

FOREST RESOURCE CONSULTANTS LIMITED

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February 28, 1979.
RM 102

Mr. Don Dowling,
Manager, Eve River Division,
MacMillan Bloedel Limited,
Box 160,
Sayward, B.C.
VOP 1R0

ECOLOGICAL RESERVES COLLECTION
GOVERNMENT OF BRITISH COLUMBIA
VICTORIA, B.C.
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Dear Mr. Dowling:

Re: Proposed Operations at Tsitika River

We take pleasure in submitting our report titled "Evaluation of Potential Booming and Barge Loading Sites in the Vicinity of Tsitika River". The study was carried out jointly by Forest Resource Consultants Limited and Northwest Hydraulic Consultants Limited.

The report deals with the selection of potential sites for barge loading and booming operations for the proposed harvesting of MacMillan Bloedel's Tsitika River drainage timber rights. Two sites were selected for detailed study. Specifically, conceptual designs, capital and operating costs were developed for the various alternatives considered at each of these two sites. Only marine based operations were investigated.

Cost estimates prepared indicate that booming and towing is considerably more economical than barging logs from Tsitika River operation to market. Capital costs for construction of booming facilities at the two sites investigated are within 8%, not a significant difference in view of the preliminary nature of the cost analysis performed. The criteria that will dictate which of the alternative sites is the most economical will be the added costs of land based operations such as sorting and transport of bundles to bullpens. This analysis will be carried out by MacMillan Bloedel Limited.

Yours very truly,

FOREST RESOURCE CONSULTANTS LIMITED

Tarek Jandali, Ph.D., P. Eng.

EVALUATION OF POTENTIAL BOOMING
& BARGE LOADING SITES IN THE
VICINITY OF TSITIKA RIVER

ON BEHALF OF
MacMillan Bloedel Limited
Eve River Division

BY

FOREST RESOURCE CONSULTANTS LIMITED
402 West Pender Street
Vancouver, B.C. V6B 1T9

February, 1979

ACKNOWLEDGEMENT

The contributions and assistance received from MacMillan Bloedel Limited staff are gratefully acknowledged. In particular, thanks are extended to Mr. Don Dowling and Dennis Bendickson for their help throughout this study. Thanks are also extended to Mr. Peter Brown of Kingcome Navigation for his helpful suggestions and valuable assistance.



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PART 1

STUDY OUTLINE

1.0 INTRODUCTION

MacMillan Bloedel Limited (MB) propose to harvest their Tsitika River drainage timber rights. This study was initiated by MB to investigate various potential booming and barge loading sites in the vicinity of Tsitika River. The study area extended along Johnstone Strait from Naka Creek on the east to Kaikash Creek on the west. Suitable locations were narrowed down to two sites. One is located at Robson Bight (just west of the Tsitika River Delta) and is referred to as the West Delta Site. The other is located approximately one mile west of the Tsitika River Delta and is referred to as the Mile West Site. Figure 1 depicts these locations relative to the Tsitika River estuary.

All other sites considered presented difficulties in providing adequate protection against wind and waves for either booming or barge operations. Thus, the report deals specifically with conceptual designs, capital and operating costs of the various alternatives considered at each of these two sites. Only marine based operations are considered.

This study was carried out jointly by Forest Resource Consultants Limited and Northwest Hydraulic Consultants Limited.

1.1 DESCRIPTION OF PHYSICAL SETTING

The Tsitika River drains into Robson Bight located along Johnstone Strait on the north coast of Vancouver Island. Robson Bight is located approximately 37 miles east of Port Hardy and approximately 28 miles west of Kelsey Bay. Johnstone Strait is a narrow channel approximately 3 miles in width extending for about 60 miles in an east - west direction.



The topography in the vicinity of Robson Bight is rugged with mountain peaks rising to approximately 5000 feet within two or three miles from shore. Thus, slopes near the shore are steep and extend into Johnstone Strait. Water depths quickly reach 300 feet within a distance of only 1000 feet from shore. This slope of the sea floor will necessitate the use of a floating breakwater at the Mile West site to provide protection against wave action.

1.2 OBJECTIVES

Study objectives are as follows:

1. Identify potential sites for booming or barge loading between Naka and Kaikash Creeks;
2. Select two sites for evaluation and conceptual design;
3. Provide capital cost estimates for construction of proposed facilities, and operating costs of either a booming ground or barge loading facility; and
4. Provide conceptual design and construction costs for a floating breakwater at the alternate site that offers the same protection against wave action as would be provided at the West Delta Site.



PART 2

BUNDLE BOOMING FACILITIES

2.1 SITE DESCRIPTION AND REQUIREMENTS

2.1.1 West Delta Site

a) Booming Area

The booming area is situated on a flat immediately west of the Tsitika River estuary. This flat is composed of gravel, sand and boulders to a depth of at least 40 feet. Several feet of overburden and stumps would have to be disposed of by burning and burying.

The entire flat in the vicinity of the booming ground will be logged and cleared of stumps except for a strip of timber, approximately 120 feet wide, running along and adjacent to the side channel of the Tsitika River (refer to attached plan of West Delta Site). This timbered buffer strip will provide a barrier between the proposed booming area and the Tsitika estuary.

The booming ground faces slightly west of north and will be excavated to a depth of 29 feet below high water level (HWL). The width of the excavation will be 350 feet providing room for 4 pockets and 3 alleys. Side slopes of the excavation to the ground surface will be constructed at 1.5 to 1.0. The total length of excavation is approximately 900 feet. The area surrounding the excavation will be levelled and surfaced to a height of 4 feet above HWL.



The booming area will be protected from the southeast winds and waves by a gravel and rock groin structure situated immediately to the east as shown on the attached plan.

b) Boom Storage Area

The boom storage area is situated immediately to the north-west of the booming ground. Four dolphins are required to be installed at low water depths ranging from 6 to 30 feet. A single stick standing boom is installed along the outside and attached to each dolphin.

The boom tie-up is designed to store four booms, 6 or 8 sections each. The groin structure will provide limited protection from easterly winds and waves.

2.1.2 Mile West Site

a) Booming Area

The booming area is situated about one mile west of the Tsitika River estuary and is partially protected from easterly winds by a rocky projection (see Figure 1). However, to provide similar protection to the West Delta site, it will be necessary to install a floating breakwater designed by Northwest Hydraulics Consultants Ltd. and described in their appended report.

The degree of protection to be offered by the floating breakwater at the Mile West site will be similar to that offered naturally at the West Delta site prior to development. The proposed groin structure at the West Delta site will further reduce impact of wave action within the booming ground. A floating breakwater cannot reduce impact of waves to the same extent as a groin.



Water depths are too great for the installation of dolphins and therefore a system of underwater lines and anchors tied to the rocky shore has been designed. The booming ground will provide four pockets, one alley and a bullpen. A decline ramp will be constructed with two log skids and racks installed about three feet above HWL.

b) Boom Storage Area

The storage area is situated immediately west of the booming ground and provides a tie-up for 6 or 8 section booms. Booms are held in storage by a system of buoys with anchors and chains. A single standing boom is stretched between the four buoys.

2.1.3 Effect of Wave Action

Detailed analysis of waves at each site are presented in a report prepared by Northwest Hydraulic Consultants Limited, appended to this document. The West Delta site is naturally protected against waves generated by wind from the west. Wind from the north does not pose a serious concern due to its infrequent occurrence and influence of the topography on flow retardation. Waves generated by east winds are also reduced in magnitude before they reach the Delta site. This is due to severe diffraction that occurs off the point located approximately 3/4 of a mile east of the Delta. Further protection will be offered within the proposed booming area depending on the extent of proposed landfill between the Delta and the boom area.

The Mile West site is also protected to the same extent as the West Delta site from waves generated by wind from the west and the north.



However, for waves caused by east wind the degree of natural protection is considerably less at the Mile West site. Thus, a breakwater will be required at the Mile West site in order to provide acceptable working conditions for log booming.

In view of the slope of the sea floor, the only economically feasible breakwater is the floating type. Hence, details of the conceptual design are based on a combination concrete and styrofoam floating breakwater chained to cement anchors.

2.1.4 Operating Procedures

Estimated production for the Tsitika operation is based on 60,000 Cunits per year with an operating season of 200 days per year.

- Bundle size for booms is 15 Cunits
- Bundle size for barge is 5 1/2 Cunits

2.2 DESIGN, CONSTRUCTION AND CAPITAL COSTS

2.2.1 West Delta Site

Construction costs are preliminary estimates and are based on the designs as illustrated on the attached plan.

a) Booming Ground

Log area of excavation and surrounds,
approximately 10 acres

N/A



Clear, stump, grub 10 acres with D8 Cat
@ \$ 2,000/acre \$ 20,000.

Excavate B/G with crane, dragline & bucket
and levelling with D8 Cat 332,000 cu.yds.
@ \$ 1.50 /yd. 498,000.

Construction of core of groin structure,
included in excavation cost ---

Surfacing of groin structure, 20 % of total
volume 4000 cu.yds. shot rock placed on groin
@ \$ 5/yd. 20,000.

Installation of B/G including dolphins,
standing boom, etc. 30,000.

Log skids and automatic dump racks 30,000.

Total \$ 598,000.

b) Boom Storage Facility

Dredge 1000 cu.yds. in south corner to
increase LWL depth to minimum of 12 ft.
@ \$ 1.50/yd. \$ 1,500.

Install 4 dolphins @ \$ 1,000 ea. 4,000.

Install single stick standing boom 530
ft. long 1,000.

Total \$ 6,500.



c) Total for Booming Ground and Storage Facility

Total a) and b) above	\$ 604,500.
M & B supervision, engineering and camp cost (3 men, 4 months)	<u>30,000.</u>
Total Capital Cost	<u><u>\$ 634,500.</u></u>

2.2.2 Mile West Site

a) Booming Ground

Clear decline area and surrounds, 3 acres @ \$ 2,000/acre	\$ 6,000.
Construct decline and dumpsite, 3000 yds. rock @ \$ 4./yd.	12,000.
Log skids and automatic dump racks for 15 C bundle	30,000.
Installation of B/G including lines, anchors, standing boom, etc.	<u>50,000.</u>
Total	\$ 98,000.



b)	Boom Storage Facility	
	Install 4 buoys, 6 anchors and chains	\$ 6,000.
	Install single stick standing boom, 530 ft. long	<u>1,000.</u>
	Total	\$ 7,000.
c)	Floating Breakwater	
	For towing to the site and for remote installation, the estimated cost is \$450,000, including \$35,000 for engineer- ing. The engineering costs reflect the need to conduct a hydraulic model test to check internal stresses under wave action.	\$450,000.
d)	Total for Booming Ground, Storage Facility and Breakwater	
	Total a), b) and c) above	\$555,000.
	M & B Supervision, engineering and camp costs (3 men, 4 months)	<u>30,000.</u>
	Total Capital Cost	<u><u>\$585,000.</u></u>

2.2.3 Conceptual Design and Costs of Breakwater

Details of the conceptual design and costs are presented in a report prepared by Northwest Hydraulic Consultants Limited, appended to this document. The recommended breakwater would be constructed of post tensioned reinforced concrete, cast around blocks of styrofoam flotation. The design would be V-shaped in plan for added stability against rolling motion.

The breakwater must provide protection against waves within the entire booming ground and tie-up area. The breakwater will be 450 feet in length and will be installed along the azimuth 349°, as shown on the attached plan.

Capital costs and engineering fees for construction, towing and installation are estimated to be \$450,000 including \$35,000 for detailed engineering design.

PART 3

BARGE LOADING FACILITIES

3.1 SITE DESCRIPTION AND REQUIREMENTS

3.1.1 West Delta Site

Two alternate barge loading methods from land to barge were considered at this site. First, excavate canal in low bench similar to the booming ground facility. The excavation would be large and particularly deep, approximately 50 feet. The hazard of the loaded barge becoming grounded was too great and therefore this method was rejected.

Second, construct a 250 foot wide ramp with a vertical face at a depth of 47 feet below HWL as shown on the attached plan. Additional protection from wind and waves for the docked barge is not considered necessary.

3.1.2 Mile West Site

Barge loading at this site has reasonable potential by placing the log bundles in the water and containing them in a large pocket behind a stiffleg. This stiffleg would be attached to the rock nose just north of the dumping facility and stretch 1500 feet in a westerly direction and anchored to the shore. The log bundle dumping arrangement would be similar to that shown on the attached plan for bundle booming.

Note: Kingcome Navigation recommends that tie-up for barge loading be done east of the Delta by towing bag booms from the dump site (Mile West) to this tie-up grounds. Reasons are principally reduced wind and wave action at this site.



3.2 DESIGN, CONSTRUCTION AND CAPITAL COST

Construction costs are preliminary estimates only.

3.2.1 West Delta Site

Refer to plan design.

Clear area adjacent to dock fill site, 5 acres @
\$ 2,000./acre \$ 10,000.

Construct 70 % of gravel-rock ramp with nearby
source, 70,000 yds @ \$ 2.50/yd. 175,000.

Install creosoted piling along face @ 5'
centers, 70 piles @ \$ 800 each. 56,000.

Install 1/2 " metal plates to entire inside face,
15,000 sq.ft. @ \$ 8.00/sq.ft. 120,000.

Tie-backs every 10 feet along face and every 6
feet in depth to deadmen, total 240 tie-backs @
\$ 200. each 48,000.

Backfill remainder with sorted gravel along inside
face of dock, 28,100 yds. @ \$ 4.00/yd. 112,400.

Install two tie-up dolphins @ \$ 5,000 each 10,000.

Install 4 sets of log bunks along dock face for
spotting bundles 2,000.

Install rise and fall boomsticks along outer face
of dock 2,000.



Total for Barge Loading Dock	\$ 535,400.
M & B supervision, engineering and camp cost	<u>30,000.</u>
Total Capital Cost	<u><u>\$ 565,400.</u></u>

Note: Other methods of dock construction should be investigated for cost comparison. Some of these are the installation of sheet metal piling or sheet pile cells for the face of the dock. Another method is to construct the gravel-rock ramp and attach a piling-beam structure to the outer edge of the fill. This wood structure must be designed to carry several F.E. loaders with log bundles plus the storage of log bundles near the face of the dock.

3.2.2 Mile West Site

The following method of barge loading requires the log bundles be stored in the water for loading onto the barge. It should be noted that log bundle size for barge loading is based on 5 1/2 Cunit bundles. This will increase substantially the cost of banding or strapping of log bundles. MB's 10 Cunit self-loading barge is fully committed to Queen Charlotte Island production. Replacement cost for such barge and tug is \$ 11 million.

Estimated costs for barge loading facilities are:

Clear decline area and surrounds, 3 acres @ \$ 2,000./acre	\$ 6,000.
Construct decline and dumpsite, 3000 yds. rock @ \$ 4.00/yd.	12,000.
Log skids and brow log	10,000.



Installation of 1500 feet double-stick stiffleg with anchors	\$ 20,000.
Four bag pockets	2,000.
Install 30 ton anchor, chain and buoy for barge	<u>8,000.</u>
Total	\$ 58,000.
M & B supervision, engineering and camp cost	<u>15,000.</u>
Total Capital Cost	<u><u>\$ 73,000.</u></u>



PART 4

OPERATING COSTS

4.0 OPERATING COSTS FOR BUNDLE BOOMS AND BARGING

In order to compare operating costs of moving log bundles by boom or barge, it will be assumed that the destination is Harmac. It should be noted that these costs form only a part of the total log costs.

4.1 BUNDLE BOOMS

Cost estimates are for both the West Delta Site and Mile West Site.

<u>Cost Phase</u>	<u>Cost/Cunit</u>
Booming of 15 Cunit bundles at rate of 300 cunits/day	\$ 1.50
Towing from Robson Bight to Harmac (min. 54 sections @ 75 C/Section)	5.70
Storage at Harmac holding grounds	0.25
Final delivery from storage to mill	<u>0.20</u>
Total Operating Cost of booming and towing to Harmac	<u><u>\$ 7.65</u></u>

4.2 BARGING

Cost estimates are for both the West Delta Site and Mile West Site.



<u>Cost Phase</u>	<u>Cost/Cunit</u>
Load 3500 C on barge, tow and dump (Robson Bight to Howe Sound).	\$ 10.40
Sort and reboom at Howe Sound	4.75
Tow from Howe Sound to Harmac holding grounds	2.00
Storage at Harmac holding grounds	0.25
Final delivery from storage to mill	<u>0.20</u>
Total Operating Cost of barging and towing to Harmac	<u>\$ 17.60</u>

4.3. COMPARISON OF OPERATING COSTS

1. Difference between barging and bundle booms	\$ 9.95/Cunit
2. Annual savings by bundle booming	<u>\$597,000.00</u>

Note: Above operating costs exclude such costs as depreciation, interest, insurance and annual maintenance on the booming and barging facilities proposed for Tsitika River.



PART 5

SUMMARY OF CONCLUSIONS

5.1 SUMMARY OF COSTS

	<u>Total Capital Cost of Facility</u>	<u>Operating Cost/Cunit Robson Bight to Harmac</u>
A. Bundle Booms:		
1) West Delta Site	\$ 634,500.	\$ 7.65
2) Mile West Site	\$ 585,000.	\$ 7.65
B. Barging:		
1) West Delta Site	\$ 565,400.	\$ 17.60
2) Mile West Site	\$ 73,000.	\$ 17.60

5.2 CONCLUSIONS

All possible sites, along Johnstone Strait between Naka Creek and Kaikash Creek, were reviewed to establish potential booming and barge loading sites for MB's proposed Tsitika River operations. Suitable locations were narrowed to two sites. All other sites presented difficulties in providing adequate protection against wind and waves for either booming or barge operations.

The two sites considered in this study are located at Robson Bight (West Delta site) and one mile west of the delta (Mile West site). Conceptual designs, capital, and operating costs were developed for each of these two sites. A floating breakwater is required in order to provide the same protection at the Mile West site as is naturally



offered at the West Delta site prior to development. The construction of a groin at the West Delta site will offer considerable additional protection from wave action within the booming grounds. This additional degree of protection cannot be obtained at the Mile West site, due to the fact that floating breakwaters are not as effective as groin structures in providing protection. Furthermore, due to the slope of the floor and excessive depths at the Mile West site a groin structure there will not be possible.

Comparison of operating costs indicate that booming and towing is more economical than barging logs from the Tsitika River operation to market. Capital costs for the construction of booming facilities at the West Delta and Mile West sites are within 8% - not a significant difference in view of the preliminary nature of the cost analysis performed. The criteria that will dictate which of these alternative sites is the most economical will be the added cost of land based operations such as sorting and transport of bundles to bullpens. This analysis will be carried out by MacMillan Bloedel Limited and will form part of the overall submission to the Tsitika Follow-up Committee.

FIGURE 1

PROPOSED BOOMING AND
BARGE SITES

MacMillan Blodell Limited
TSITIKA RIVER OPERATIONS

Forest Resource Consultants Ltd.

Scale: 1" = 1000'

Depth in
Fathoms

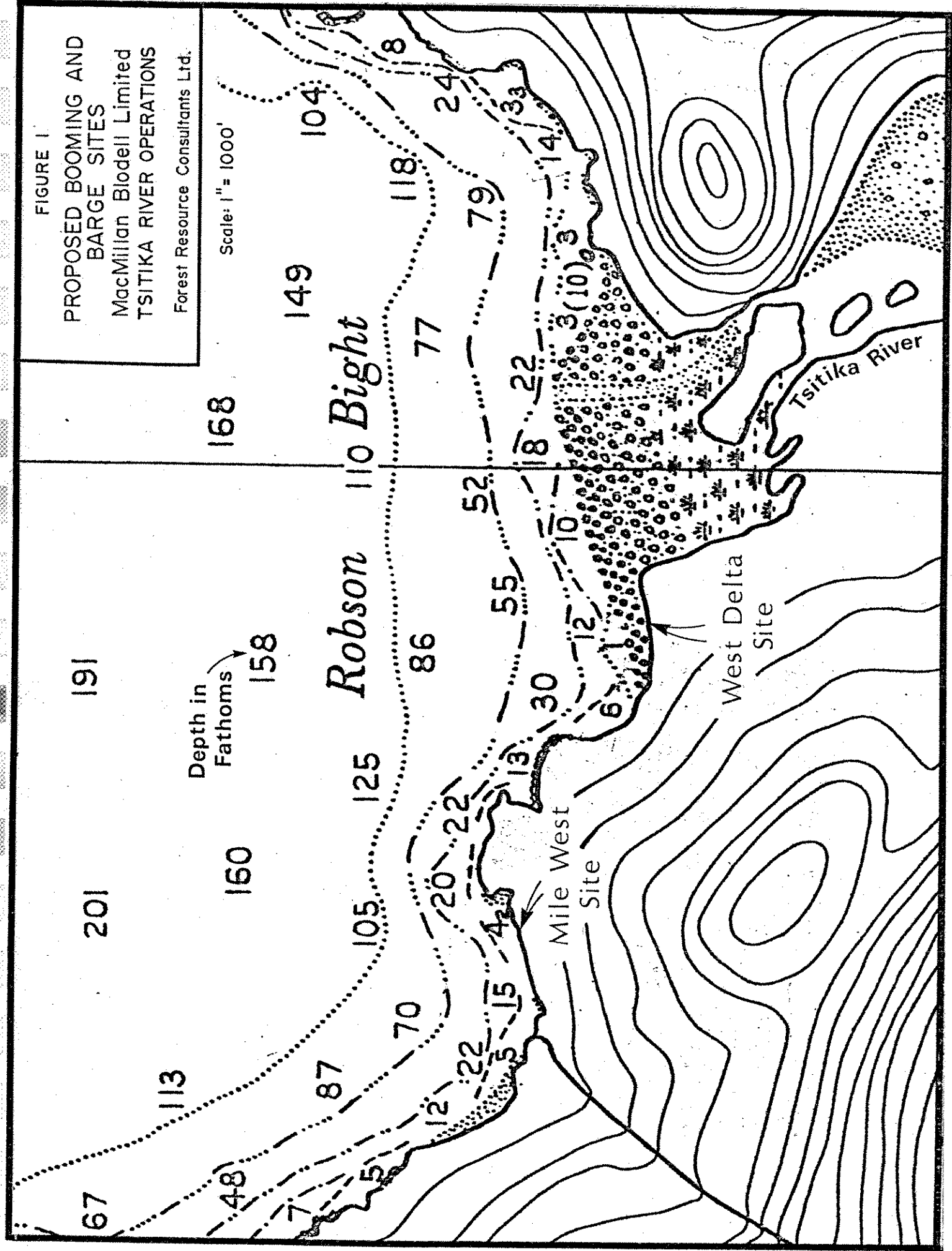
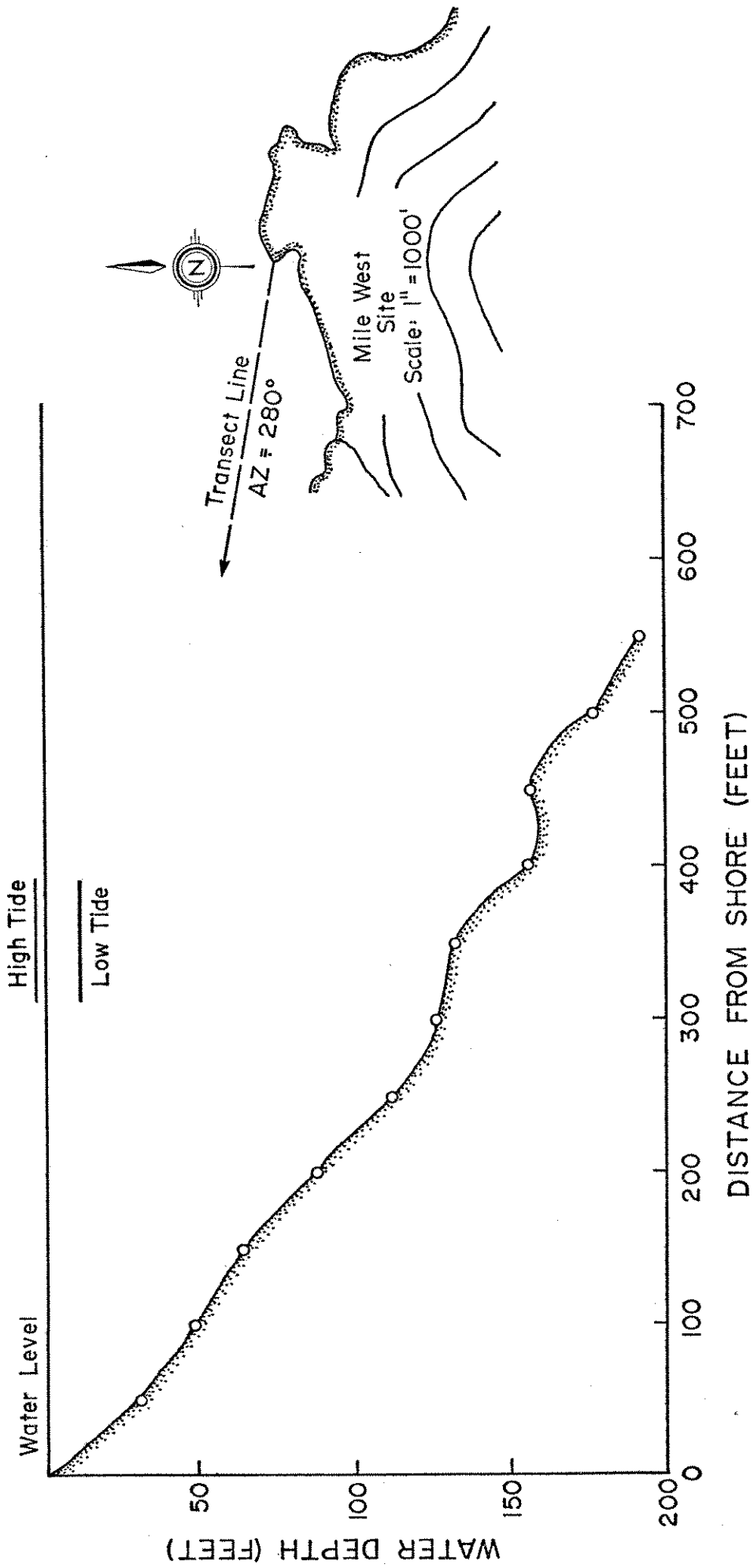


FIGURE 2
 DEPTH SOUNDINGS AT MILE WEST SITE

Depth measurements recorded
 at 1:30 p.m., Nov. 28, 1978



prepared for:

FOREST RESOURCE CONSULTANTS LTD.

by:

NORTHWEST HYDRAULIC CONSULTANTS LTD.

Edmonton - Vancouver - Calgary

January 1979

FLOATING BREAKWATER
FOR MACMILLAN BLOEDEL OPERATION
TSITIKA RIVER

northwest hydraulic consultants ltd.

INTRODUCTION

Forest Resource Consultants Ltd. (FRCL) have been retained by the Eve River Division of MacMillan Bloedel Ltd. (M-B) to carry out a study aimed at the selection and evaluation of potential booming or barge loading and dry sort sites at their proposed operations at Tsitika River. Northwest Hydraulic Consultants Ltd. (NHCL) were retained in turn to prepare a conceptual design for a breakwater for a booming ground site called the Mile West site. The breakwater is to offer the same degree of protection at the Mile West site as would be offered naturally at a second site called the Delta site. This report summarizes the details of this design.

SITE DESCRIPTION

The Mile West site and the Delta site are located on the north coast of Vancouver Island near the estuary of the Tsitika River. Both sites are exposed to waves generated by winds blowing over Johnstone Strait in directions varying from NW to ENE. In addition, the Mile West site is exposed to waves from ENE to east.

The booming ground at the Mile West site would be located in water up to 250 ft. deep, according to soundings on hydrographic charts, so that wave protection would have to be provided by a floating breakwater. The shoreline is rocky but the nature of the sea bed is unknown except that the available charts indicate that the bed slopes off at about 1 on 4 to the deeper water of the strait.

During a site visit on November 28, 1978, personnel of FRCL made soundings in the area, but were unable to sound at the breakwater location because of an equipment failure. They did measure surface currents averaging 0.4 knots east to west at

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the Mile West site at about 1300 hrs. Tide tables show that high tide was 15.7 feet at about 1130 hrs that day and low tide was 3.1 feet at about 1830 hrs so that there was a strong ebb flow at that time. The tidal range at the site is about 16 feet.

WAVE CLIMATE AT PROPOSED BOOMING GROUNDS

Johnstone Strait runs almost directly east-west in the vicinity of the site and is relatively narrow with a fetch of only about 2-3 miles directly across.

The nearest wind stations are located at Port Hardy about 60 miles to the WNW and Chatham Point about 40 miles to the ESE. Although these are relatively far from the site there is considerable valley effect (E-W winds) and use of that data should be reasonable.

A frequency analysis of wind directions at these two stations, carried out by the Atmospheric Environment Service, indicates that the winds are predominately from the E during the winter months and NW during the summer months at Port Hardy. At Chatham Point the winds follow this trend but are more frequently from the west during the summer.

Detailed tabulations of wind characteristics at the two wind stations are available. The periods covered are 1953-1976 for Port Hardy and 1964-1976 for Chatham Point. The tables divide the wind data into 8 wind directions, wind speeds in 10 mph ranges and durations in hourly units; and list the number of occurrences found for each combination of conditions. This form of data is ideally suited to wave hind-casting.

Effective fetches have been estimated for the 14 wind directions as shown in Table 1. The number of hours per year that different wind speeds have been exceeded are also shown in this table. The significant wave height and period for each wind speed and fetch, obtained from hindcasting charts, is also shown.

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TABLE 1
SIGNIFICANT WAVE HINDCAST FROM WIND DATA AT
PORT HARDY AND CHATHAM POINT

Direction	Effective Fetch (miles)	Speed (mph)	Time Wind Speed Exceeded (Hours/Yr)		Significant Wave	
			P. Hardy	Chatham Pt.	Height (ft)	Period (sec)
NW-NNW	4	40	0.2*	0.1	3.3	3.7
		30	0.2	9.0	2.5	3.2
		20	24	207	1.8	2.7
N-NNE	3	20	1.2	0.4	1.8	2.7
WE-ENE	3.5	30	0.2	4	2.5	3.2
		20	4	75	1.8	2.7
E-ESE	5	50	0.1	0.0	5.0	4.5
		40	4	8	4.0	4.0
		30	116	3	2.8	3.5

*1 hr in 5 years

The Delta site and the Mile West site are equally exposed to the top three directions of Table 1 (NW-NNW-N-NNE-NE-ENE). Wave heights of 2 to 3 feet are expected to be a fairly rare occurrence from these directions.

Only the Mile West site is exposed to the E-ESE, the direction from which the largest waves can be expected. Even here the waves would have to experience about 10 degrees of diffraction before they impinged on the site. This diffraction can be expected to reduce wave heights by about 40 percent. The Delta site requires about 30° of diffraction at which angle wave heights can be expected to be reduced to at least 25 percent of their original height (75 percent reduction) and will be further protected by a groin. This difference in the sites is to be compensated for by the floating breakwater.

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A reasonable design wave for the E-ESE direction would be the wave associated with a 40 mph wind event, that is a height of 4.0 feet and a period of 4.0 seconds. Allowing for 40 percent reduction, this would be a wave 2.4 feet high. The breakwater would have to completely stop this wave to match the delta site conditions but this would require a very large floating structure. A more reasonable criteria would be to reduce the wave height to 1 foot which is equivalent to a breakwater transmission coefficient of 40 percent.

CONCEPTUAL BREAKWATER DESIGN

The Mile West Site requires a breakwater 450 ft. long across the east end of the booming ground. As explained in the previous section, it would have to develop a transmission coefficient of 0.40 percent with a 4.0 sec wave. There are a number of different concepts available for wave protection but durability has been a persistent problem for most designs. A conservative design developed by NHCL is shown in Figure 1 as Alternative B. Two of these structures would be required. It would be constructed of post-tensioned reinforced concrete, cast around blocks of styrofoam flotation. The V-shape in plan increases the resistance to rolling and permits alignment such as depicted in Figure 2 as Alternative A. The transmission coefficient for both designs is 0.40 for a 4.0 sec wave as indicated in Fig. 3. Both designs have approximately the same mass. The V-shaped design performs much better at wave lengths greater than design values, however,.

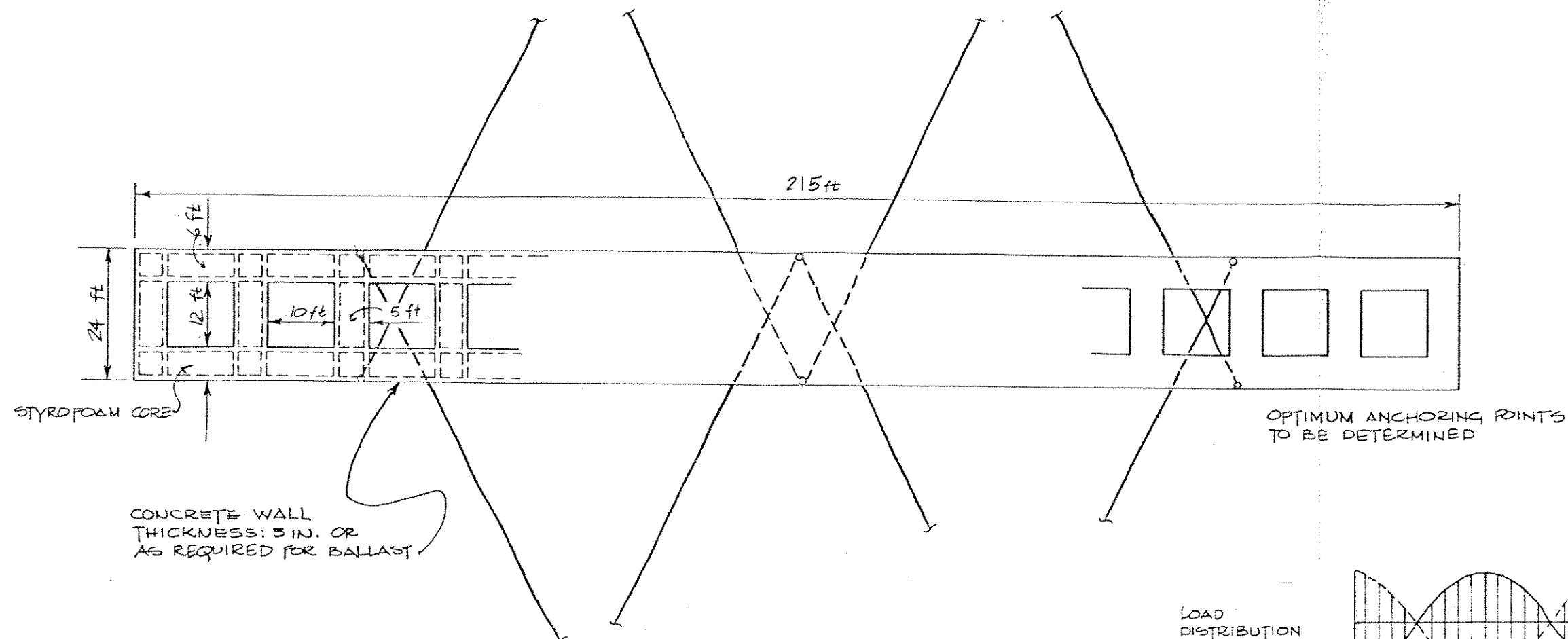
Floating breakwaters in deep water are moored by chain to deadmen on the sea bed with enough slack that they can rise and fall with the tides. There has to be enough tension, however, to prevent excessive drift under the action of tidal currents or wave induced currents. Proper design can limit this drift to approximately 0.3 times the water depth which would amount to approximately ± 75 feet at the sea-end of the breakwater.

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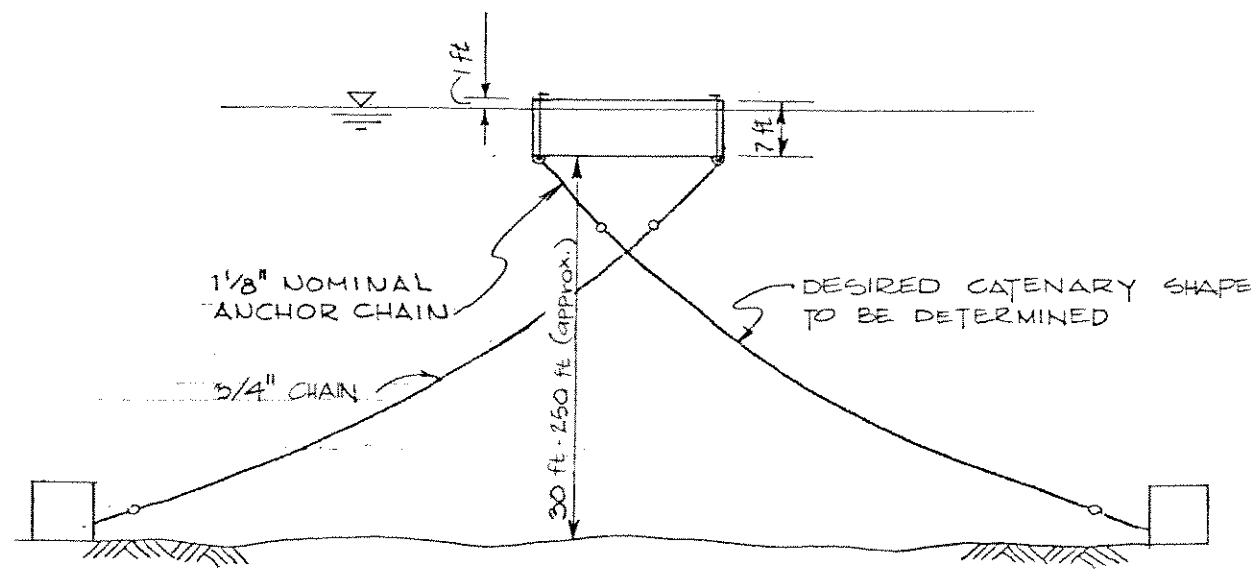
Maintenance would be minimum for the concrete, but the chains would corrode rapidly near the surface. The upper parts of the chain would probably require replacement every 5 years, but most of the chain would be good for 20 years or more.

ESTIMATED COST

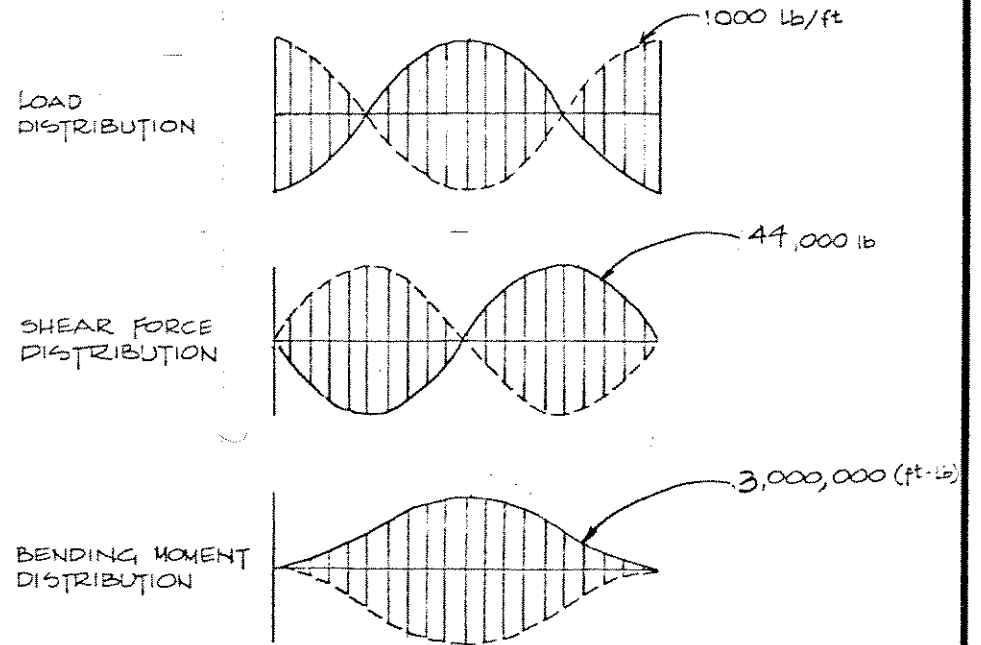
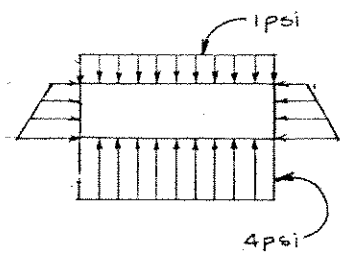
The estimate of the cost of constructing and installing the V-shaped breakwater is based on a joint bid prepared by NHCL and Dillingham Corp. Ltd. in 1978 for a similar breakwater to be installed in Vancouver Harbour. (The bid was recommended for acceptance but a contract was never awarded.) Allowing for somewhat different scope of work, for 1 year inflation, for towing to the site and for remote installation, the estimated cost is \$450,000 including \$35,000 for engineering. The engineering costs reflect the need to conduct a hydraulic model test to check internal stresses under wave action. Annual maintenance would average less than \$1,000 per year.



PLAN VIEW

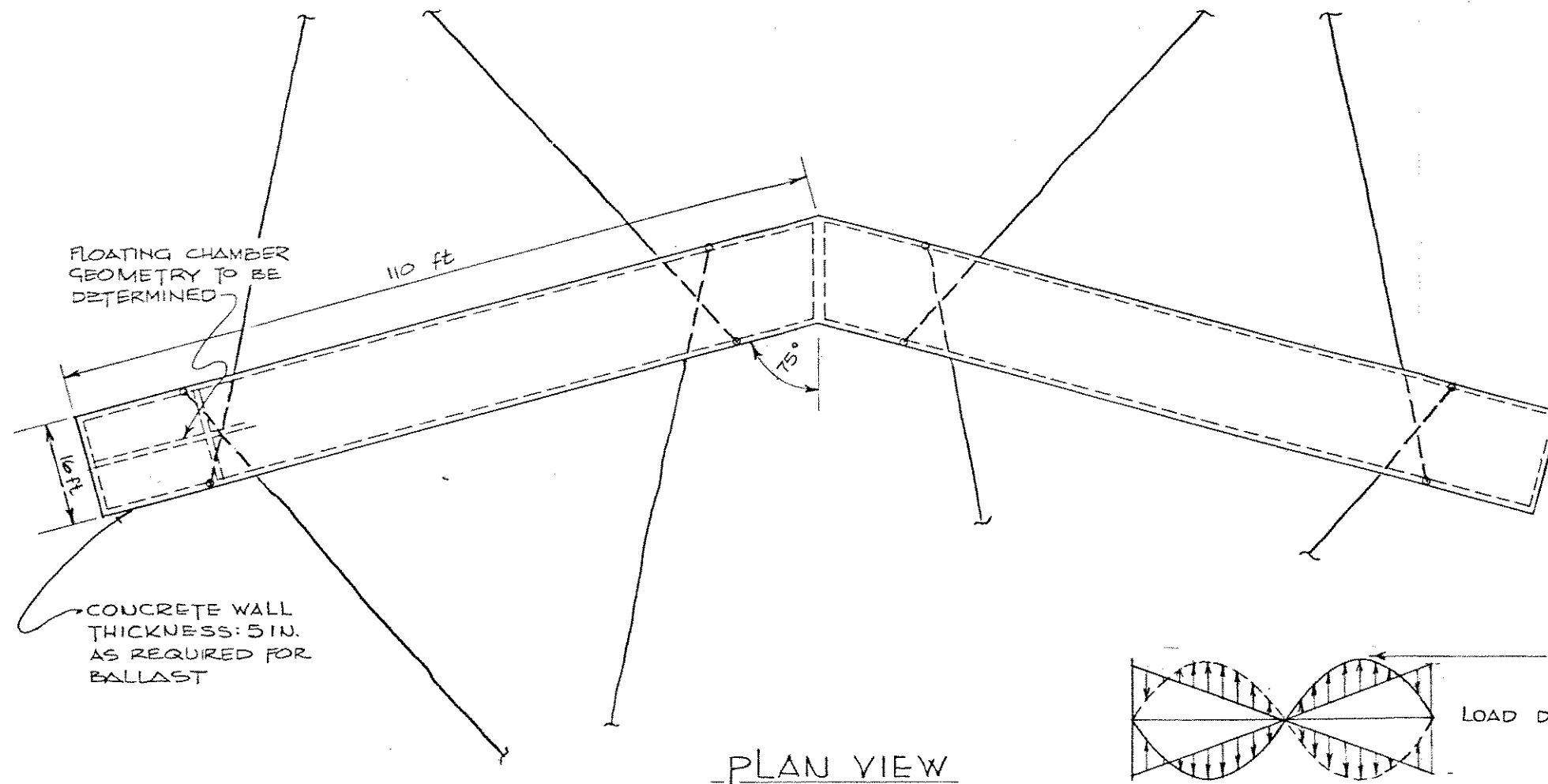


END VIEW

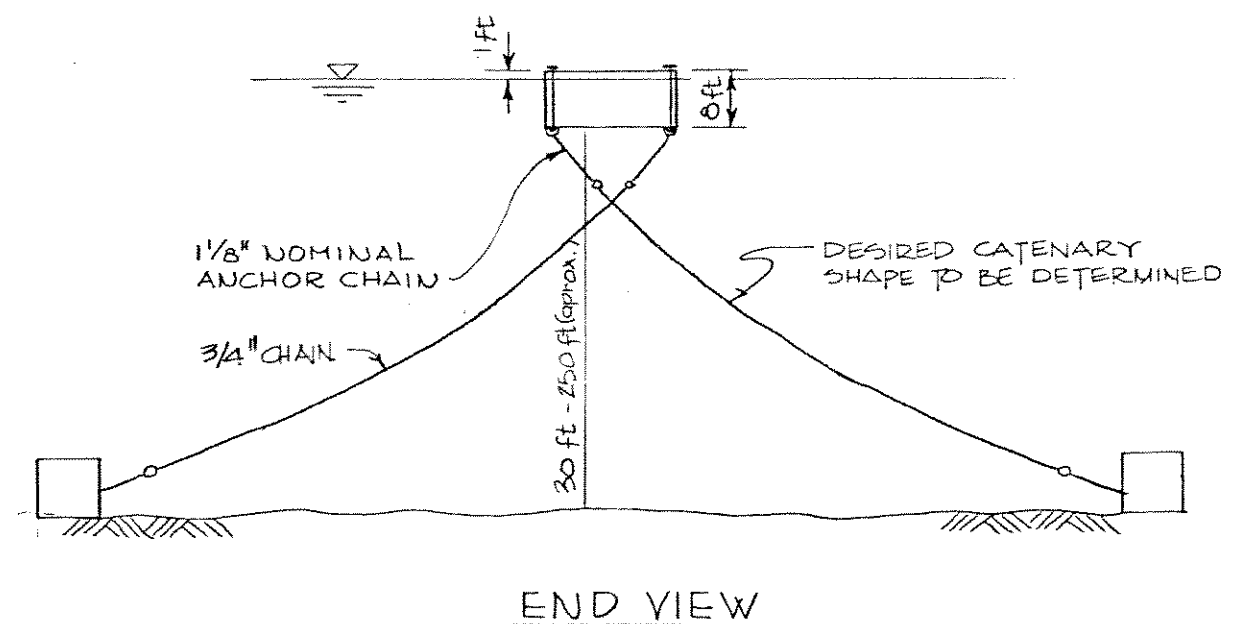
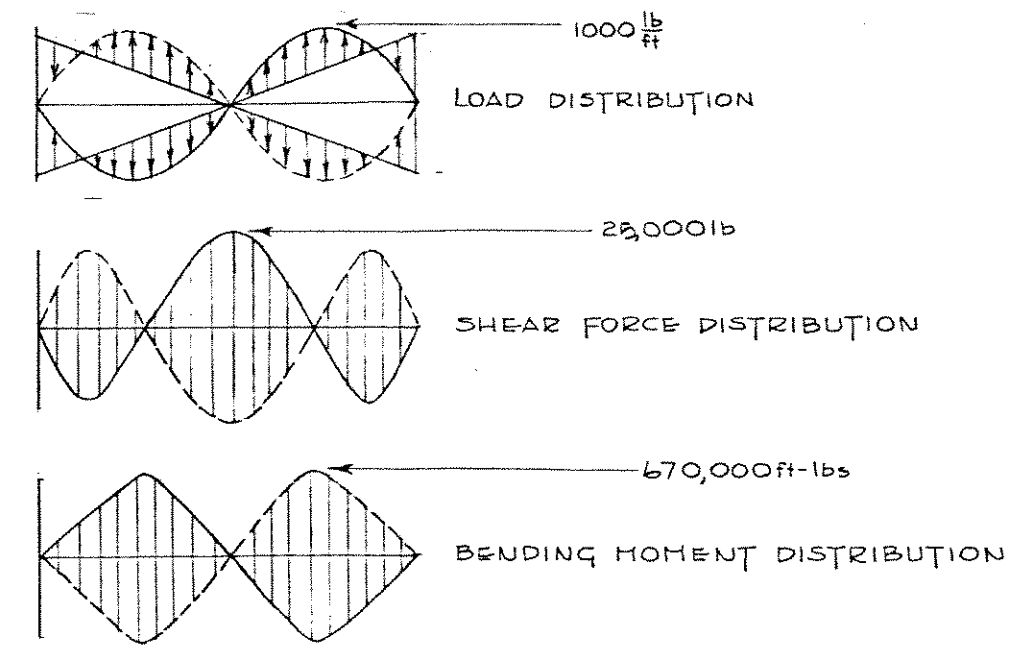
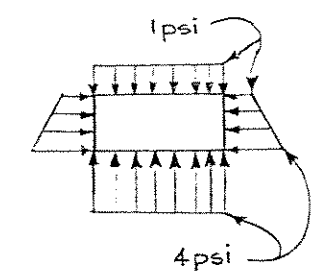


NOTE:
 1. STYROFOAM FLOATATION ADDED FOR BUOYANCY
 2. 4 ANCHORS - 25 TON CEMENT BLOCKS

MACMILLAN BLOEDEL LIMITED		
FLOATING BREAKWATER LAYOUT "A"		
northwest hydraulic consultants ltd.		
Drawn: I.M.	Date: JAN, 1979	Dwg: 2



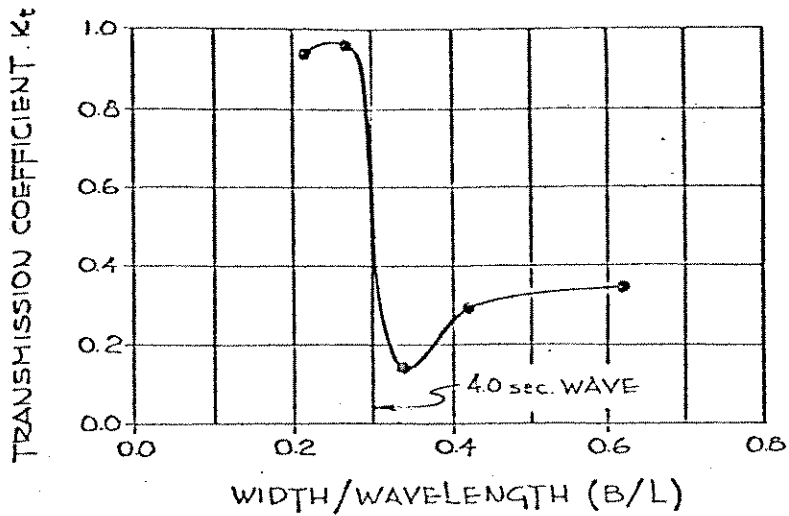
PLAN VIEW



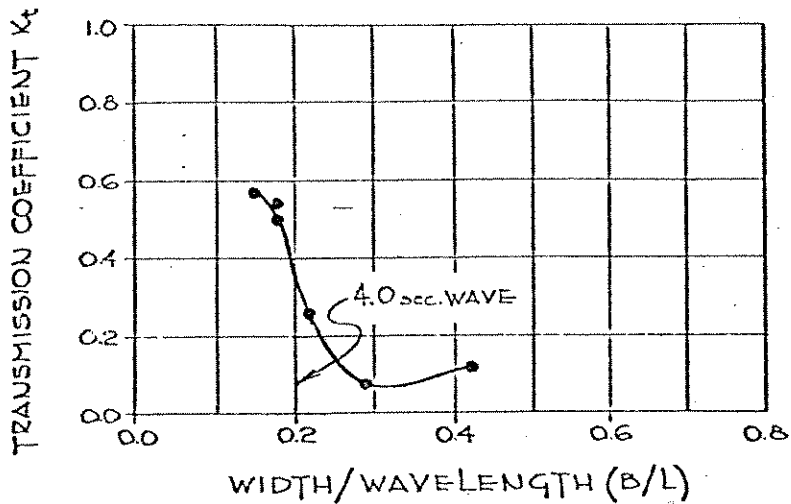
END VIEW

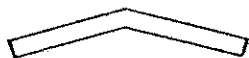
- NOTES:
1. STYROFOAM FLOATATION ADDED FOR BUOYANCY
 2. 4 ANCHORS - 25 TON CEMENT BLOCKS

MACMILLAN BLOEDEL LIMITED		
FLOATING BREAKWATER LAYOUT "B"		
northwest hydraulic consultants ltd.		
Drawn: I.M.	Date: JAN. 1979	Dwg.: 1



 LAYOUT A



 LAYOUT B

NOTES:

$$K_t = \frac{\text{TRANSMITTED WAVE HEIGHT}}{\text{INCIDENT WAVE HEIGHT}}$$

LAYOUTS A AND B CONTAIN APPROXIMATELY THE SAME MASS

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