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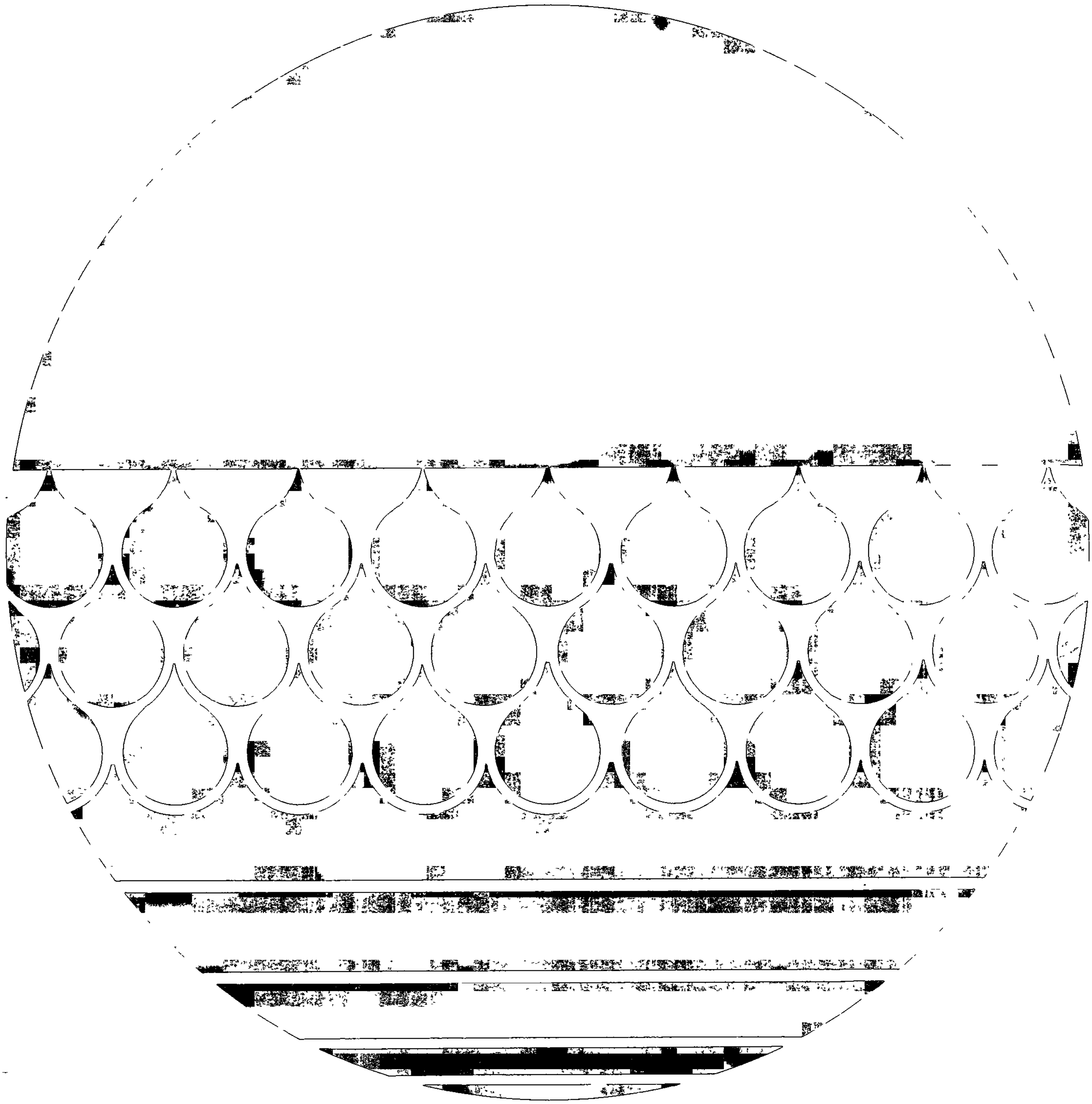
REVIEW OF THE ENVIRONMENTAL FORCES FOR THE DESIGN OF THE TINER POINT OIL TERMINAL

H.J.A. NEU AND P.E. VANDALL JR.

REPORT SERIES/BI-R-76-7/AUGUST 1976



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REVIEW OF THE ENVIRONMENTAL FORCES FOR THE DESIGN OF THE TINER POINT OIL TERMINAL

by

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SYNOPSIS

At the request of the Environmental Protection Service, the environmental conditions affecting the proposed Tiner Point Oil Terminal and the results of a model study for the design of the facility are reviewed and evaluated. It is concluded that the forces acting in this area, particularly those of currents and waves, are appreciably larger than those chosen for the design and operation of the wharf. Furthermore, the surging character of the currents, which make berthing difficult and even hazardous, have been completely overlooked in the design and model studies.

It follows that the proposed fixed wharf design carries with it a greater environmental risk from a large scale oil spill than does a 'soft' berth such as a single-point mooring.

SOMMAIRE

A la demande du Service de protection de l'environnement, on étudie et évalue les conditions du milieu qui influent sur le projet de terminal pétrolier de Tiner Point ainsi que les résultats d'une étude sur maquette portant sur la conception de l'installation. On conclut que les forces qui agissent dans cette région, particulièrement celles des courants et des vagues, sont considérablement plus importantes que celles prévues pour la conception et l'exploitation de l'embarcadère. De plus, les études de conception et les études sur maquette n'ont pas du tout tenu compte de la nature houleuse des courants qui rend le mouillage difficile, voire même dangereux.

Il s'ensuit que le modèle d'appontement fixe proposé risque plus de provoquer un déversement d'huile de vaste envergure qui endommagerait l'environnement qu'un appontement 'mou' tel un poste d'amarrage en un point unique.

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1.0 INTRODUCTION

The development of an oil terminal on the northern shore of the Bay of Fundy, west of Saint John, N.B. (Fig. 1 and 2), has been under discussion since 1971. The first of two proposals was referred to, variously, as Lorneville Superport, Canport, and Saint John Deep, and the second, more recent, is known as Tiner Point Oil Terminal. The Lorneville design was the subject of an environmental impact study which is reported in the Lorneville Impact Report (Neu, 1973). Environmental conclusions and recommendations discussed in the report are still valid today. The prime recommendation was that a single point mooring system should be chosen because this will allow a vessel to weather-vane into the prevailing environment. A fixed structure is unable to do this.

The present design for Tiner Pt., which is a reduced version of the original Lorneville plan, proposes a terminal which will handle ships in the range of 26,000 to 100,000 D.W.T. supplying Bunker C fuel oil to the nearby Colsen Cove power generating station. An estimated one to six arrivals of a tanker per month will be needed to adequately supply the plant.

For both proposals, the Bedford Institute of Oceanography was asked to act as an advisor on physical oceanographic problems and their implications.

2.0 GENERAL PRINCIPLES FOR SITE SELECTION

Traditionally, the prime function of harbours is to provide protection for ships from waves and currents. For this reason, with the exception of Canaport, the Irving Oil Co. facility near Saint John, all major Canadian oil terminals along the Atlantic coast are placed in sheltered waters, e.g. Halifax Harbour, Strait of Canso, Come By Chance and Long Harbour. In contrast, Tiner Pt. is located in an environment exposed to large tides, strong tidal currents, and all types of current surges and fluctuations which are common in the Bay of Fundy. The area is also open to ocean waves from the southwest, the direction from which the largest storms of the North Atlantic approach. It is obvious that before a decision is made to build a major oil unloading facility in such an area, all aspects of the environmental forces must be rigorously considered and steps taken in the design to minimize their effect. This is a point that the representative

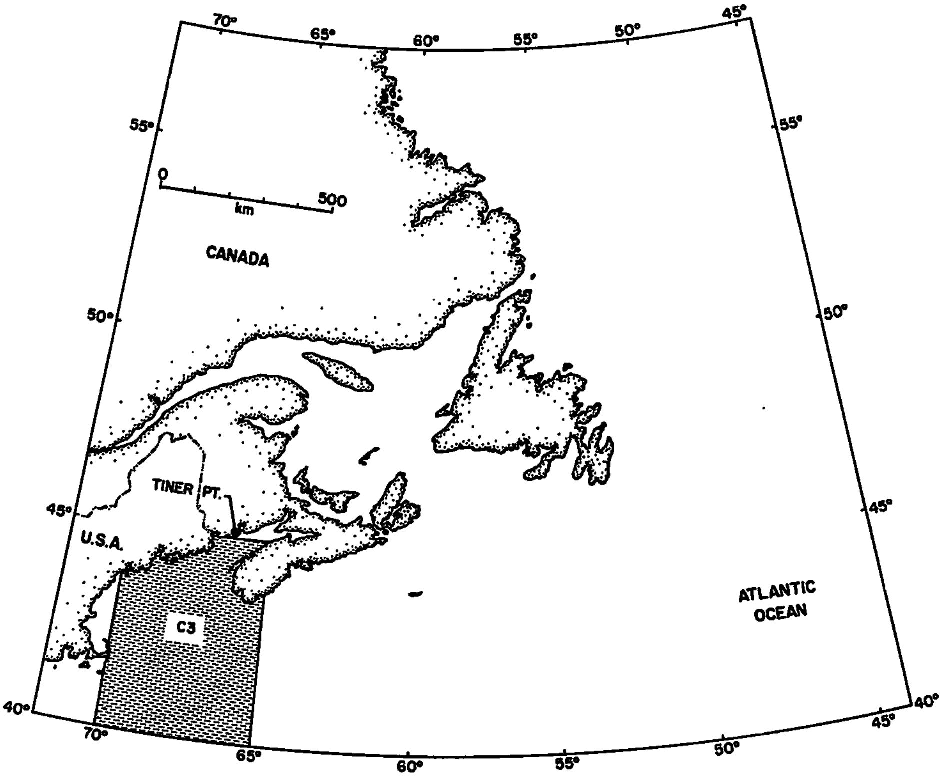


Figure 1. General Location Map

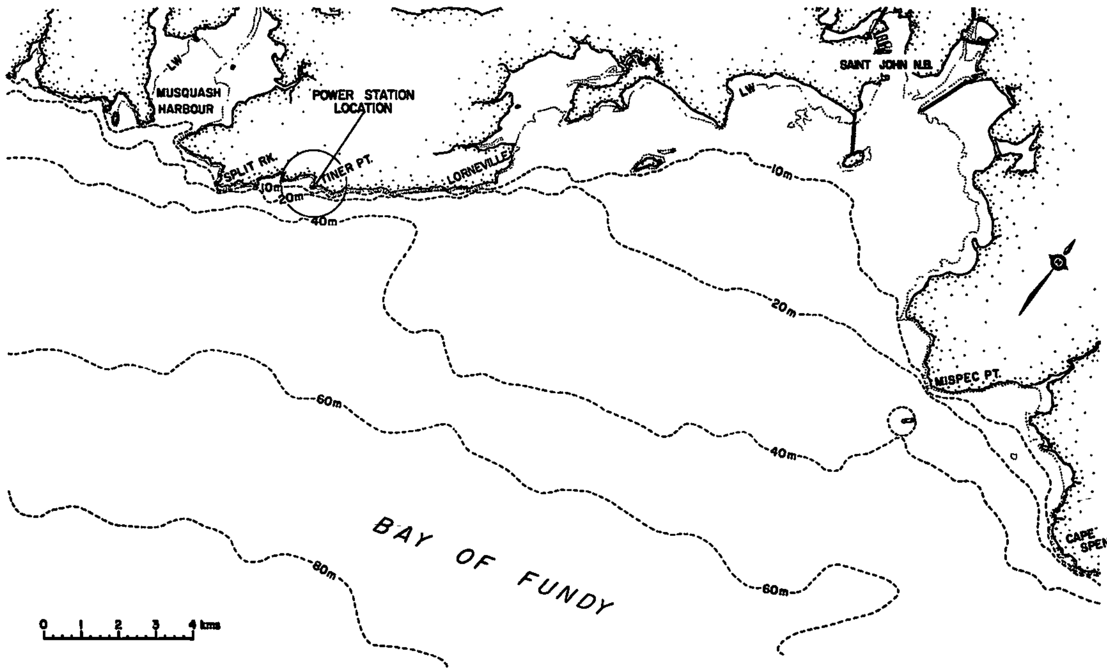


Figure 2. Location of Power Station and Loading Facilities

of BIO has stressed at every discussion on the subject.

3.0 ENVIRONMENTAL DESIGN FACTORS

The design of an oil terminal depends initially on three factors. These are:

(a) The structure and its survival for at least its planned lifetime,

(b) The safe navigation and docking of tankers at any required time, and

(c) The safe unloading of the cargo when the ship is tied up.

From an environmental point of view, (b) and (c) are of particular concern, because during these phases of operation the danger of an oil disaster exist.

Using reports and articles by various representatives of the consulting team of Eastern Designers-Swan Wooster, the following list of parameters for the design of the required facilities has been developed:

Parameter	100-year Value
Wave height	12.1 m
Tidal range	9.2 m
Wind-induced current	0.8 m/s (1.6 knots)
Fresh water current increase	0.6 m/s (1.2 knots)
Ebb current - surface	1.5 m/s (3 knots)
Ebb current - bottom	1.2 m/s (2.4 knots)
Flood current - surface	1.3 m/s (2.6 knots)
Flood current - bottom	1.1 m/s (2.2 knots)
Total currents - surface (wind + ebb)	2.3 m/s (4.6 knots)

In an endeavour to minimize the environmental risks during terminal operations, the consultants have also suggested the following operating limits for certain environmental parameters:

Parameter	Limit	% Occurrence
Visibility	< 1.6 km	19.5
Offshore winds	11 m/s	2.2
Onshore winds	9 m/s	11.0
Wave height	2 m	4.0
Wave height at periods > 9 s	1 m	1.0

When any one of these limits is exceeded (with the exception of visibility) the ship will not be moored, or, if already moored, the ship will have to vacate the terminal. No information was given with respect to the occurrence of unusually high currents and large current fluctuations.

4.0 DESCRIPTION OF THE ENVIRONMENT

Several marine environmental surveys have been conducted in the area of Lorneville and Tiner Pt., both prior to and during the design phase for the proposed terminal. Some results are reported in the literature (Neu, 1960, and Khanna and Andru, 1974) and in internal reports (Neu, 1973, and Joy and Horrer, 1976).

The most important environmental forces affecting the operation at Tiner Pt. are due to waves and currents. The weather also plays an important role, particularly with fog and wind conditions, but these data and their interpretation can be obtained directly from the Atmospheric Environment Service. In this review, attention is given primarily to the hydrodynamic forces. The atmospheric effects are only brought into discussion when a strong interaction exists between the two force fields.

4.1 Wave Conditions

4.1.1 Wave Climate

The wave climate of the area was investigated by Neu (1971 and 1973) and Khanna and Andru (1972), the former using the sea state of the open ocean at the entrance to the Bay of Fundy and the latter utilizing Datawell wave rider measurements made by Public Works of Canada and Environment Canada at the site for a one-year period.

For wave height and long-term probability statistics, Neu used the log-normal distribution, and Khanna and Andru the Weibull distribution. In Figure 3 Khanna and Andru compared the two distributions of the same data. The two plots give similar results for the smaller and medium wave heights but differ in the larger waves; the former provides a 100 year significant wave height of 9.1 m while the latter provides only 6.4 m.

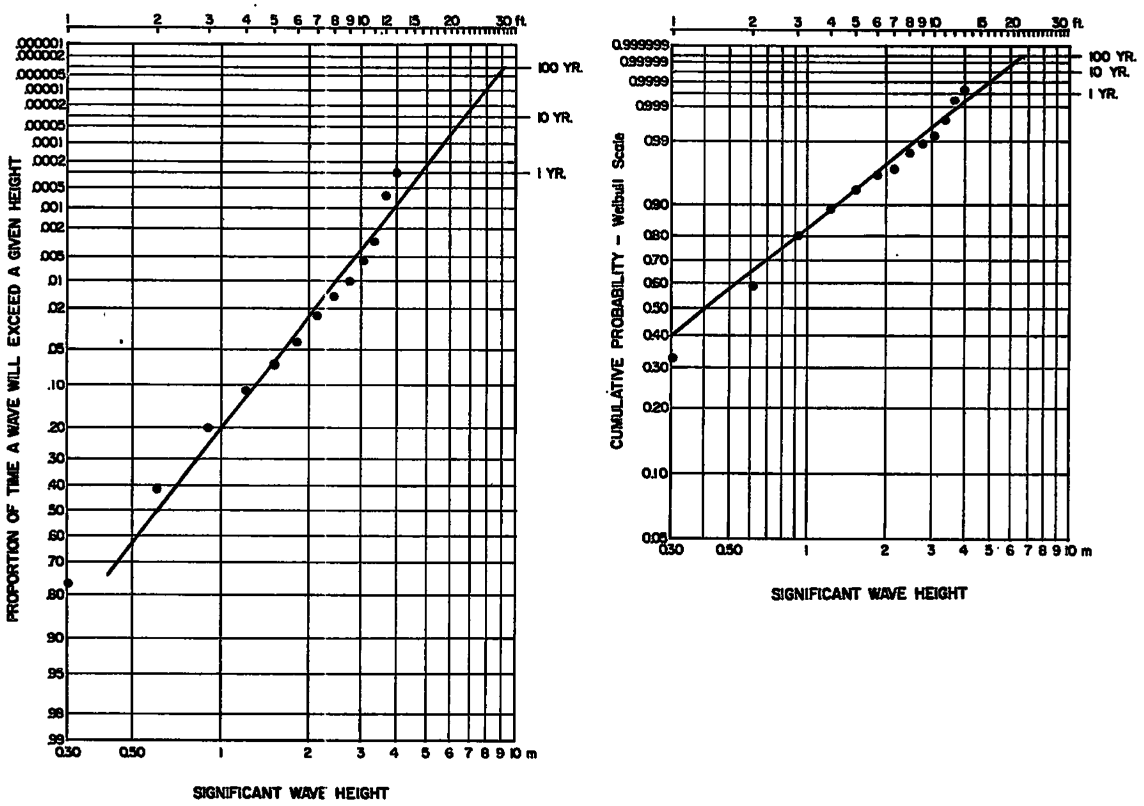


Figure 3. Log-normal and Weibull wave height distribution curves (after Khanna and Andru).

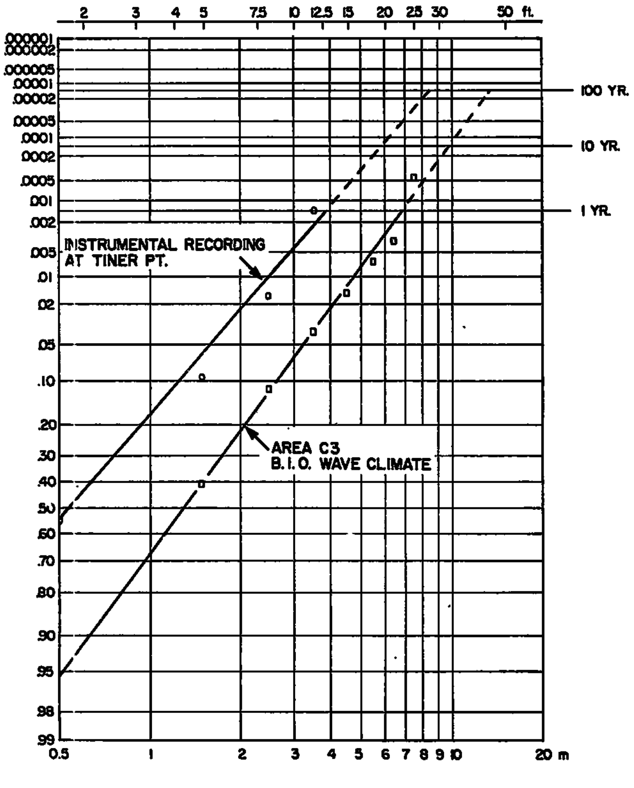


Figure 4. Significant wave height distribution at Tiner Pt. and entrance to Bay of Fundy (Area C3).

A significant wave height of 6.6 m was measured at Point Lepreau during a storm in February 1976 which lasted for more than 12 hours. Point Lepreau is located 25 km southwest of Tiner Pt. and is in an area which is more protected from ocean waves. Meteorological conditions which produced the storm have a return period of about 20 years. This agrees with the percent occurrence for this wave on the log-normal curve (Fig. 4). As mentioned, the extrapolation of this curve provides a 100-year significant wave height of about 9 m.

Using the log-normal distribution plot, in Figure 4, the distribution curve of the site measurements is compared with a three-year (1970-72) average obtained by BIO for AREA C-3 (Fig. 1) at the entrance to the Bay of Fundy. The site data were augmented with BIO data to cover the breakdown periods for the equipment which caused more than 13% of the one-year's measurements to be lost, including six major storms. The comparison shows that the wave heights at the site are about 60% of those of the open Atlantic at the entrance to the Bay of Fundy. This clearly demonstrates the protection provided by the Bay. Since far more wave data are available for the open Atlantic than for Tiner Pt. and since monthly statistics are required which cannot be meaningfully obtained from the Tiner Pt. data, the BIO Atlantic data, reduced by 40%, will be used in the review.

The significant wave height is not an ultimate value but is, rather, a useful comparative parameter expressing the state of the sea. By definition, it is the mean height of the highest third of all waves in a wave record; thus, nearly one-sixth of all the waves are larger than this value. The height of these larger waves depends on the length of the record or the duration of the storm. For a constant sea state of several hours the ratio between the significant wave height and the maximum wave height is about 1 to 1.8; for a storm in excess of 10 hours duration it becomes 1 to 2. This yields, for the storm of 2 February 1976, a maximum wave height of 13 m and a 100-year extreme wave of 16 m. Thus any structure placed in this area of the Bay of Fundy should be designed for a wave height of at least 15 m (50 ft). As also indicated by the February storm, the peak or design period for this wave should be in the order of 16 seconds. The maximum wave height chosen by the consultants for the design of the terminal is apparently 12 m and no mention is made of its probable period.

The operation of tugs at the terminal is restricted when a wave height of 1.8 m is reached. When referred to, it is never clear whether this ceiling value is the significant or maximum wave height. If it is the significant wave height then this would imply that the tugs must be able to operate in waves with heights of up to 3.2 m; however, if it refers to the maximum wave height, the corresponding significant wave height would be 1.0 m. The significance of this difference is demonstrated by each percentage of exceedance, which is 3% and 16% respectively.

So far, the percent exceedance values given here for the waves are annual values and do not indicate the seasonal variations. Using BIO data, Figure 5 shows a plot of the monthly percentage of exceedance for $H_{sig} > 2$ m ($H_{max} > 3.6$ m) and $H_{sig} > 1$ m ($H_{max} > 1.8$ m). These values of H_{sig} were chosen because the original data were coded in one-metre intervals and the differences between these values and the values given in the operational limits are within the experimental error. As can be seen, tug assistance cannot be provided for either 4% ($H_{sig} > 2$ m), or 21% ($H_{sig} > 1$ m) of the time during the winter months, depending on which wave is defined in the operational limits.

Another operational criterion which will terminate the transfer of oil and initiate removal of the tanker from the terminal is one that occurs when wave periods exceed 9 seconds with wave heights in excess of 0.9 m. The consultants, again, do not define the meaning of the period being used. In our view the most appropriate period parameter is the peak period, which is the period located at the peak of the power spectrum. Just as the significant wave height is an indication of the range of heights in a wave field, so the peak period relates to the range of periods. It is the most influential period in the record but there is a large number of waves, about 10 to 15% on the average, which have greater periods. Depending on the type of storm, its duration and on the underlying ocean swell, some of these periods may be as long as 16 seconds. The second restriction of 0.9 m significant wave height combined with the peak period of 9 seconds, therefore, means that the terminal must be expected to operate under sea conditions with wave periods of up to 16 seconds and wave heights up to 1.6 m.

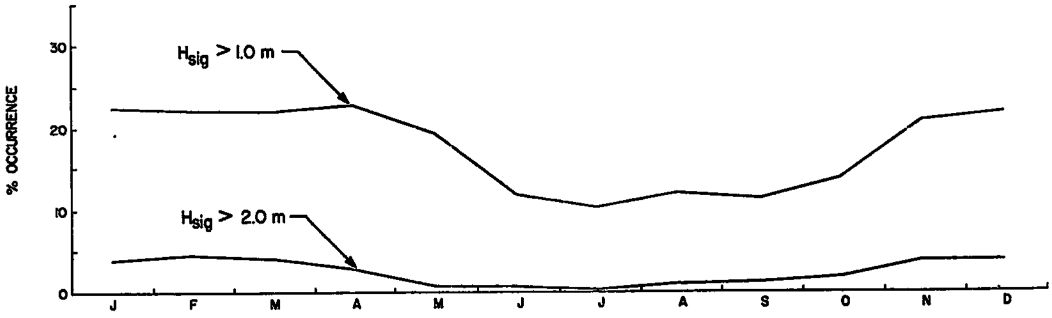


Figure 5. Monthly exceedance of critical sea state.

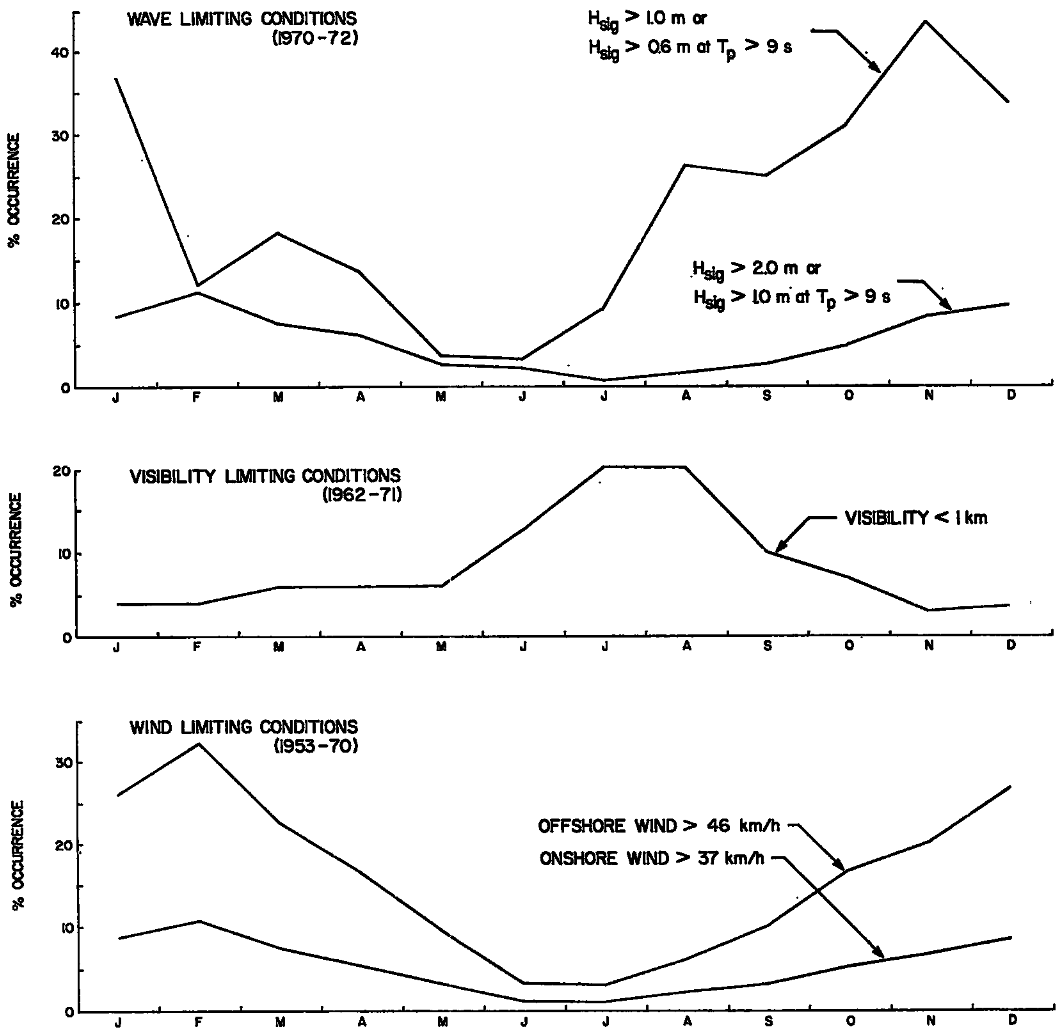


Figure 6. Monthly exceedance of limits of operation.

Estimates were made to determine the monthly down-time at the terminal due to wave action and weather conditions. The effect of each of the following factors was investigated:

(1) Significant wave heights in excess of 2 m or 1 m;

(2) Significant wave heights in excess of 1 m or 0.6 m at periods > 9 s; significant wave heights in excess of 2 m or 1 m at periods > 9 s.

(3) Wind in excess of 45 km/hr; data were provided by the consultants;

(4) Fog with visibility between 0 and 1 km.

The percentages of down-time per month for the individual components are plotted in Figure 6.

It is clearly demonstrated that waves and wind are the major factors during the winter and fog during the summer, where the effect of the wind is much lower. Assuming the limiting wave conditions referred to are significant wave heights (Fig. 6), the average and maximum combined down-time expected in days were determined for each month as indicated in the table below.

No. of Days	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean	5.9	6.9	6.2	5.3	3.7	4.3	6.7	7.4	4.8	5.4	5.4	6.6
Max.	9.4	8.4	11.8	7.8	7.6	9.2	18.8	16.7	8.4	9.6	11.1	10.7

The maximum figures correspond to the maxima found during a three-year period and therefore cannot be integrated to determine an annual maximum. The consultant's estimated down-time of 15.3% of the year (about 4 to 5 days per month) is too low, particularly during the winter months.

It should be noted that 6.6 days down-time shown for December, for example, is an integrated time and is made up of a number of down-time periods. The types of interruption and their actual occurrence is shown on the wave record of Point Lepreau for December 1975 (Fig. 7). There are as many as 11 down-times during the month, 7 caused by waves exceeding heights of 1.8 m and 4 caused by waves exceeding 0.9 m wave height and periods of 9 s. During the entire month, there were only four occasions, comprising 2, 3, 5, and 7 days, respectively, when uninterrupted unloading could have been performed. This operating time was further curtailed by wind and fog as indicated.

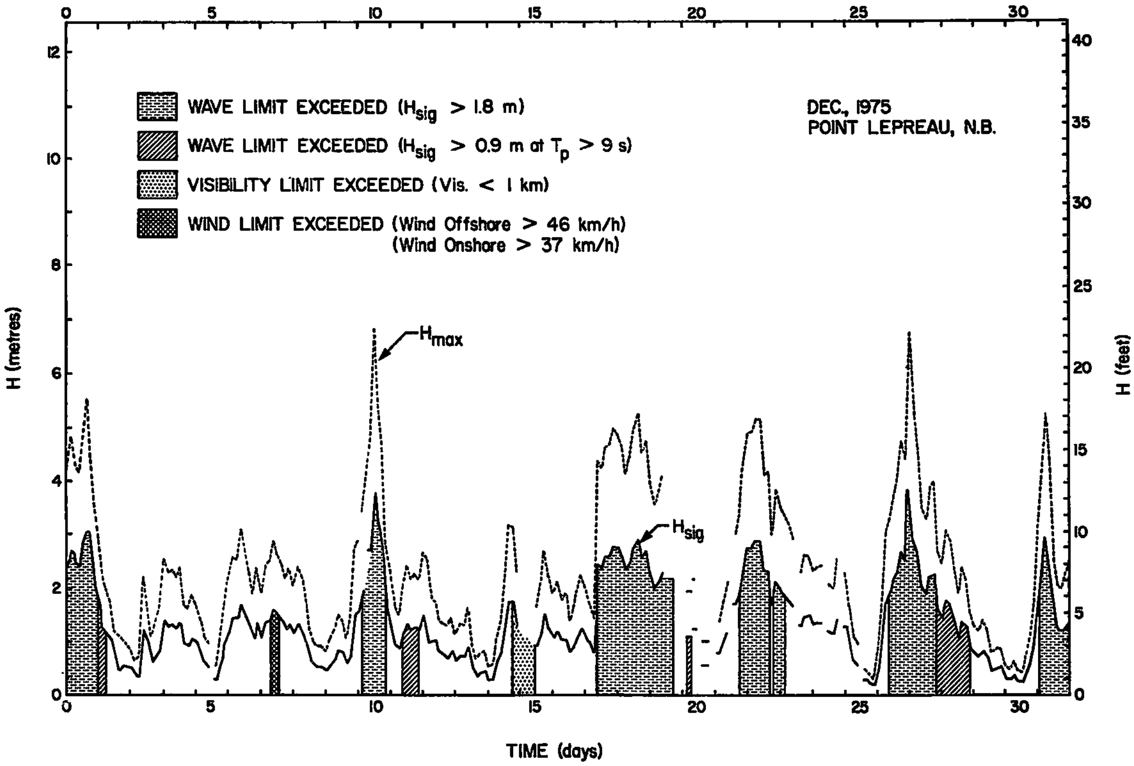


Figure 7. December 1975 wave record at Point Lepreau showing periods of down time.

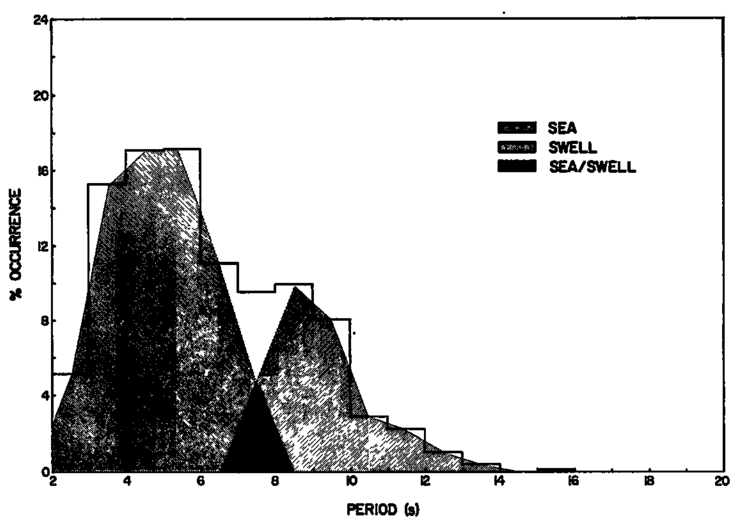


Figure 8. Wave period distribution for Tiner Pt.

It must be realized that these down-time estimates are conservative and based on hindsight and not on foresight. Unfortunately, the latter, on which the operation depends, can predict the operating days only very approximately. Thus, it appears that operating the terminal during the winter months will be difficult and on occasion impossible. This applies to the smaller tankers even more than to the larger ones. Not yet included in the estimates are disturbances from currents. These must further increase the down-time.

4.1.2 Wave Forecasting

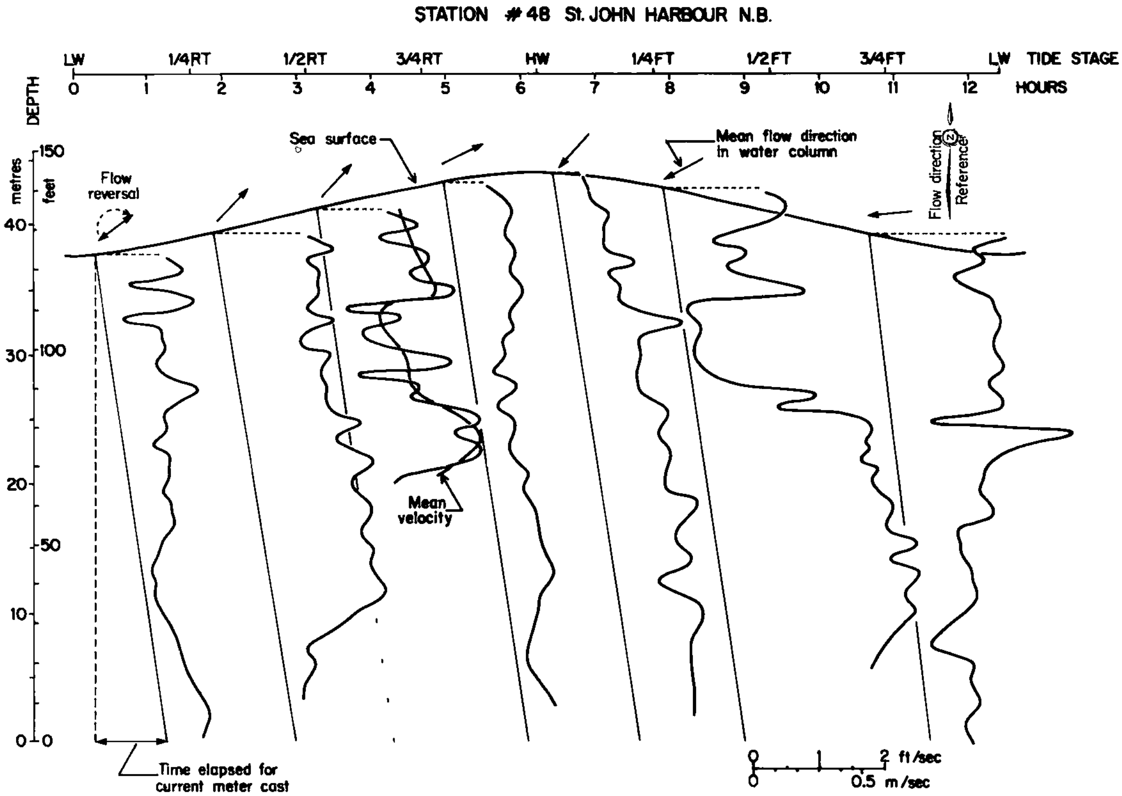
For the safe operation of the terminal, the consultant places great emphasis on wave forecasting. This method is acceptable for larger regions and more exposed bodies of water but is not sufficiently accurate for particular locations such as Tiner Pt. especially when operational decisions such as when to dock or vacate the terminal are involved. This has been demonstrated on oil exploration platforms operating off the East Coast and in the North Sea (see Anon., 1976) on numerous occasions. Wave forecasts depend largely on the proper prognosis of winds but insufficient meteorological observations are made over the ocean either in time or space to adequately predict the local wind. In addition, local wave conditions can be affected to a large extent by waves originating outside the local area. At Tiner Pt. approximately one-third of all waves come from outside the Bay of Fundy (see Fig. 8). These waves cannot be predicted using local wind observations.

The difficulties which exist in forecasting waves can be demonstrated with the storm of 2 February 1976. The Canadian Forces Metoc Centre provides synoptic wave charts and 12-hour forecasts at 0800 and 2000 AST. The storm started to develop at around 0600 hours and reached full strength at 0900 hours with wave heights > 3 m at this time. The predicted wave height was 1 to 2 m. At 1500 hours the significant wave height was 6.5 m, with a maximum wave height of 13 m, while, according to the forecast, waves of only 2 m were predicted. So, for the Bay of Fundy, the storm was completely missed by the forecaster. Operational decisions made on this information could only have led to a most dangerous situation.

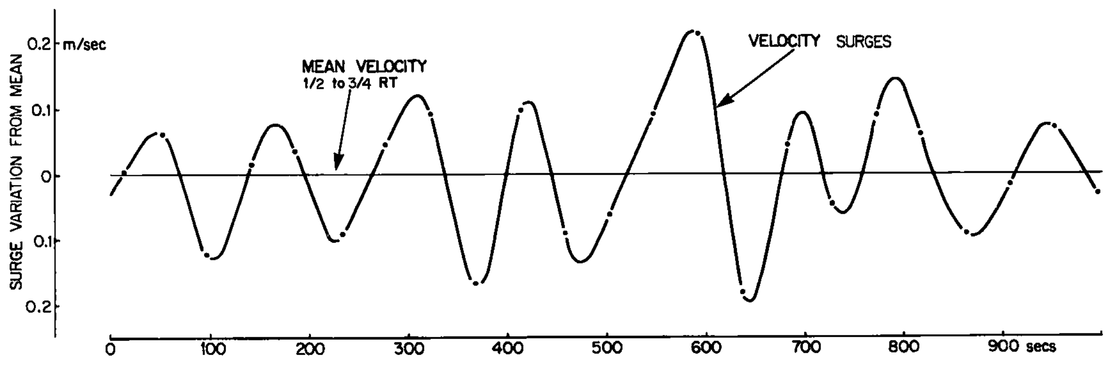
4.2 Current Velocities and Current Surges

Next to waves, currents and current surges are the most important environmental forces affecting the operation and safety of a terminal in this area. The consultants used data collected in 1969, 1971, 1972, and 1975, along with those collected by Neu (1960), to determine the design velocity for the structure. The current data given by Neu are vertical profiles from which short-term current surges have been filtered out. The consultant measured velocities with drift poles and various types of current meters. His earlier measurements were made by vertical profiling, while the others were *in situ* recordings using moored meters with recording intervals of 20 minutes and 0.25 minutes. The earlier measurements indicated a maximum velocity of 1.45 m/s (2.9 knots) but, because of the long recording intervals, were unable to show any high frequency fluctuations that may have existed on the average current.

Current fluctuations in the period range of one to 30 minutes are quite common in and around coastal bays and inlets. With this in mind, and the knowledge that ships undergoing a docking or undocking maneuver in such situations experience considerable difficulty, the consultants were asked to carry out high frequency current measurements off Tiner Pt. for a one-month duration. The results of these measurements are reported by Intersea Research Corp. in 'Current Studies at Tiner Pt., N.B.' (May 1976). In this December survey the maximum velocity was 1.2 m/s (2.45 knots), using a sampling rate of 4 samples/minute. This current occurred during ebb flow and is lower than that which was recorded earlier in the spring. This is probably a seasonal effect but without further data this cannot be verified. From the analysis of the data the consultants concluded that there are no surges of any significant nature in the currents. This contradicts the consultant's previous findings as indicated in Item 22 of the New Brunswick Transportation Authority Information Manual, and is in complete disagreement with the observations by Neu in the summer of 1958 and spring of 1959. As shown in Figure 9, the field data during a tide cycle at a station 2 km off Tiner Pt. show continuous current surges of 2 to 8 minute periods, superimposed on the tidal currents. These seiche type surges were present throughout the Saint John Bay at more than 60 locations during the entire summer as well as during the spring survey. As can be seen, the strength



Recorded current profiles during a tide cycle



Current surges between 1/2 and 3/4 rising tide

Figure 9. Current data taken 2 km off Tiner Pt., 27 August 1958.

of these surges varies greatly but there are a number in this record with ranges in excess of 0.5 m/s and one of 0.7 m/s at 3/4 FT. Long-term observation would probably reveal much larger values. Since surges occur randomly, it was hoped that from last December's observations, after the tidal constituents had been removed, distribution plots similar to those for waves would have been developed from which longer term extremes and their percentage of occurrence could be obtained. This, however, was not done.

The probability of the existence of these oscillations can also be demonstrated by considering the normal modes of oscillation of the Bay of Saint John. Lamb (1945) developed the following equation to determine the normal periods of oscillation for a rectangular basin:

$$T_{m,n} = \frac{2\lambda}{C\sqrt{m^2+(\lambda n/B)^2}}$$

where m,n specify the order of mode

λ is the length of Bay

B is the breadth of Bay

C is shallow water wave velocity = $\sqrt{g \cdot d}$

g is the acceleration due to gravity, and

d is the average depth

Choosing d = 7.4 km, B = 8.3 km, and d = 15 m,

then $T_{2,1}$ = 9 min, $T_{1,2}$ = 4.9 min, and $T_{2,2}$ = 2.8 min.

These results are verified by Neu (1960).

Although the existence of these oscillations can be demonstrated quite well, their occurrence cannot be predicted because they are caused by a variety of random factors originating either in the atmosphere or in the ocean.

5.0 DOCKING PROCEDURES

As indicated in Section 3.0 the docking of a ship at an oil terminal is an important concern in the design of the facilities. The approach of a large ship to a terminal is quite critical and requires good visibility, precise timing, knowledge of the response of the ship or tugs to tide, current, wave conditions etc. The care and attention to detail that is required in this situation is evident in the average of four hours required to berth a very large container carrier. Thus, current fluctuations having ranges of 0.5 m/s (1.0 knot) and periods of a few minutes superimposed on tidal currents of 1.2 m/s (2.4 knots) are obviously of major concern to those responsible for docking a large oil tanker.

No consideration of this aspect of the terminal operation was included.

6.0 MODEL STUDIES

Model studies were carried out for this development by the Danish Hydraulic Institute. The model tests and their results as discussed in the report 'Tiner Point Wharf Disturbance Tests' appear to be quite thorough and comprehensive but are of limited value since these tests were based on inadequate environmental data. Wave heights were restricted to less than 1.2 m (4 ft) and only steady non-fluctuating currents were examined. These wave heights are much less than those chosen for the operating limits and the current patterns chosen are not very realistic.

7.0 FIXED STRUCTURE VERSUS SINGLE POINT MOORING

Although there are several types of offshore terminals, only the fixed structure and the single point mooring (SPM) will be discussed in this review. As early as 1970 in the preliminary proposals for Lorneville Superport, the consultant, Swan Wooster Engineering Co., favoured the fixed structure design, which was opposed by Neu on the grounds of involving potentially high environmental risks. The design for Tiner Pt. is, with the exception of the size of the facility, very similar to that of Lorneville Superport. The main reason given for choosing the fixed structure over the SPM is that there are technical problems in handling Bunker C with submarine pipelines in a cold environment. This problem can be solved with a heating system and a well insulated pipeline.

Obviously, it would have been desirable to have a rating system of environmental risk factors with which to evaluate the total risk inherent in each proposal. This, however, is impracticable at present. A more reasonable approach is to compare two schemes directly.

In recent years, a number of impartial reviews on the subject have been published, the latest and most comprehensive being by Bragaw *et al.* (1976) in the book *The Challenge of Deepwater Terminals,* where it was clearly demonstrated that both economically and environmentally the SPM system is superior. This is also the reason why the majority of the more than 160 deep sea terminals in the world are of this type. According to Bragaw *et al.,* the installation costs of the terminal are usually smaller, while the long term maintenance costs seem to be higher than for a fixed structure. A specially designed hose with heating facilities for pumping Bunker C oil will increase the installation and operating costs.

The basic advantage of an SPM is that the vessel is free to weathervane into the prevailing environmental forces thereby reducing mooring loads and allowing the ship to remain in far more severe conditions than at a fixed structure. It would be possible to tolerate seas greater than 7 m if necessary. Navigating and maneuvering into and out of an SPM is quicker and safer than with a fixed terminal and does not normally require the use of tugs. Waves and current surges, within limits, have little effect on the docking operation because both vessel and mooring are responding together to the same environmental forces. In an emergency, a tanker can disconnect hoses, release moorings and vacate the terminal quickly without great difficulties.

Taking all these factors into consideration and relating them to the environmental conditions at Tiner Pt., the reviewers are convinced that the 'fixed' structure has a much higher potential risk of an environmental disaster than the 'soft' terminal. It is realized that any form of oil transfer in this body of water risks environmental dangers. However, of all designs, with the exception of a protected harbour, the SPM has the smallest risk. For this reason, many government agencies, including those of the United States, are promoting this type of terminal for the Atlantic coast. The problem of pumping Bunker C oil to shore in a cold environment does not outweigh the environmental risks which arise from the fixed structure design.

8.0 CONCLUSIONS

(i) The Tiner Pt. terminal will be one of the first deep-sea oil unloading facilities on the Canadian Atlantic coast which will be fully exposed to the open ocean environment. A comprehensive study is therefore required to determine the suitability of the design and the potential risk of an oil disaster.

(ii) The planning of field surveys carried out by the consultants and the interpretation of the resulting data were done with little appreciation of the complex hydrodynamic conditions in the Bay of Fundy.

(iii) The most disturbing factors for the operation of the terminal are waves and winds in the winter and visibility or fog in the summer.

(iv) There are two types of wave conditions to be considered: the first is the 100-year maximum wave or design wave and the second is the operational wave condition which determines the closure of the terminal. In the first case, a 12 m wave height is too small for the design of the structure and a wave height of at least 15 m must be considered. The period with this wave must be in the order of 16 seconds. The second type of waves which, when exceeded in height, or in a combination of height and period, will shut down the operation is 20 to 30% more frequent than determined by the consultant, particularly during the winter months.

(v) The integrated down-time due to waves, fog and wind is between 4 and 7.5 days per month. The down-time during the summer due to fog is less of a factor since it affects only docking and does not interfere in the actual unloading of oil. During the winter, however, when waves primarily are causing the interruptions, the operational time of the terminal of 20 to 25 days can be interrupted 10 to 20 times. Since these down-times cannot be forecast with certainty, it must be expected that in a number of months during the winter, unloading of oil would be impossible without jeopardizing the safety of the operation and thus inviting an environmental disaster.

(vi) The down-time mentioned is based on wave and weather disturbances only. No consideration was given to exceptional currents and current surges, which will affect docking. The consultant's conclusion, derived from the November 1975 current survey, that there are no surges of any significant nature in the area of the terminal, is in complete disagreement with the results of Neu who, in 1958 and 1959, found seiche type surges with periods between 2 and 9 seconds and average current amplitudes of 0.25 to 0.5 m/s (½ to 1 knot) were continuously present. Surges of up to 0.7 m/s (1.4 knot) were observed and it must be assumed that on occasion they will reach or even exceed 1 m/s (2 knots). As shown on Figure 9, these surges can temporarily reduce the peak ebb flow to zero. By themselves, but especially in the presence of waves, these surges will cause situations which are potentially hazardous, particularly during the docking operation. This danger has not been investigated. It must also be assumed that these surges will increase the down-time.

(vii) The model studies of the Danish Hydraulic Institute dealt only with the phase of the operation where the tanker is tethered to the fixed structure. It did not investigate the problem of docking. The data used in the experiments were not representative of the environmental forces of the area and the results are therefore not conclusive.

(viii) The need for a deep-water port in the area of Colsen Cove power generating plant is recognized. The environmental forces in the area, however, are harsh and unpredictable. Any transfer of oil is therefore risky and may cause an environmental disaster. The type of the unloading facility to be chosen is, therefore, important. In the opinion of the reviewers, the SPM, from an environmental viewpoint, is far less risky than the fixed structure.

(ix) In the case of a major oil disaster, there is hardly any coastline in the Bay of Fundy and Gulf of Maine which would not be threatened by oil pollution (Neu, 1973).

9.0 SUMMARY

The decision to build the terminal at Tiner Pt. and to choose the fixed structure design is based on insufficient data and has been made without a comprehensive study and therefore a full appreciation of the environmental forces of the region. It is concluded that the environmental forces are significantly more severe than described in the reports of the consultants and that the environmental risks from an oil disaster are appreciably greater than assumed.

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