, lubricating oil, or from other vessels cannot entirely be discounted and their effect on herring is the same as that described in the previous salmon section (4.5.2.1).

c) Groundfish

Construction

Groundfish known to occur in Port Simpson Bay are soles (pleuronectidae) and rockfish (scorpaenidae). Groundfish stock are unlikely to be affected by the construction of an LNG terminal in Port Simpson Bay. Most of these species spend their life in waters deeper than 100 metres and only during spawning and juvenile life cycles do they occur in near-surface waters. No spawning activity is expected in Port Simpson Bay. However, some juveniles could be in near-surface water from March to July.

During the construction of marine and land based facilities, care will be taken to prevent siltation and other water quality changes which could affect juvenile groundfish. Chemical spills or loss of runoff water from peat and over-burden storage sites will be avoided as described in Section 4.1.0.

Operation

Cooling water is required in the liquefaction process. Proper location of the water intake and discharge diffuser as described in Section 4.1.0 will be provided such that no impact to groundfish is expected as the structures will be designed to the same standard as that outlined in the previous section on salmon.

Fuel spills during operations will be unlikely because of the use of natural gas as the fuel for the LNG carriers. The design of the storage tanks and contingency planning for loading and storing of fuels (Section 4.1.0) have been described previously in the salmon section 4.5.2.1.

d) Other Fish

Construction

No eulachon or sea-going trout have been reported at Port Simpson Bay. However, relatively high diversity of other small inshore fish have been recorded. These inshore fish utilize Port Simpson Bay as spawning, rearing, and feeding areas.

Direct habitat alteration in the construction phase of the service wharf will result a localized short-term effect on those inshore fish that utilize the habitat until the rocky substrate is recolonized by algae and invertebrates. The LNG carrier pier will have a minimal impact because of its open piling and sheet pile construction.

The construction of marine and land based facilities could cause water quality changes including siltation that may affect nearshore fish. Chemical spills or loss of runoff from peat or overburden storage sites will be prevented as outlined in Section 4.1.0.

Operation

Possible changes in water quality due to the operation and the ship movements during operation may have some minor impact on inshore fish population. No spawning or rearing habitat loss is expected. Ship movements and loading activities may result in an avoidance reaction and a minor effect on newly hatched larvae and rearing juveniles.

Cooling water is required in the liquefaction process. Proper location of the cooling water intake and discharge pipe will be conducted as described in Section 4.1.0.

Fuel spills during operations will be unlikely. Carrier design and spill contingency plans will be implemented as described in the previous section on salmon (4.5.2.1).

e) Commercial Fishing

Construction

Commercial fishing for herring and salmon occurs in Port Simpson Bay and immediate approaches to the bay. The commercial fishing for herring is usually restricted to two or three days, while salmon trolling can occur during most of the summer. As most of the herring fishing occurs south of Port Simpson Bay and fishing regulations permit only a limited number of boats to fish, adequate access would be available to reach the LNG terminal construction site. The construction site does not preclude commercial fishing.

Operation

The area immediately adjacent to the service dock and LNG pier will not be as accessible as at present for commercial herring fishing or salmon netting due to the loading wharf. This small inshore area is not known to be a particularly important commercial fishing area. As discussed for the construction phase of the project, fishing activities in and around Port Simpson Bay occur during restricted time periods and concentration of fishing vessels will not pose a problem for LNG carriers. Therefore, no effect on the commercial fisheries is expected. This subject is discussed in more detail in Section 4.1.4 Alternate Human Uses and Activities.

p4.6.2.2 Invertebrates

a) Intertidal and Benthic Invertebrate Species

Construction

The invertebrate fauna is affected through the alteration of intertidal and subtidal habitat. Construction of the service wharf will result in changing the existing intertidal and subtidal rock shelf to a small rock filled dock. This dock will be used to unload supplies and equipment for the facility. Its faces will be rip-rapped on the north and south sides. The immediate effect of this construction will remove the existing invertebrate fauna and create a new rip-rap boulder substrate to be recolonized by algae and invertebrates. The LNG loading wharf, on the other hand, would have a minimal impact because of its piling and sheet pile construction. Invertebrates may in fact utilize the sub and intertidal portion of the LNG loading wharf.

The construction of marine and land based facilities can cause water siltation and water quality changes that may affect intertidal and subtidal invertebrates. Strict control of chemical spills or loss of runoff water from peat or overburden storage sites to prevent detrimental effects to invertebrates and newly hatched larvae.

Construction of wharves and discharge of treated effluent from the construction camp will result in imposition of a fisheries closure to the harvesting of shellfish in the intertidal and subtidal area, 125 metres on either side of the wharves. Broader closure zones might be required depending on resultant coliform levels in Port Simpson Bay.

Operation

Direct loss of intertidal and subtidal invertebrate habitat is minimal in the operational phase. Of importance is the impact of treated sewage effluent and accidental spills or leaks. Contingency plans as described earlier (Section 4.1.0) will minimize the occurrence of spills or leaks and maximize the success of the clean-up should an accidental spill occur.

The shellfish harvesting closure around the wharves will exist throughout the operation of the facility. Cooling water is required in the liquefaction process. Proper location of the water intake and discharge pipes will be determined as described in Section 4.1.0.

Fuel spills during operations will be unlikely because of the use of natural gas as the main fuel for the LNG carriers. The carrier design and fuel storage, loading facility and contingency plans described in Section 4.1.0 will be followed in the event of a spill.

b) Commercial Invertebrate Species

Construction

Commercial invertebrate species such as crabs and clams are primarily affected through habitat alteration and/or removal. The dock service area would change a portion of intertidal and subtidal habitat and substitute a rip-rap intertidal area which likely will be recolonized by algae and most invertebrate species. In contrast, the LNG loading wharf would have little effect on commercial invertebrates such as crabs, mussels, and clams.

Water quality changes due to construction, such as siltation and introduction of effluent, will have a minor effect on invertebrate populations.

Spills or leaks which may affect water quality may have effects on intertidal and subtidal invertebrate communities. Proper storage and contingency plans for fuel and construction chemicals (see Section 4.1.0) will be maintained.

Operation

The operation of LNG carriers and additional project-related vessel traffic will have little impact on commercial invertebrate species in or adjacent to Port Simpson Bay. Strict control of chemical storage and runoff from peat storage will be provided as outlined in Section 4.1.0.

Cooling water is required in the liquefaction process. Proper location of the water intake and discharge diffuser will be designed as described in Section 4.1.0.

Accidental spills or leaks of hypochlorite, LNG, fuel or lubricants may affect the commercial invertebrate species. Proper environmental design and contingency planning as outlined in Section 4.1.0 will be provided to prevent these occurrences or minimize their effect.

4.6.2.3 Planktonic Communities

Construction

Plankton species occur in Port Simpson Bay and surrounding waters. Plankton "blooms" occur particularly in May, June and July. Plankton are primarily affected by direct disturbance of the surface layers of the water column. Alterations of habitat due to land-based and intertidal construction of the LNG facility have little impact on plankton. Increased vessel traffic due to construction may have some temporary localized effect on phytoplankton and zooplankton in the bay.

Construction of marine and land-based facilities can cause water siltation and water quality changes that may affect plankton. Chemical spills or loss of runoff from peat and overburden storage sites will be strictly controlled. Leaks of fuel, lubricants or other construction chemicals will be controlled and contingency plans as described in Section 4.1.0 will be provided.

Operation

The addition of once through cooling water to the bay may slightly increase productivity of plankton in the bay.

Fuel spills during operation will be unlikely because of the use of natural gas as the primary fuel for the LNG carriers. Carrier design, fuel storage requirements and contingency planning are described in Section 4.1.0.

Spills or leaks of hypochlorite, fuel, LNG and lubricants may conceivably affect plankton of Port Simpson Bay. Strict control of the storage and handling of these chemicals, and adequate contingency planning will be provided as described in Section 4.1.0.

4.7.0 WILDLIFE

4.7.1 MARINE APPROACHES

4.7.1.1 Marine Mammals

There will be minimal effect on marine mammals from LNG carrier traffic. Marine mammals are seasonal residents or migrants and few species are common throughout the area year-round. The remote possibility of a fuel or lubricating oil spill resulting from a collision with a fixed object or another vessel could affect surfacing marine mammals. However, such an effect would be extremely localized and have to occur when marine mammals were in the area.

4.7.2.1 Marine Birds

The effect on aquatic birds from marine LNG carrier traffic is expected to be insignificant. No direct effects are expected since marine birds are well dispersed throughout the marine approaches. Only where seabird colonies and associated feeding areas result in large concentrations of seabirds can the remote possibility of a fuel or lubricating oil spill result in an impact. However, since LNG carriers carry a minimal amount of bunker fuel and lubricants, oiling of seabirds is considered to be an extremely remote possibility.

4.7.2 TERMINAL SITE

4.7.2.1 Marine Mammals

Construction

Marine Mammals are occasional visitors to the Port Simpson Bay Area. It is unlikely that marine mammals would be affected due to the construction of the LNG terminal.

Operation

It is unlikely that marine mammals would be affected due to the operation of the LNG terminal in Port Simpson Bay. Effects on marine mammals would be indirect and only if their prey (herring, salmon, and other fish) were affected as described in previous sections on fishes.

4.7.2.2 Marine Birds

Construction

Aquatic birds are unlikely to be affected by the construction of the LNG terminal. Most of the aquatic birds are divers and reside in the open bay. The only effect on aquatic birds will be due to the remote possibility of a fuel spill during the construction of the LNG terminal. Contingency plans as described in Section 4.1.0 will be provided.

Construction of the marine and land-based facilities may cause minor water siltation that affects the food source of aquatic birds. Chemical spills or leaks may affect the birds directly. Strict control of chemical storage and runoff from peat and overburden storage areas will be provided (Section 4.1.0).

Operation

Possible changes in water quality due to the operation of the terminal and ship movement during operation may have some impact on aquatic birds.

The once through cooling water required in the liquefaction process will have no impact on marine birds. Fuel spills during operation will be unlikely because of the minimal storage of fuels at the site. Engineering design and contingency plans are described in Section 4.1.0 will be provided for fuel spills or leaks.

Spills or leaks of hypochlorite, LNG, and lubricants, as well as spills of diesel fuel from other vessels cannot be entirely discounted. Consequently, similar mitigative measures as those for fuel spills will be provided.

4.7.2.3 Big Game Animals

Construction

Big game animals can be affected through alteration of their habitat. The two big game species present at the terminal site are black-tailed deer and black bear. The removal of 40 ha of forested habitat will be a minor affect on available habitat for both big game species. However, the density of deer populations on the Tsimpsean Peninsula are thought to be low. Deer distribution is not limited by food availability in the area. Therefore removal of deer habitat would not significantly affect deer density. Of the two critical habitats, the bog habitat is thought to be good browse habitat (approximately 10 hectares on the site). The Sitka spruce-hemlock forest habitat along the foreshore is regarded as important winter habitat because it does not have normally deep snow accumulation (approximately 12 hectares).

Black bear occur primarily in the forest bog fringe which makes up about 40 hectares of the LNG terminal site. Bears are thought to be common to the Tsimpsean Peninsula. However, little evidence of bears was determined during field visits and discussions with locals.

Construction noise may lead to temporary avoidance followed by noise aclimation by most big game animals in the general terminal area. No serious effect is expected. Accidental spills or leaks of construction chemicals during construction are unlikely to occur. If an accident occurred it would not affect big game animals because construction activity would not attract them to the working site, and contingency plans would be implemented to clean up an accidental release of fuel or lubricants (Section 4.1.0).

The influx of construction workers and the creation of new access generally results in dispersion of big game animals away from the accessible areas. Illegal hunting by construction workers will be discouraged. Removal of garbage and kitchen wastes will be such that bears will not be attracted to the sanitary landfill by improper disposal methods (see Section 4.1.0).

Operation

The operation of the LNG terminal and its associated ship movements are not expected to have any significant impact on big game animals. Since most habitats seem to be under-utilized and the plant has a significant buffer (160 ha) surrounding the refrigeration and storage facilities which itself will be important new edge habitat for ungulates, no effect on big game animals will be anticipated.

The new access provided will however increase the potential for big game harrassment and poaching. Most of these activities are controlled by the B.C. Fish and Wildlife Branch personnel. However, the company will develop a policy of full cooperation to institute measures necessary for the preservation of big game species on the northern Tsimpsean Peninsula.

The remote possibility of an accidental spill or leak of hypochlorite, fuel, LNG, or lubricant is unlikely to affect big game animals because animals are not expected to be in the vicinity of the plant and loading pier.

Consumptive and Non-Consumptive Uses

Construction

Present consumptive use of big game animals is low. The terminal site itself would represent a fraction of a percent of the management unit. The Tsimpsean Peninsula as a whole represents less that 5% of the management unit area. Only a few animals were harvested; therefore, little direct effect on consumptive use patterns by the LNG terminal construction is expected. It is unlikely that construction workers would poach or hunt such a small game resource and will be discouraged from doing so.

Data on subsistence hunting by natives in the Port Simpson area has been difficult to obtain. It is expected that the Port Simpson Band derives a portion of their food through hunting. Since the LNG terminal construction is not expected to affect the ungulate resource, little effect is expected on Native hunting.

Operation

An insignificant ungulate and big game resource in the Port Simpson area coupled with under-utilized hunting and fishing use is expected to show little effect as a result of the operation of the LNG terminal. Native subsistence hunting is expected to continue to take place in the vicinity of the terminal site. Increased access will also increase harassment of big game species, and thus their avoidance of the site area.

4.7.2.4 Furbearers

Construction

The effects on furbearers through the construction of the LNG terminal will be small. Most furbearers occur along creeks and estuaries and therefore the LNG terminal site construction will not affect significant furbearer habitat. Trapping by the Port Simpson band is reported to be confined to Stumaun Bay, Stumaun Creek and other drainages to the south. Therefore, no traplines will be directly affected by the terminal construction.

Ancillary facilities to the terminal site such as roads, gas pipeline, powerlines, and their increased access will affect furbearers and respective trapping.

Operation

Once access is provided and the terminal is in operation, little impact on furbearers and trapping is expected. The furbearer resource seems to be very small at the site.

4.7.2.5 Raptors and Other Birds

The construction of the LNG terminal will have some local effect on raptors and other birds. This will be through habitat removal and, to some extent, provision of access. Raptors (bald eagles in particular) frequent terrestrial fringe habitat at the shoreline at Port Simpson Bay, especially during herring spawning season. Approximately 600 metres of terrestrial fringe habitat will be removed along the foreshore. Further disruption of terrestrial fringe habitat will be minimized as heritage resources are typically found along the shoreline. In relation to the many kilometres of forested shoreline on the Tsimpsean Peninsula, this represents an insignificant impact.

The rare peregrine falcon is not reported to frequent the area and so will not be affected by the construction and operation of the LNG terminal and carrier operation. Birds occur on Dundas Island well away from any direct activity.

Upland game bird such as the blue grouse occur and are hunted in the vicinity of the terminal site. It is expected that most of this hunting is by the Port Simpson band members. The birds prefer bog habitats. A bog of 10 hectares will be removed during construction. The creation of other edge habitat at the site and the access corridors will probably result in a net increase of grouse population.

If hunting is properly controlled and managed no impact on upland game birds by the LNG terminal facilities is expected.

Sandhill cranes utilize open habitats near the coast for breeding but in general they are uncommon along the north coast. Thus any effects the plant might have on sandhill cranes through habitat loss is expected to be insignificant.

Other birds such as shorebirds and songbirds are affected only insignificantly by the proposed LNG terminal. Habitat removal such as foreshore and terrestrial fringe habitat would be the more significant impact on these bird population. Accidental spills or leaks may affect shorebirds if their habitat is degraded. Careful control and proper contingency planning will be followed to prevent such accidents and maximize clean up success (Section 4.1.0).

4.80 SURFACE WATER HYDROLOGY AND WATER QUALITY

Construction

There are no permanent streams or lakes in the immediate site area which could be affected by construction of the project. One unnamed watershed draining to Work Channel will be developed as a freshwater supply (see Section 3.10.3.1 Surface Waters). However, intermittent surface runoff from rainfall will be disrupted by construction, and the water balance of a nearby bog area will be affected. The most significant effect of construction will be the occasional release of fine sediment into surface water runoff, and ultimately into the harbour. This effect will be minimized by taking measures to prevent soil erosion during site clearing and construction, and by constructing channels, culverts and settling ponds adequate to carry surface runoff from the site area.

The watershed of Neaxtoalk Lake could be affected by road or pipeline access. Sedimentation problems will be minimized by avoiding, as much as possible, organic deposits and unstable material on steep slopes in the Neaxtoalk Lake watershed.

The development of fresh water supplies from the unnamed stream will affect the surface water hydrology of the watershed, as intake structures and, possibly, storage reservoirs will be necessary. Fisheries mitigation and enhancement potential will be evaluated during future studies.

Effluent from the construction camp workforce will be treated to the required degree, so as to maintain acceptable surface and sea water quality. A potential water quality problem exists from spills of fuel or chemicals used in construction. The risk of any problems will be reduced significantly because such substances will be contained in safe areas, and contingency plans developed for clean-up of any spills or leaks as described in Section 4.1.0.

The disposal of peat excavated from the site area could have a potentially serious effect on water in bog areas and on surface and groundwater quality. In order to minimize water quality problems, peat will be disposed of in depressional areas inland to prevent leachates from reaching the harbour or affecting surface or ground waters.

Operation

Fresh water will be required for domestic needs of the work force, supply of LNG carriers, and plant process water. The much larger requirements of cooling water and for fire-fighting will be met using sea water. Exploitation of surface water sources for fresh water supply will have no significant effect on the water balance of the source watersheds during most of the year; however, there could be an effect in some years during the dry midsummer months. Adequate storage facilities will be provided at the site to ensure sufficient water supplies during drought periods, and to maintain existing minimum flows in the source watershed. (At this stage, a water supply source stream has not been chosen.)

At this time, groundwater is not being considered as a fresh water source. However, no environmental effects are anticipated if groundwater sources were to be selected in the future for fresh water supply.

While unlikely, the possibility of spills of fuels, lubricants, or other chemicals may affect water quality in bogs or groundwater at the site area. The chance of contamination will be reduced by proper storage and development of contingency plans for the clean-up of any spills or leaks as outlined in Section 4.1.0.

The maintenance of access roads will have a minor effect on surface water quality near the site; however, with normal maintenance procedures, significant effects will be avoided.

4.9.0 HERITAGE RESOURCES

4.9.1 MARINE APPROACHES

There will be little, if any, effect on heritage resources due to marine carrier traffic. However, where navigation equipment needs to be installed on land, a preliminary survey of the sites will be conducted to avoid disturbance of archaeological sites. These surveys will comply with the guidelines laid down by the provincial archaeologist.

4.9.2 TERMINAL SITE

Only one Indian midden Archaeological site (GdTo-23) has been identified. It is near where the service dock will be built. If the project is seen to affect the site, this site will be salvaged before construction activities commence. It is anticipated that two to three months are necessary to salvage this midden. Additional surveys will be undertaken to determine whether ancillary facilities such as access corridors traverse archaeological and/or historical sites of significance. These surveys will be conducted prior to construction activities.

4.10.0 CLOSURE

The development of an LNG export terminal at Grassy Point in Port Simpson Bay has been discussed in this document in the context of the biophysical resources in the proximity of the development. It is Dome's intention to construct and operate the project as described in Section 4.1.2 Environmental Specifications, 4.1.3 Environmental Management.

The Environental Assessment Section (page 4.0-1) concludes that there will be no significant environmental disruption. Section 4.1.4 Alternate Human Uses and Activities discusses the potential effects of the project on other human, renewable and non-renewable resources in the project area and concludes that the project will not adversely affect these resources.