SUPPLEMENT TO VOLUME THREE

ENVIRONMENTAL SETTING AND ASSESSMENT

FOR

A LIQUEFIED NATURAL GAS TERMINAL

GRASSY POINT, PORT SIMPSON BAY

NORTHERN BRITISH COLUMBIA

by:

Dome Petroleum Limited

August 15, 1982

FOREWORD

This Supplement to the December 1981 document entitled "Volume Three Environmental Setting and Assessment for a Liquefied Natural Gas Terminal Grassy Point Port Simpson Bay Northern British Columbia" is to provide additional project related information concerning the project description, results of studies that were underway at, or started after December 1981, provide refinements or improvements to the document as a result of reviews by government agencies and advise of typographical corrections.

Developing a project of this size and scope incorporates a continuing process of review, optimization and improvement. Issue of Supplements is to provide periodic updates on the project and answers to environmental protection/enhancement questions.

1.00 SUPPLEMENT - THE ENVIRONMENTAL ASSESSMENT PROGRAM

Page 1.3-2 line twelve last paragraph should be modified to "Development. Information from the Department of Fisheries and Oceans, Environment Canada specifically Atmospheric Environment, ..."

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

Page 2.1-1 Section 2.10 line three please replace "14.3" with 13.6.

3.00 SUPPLEMENT - EXISTING ENVIRONMENT

Page 3.1-34 Section 3.1.2.3 Waves. Please replace the first sentence with "Prior to Dome installing a waverider buoy in Port Simpson Bay during the period May 1, 1981 to March 22, 1982, there had been no direct long term wave measurements in Port Simpson Bay."

Page 3.1-39 Waves - please add the following after the last sentence:

"The wave measurement system was provided by the Wave Climate Study of the Marine Environmental Data Service, Department of Fisheries and Oceans, Ottawa. The system consisted of a buoy containing an accelerometer to measure the vertical acceleration of the buoy and appropriate electronics to transmit the vertical displacement to a receiving site. The receiving site was at the settlement of Port Simpson. A receiver and tape recorder comprised the receiving system.

An electronic clock in the receiver controlled the recording of the data, turning the receiver and recorder on for 20 minutes every three hours. The buoy, installed in May 1981, was replaced on two occasions, November 25, 1981 and January 26, 1982, then was removed on March 22, 1982. Data processing and analysis were carried out by the Wave Climate Study in Ottawa.

Periodic problems with the wave buoy electronics and its shore receiver system resulted in approximately 54% recovery of wave data over the period of measurement.

Due to the malfunction of the meteorological station at Port Simpson, the wind meaurements at Prince Rupert were used for the months of January 1982 through March 1982; and for the first half of May 1981 to evaluate effect of wind on waves observed. The statistical evaluations of the complete wave record collected at Port Simpson are presented in Figures s3.1-1 to s3.1-3.

In general, the observations indicate very low wave energy at Port Simpson, with amplitudes less than 1 m and peak periods usually shorter than 5 seconds (Figures s3.1-1 to s3.1-3). The findings indicate that the wave field at Port Simpson is dominated by locally generated seas. This appears reasonable considering the protection offered by the various islands and reefs near the proposed dock site; and the fetch-limited nature of the surrounding waters. However, during some of the winter months (December and January) no wave record data were collected due to buoy malfunction. Overall the highest observed significant wave height (0.82 m) occurred January 14, during a one-day operation of the unit. The highest recorded wind event during the 1981-82 measurement happened December 9, when hourly winds greater than 60 km/hour from the north were recorded but, unfortunately, no wave data were recovered on that day.

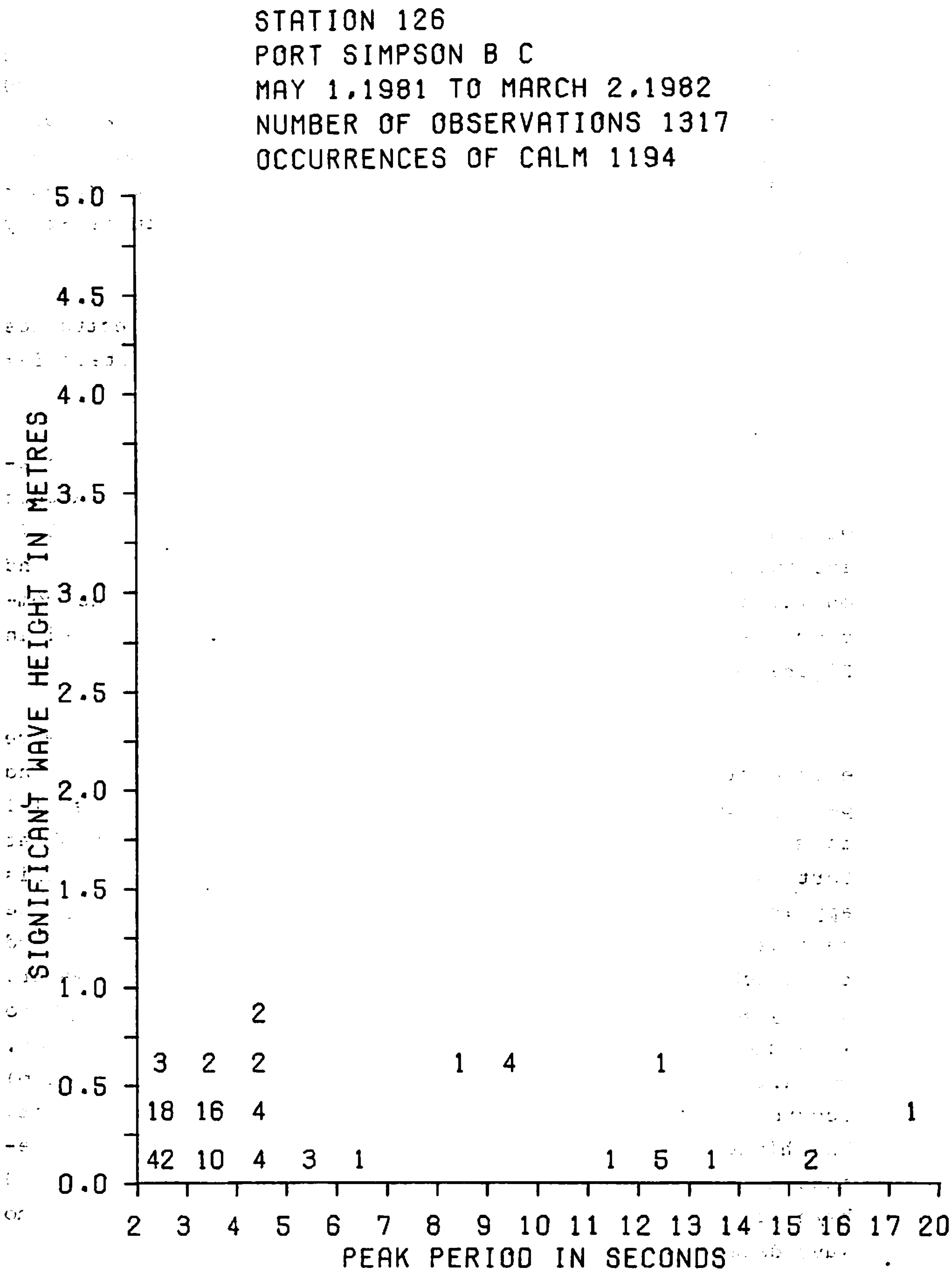

Figure S3.1.1 Scatter diagram of peak period versus significant wave height.

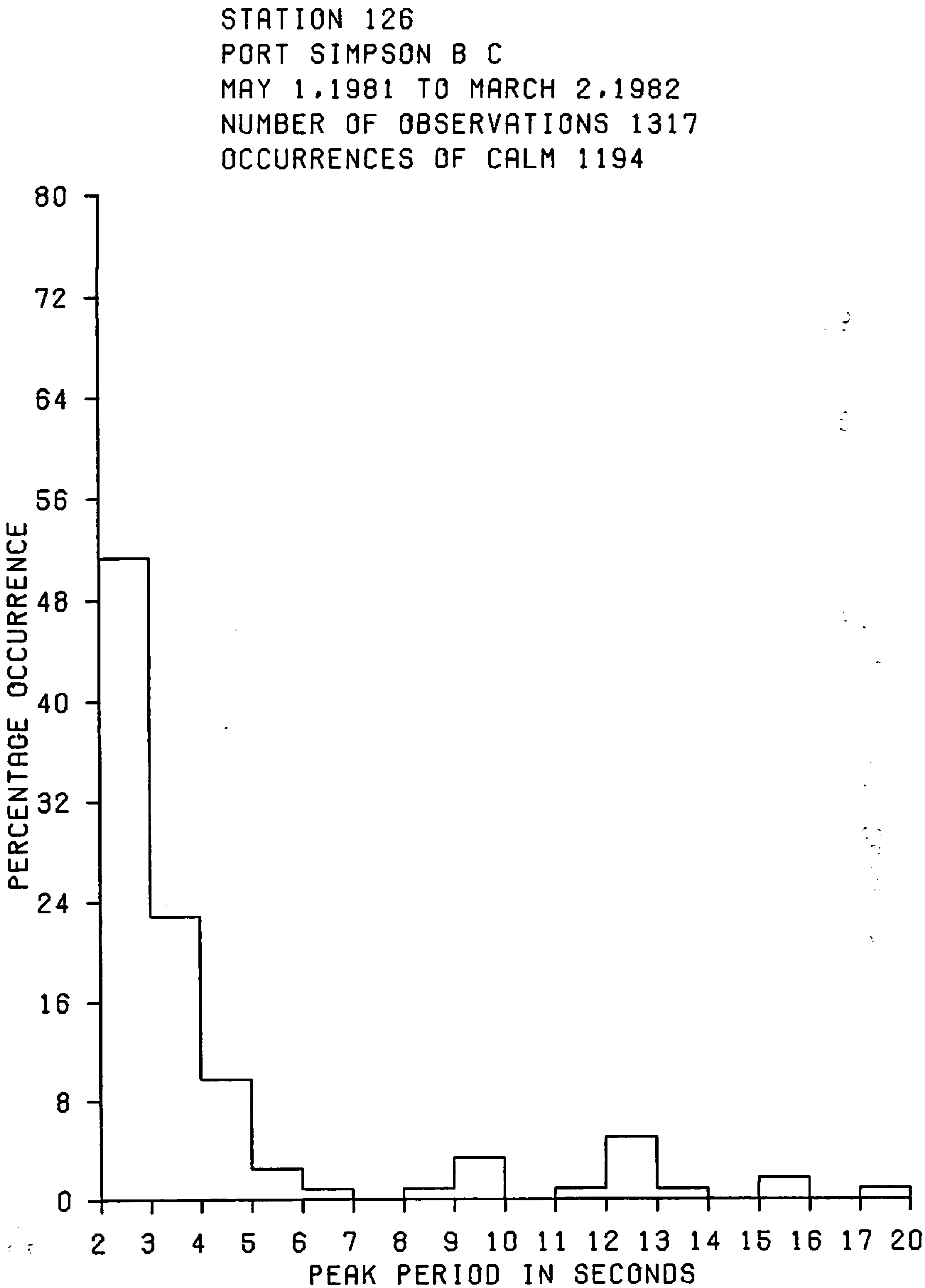

Figure S3.1.2 Peak period histogram

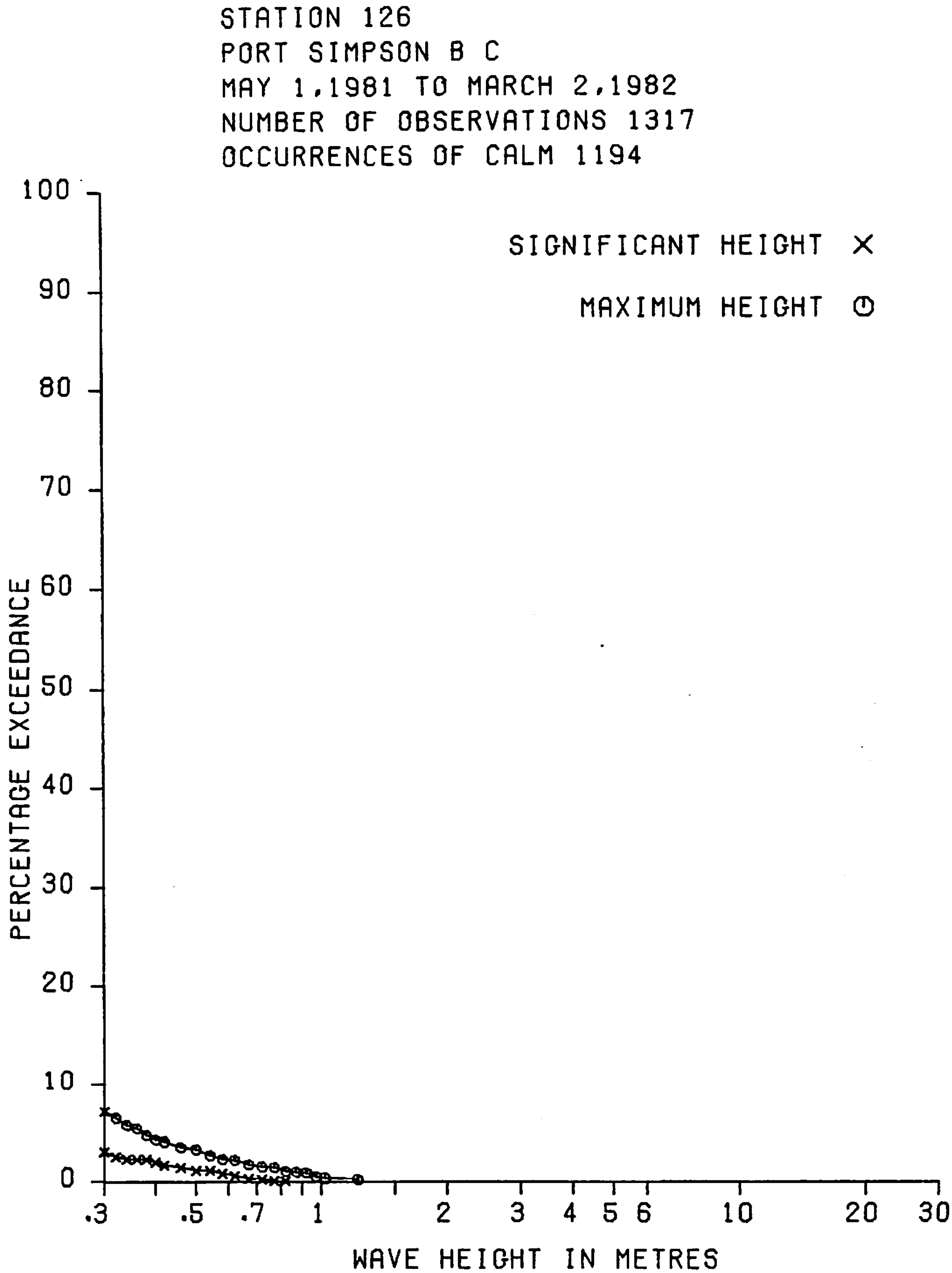

Figure S3.1.3 Exceedance diagram.

An attempt was made to correlate the observed winds at the Port Simpson dock with the significant wave events. From the available measurements it does not appear that the relationship between winds and waves is straightforward in Port Simpson. Throughout the 1981-82 study period there were a fair number of strong wind events, usually from the southerly quadrant. Most occurrences of these southerly high winds corresponded to an increase in wave activity at the wave buoy, but for a few occurrences they did not. In particular, the relatively high, short period (less than 5 seconds), wave events which occurred on September 30 - October 1, October 25-26, October 30-31, November 4-5, November 25, January 14, and February 18 (using the Prince Rupert winds as an indicator of local winds), appeared to have been directly related to local wind forcing. Local residents have estimated waves within the bay to be as high as 2.5 m during periods of strong westerly winds. (Oceanographers note local observations are often greater than actual measurements.) The present data set shows no indication of these large wave events, although this may be a reflection of year-to-year variations in the wave field."

Page 3.1-40 Replace Figure 3-1.9 with Figure s3-1.9.

Page 3.1-41 Section 3.1.2.3 Tsunamis Delete paragraph "A study commissioned ... events." and replace with:

"A review of available tidal records (1902-1926) at Port Simpson has revealed that numerous small tidal irregularities or seiches (heights usually less than 15 cm) occur each year in Port Simpson Bay, 78 percent of which are observed in the winter months October to March. The wave periods of these seiches are typically 20 to 24 minutes which probably reflects the natural resonance period of the Bay.

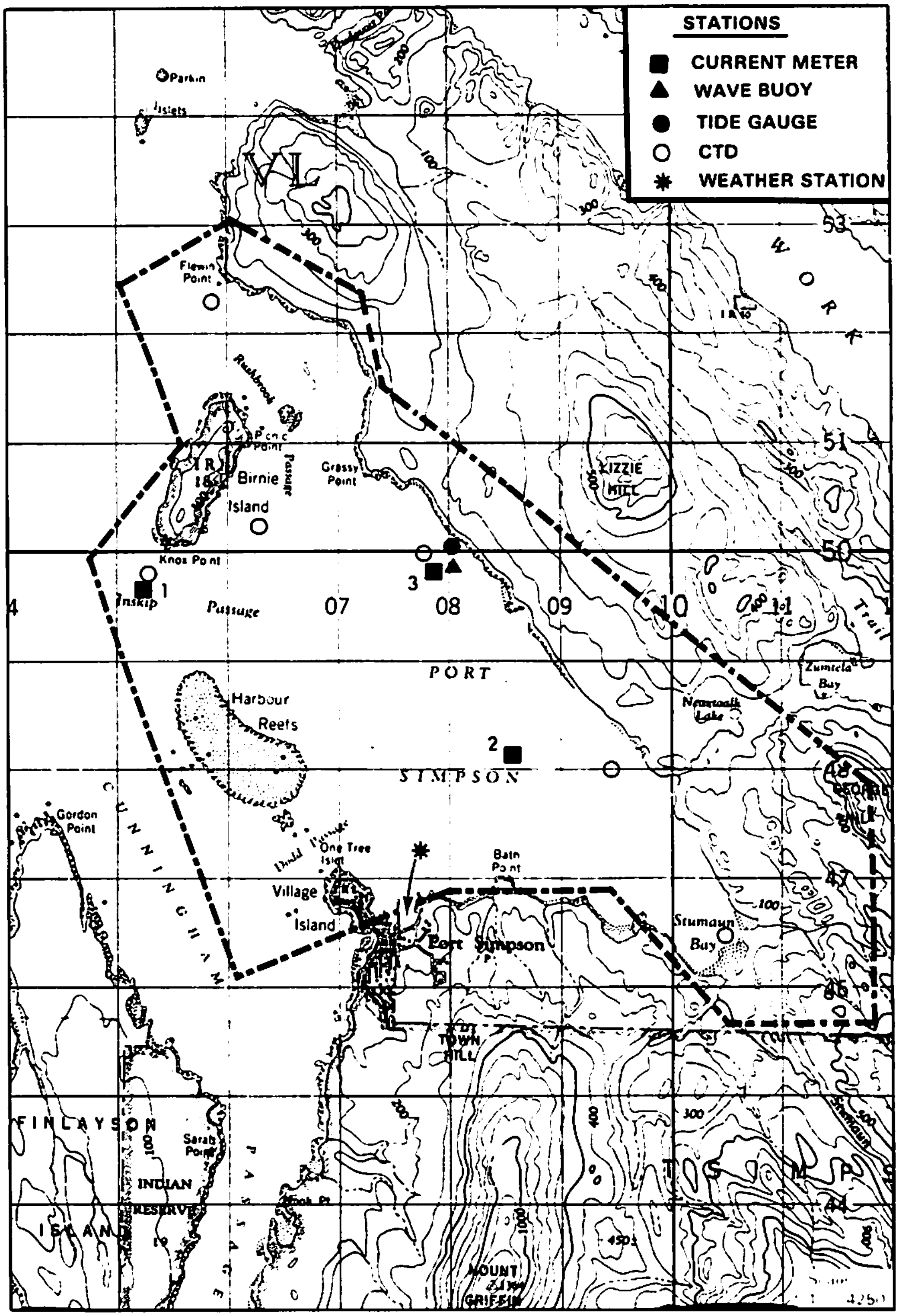

FIGURE S3-1.9 OCEANOGRAPHIC STUDY SITES OCCUPIED BY DOME PETROLEUM LIMITED IN 1981

The occurrence of most observed seiches (1902-1926) were not associated with times of tsunamis generated by earthquakes. It is suggested that another possible triggering mechanism for these resonant seiches is large atmospheric pressure drops or rises caused by the passing of weather systems.

The period 1902-1926 was a relatively quiet time for tsunamis generation off the B.C. coast, only 12 tsunamis were documented at Tofino and the largest was only 27 cm high. More recently, the 1960 Chilean earthquake and the 1964 Alaskan earthquake have generated much larger tsunamis, 126 cm and 240 cm high respectively at Tofino. However, the residents of Port Simpson recall no significant events or damage that may have coincided with these occurrences. In late March 1963, a large (3.7 to 5.5 m) unexplained wave reportedly entered Dixon Entrance on a high tide and caused significant damage at Langara Island, Wiah Point, and at Masset on Graham Island. It is thought this wave may have reached Port Simpson but the interviewed residents recall no major damage if it did.

Although the reviewed data base for this assessment was small and not very recent (1902-1926), the fact that there was a poor correlation during this period of seiche occurrences at Port Simpson with documented tsunamis arrivals at Tofino and that there were no observations recorded by local residents of significant damage during the more recent larger tsunamis which did cause damage to nearby Metlakatla and Prince Rupert (e.g. 1964 Alaskan earthquake) suggests that Port Simpson is probably more protected and less susceptible to significant damage from tsunamis than many of the northern B.C. coastal communities. Also, its natural period of resonance (approximately 20 to 24 minutes for Port Simpson Bay) is much less than the period observed for most incoming tsunamis off the B.C. Coast. An incoming tsunamis at or near the natural resonance period could cause resonance in a much larger wave form to occur (e.g. the tsunamis that occurred at Port Alberni after the 1964 Alaskan earthquake)."

Page 3.1-42 Section 3.1.4.2 Tides - delete last paragraph on page and replace with:

"An Aanderaa Instruments Ltd. model TG4A tide gauge was used for tide measurements. Water elevation is measured by a pressure sensor in the instrument and data recording is similar to that of the current meters. The TG4A used in this study has a resolution of 3×10^{-4} dbar (equivalent to about 3×10^{-4} m) and an accuracy of ± 0.01 dbar.

The tide gauge results were calculated with air pressure in decibars (measured at Prince Rupert) removed. A change of water elevation of 1 m results in a pressure change of about 1 dbar in sea water. The tide is of a mixed semi-diurnal type with the maximum range of 7 m and a minimum range of 2 m between successive high and low waters. An examination of portions of the data has shown irregularities in the tidal signal that may be due to seiches. The natural seiche period of Port Simpson appears to be about 20 to 24 minutes based on historical data. The sampling rate of the tide gauge is capable of detecting variations of this period but such a signal would not be well resolved.

An harmonic analysis was performed on the measured tidal data. A comparison of the tides measured near the proposed docksite with the historical results from the Port Simpson townsite is given in Table s3.1-1. The limits were chosen due to the lower statistical reliability of results outside these limits as a result of the background noise level and record length of the time series. The results indicate there is less scatter in the amplitudes than in the phases. This can be attributed to the fact that measurements of tide over approximately one month do not give as reliable a measure of phase as those from longer data records such as the 1902 to 1926 tidal results for Port Simpson from Fisheries and Oceans. As a result, the best fit line through the points does not pass exactly through the origin. However allowing for the scatter of the data, there is a one-to-one correspondence of both amplitude and phase of the constituents calculated from the observations near the docksite with the historical results for Port Simpson. Port Simpson is a secondary tidal port referenced to Prince Rupert. Hence the above results shown that for predictive purposes, the tides at the docksite can be derived from the Prince Rupert tide tables."

TABLE s3.1-1 Port Simpson Tidal Constituents

Name	Measured at Docksite* Amplitude (m)	Measured at Docksite* Greenwich Phase (0)	Historical Results from Port Simpson** Amplitude (m)	Historical Results from Port Simpson** Greenwich Phase (0)
ZO	3.72	0	3.69	0
MSF	.04	76	.02	178
2Q1	.03	207	-	-
Q1	.06	227	.05	237
O1	.31	241	.30	243
NO1	.02	273	-	-
P1	.16	265	.16	256
K1	.47	258	.51	259
J1	.03	294	.03	277
OO1	.02	285	-	-
EPS2	.02	232	-	-
MU2	.07	236	.04	232
N2	.43	236	.37	243
M2	1.84	265	1.86	267
L2	.06	280	.05	297
S2	.52	299	.61	299
K2	.14	322	.17	289
ETA2	.02	321	-	-
MO3	.01	88	.01	328
M3	.02	334	.02	326
SK3	.04	109	-	-

* Only constituents with amplitudes $\geq$0.01 m are included in this comparison.

** Tidal results from 1902 to 1926 provided by Tides and Currents Group, Institute of Ocean Sciences, Sidney, B.C.

Page 3.1-45 Section 3.1.2.5 Currents - delete the second paragraph and replace with:

Current Meter Results

Four Aanderaa RCM 4 current meters were placed in Port Simpson Bay at the three locations shown in Figure s3-1.9 and obtained data over the period:

Station	Instrument Depth (m)	Date (GMT) Installed	Date (GMT) Recovered	Days of Data
1	6	2-5-81	2-6-81	31.6
2	6	2-5-81	2-6-81	31.5
3	7	2-5-81	2-6-81	31.0
3	26	2-5-81	2-6-81	31.0

Note: All depths are relative to lowest low water.

Table s3.1-2 summarizes the current meter statistics. In general the highest currents were in the near surface measurements and the smallest at 26 m in the deeper water. Velocities in Inskip Passage are greater than in Port Simpson Bay although the highest observed speed occurred at Station 2 in the middle of the bay. The largest mean velocity magnitude was observed at 26 m at Station 3. Examination of progressive vector diagrams shows that although the speeds were the smallest at this recording current meter (RCM), the direction of the current was more consistently in one direction, resulting in a larger mean velocity magnitude. This also illustrates the difference between the mean of the scalar speed and the vector velocity.

The Inskip Passage RCM shows the second largest mean velocity magnitude. The mean flow was outward i.e. to the southwest. This may be a reflection of the estuarine circulation which is a density driven circulation where brackish surface water (due to freshwater input to a body of water) moves seaward and deeper saline water flows into the inlet. The major freshwater contribution to the estuarine environment in Port Simpson Bay is from the discharge of the Skeena and Nass Rivers. The freshwater discharge from Stumaun Creek represents about 0.1% of the semi-diurnal tidal exchange. The mean outflow may also be the result of wind effects. Tidally induced circulation does not appear to be a major factor since periods of relatively small mean flow sometimes coincided with a large tidal range. It appears that the mean velocity magnitude over 5 days at Station 3 at 26 m, (near the dock site) can vary by a factor of 4 over the month of data collected.

Table s3.1-2 Current Meter Statistics

Station	Depth (m)	Mean Speed (cm/s)	Std.Dev. (cm/s)	Mean Mag. (cm/s)	Veloc. Direct. (°T)	Max Speed (cm/s)	Direct. (°T)	% of Observ- ations <5 cm/s
1	6	8.5	4.4	1.7	234	22.8	306	23.7
2	6	4.9	2.9	0.7	093	29.2	122	58.8
3	7	4.9	3.0	0.5	073	22.8	126	60.9
3	26	3.4	2.5	2.4	327	14.7	324	76.8

Current Follower Drogues

Four tracking sessions, three of which covered complete tidal cycles (25 hours) were conducted in Port Simpson Bay as:

Tracking Session	Start (GMT)	Finish (GMT)	Predominant Wind
1	2330 24 May	0200 26 May	light, north-westerly
2	1616 27 May	1859 28 May	light, north-westerly
3	1742 30 May	0252 31 May	moderate, southwesterly
4	1508 31 May	1745 1 June	light, south-westerly

Notes: 1) Winds were measured at the meteorological station installed at the government breakwater at Port Simpson

2) Mean hourly wind speeds never exceeded 6 m/s during the tracking sessions.

The basic design of the drogues used in the study incorporated a sail or drag element 3 m wide by 2 m deep and constructed of Polyweave, a strong flexible fabric. This design has been shown to align itself perpendicular to the flow after travelling two or three times its own length and thereafter follow the current to within 10°. For surface drogues the wooden crosspiece sewn into the top of the sail was hooked to the surface float and the reinforcing rod at the bottom hooked to the base of the lower aluminium pole. In the case of deep drogues 20 m of braided nylon cord was attached to the wooden crosspiece and the other end passed through the snap hook at the bottom of the aluminium pole and attached to the surface float. With this arrangement the surface drogues followed the flow between 0 and 2 m depth and the deep drogues between 20 and 22 m depth. For these drogues, the effect of wind drag on the drogue is small at low wind speeds (less than 5 m/s) and is the greatest for a drogue in a vertically homogeneous, horizontal current. For the worst case the error is calculated to be 0.4 cm/s for a

1 m/s wind and 2 cm/s for a 5 m/s wind (Buckley, 1977). The usual presence of a vertical shear in the current reduces the wind induced error.

A 33 cm radar reflector was mounted at the top of each unit. A strobe light was attached below the reflector to aid in identification during night operations. Deployment and recovery of the drogues is a relatively simple affair and was undertaken from two small vessels, a herring skiff and a 4 m runabout.

The radar unit used to track the drogues was a Decca 202 aboard an 11 m fishing vessel. This unit was used on a range of 3 nautical miles (5.6 km) for most of the study. Specified range accuracy was within 1.5% of maximum scale (approx. 0.08 km over a 5.6 km maximum scale) and bearing accuracy within approximately 2°. The error associated with reading the range from the radar unit was ±0.05 km.

The data acquired are Lagrangian measurements i.e. the drogues move with the water and the distance over time is measured to calculate velocity as opposed to measuring the water velocity at a point. The deep water drogues (20 to 22 m depth) showed generally lower velocities than the surface drogues. The highest observed deep water speed was about 12 cm/s with most velocities less than 10 cm/s. Average velocities were in the 1 to 3 cm/s range. A clockwise eddy was observed east of Birnie Island in session 1. There appears to be a tendency to counter-clockwise circulation in the central portion of the Port Simpson Bay basin. This result from the deep drogues is consistent with the measurements of the Station 3 deep current meter near the dock site. The speed observed in the deep drogues near the dock site was small with a mean speed of 3.3 cm/s and a maximum of 4.3 cm/s.

Buckley, J.R. The Currents, Winds and Tides of Northern Howe Sound, University of B.C., Ph.D. Thesis 1977.

Nearly all the deep drogues show the effects of the tide in their motions. This was confirmed by the in-situ measurements of deeper currents at the moored current meter near the dock site. However, there were some exceptions. On 27/28 May a drogue showed no tidal influence in its movement except near low water.

The near-surface drogues (0 to 2 m) provide more information but there is less consistency from day to day. Session 1 (24-26 May) gave results that were easy to interpret. The circulation in the central region of the bay was a counter-clockwise gyre with velocities ranging from less than 1 cm/s to about 30 cm/s. Frequent observations were made of flotsam accumulation near the centre of the bay, further confirming the existence of the gyre. During this tracking sessions winds were light and variable from the northwest quadrant. Some drogues moved out of the bay through Inskip Passage and Dodd Pass. One drogue left through Inskip Passage on flood tide. The general motion near the dock site was to the northwest, parallel to the shore.

During the second session (27-28 May) the wind was light, switching in direction from west and northwest to easterly for the last half. Surface drogues were again observed leaving the bay, through Rushbrook Passage on the ebb and through Inskip Passage on the flood. Aside from this, the main tidal influence appears to be in the higher speeds on the first flood cycle. The counter-clockwise circulation of the first tracking session was not in evidence. Instead there was a general flow to the southeast into Stumaun Bay during the first half of the session followed by general west or northwesterly flow in the second half. This correlates well with the observed change in wind direction. Near the proposed dock site both northwesterly and southeasterly flows were observed. During the first half of the session a drogue moved slowly northwestward from near the dock site and then early in the second half (on an ebb tide) it picked up speed and went out through Rushbrook Passage. A counterclockwise eddy was found east of Birnie Island. Observed velocities range from less than 1 cm/s to 17 cm/s during the session.

The results from the third tracking session (30 May) are the easiest to interpret. The strongest wind of all the sessions, about 5 m/s from the south-southwest was observed. In this session, the circulation was examined through Rushbrook Passage. Observed velocities ranged from less than 1 cm/s to 29 cm/s. A northerly set was frequently noted in Cunningham Passage. Here it appears that the southerly wind causes a generally northerly surface flow except in Port Simpson Bay itself. A clockwise circulation is probably set up around Birnie Island leading to an inflow through Rushbrook Passage. There appear to be some localized eddies set up by the reefs in Rushbrook Passage.

The fourth and final tracking session (31 May/1 June) produced results somewhat similar to the second session. Winds during session 4 were about 3 m/s from the southwest decreasing to easterly at approximately 1 m/s in the last half. During the first half the surface motion was generally southeast towards Stumaun Bay. Towards the centre of the bay there appeared to be a tendency towards clockwise circulation. One drogue did move northwest into Rushbrook Passage during the ebb but it returned to the bay, eventually ending in a small counter-clockwise eddy east of Birnie Island at the end of the session. The only other sign of tidal effects was in the south part of the bay. Velocities during the first half were the highest observed in all tracking sessions, the fastest exceeding 40 cm/s. As the wind dropped and changed direction for the second part of the tracking session, drogue velocities decreased as well. The highest velocity was 23 cm/s during this time. There is evidence of tidal effects on the velocities both near Inskip Passage and along the shore between the dock site and Stumaun Bay. Generally, the wind had a greater influence than the tide, leading to southwest flow during the last part of the session. At this time one drogue left the bay through Dodd Pass on a flood tide.

In summary, near-surface current measurements at the proposed LNG dock site during May 1981 indicated mean speeds of about 5 cm/sec influenced by the wind and showing little preferred direction. The movement was observed both parallel and perpendicular to the shore for periods of several hours. Measurements at 26 m depth showed that deeper currents had a mean speed of about 3.5 cm/sec and a preferred direction to the northwest, forming part of the counter-clockwise circulation.

At mid-bay the surface velocities in May 1981 had a mean speed of about 5 cm/s and were generally less than 10 cm/s. Although the mean direction was eastward, the current can set in any direction. The set was both parallel to shore and perpendicular to the shore for periods of several hours. At times of low winds there appeared to be a preferred counter-clockwise surface circulation in the mid-bay area but with increasing winds the movement of surface water reflected the direction of the wind. The circulation of deep water in the bay also appeared to be slowly counter-clockwise."

Page 3.1-50 Salinity, Temperature, Density and Dissolved Oxygen, following the last paragraph please add:

"The conductivity/temperature/depth (CTD) probe employed in this study was an Applied Microsystems Ltd. CTD-12 instrument. The instrument was operated in the low resolution (10 bit) mode of recording which gives resolutions of t = 0.03 C°, S = 0.07 o/oo and p = 0.2 dbar. Sensor accuracy is ±0.01C°, ±0.03 o/oo and ±1 dbar (about ± 0.2 m).

A review of the seasonal CTD data indicates that Port Simpson Bay is a well-defined two layer estuarine system during the spring, summer and fall. The brackish surface layer is about 10 m thick and separated by a strong halocline and thermocline from the deeper more saline oceanic waters. The relatively strong gradient between the two layers effectively isolates the deeper water in Port Simpson Bay from direct wind effects.

From May through August, 1981, the surface layer in Port Simpson Bay showed a general warming trend due to solar heating. Surface water temperature increased from about 11 to 14°C. Surface salinities were lowest in the May-June period, in some cases less than 20 o/oo. Vertical stratification, especially related to salinity, was strongest in May-June. A strong halocline and thermocline were located at the 6 to 10 m depth. By August a more gradual gradient was observed extending to depths of about 40 m. Also, the underlying water mass in August (below approximately 40 m) had cooled by over 0.5°C suggesting an influx of cooler, more saline water at depth.

During the winter sampling months, the salinity and temperature stratification was less evident and Port Simpson Bay was relatively well-mixed. The November CTD profiles showed a total salinity variation throughout the column of only 2-4 o/oo and the January profiles, 1 o/oo. This may be compared to summer variations of 6-9 o/oo. The temperature gradients in November and January also showed a thermal inversion in Port Simpson Bay, i.e., a shallow layer of cool water overlaying a warmer, slightly more saline water at depth. The surface layer cooling is attributed to the rapid decline in solar radiation through autumn and a resulting loss of heat from the surface layer to the atmosphere.

The water temperatures measured at the tide gauge shows some interesting features. First there is a small increase in daily mean temperature from the start to the end of the data record. This is presumably a reflection of the seasonal heating of the upper water column. A more obvious feature is the change of temperature on two time scales; that is, over several days and over half a day. The major variations at time scales of less than a day are associated with the tide, warm temperatures coinciding with low tide and cold temperatures with high tide. This is explained by the fact that the waters in Port Simpson Bay form a two layer system; the surface or upper layer floats on a denser lower layer moving up and down with the tide. An instrument at a fixed depth relative to the bottom and near the interface between the two layers, will see relatively large and regular variations in temperature or salinity as the tide moves the water level and thus the interface up and down.

The large and less regular temperature variations (over periods of several days) are likely associated with weather events through either wind inducing mixing of the upper water column or the advection of warmer water into the bay. The wind mixing produces a thicker, more uniform surface layer with salinity and temperature values between that of the deeper water and that of the surface layer prior to mixing. An example of this occurred around 9 May, 1981. Winds measured at Prince Rupert airport (the Port Simpson weather station had not yet been installed) picked up to 8 to 10 m/s (15 to 20 knots) for the southeast with higher gusts. The combination of a low tide and the deepening of the interface between the upper and lower layer resulted in an increase in temperature at the tide gauge depth. As the mixing continued, the addition of the cooler, more saline deep water resulted in a cooler, more saline upper layer and hence a decrease in measured temperature. This phenomena was also seen in the current meter data near the dock site. An intrusion of surface water with different temperature and/or salinity may also cause these changes. The Skeena and Nass rivers are the major local sources of fresh water (as described in Section 3.10.0).

The seasonal measurements of dissolved oxygen within and adjacent to Port Simpson Bay, indicate that surface waters at Port Simpson are saturated or supersaturated with dissolved oxygen throughout most of the year. The highest annual near-surface dissolved oxygen concentrations (up to 8.7 mL/L or 133% saturation) were found in May-June probably due to increased photosynthesis due to phytoplankton blooming that occurs at this time of year. The lowest dissolved oxygen concentrations were found near the bottom of Port Simpson Bay in August, 1981. The August near-surface waters were saturated with oxygen but, with depth, the concentrations decreased to near-bottom levels of 4.3 to 4.8 mL/L or 60 to 70 percent saturation. During winter months the concentration of dissolved oxygen was more homogeneous with depth, ranging from 5.95 to 7.56 mL/L or 91.8 to 112.2% saturation.

Additional CTD information was gathered by the Environmental Protection Service on August 4 and 5, 1981 and will be reported in the regional program report 'Baseline Environmental Conditions in the Vicinity of a Proposed Liquid Natural Gas Plant at Port Simpson, B.C.' 1981 (in press)."

Page 3.2-1 Section 3.2.1.1. Please insert after the first paragraph:

"SSMO data are acquired from ships travelling along specific marine routes and as such have a bias toward records of fair weather. This is because vessels tend to avoid storms whenever possible by altering direction thus not being in a position to record 'worst case'.

Routing of ships using weather forecasts developed from satellite imagery groundtruthed to weather provided from ships in the area is a common practice. Companies such as Oceanroutes Inc. are in the business of providing ships with optimum weather routing."

Page 3.2-41 Section 3.2.2.7. Please add the following sentence to the last paragraph:

"Port Simpson Bay is more protected than the Digby Island (Prince Rupert) weather station, particularly from westerly winds. Port Simpson Bay is protected from the Westerlies by Dundas, Finlayson and Birnie Islands; from north winds by the hills along the spine of the Tsimpsean Peninsula (i.e., Lizzie Hill) and from the south by Mount Griffin south of the community of Port Simpson.

A meteorological station was located in the boat harbour in Port Simpson Bay (Figure s3-1.9) in May, 1981 which will provide on-site data for extreme wind calculations.

Wind

Simultaneous hourly measurements of wind speed and direction were recorded at Port Simpson and Prince Rupert during the period extending from May 14, 1981 to December 16, 1981. These data were correlated using the techniques developed by Walmsley and Bagg (1978) in order to improve the statistical reliability of the short-term data recorded at Port Simpson. Both short-term and estimated long-term annual frequency of wind at Port Simpson are depicted in Figure s3-2.1. Also shown for comparison are the corresponding short and long-term frequency distributions for Prince Rupert.

Topographic features at each station play a dominant role in dictating the prevailing wind patterns. A comparison of the mean monthly frequency of wind at Port Simpson (Table s3-2.1) and Prince Rupert (Table s3-2.2) together with a qualitative assessment of topographic effects suggests the following general patterns:

a. The wind is most frequently from the SE at Prince Rupert. During these occasions, the wind at Port Simpson will most likely be from SSE, S or SSW. This is due to the influence of the topography of the Tsimpsean Peninsula.

b. A wind from the west at Prince Rupert tends to exhibit a shift to a wind from WNW and NW at Port Simpson. This is likely due to the local influence of Village Island on the anemometer location at Port Simpson.

Walmsley, J.L. and D.L. Bagg. A Method of Correlating Wind Data Between Two Stations with Application to the Alberta Oil Sands, Atmos-Ocean 16(4), 333-347, (1978).

TABLE s3-2.1

Mean Monthly Wind Speed Frequency

STATION: Port Simpson, B.C.
PERIOD OF RECORD: May 14-December 16, 1981
HT. ABOVE GROUND: 10 meters

	WIND SPEED (km/hr)												
DIRECTION	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	≥51	TOTAL	MEAN SPEED
NNE	73	20	9	16	14	7	3	1	2	1	6	152	13.0
NE	95	94	53	16	3	0	0	0	0	0	0	261	8.5
ENE	189	309	46	5	0	0	0	0	0	0	0	549	7.3
E	313	180	14	1	1	0	0	0	0	0	0	509	5.6
ESE	242	130	24	4	0	0	0	0	0	0	0	400	5.9
SE	207	107	58	8	2	0	0	0	0	0	0	382	6.8
SSE	179	87	119	66	43	20	4	0	0	0	0	518	11.4
S	171	164	141	96	46	18	10	8	3	0	0	657	12.2
SSW	99	188	184	146	42	19	3	3	0	0	0	684	13.0
SW	39	78	79	36	11	3	0	0	0	0	0	246	11.7
WSW	39	28	16	3	1	0	0	0	0	0	0	87	7.7
W	35	44	7	1	2	0	0	0	0	0	0	89	7.4
WNW	64	78	33	1	0	0	0	0	0	0	0	176	7.7
NW	112	132	16	1	0	0	0	0	0	0	0	261	6.7
NNW	69	29	0	1	0	0	0	0	0	0	0	99	5.1
N	76	22	12	4	0	3	1	0	0	0	0	118	6.8
CALM												18	0.0
TOTAL	2002	1690	811	405	165	70	21	12	5	1	6	5206	9.1

TABLE s3-2.2

Mean Monthly Wind Speed Frequency

STATION: Prince Rupert, B.C.
PERIOD OF RECORD: May 14 - December 16, 1981
HT. ABOVE GROUND: 14 meters

	WIND SPEED (km/hr)												
DIRECTION	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	≥51	TOTAL	MEAN SPEED
NNE	23	20	4	0	0	0	0	0	0	0	0	47	6.5
NE	33	58	15	0	0	0	0	0	0	0	0	106	7.7
ENE	92	214	64	3	2	0	0	0	0	0	0	375	8.3
E	104	206	73	11	5	2	0	0	0	0	0	401	8.7
ESE	35	87	85	63	36	17	2	5	0	0	1	331	14.4
SE	47	100	197	179	174	123	42	30	8	7	1	908	19.7
SSE	35	77	85	88	84	57	27	31	8	7	4	503	20.2
S	49	126	84	35	23	8	6	6	0	2	0	339	12.7
SSW	54	66	35	4	10	9	0	0	0	0	0	178	10.0
SW	39	58	32	10	5	2	1	1	0	0	0	148	10.1
WSW	33	84	59	16	2	0	1	0	0	0	0	195	10.3
W	42	116	159	86	31	7	2	0	0	0	0	443	13.2
WNW	34	65	64	16	2	0	0	0	0	0	0	181	10.4
NW	24	42	39	16	2	1	0	0	0	0	0	124	10.8
NNW	28	37	33	14	3	1	0	0	0	0	0	116	10.4
N	22	33	22	0	0	0	0	0	0	0	0	77	8.5
CALM												663	0.0
TOTAL	694	1389	1050	541	379	227	81	73	16	16	6	5135	11.9

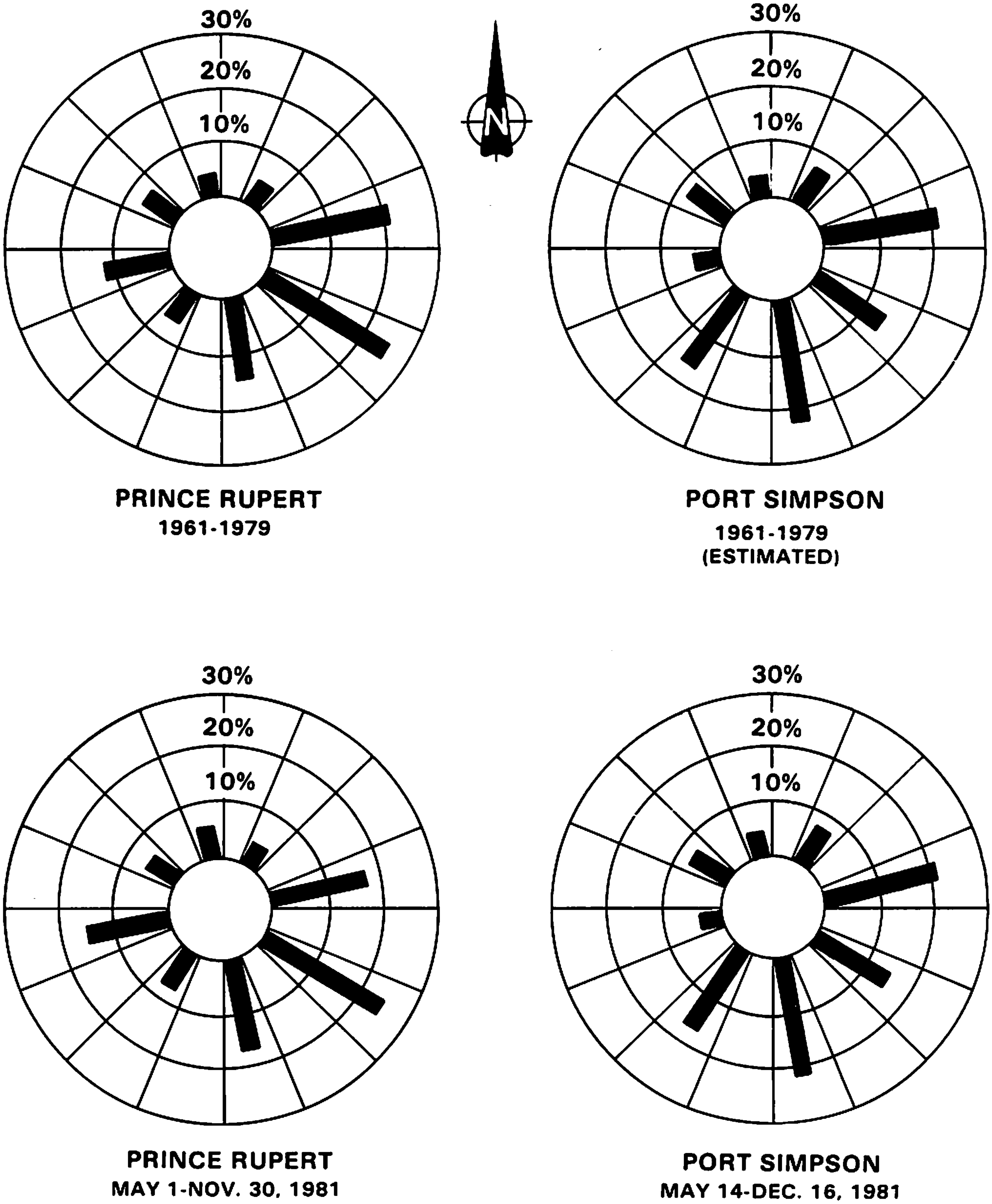

FIGURE S3-2.1 FREQUENCY OF WIND DIRECTIONS

c. A comparison of mean speeds (by direction) contained in Tables s3-2.1 and s3-2.2 indicate that on the average, speeds at Port Simpson are approximately 25 percent lower than those measured at Prince Rupert. Extreme hourly mean wind speeds and associated return periods for Port Simpson and Prince Rupert were estimated and are presented in Table s3-2.3.

TABLE s3-2.3
Extreme Hourly Mean Wind Speed (km/h)

	Return Period (years)		
	10	30	100
Prince Rupert	90	99	109
Port Simpson	74	81	89

Prevailing wind patterns within Port Simpson Bay will be somewhat different than those recorded at the anemometer station (Port Simpson). It is estimated that wind over the open water will be more frequent and stronger from the west, stronger from the south and south-southwest, and slightly more protected from the north wind.

Several different electronic malfunctions in the recording station resulted in the loss of all data for the period December 16, 1981 to July, 1982. A new electronic recorder and a mechanical back-up recorder have now been installed to gather wind data."

Page 3.3-22 Section 3.3.2.3 Regional Seismicity. Line 6 please replace "periodicity" with "return period".

Page 3.3-23 Paragraph 1, line 7, 8 and 9 please replace with:

"mainland, for example, the effects of a magnitude 8 event which occurred in 1949 in the Queen Charlottes (Milne et al, 1978) - the largest seismic event recorded in Canada."

Page 3.3-23 Paragraph 2 please replace line 3 with:

"The accumulated strain was released in a magnitude 7.6 event."

Page 3.3-23 Paragraph 2 please replace line 9, 10 and 11 with:

"sufficient strain available to generate an event of magnitude 7 or greater (Milne et al, 1978)."

Page 3.3-23 Paragraph 3 please replace with:

"One large seismic event was thought to have occurred close to the mainland, on the eastern side of Hecate Strait south of Banks Island in 1929 (Milne et al, 1978). The earthquake had a magnitude of 7 and generated a localized tsunamis which affected parts of Hecate Strait (Slaney, 1973). The location of this earthquake has recently been revised to the Queen Charlotte Fault region (Basham, pers. comm. 1982)."

Page 3.3-24 Section 3.3.2.4 Seismic Response of Surficial Deposits, please replace line 1 and 2 with:

"Seismic activity can have a considerable effect on the internal integrity and stability of surficial ...".

Page 3.3-25 Please replace paragraph 3 with:

"Certain surficial deposits could be severely affected by seismic events (Maynard, 1979). Loose or low density granular material including alluvial deposits, recent fill and organic deposits are likely to experience higher seismic intensities. Loose fine sands and soft silts and clays with high water table conditions and organic deposits are susceptible to liquefaction. Unstable and potentially unstable slopes could fail during seismic events."

Page 3.3-25 Please replace remainder of Section 3.3.2.4 and 3.3-26 with:

"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 (Clague, 1978). The failure zone occurs at the bedrock-soil mantle interface and can be initiated by heavy precipitation. Such failures could be triggered by large seismic events (Alley and Thomson, 1978). 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, clays and organic deposits are liable to liquefaction during seismic events and therefore are not good foundation materials.

The influence of site conditions on seismic intensities has been recognized in a number of studies on microzonation (for example, Seed and Schnabel, 1972). In Canada, the only systematic attempt at microzonation has been a recommendation that an amplification factor of 1.5 be applied to highly compressible surficial deposits (Milne & Rogers, 1972; Canada, National Building Code, 1980).

The National Building Code recommends 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). A factor of 1.3 should be applied to such deposits with a depth of less than 15 m, and to compact coarse-grained sediments and stiff fine-grained deposits with a depth greater than 15 m. Recently, however, it has been suggested that acceleration values for surficial deposits should be increased by a factor of 2 (Weichert, 1980 pers. comm.)."

Page 3.3-34 Section 3.3.3.3 Bedrock Geology. Third line, please replace "Quantities" with "Quartzites".

Page 3.3.-37 Please replace paragraphs 2 and 3 and paragraph 1 on page 3.3-38 with:

"The data in Table 3-3.3 are based on a statistical analysis of recorded seismic events, which is equivalent to the statistical analysis used to derive the 1970 seismic zoning map of Canada. It is emphasized that these data are presented only in the context of site geology and regional tectonics, and there is no intent that these replace site specific engineering investigations. The seismic zoning map (Canada, National Building Code, 1980) is based on accelerations with a return period of 100 years. This statistical analysis may not be appropriate for the lower exceedence probabilities (return periods of 475 years or 10,000 years) which may be required for the design of LNG facilities (Golder Associates, 1981).

The 100 year return period acceleration for Grassy Point is computed as 8.2%g (Table 3-3.3) which corresponds to an intensity of VII on the Modified Mercalli scale. The acceleration values are for firm or compact soil or bedrock. Other surficial deposits may alter the values by at least one unit of intensity.

Grassy Point has experienced a peak acceleration of 7%g which corresponds to an intensity of VII on the Modified Mercalli Scale. An event of intensity VII 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.'

This event was caused by the magnitude 8.0 Queen Charlotte Islands earthquake of 1949. An event of this intensity would be approximately equivalent to an event of magnitude 5.7 located at the site (Holmes, 1965, cited by Alley and Thomson, 1978)."

Page 3.3-40 Please add the following paragraph after line 5:

"Dome has retained a recognized seismic experienced consulting firm and is presently working with the federal Earth Physics Branch of the Division of Seismology and Geothermal Studies, Department of Energy, Mines and Resources; to assure that the design of the facilities comply fully with National Building Code and CSA Z276-1981."

Page 3.3-41 Section 3.3.3.6 Seismic Response of Surficial Deposits, please add to the end of line 3 "(Seed and Schnabel, 1972; Maynard, 1979)."

Page 3.3-41 Paragraph 1 second sentence, please replace with: "Schist bedrock, however, could be more susceptible to failure and fracture than other bedrock types."

Page 3.3-41 Paragraph 4, please insert the following at the beginning of the third sentence "The material should be removed or ...".

Page 3.3-42 Please replace second sentence with "Alluvial deposits are of limited extent in the area of the site".

Page 3.3-42 Fourth paragraph, third line, please replace "solium" with "solum".

Page 3.3-47 References, please insert after fifth reference:

"Basham, P. W. (1982), Personal Communication, Earth Physics Branch, Division of Seismology and Geothermal Studies, Ottawa. (Review of draft of 'Environmental Setting and Assessment for a Liquefied Natural Gas Terminal, Grassy Point, Port Simpson Bay, Northern British Columbia', December, 1982 Dome Petroleum Limited.)."

Please relocate last reference from page 3.3-48 after the Brew reference as "Canada, National Building Code ...".

Page 3.3-48 Please insert after Gabrielse reference:

"Golder Associates (1981), 'Tentative Seismic Report Regarding OBE and SSE Design Accelerations for the proposed Grassy Point LNG Terminal, British Columbia', prepared for Dome Petroleum Limited, April, 1981.

Golder Associates (1982), 'Report on Seismic Analysis for Proposed LNG Site Grassy Point, British Columbia Supplemental Investigation to Report of April, 1981', June, 1982."

Page 3.3-48 Please insert after Johnson reference:

"Maynard, D. (1979), 'Terrain Capability for Residential Settlements: Background Report', British Columbia Ministry of Environment, Resource Analysis Branch."

Milne, W. G. and G. C. Rogers (1972), 'Evaluation of Earthquake Risk in Canada'. Proceedings of the International Conference on Microzonation for Safer Construction, Research and Application, Seattle, Washington, p.217-230.

Page 3.3-49 After Rogers reference please insert the following two references:

"Seed, H. B. and P. B. Schnabel (1972), 'Soil and Geologic Effects on Site Response during Earthquakes'. Proceedings of the International Conference on Microzonation for Safer Construction, Research and Application, Seattle, Washington, p.61-86.", and

"Slaney, F. F. & Company Ltd. (1973) 'Preliminary Environmental Effect Assessment: Superport Development, Prince Rupert Region'. Department of the Environment Ottawa."

Page 3.4-3 3.4.1.1 Salmon, please replace line 11, 12 and 13 with:

"periods. While some species leave their freshwater environments soon after hatching (chum, pink), other species (coho, sockeye, chinook) remain in freshwater to rear for up to one year or longer and enter the sea as juvenile fish."

Page 3.4-18 Native Food Fishery, please add the following:

"Additional studies presently underway funded by Dome with Terms of Reference developed by the Port Simpson Band may provide a more indepth review of the volumes and types of fish taken by the Port Simpson Band for its own consumption."

Page 3.5-8 3.5.2.1 Intertidal and Shallow Subtidal Invertebrate Communities, please replace line 4 and 5 with:

"of substrate and wave exposure described in Section 3.3.3.10 The Coastline and Offshore Environment and on Map 3-3.3 Terrain and Nearshore Classification."

Page 3.5-14 Sand and Mud Substrates, paragraph 2, line 4 and 5, please replace with:

"been discussed earlier, and it generally supports a predictable group of invertebrate species."

Page 3.6-2 Please replace the second complete paragraph with:

"In general, phytoplankton communities are a good indicator of nutrient conditions in the water. Flagellates are indicative of relatively nutrient deficient waters, while diatoms increase in importance in Hecate Strait and Chatham Sound which are affected by large freshwater input from the Skeena and Nass Rivers; as well as in protected waters of the inside mainland coast (Fogg, Raymont)."

Page 3.6-8 Please correct the word "expecred" to "expected" on the second line above the heading 3.6.2.2 Zooplankton.

Page 3.8-20 Section 3.8.2.1 Aquatic Vegetation, please insert the following paragraph before the title "EMERGENT":

"Subsequent to the issue of this document in early 1982, personal communication with Haegele revealed that a very comprehensive report is in press that maps shoreline vegetation in Port Simpson Bay using infrared aerial photography ("Shoreline Vegetation on Herring Spawning Grounds in Chatham Sound, British Columbia" by C. W. Haegele and M. J. Hamey, June, 1982 Canadian Manuscript Report of Fisheries and Aquatic Sciences; in press)."

Page 3.9-26 Map 3-9.3 Marine Bird Aggregation, in the Legend for Number of Individuals, please correct 3 to read "3 51-100" from "3 351-100".

Page 3.9-27 Line 17 please change "wates" to "waters".

Page 3.9-27 Line 7 of Recreational Values please change "relative" to "relatively".

Page 3.9-48 Line 6 of Trophic Considerations, please change "whos" to "whose".

Page 3.9-48 Line 2 of Trophic Considerations, please change "mareine" to "marine".

Page 3.9-50 Line 10 please change "ithe" to "in the".

Page 3.9-50 Line 20 please change "benthis" to "benthic".

Page 3.10-1 3.10.1 Marine Approaches, paragraph 2, please replace second sentence with:

"As recorded over a 36 year period at Usk (150 km upstream), the average mean monthly flow is 919 m^3/sec (Water Survey of Canada, 1979) ranging from a minimum of 51.8 m^3/sec to over 9340 m^3/sec. Typical and 1975 maximum flow year hydrographs are shown in Figures 3.10.1 and 3.10.2 (NEAT, 1975)."

Page 3.10-5 Please insert after the first sentence:

"The average mean monthly flow is 788 m^3/sec (Water Survey of Canada, 1979) ranging from a minimum of 24.4 m^3/sec to over 9460 m^3/sec."

Page 3.10-13 Please modify Table 3.10.1 as follows:

"A1	Plant using sea or fresh water for once-through cooling.	337,000 l/min	350,000 l/min
A2	Plant using fresh water for cooling tower makeup.	24,600 l/min	25,550 l/min"

and insert the following paragraph immediately after Table 3.10.1:

"The variation in once-through cooling water use is a result of the increased plant throughput. The variation in the water requirement for cooling tower makeup includes evaporation makeup. The 7,600 l/min values in the December, 1981 document are approximate blowdown volumes that would be discharged to Port Simpson Bay."

Page 3.10-13 Please replace the last sentence of section 3.10.3 with:

"A specific volume of water in the freshwater tank will be dedicated to the fire water system. This system provides cooling and deluge water to reduce the hazard from thermal radiation in the event of a fire and to control and extinguish any fires that can be controlled with water.

In addition, seawater deluge and sprinkler systems will protect the loading arms, exposed compressor building exteriors, vulnerable piping to the LNG tanks, the LNG tanks themselves, the under deck structure of the jetty and the ethylene, propane, diesel and bunker tanks against thermal radiation."

Page 3.10-29 Please add the following paragraph at the end of the page: "Water and sediment chemical analysis for dissolved nutrients and heavy metals respectively were collected by the federal Environmental Protection Service in August of 1981 and are reported in the regional program report 'Baseline Environmental Conditions in the Vicinity of a Proposed Liquid Natural Gas Plant at Port Simpson, B.C.' 1981 (in press)."

Page 3.10-30 Table 3.10-2, please correct "Snifates" to "sulphates" the fourth parameter under Dissolved Anions.

Page 3.10-31 Please add the reference "Water Survey of Canada, 1979. Historical Stream Flow Summary, British Columbia. Canada Department of Environment. Inland Waters Directorate".

Page 3.11-1 3.11.1.2 Development Consideration, please delete and replace with "3.11.1.2 Heritage Resource Impact Assessment.

In April of 1982 a Stage 2 Heritage Resource detailed impact assessment of the proposed Grassy Point Liquefied Natural Gas Project site was undertaken by ARESCO Ltd. (Heritage Conservation Approval M.O. 1982-5). The study concentrated on site GdTo23 but included a survey along the length of the shoreline of the proposed project site. The following is taken from the report:

'7.0 RESULTS

The survey of the shoreline along the length of the proposed plant site resulted in the discovery of no additional sites. However, an isolated find consisting of a grooved granite net sinker was collected 400 m southeast of GdTo23.

Survey of the inland area to the north and east of GdTo23 also resulted in the location of no additional sites. The area was found to be very rough in microtopography, containing isolated marsh areas unsuitable for occupation.

8.0 RECOMMENDATIONS

Site GdTo23 is a very small (ca. 24 m^2), previously disturbed historic shell midden that is considered to have low potential for further understanding of cultural utilization of Port Simpson Harbour. It is recommended, however, that if possible GdTo23 be avoided by the proposed development of the LNG plant site. If this is not feasible, it is suggested the proponent be allowed to proceed without further concern for the heritage resource. This is suggested in light of the nature of GdTo23 and the presence of larger, more intact sites nearby (Inglis 1974). Final decisions regarding the disposition of GdTo23 are, however, the responsibility of the Heritage Conservation Branch (ARESCO, 1982).'

The report was submitted to the Heritage Conservation Branch. The letter of concurrence regarding the report recommendations received from the Heritage Conservation Branch follows."

3.11.1.3 References, please add:

"ARESCO Ltd. 1982. Grassy Point LNG Plant Heritage Resource Impact Assessment Prepared for Dome Petroleum Limited (M.O. 1982-5)."

Province of British Columbia

Ministry of Provincial Secretary and Government Services

Heritage Conservation Branch
Parliament Buildings
Victoria
British Columbia
V8V 1X4

File 84.3

RECEIVED
MAY - 6 1982
ENVIRONMENTAL AFFAIRS

April 30, 1982

Mr. Gary A. Webster
Manager
Environmental Engineering
Dome Petroleum Ltd.
Box 200
Calgary, Alberta
T2P 2H8

Dear Sir:

Re: Proposed Grassy Point LNG Plant Site
Heritage Resources Investigations

Upon review of the above captioned study, please be advised the report satisfies our Stage II requirements. Further, our office is in agreement with the recommendations and as such will not require any additional research with respect to the proposed L.N.G. plant site at Grassy Point. We do wish to stress, however, ARESCO Ltd.'s recommendation on page 6 that, if possible, GdTo 23 be avoided. This request is in light of the telephone conversation March 25 between Mr. Apland of this office and yourself, whereby it was noted that any sites along the coastline could be avoided, since the major exploration and possible future construction activities will be primarily located well back from the coast. This will not be a requirement, however, given the apparent low significance of this site.

In accepting the study results, however, I do have the following comment related to the terms and conditions associated with the Ministerial authorization. On page 4, it is stated that "the area of the project away from the shoreline was noted to be densely vegetated and poorly drained. Thus, the field approach was modified from the proposed method of systematic transects to a more judgemental approach." Since ARESCO Ltd. undertook the Stage I overview of this plant site, we assumed that they were aware of the ground conditions prior to submission of their proposal. Further, Mr. Apland informs me that during his conversation with you, the marshy and heavy forest terrain conditions were noted, and that this was subsequently discussed with Mr. Wilson. We have no problem accepting that a

...2/

judgemental approach is justified given those conditions. However, we also feel that ARESCO Ltd. had proposed a systematic transect approach with at least some knowledge of those conditions, and thus we do not completely accept the rationale for altering their methodology. The Ministerial Order (1982-MO-5) had stated that the field survey would be carried out in a manner consistent with ARESCO Ltd.'s proposal.

This satisfactorily concludes our review for approval-in-principle of the captioned project.

Sincerely,

S. Acheson

Steve Acheson
Research Officer
Impact Assessment & Protection Section

SA/bjk
bcgeu
cc: Ian Wilson
ARESCO Ltd.

4.00 SUPPLEMENT - ENVIRONMENTAL ASSESSMENT

Page 4.1-2 Section 4.1.1 Terminal Design and Siting Considerations subsection c., please replace the last sentence with:

"The topography of Barge Point results in a smaller area of intertidal disruption for service wharf construction than other potential locations within Port Simpson Bay. Barge Point does not appear to be as extensively utilized for herring spawning as areas to the northwest and southeast (pers. comm. C. Haegele, B. Huber)."

Page 4.1-3 Please replace line 7 through 11 with:

"The barge service wharf area at Barge Point has been re-evaluated since December, 1981. A revised design results in a 3.1 hectare (7.7 acres) (versus 6 hectares in an earlier design)."

Page 4.1-7 Air Emissions, paragraph 1 please delete sentence 2 and 3 and paragraph 2. Please add the following new paragraph after paragraph 1:

"The refrigeration compressors for the liquefied natural gas facility on Port Simpson Bay will be electrically driven rather than natural gas turbine driven as described in the December, 1981 document. As a result, air emissions at the Grassy Point site will be from small gas fired heaters that would meet the appropriate B.C. Waste Management Branch Objective and the federal Clean Air Act Ambient NO_2 Guideline values of 400 $\mu g/m^3$ (1 hour average), 200 $\mu g/m^3$ (24 hour average) and 100 $\mu g/m^3$ (1 year average)."

Page 4.1-9 Plant Cooling Water System, please replace paragraphs 1 through 3 with:

"The liquefied natural gas plant requires cooling of the compressed refrigerant. The proposed cooling system is a once-through, sea water system. This approach has been selected after consideration of other alternative cooling water systems.

The present design concept calls for a sea water intake located at the loading wharf. This intake structure will be screened and will have a low approach velocity to minimize the possibility of entraining fish. The sea water will be chlorinated to prevent fouling of the heat exchangers by marine organisms. The design heat duty will require up to 350 m^3/min of cooling water resulting in a temperature increase in the cooling water across the process of 11°C. After passing through the heat exchange system, the cooling water will be returned to an outfall/diffuser located outside of Birnie Island. The diffuser will be designed to dilute the cooling water so the ambient water temperature is not raised more than 0.5°C at 100 metres from the outfall.

The most significant environmental considerations in the cooling water system are:

1. potential for entrainment of aquatic organisms by the water intake;

2. potential effects of the impact of heat to the receiving environment;

3. potential effects of residual chlorine in the cooling water discharge.

COOLING WATER ALTERNATIVES

The alternatives to once through sea water cooling do not offer any advantages in environmental protection.

1. Once Through Fresh Water

Section 3.10.0 of the Environmental Setting and Assessment Document has assessed several nearby sources of fresh water as potential supply for the plant. Even the largest of these is inadequate to provide the volumes of water required for cooling.

If there was sufficient volume of fresh water, this approach would not eliminate the need for chlorination and would add the same heat load to the receiving waters.

2. Recycled Fresh Water System

By using cooling towers, the requirement for cooling water can be reduced to the amount needed to make up the evaporative losses across the tower and the volume of the blowdown (bleed-off) to control the build up of dissolved solids in the system. This volume is estimated at 24,600 litres/minute. The available water supply streams cannot provide this amount of water without over taxing their capability. The make up volume of 24,600 litres/minute would represent more than one half of the average theoretical yield of the largest nearby watershed, Georgetown Lake (See Table on page 3.10-26). Such an approach could seriously affect the viability of the watershed.

Although the volume is reduced by the use of cooling towers, the actual temperature of the blowdown would be greater than that of a once through system. As with other systems, chlorine disinfection and in this case other chemicals would be required to prevent fouling of tubes by plating out of dissolved cations such as calcium and growth of marine organisms.

3. Recycled Sea Water System

This approach has been considered although very little actual practical operating experience has been discovered with this concept. The potential advantage would be a reduction in the volumes of sea water required. However, there are many problems that clearly outweigh the volumetric reduction. There would be significant operational problems with scaling and corrosion by using recycled sea water. Larger amounts of chemicals would be required to control biological growth. Lenduai-Lintner, et al (1978) have reported on the chemicals required in a sea water cooling tower to control corrosion. The complex combination of chemicals developed included polyphosphates, phosphates, zinc chloride, iron chelating and dispersing agents, sodium hypochlorite and an organosulfur biocide. The heat load to the receiving waters may be reduced but the chemicals added to the environment would increase significantly.

It is Dome's opinion that the most environmentally acceptable alternative is once through sea water cooling. Several design measures have been employed to minimize the environmental impacts of the cooling water system.

ENTRAINMENT

Pumping sea water through the process will result in entrainment and death of some marine organisms. The present design calls for coarse trash bars and travelling screens in front of the pump intakes. Under the worst conditions, the approach velocity across the face of the intake screens will not exceed 0.5 ft/second. This approach velocity is the value requested by Fisheries and Oceans in water intake design.

Non-mobile organisms that are smaller than the screen size will be entrained and pumped through the cooling system. Most of these entrained organisms will be killed.

Entrained organisms are exposed to mechanical stress, chlorination, and sudden temperature increase. A number of investigators have attempted to evaluate the survival rate of plankton passing through a cooling water system.

Marcy (1973) reported that most (95%) of the entrained larval and juvenile fish died before escaping the system; 80% of the death rate was attributed to mechanical stress and 20% to thermal shock.

Simpson and Dudaitas (1981) as well as Erickson and Foulk (1980) have also reported on the effects to plankton entrained in sea water cooling systems. They also found that most organisms are killed as they pass through the system.

The purpose of chlorination is to inhibit marine organisms from attaching themselves to the inside of the water piping or heat exchange surfaces or otherwise fouling the system. Therefore, we must conclude that most organisms entrained in the intake sea water will be killed by mechanical, thermal or chemical stress.

The environmental protection measures associated with the water intake are related to minimizing the number of entrained organisms. The intake structure will have a coarse screen to keep out large debris and large fish. Smaller fish will be screened by a self-cleaning screen. This should keep out all but the plankton and some larval stage fish. The intake will be located below the photic zone to further minimize the amount of plankton and larval stage fish that might be entrained.

TEMPERATURE EFFECTS

The cooling water discharge will be about 11°C warmer than the receiving water. This heat load must be assimilated by the marine environment without causing excessive impacts. The proposed system has been selected with that objective.

Common practice is to discharge cooling water near the low water mark and allow tidal flushing to dissipate the thermal energy by mixing. Environmental studies have shown the foreshore areas to be important fish habitat in the Port Simpson area, so the outfall location has been moved outside Birnie Island to take advantage of deeper, colder, well flushed waters. In this way the initial mixing is with colder water and the thermal plume will be further diluted as it rises toward the surface.

The initial design location of the diffuser was within Port Simpson Bay. However, current studies suggested there may not be sufficient flushing of the Bay to ensure the thermal load is adequately dissipated.

The design objective is to achieve a maximum 0.5°C rise above ambient at 100 metres of the outfall. The cooling water will be uniformly distributed by the diffuser to achieve at least a 25:1 dilution ratio. Detailed hydraulic calculations will be used for the final outfall and diffuser design once the layout and location are selected. However, the type of system envisaged will easily achieve the 25:1 dilution required to meet the receiving water criteria.

The effects of a thermal plume with a temperature gradient of 11°C to 0.5°C above ambient for a distance of 100 metres or less cannot be definitely stated. The temperature survey reported in the environmental report showed about a 1.0°C temperature difference from top to bottom of the water column (8.5 to 9.5°C). The annual surface water temperature variation is expected to be about 6°C (6.4 to 12.7°C at Triple Island).

Since the time of filing the environmental assessment with the TERMPOL application, additional oceanographic surveys have been undertaken.

Conductivity/temperature/depth (CTD) probes were run at five locations in Port Simpson Bay in May and June, 1981. Additional data has been collected to reflect seasonal variation as described in Section 3.1.0, Physical and Chemical Oceanography Supplement.

Over a 10-day period the station near the proposed dock showed at surface temperature variation of 3°C (10.5 to 13.6°C). Below 10 m the temperature is fairly uniform at 8.8°C.

The temperature rise above ambient of 0.5°C should have no effect on marine organisms since it is less than daily or spatial variations the organisms would encounter elsewhere. Even a temperature of 11°C above ambient would not cause mortality to adult fish unless the fish stayed in this part of the jet for an extended time. Table 4.2 summarizes the upper incipient lethal temperatures of the main species of concern (salmon and herring).

TABLE 4.2

THERMAL TOLERANCE IN FISH

SPECIES	STAGE	UPPER LT50 (depending on acclimation T)	ULTIMATE UPPER TEMP(°C)	REFERENCE
SALMONIDAE				
Oncorhynchus gorbuscha (pink salmon)	juvenile	21.2-23.9	23.9	Brett, 1952
Oncorhynchus keta (chum salmon)	juvenile	21.8-23.8	23.8	Brett, 1952
Oncorhynchus kisutch (coho salmon)	juvenile	22.9-25.0	25.0	Brett, 1952
	juvenile	23.2-23.5		Blahm and McConnell, 1970
	adult	25		Coutant, 1970
Oncorhynchus nerka (kokanee salmon)	juvenile	22.2-24.8	24.8	Brett, 1952
	underyearling	21.5-23.5		McConnell and Blahm, 1970
	yearling	23.5		McConnell and Blahm, 1970
Oncorhynchus tshawytscha (chinook)	juvenile	21.5-25.1	25.1	Brett, 1952
	juvenile	23.0-24.8		Blahm and McConnell, 1970
	"Jacks"	22		Coutant, 1970
	adult	21-22		Templeton and Coutant, 1970

CLUPIDAE

Pacific herring have been maintained at temperatures up to 20°C with no apparent detrimental effect (Hay, pers. comm.).

The placement of the outfall where there is good circulation will ensure that the thermal impact to the environment will be negligible.

RESIDUAL CHLORINE

Another environmental impact of the cooling water discharge is the effect of residual chlorine to marine organisms in the area of the discharge. This impact is believed to be well within acceptable limits.

Chlorine is widely used as a disinfectant in treatment of drinking water, domestic waste water and cooling water. In cooling water the purpose of disinfection is to prevent marine organisms from adhering to the heat exchanger surface. Presence of organisms would reduce the heat exchange capacity, increase pressure drop (i.e. pumping costs) and increase corrosion. It is also necessary to prevent fouling throughout the entire system to reduce corrosion or plugging. The usual practice is to add chlorine continuously at a concentration sufficient to prevent organisms from attaching to the surface of the piping. This generally requires about 0.5 ppm (mg/l) (compared with 1.0 or 2.0 ppm in drinking water where the objective is to disinfect the water).

The most common form of chlorine for this purpose is gaseous chlorine added directly to the inlet water. Dome has preferred to use sodium hypochlorite (NaOCl) for several reasons. It is safer since there is no danger of chlorine gas release. It can be manufactured on site (see Baur (1972) and Connolly (1975)) so there is no need to ship chlorine gas.

When hypochlorite (or chlorine) is added to water it reacts almost instantly to form hypochlorous acid (HOCl). Some of the chlorine reacts with other compounds in the water (ammonia, amines and some organics). The amount of chlorine consumed in these reactions is referred to as the "chlorine demand". Once the chlorine demand has been satisfied, the remaining chlorine stays in solution and is referred to as the free residual chlorine. The "residual" is what is available for disinfection. General practice is to add sufficient chlorine to satisfy the chlorine demand and to provide a residual to suit the desired purpose. In this case the desired residual will be established by operating experience but will likely be in the range of 0.25 to 0.5 ppm. The residual will be measured downstream from the point of injection, and before the heat exchangers, to allow mixing to occur.

The chemistry of chlorine in sea water is very complex. See for example; Hostgaard-Jensen, et al (1977); Richardson, et al (1981); Wong (1980); Haag (1981); Duursma & Parsi (1970). Chlorine in water disappears by many reactions and is affected by temperature, pH, light, bromide concentrations, organic content and ammonia compounds.

Hostgaard-Jensen et al (1977) also found the rate of chlorine decay was affected by dilution. As the residual chlorine was diluted, the rate of decay increased. The authors developed a mathematical model of chlorine decay in the discharge plume from four power stations. The model was verified by field measurements and found to underestimate the rate of decay. Their model predicted a reduction of residual chlorine from 1.0 to less than 0.05 ppm by the time the discharge was diluted by 5:1. The field measurements found that the chlorine residual had actually declined to less than 0.05 ppm at a dilution of 3:1 in the night and 2.3:1 in the day.

Mattice and Zittel (1976) attempted to define a threshold toxicity criteria for chlorinated cooling water discharges. They reviewed more than 100 studies of chlorine toxicity to fresh water and marine organisms. This data was interpreted to estimate the LC50: the concentration causing 50% mortality to the test organisms. The data was plotted as chlorine residual concentration versus time. Each data point was extrapolated to reflect zero mortality and a curve drawn to enclose all data. For marine organisms the acute toxicity threshold was 0.3 ppm. As the time from chlorination increased the acute toxicity threshold concentration declined to 0.02 ppm and then the curve levelled out. This reflected the chronic toxicity threshold at which any length of exposure showed no effect to the organism.

This approach seems to be a very credible concept, although extremely conservative in ensuring environmental protection. The interpretation is that if the chlorine residual at the point of discharge is 0.3 ppm and it is rapidly reduced by chemical decay and dilution to 0.02 ppm (this should occur at a dilution of approximately 5:1 which is one-fifth of the dulution proposed for Grassy Point) then essentially no organisms in the receiving waters would be killed.

In fact, adult fish exposed to 0.5 to 1.0 ppm for a short period of time would probably show no effect. The Mattice and Zittel study included plankton as well as adult fish and shows the smaller organisms to be more sensitive and that brief exposures cause an effect only at relative high concentrations; in the order of 1.0 ppm for 10 minutes.

Even accepting the conservative approach of Mattice and Zittel, there will be essentially no mortality to any organism as a result of residual chlorine in the cooling water. This environmental impact is considered to be negligible.

The use of other additives may be required occasionally and will be reviewed with the appropriate regulatory agencies prior to their use.

CONCLUSIONS

Considering the potential environmental impacts associated with the use of a once-through sea water cooling system:

1. Once-through sea water cooling is environmentally preferable to the use of fresh water for cooling or the use of a recycled sea water system.

2. The design of the intake system will minimize the extent of entrainment of marine organisms.

3. The outfall will be located outside of Birnie Island and will achieve adequate mixing to raise the receiving water temperature by no more than 0.5°C at 100 metres from the outfall.

4. The effects of the thermal discharge will not be significant to the receiving environment.

5. Sodium hypochlorite will be used as an anti-foulant and the effects of residual chlorine in the discharge will be negligable.

In order for Dome to confirm these conclusions, additional fisheries resource studies, reviewed and approved by the Department of Fisheries and Oceans, were commenced in mid-July to provide intake design information.

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Page 4.1-11 Hot Oil System, please replace sentence 1 and 2 with:

"The hot oil system is a system of providing heat to the feed gas, CO_2 stripper reboiler, process plant fuel gas continuously and to the derime heater on an as-needed basis. Dome has operated facilities such as this, for example at its Edmonton plant for many years without incurring a spill. It is anticipated that a hot oil system equivalent in size to the Edmonton system would be required at the LNG facility. The system in Edmonton contains 18.9 m^3 of oil including 11.3 m^3 of oil surge capacity (Esso 1156 or equivalent). The oil is heated to about 350°C and is circulated from a furnace by a small pipeline to the individual buildings. Should a pipeline break occur, the pump would stop pumping and in most cases the pipe is in an area where the oil would flow to a sump and be collected. It is difficult to foresee how a spill of this material would first be very large, and secondly ever reach the shore or the marine environment."

Page 4.1-12 Please insert the following two topics between <u>Storage of Bulk Fuel and Lubricants</u> and <u>Process and Potable Water</u>.

"<u>Ballast Water Discharge</u>

Ballast water is carried on board the carrier in separate tanks located between the inner and outer hulls. Depending upon weather conditions during the voyage, some or most of the ballast water can be discharged in Dixon entrance or Hecate Strait prior to the ship arriving in Port Simpson Bay, thus minimizing the amount of ballast water that would be discharged in Port Simpson Bay. It should be noted that ballast water had been carried in ships for many years and transported from area to area throughout the world without significant adverse effect.

Bilge Water Discharge

Bilge washing from LNG carriers is sent to storage tanks on board the carrier. These storage tanks are discharged well out to sea in compliance with IMO convention. Any oily residue in the storage tank is separated prior to discharge and retained in the sludge tank.

Sludge tanks are discharged and treated during their annual repairs, which would not be undertaken at Port Simpson Bay."

Page 4.1-14 Prince Rupert-Port Simpson Roadway, please add the following sentences:

"Dome is aware of the negative impact that increased human access as a result of a road would have on the seabirds that utilize the Big Bay area. It is Dome's preference to locate the road on the east side of Georgetown Lake, away from Big Bay."

Page 4.1-14 Please insert the following:

"Power Supply

The project will require construction and operation of a 230 or 287 kV powerline to bring electricity from the B.C. Hydro Prince Rupert substation to the plant site. Studies are being undertaken by B.C. Hydro on Dome's behalf to identify the route and minimize the environmental impact of the power supply."

Page 4.2-2 Section 4.2.2.1 Air Quality Operation, please delete sentences 1 and 2 and replace with "Natural gas fired heaters will emit as combustion products, low levels of oxides of nitrogen (NO_x).".

Page 4.3-4 Coastal Geomorphology, please delete the last paragraph as the LNG carriers can safely navigate Inskip Passage at all tides with the existing reef in the Passage as the maximum draft of the ships will be 11 metres (6 Fathoms).

Page 4.4-1 Vegetation a) Algal Communities, please delete the last sentence in Construction paragraph as blasting is not required.

Page 4.4-3 a) Algal Communities, Construction, please add the following after the second sentence:

"Studies were commenced in mid-July, 1982 to quantify the algal communities and their density at Barge Point. Advice provided from the Department of Fisheries and Oceans (Haegele, Huber) that Barge Point is probably the best place within Port Simpson Bay for fill to occur as herring spawning does not occur at Barge Point in as significant quantities or times as other areas within Port Simpson Bay."

Page 4.4-4 b) Vascular Plant Communities, please insert after the first sentence "Haegele observed little or no eelgrass on Barge Point."

Page 4.5-1 OCEANOGRAPHY 4.5.1.1 Physical Oceanography - Construction, please delete paragraphs one and two and replace with "Construction activities should not result in any affect on the physical oceanography of the marine approaches."

Page 4.5-3 — Operation, please add to the end of the second sentence in the first paragraph "at a distance of 100 m from the diffuser."

Page 4.6-9 — Section 4.6.2.1 b) Pacific Herring - Construction please replace the first line of the second paragraph with "Habitat alteration of about 3.1 hectares ...". Please replace the last two lines of the second paragraph with "... Simpson Bay affected by the service wharf will affect about 3.1 hectares of the habitat available for spawning in the Bay."

Page 4.6-17 — Operation please delete the first sentence and replace with "The diffusion of the once through cooling water outside Birnie Island may slightly increase the productivity of the plankton in the immediate vicinity of the diffuser."