CANADA BRITISH COLUMBIA – OKANAGAN BASIN AGREEMENT

PRELIMINARY REPORT N0.15

(SUBJECT TO REVISION)

Social and Economic Aspects

of the Shoreline Survey

of Okanagan and Osoyoos Lakes

PREPARED FOR THE

OKANAGAN STUDY

COMMITTEE

CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TASK 21A

Social and Economic Aspects of the Shoreline Survey of Okanagan and Osoyoos Lakes

by

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NOTICE

This report was prepared for the Okanagan Study Committee under the terms of the Canada-British Columbia Okanagan Basin Agreement. The information contained in this report is preliminary and subject to revision. The Study Committee does not necessarily concur with opinions expressed in the report.

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ABSTRACT

A shoreline survey of Okanagan Lake was completed in 1971 which evaluates in social and economic terms, damage that may occur if the level of this lake fluctuates outside its normal operating range. A preliminary survey was also completed on the consequences of high water levels on Osoyoos Lake. This latter survey is being extended to elevation 920 in 1972 as a result of the flooding which occurred around Osoyoos Lake during the 1972 spring freshet. The results of this extended survey will be published in an addendum to this report.

A separate report is being prepared on the engineering aspects of the shoreline survey which will include commercial wharves, the floating bridge at Kelowna, and the effect of extreme low water on water supply intakes around Okanagan Lake.

Other mainstem lakes were not included in this survey as the opportunity for water storage is insignificant compared to that of Okanagan Lake, and levels on these lakes are controlled primarily for recreational purposes.

SUMMARY

The objective of this task was to survey and evaluate, in social and economic terms, damage that might occur should Okanagan and Osoyoos Lakes fluctuate outside their normal operating ranges. The survey assessed potential damage to several categories of developed shoreline landuse, including recreational, residential, transportational and commercial uses. For Okanagan Lake, the nature and extent of such damage was measured for 0.5 foot increments up to 2 feet above the present maximum elevation of 1123.8 feet and for 0.5 foot increments down to 3 feet below the present minimum of 1119.8 feet. For Osoyoos Lake, damage estimates were restricted to 0.5 foot increments up to 2 feet above the present maximum of 912 feet, as minimum elevations are effectively controlled by a natural sand bar. All information gathered in the inventory was measured in appropriate economic, social and environmental values and stage-damage curves were constructed.

The main findings of the surveys were as follows:

1. Economic damage to shoreline property around Okanagan Lake resulting from flooding would be relatively small for the first foot above the present maximum (less than $100,000.), but would rise rapidly to $600,000. if the lake rose two feet. Economic damage occurring at lake levels three feet below present minimum would also be small, as low-cost adjustments can be made to navigation wharves provided such occurrences are infrequent. These economic cost figures do <u>not</u> include possible damage to the Kelowna Floating Bridge.

2. Social disbenefits due to loss of opportunities associated with private boat docks; private property and buildings, and environmental costs due to loss of opportunity at public recreation sites, should be regarded as an inconvenience during short-term fluctuations (a few months) as many adjustments would be available. A recurrence of a prolonged drought such as occurred in 1929-32 may produce long-term costs to the tourist industry.

3. Exposure of shoreline around Okanagan Lake at drawdowns of up to 3 feet would be greatest around the Summerland, Okanagan Mission and in the Vernon Arm. Generally, exposure would be greater around developed sites than in undeveloped areas, and could present a large environmental cost during prolonged drawdowns.

4. Similar conclusions apply to potential flood damage up to 2 feet above present maximum levels for Osoyoos Lake. Direct economic damage to residential and commercial properties appears to be small ($27,000), but flooding of campsites and some motels could create significant environmental and social costs plus some loss of potential tourist revenues.

5. On the basis of a mathematical simulation of the operation of Okanagan Lake over the past 50 years of record (1921-1970), direct annual economic damage to existing shoreline landuse is estimated at $3,110. This figure does not include possible long-term impacts of severe lake level fluctuations on tourism.

6. These damage data do not include seepage problems associated with high water levels. Such problems give rise to flooding in basements and crawl spaces causing damage to furnaces, septic tanks and water systems. Although the economic costs of cleanup are not large, seepage problems can create considerable personal inconvenience. None of these problems was analysed in this report because of the difficulty of identifying properties that may be affected, but will be incorporated into this summer's field survey.

7. Damage potential was relatively large on Indian Reserves, particularly those in the North Arm of Okanagan Lake. Sub-division of fore-shore for summer cottage developments has occurred without any planning or development controls (Indian Lands are outside the jurisdiction of the Regional Districts) and because lake levels have not risen above 1123.5 feet in recent years, encroachment below the maximum levels has taken place.

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PREFACE

This report presents an analysis of the socio-economic implications of extreme lake level fluctuations on Okanagan and Osoyoos Lakes. Okanagan Lake normally fluctuates over a four foot range (1119.8 to 1123.8 feet) and controls almost 75 per cent of all storage potential within the entire Okanagan watershed. As the opportunity to increase this storage capacity to avoid flooding and to supply water in drought periods is being considered in the Okanagan Study, it is important to understand the social, economic and environmental consequences of such extreme fluctuations on existing shoreline landuse.

It should be understood that this report assumes that Okanagan Lake will not be intentionally raised above its operating maximum level of 1123.8 feet, but will only flood during abnormally high inflow years (such as occurred in 1972). If the alternative to raise the operating level on a permanent basis was considered, the socio-economic analysis would have to be extended to include expropriation costs. The actual costs of the high water levels on Okanagan Lake during the 1972 freshet will be estimated by field sampling this summer and presented in a later report.

Osoyoos Lake was included in this shoreline survey because of its flood potential in high runoff years. An understanding of the socio-economic costs of such flooding will be extremely useful in devising an improved operation of the entire main-stem system. The survey described in this report only examined flood damage potential to a level of 914 feet. (Canadian Geodetic), i.e. two feet above the operating maximum of 912 feet. In light of the flooding problems on Osoyoos Lake in the freshet of 1972, Osoyoos Lake will be re-surveyed this summer, and flood damage potential up to 918 feet (Canadian Geodetic) will be assessed. Furthermore, the actual damage occurring to private properties, recreational sites and lost revenues as a result of this year's flood will also be determined. This information will be presented in a later report along with the up-dated costs of flooding on Okanagan Lake.

Other main-stem lakes - Kalamalka and Skaha were not included in this shoreline survey as the opportunity for water storage is insignificant compared to the potential on Okanagan Lake. Lake levels in Kalamalka and Skaha are carefully controlled by dams and are maintained primarily for recreational purposes.

INTRODUCTION

The level of Okanagan Lake normally fluctuates within a four-foot range (1119.8 to 1123.8 feet G.D.). Although lake levels are controlled to some degree by a dam at its outlet near Penticton, the large variability of inflows into the watershed and the difficulty of accurately forecasting this annual runoff indicate that fluctuations outside this four-foot range are possible. In the event of such extreme fluctuations, some damage will occur to existing land use around the shoreline.

This report is designed to evaluate in socio-economic values the types of damage that might occur to shoreline land use around both Okanagan and Osoyoos Lakes should their levels exceed the designated maximum and minimum elevations. The report presents in some detail the field survey programme carried out during the sunnier of 1971 to determine the stage damage curves for both lakes and is divided into four sections. The first section discusses the objectives of the task, the evaluation approach and the scope of the study; the second section details the techniques used in the shoreline survey and interpretive methodology; the third section presents the main results of the survey and, finally, the fourth section discusses the conclusions and the implications of these results.

OBJECTIVES AND SCOPE

2-1 OBJECTIVES

The objective of this study was to survey and evaluate in social and economic values, damage that could occur should Okanagan Lake levels fluctuate outside the normal four-foot range. The same objective was applied to Osoyoos Lake though damage estimation was restricted to impacts of lake levels exceeding the maximum level of 912 feet.

2-2 SCOPE

The survey assessed potential damage to several categories of developed shoreline land use including recreational, residential, transportation and commercial uses. For Okanagan Lake, the nature and extent of damage for these land use categories was inventoried for 0.5 foot intervals up to 2 feet above the present maximum of 1123.8 feet and for 0.5 foot increments down to 3 feet below the present minimum of 1119.8 feet. The information gathered in the inventory was then measured in appropriate social, environmental and economic values and stage-damage curves were constructed. Damage that could not readily be measured in quantitative units was documented in qualitative terms.

The shoreline survey around Osoyoos Lake was restricted to assessing potential damage that could occur at 0.5 foot increments up to 2 feet above the recommended maximum elevation of 912 ft. No survey of damage resulting from low lake levels was undertaken as the minimum level is effectively controlled by a natural sandbar. In both surveys, the assumption was made that no damage would occur within the normal fluctuation range.

METHODOLOGY

The development of a methodology involved four stages. Firstly, a method had to be designed to inventory types of shoreline damage that might occur to various land use categories and secondly, a methodology was needed to interpret and analyse these data in terms of the actual damage in economic terms that might occur. Thirdly, field survey techniques had to be devised which would provide an acceptable level of accuracy within the time constraints of completing both lakeshore surveys by early September. Finally, an evaluation methodology had to be designed that was consistent with the overall evaluation approach presented by J. O'Riordan (July, 197l). This approach identified the three major study objectives of economic growth, environmental quality and social well-being as the basis for establishing values. Each of these stages will be discussed in turn.

3-1 DAMAGE INVENTORY

Initial field checks indicated that damage could occur in three general categories; direct physical damage to property (land), direct physical damage to structures, and indirect damage through the loss of revenue to commercial operations. As the latter category was encountered infrequently, inventory collection forms were designed to accommodate the first two categories only, the indirect damage being collected by individual interviews.

The inventory form was designed and revised after several field checks (see Appendix A). First of all, data had to collected to meet the scope of the study; that is, on the basis of 0.5' increments up to 2.0' above 1123.8' and down to 3.0' below 1119.8'. This formed the horizontal axis of the inventory matrix sheet. Secondly, the form had to accommodate damage to both property and structural developments as indicated by the vertical axis of the matrix.

Information on property damage was determined by recording on the inventory sheet the width between each 0.5' contour interval, the length of property frontage and a description of the property. Property was described in two ways; improved (lawn and landscaped areas) and unimproved (sand, gravel and waste areas). Different types of damage could occur in each case.

This type of information can best be shown in a diagram of a hypothetical example (Figure l).

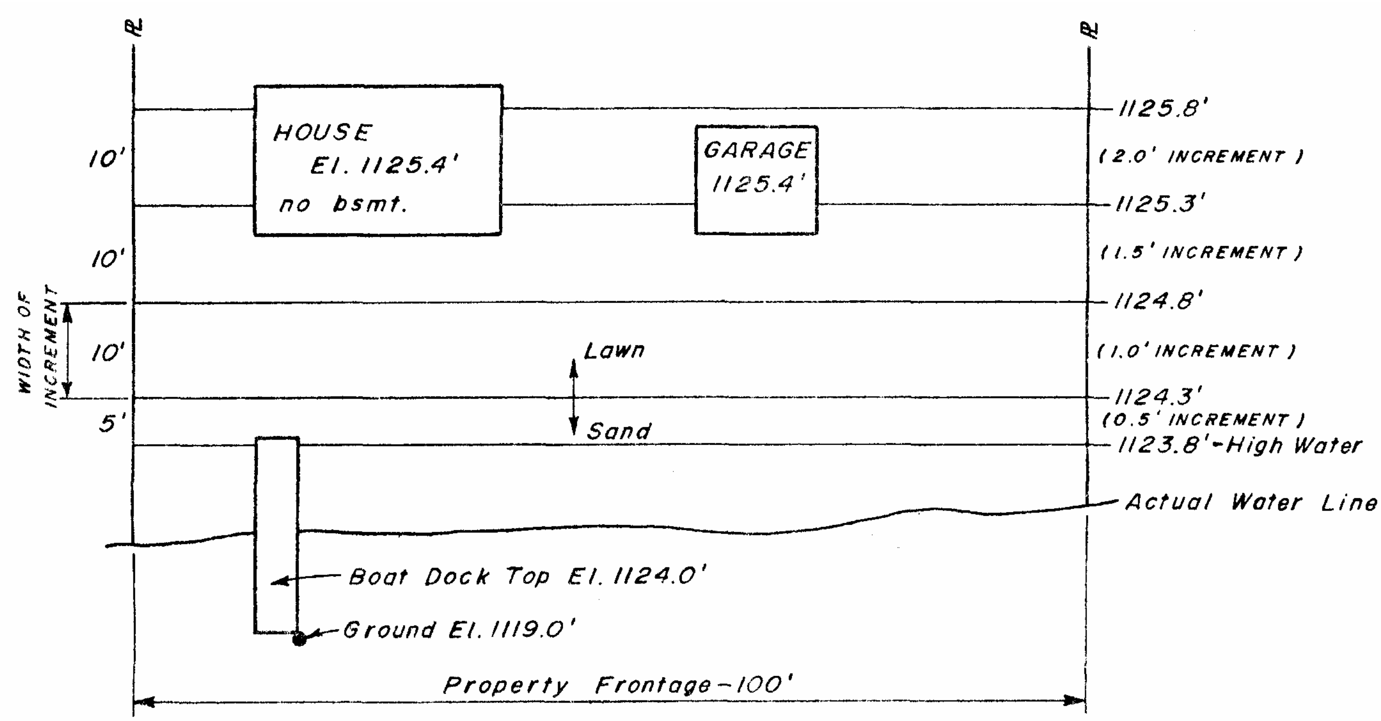


Figure 1. Hypothetical Shoreline Property Plan

In this case, the first 0.5 foot increment (1123.8 to 1124.3 feet) above high water would be recorded as 5.0' wide, 100' long and as unimproved land; the second increment (1124.3 to 1124.8 feet) as 10.0' wide, 100' long and improved land.

Recording structural damage presented more complex problems. Because early field reconnaissance indicated that most of the structures around the shoreline were for residential purposes, the inventory sheet was designed primarily for residential damage estimation but could be adopted to other land use categories. The inventory form was designed to record the increment at which damage occurred to houses (foundations, basements and main floors), garages, boat docks and retaining walls. Criteria for recording damage included the point at which water would flood the structure and the depth of flooding. Where there were retaining walls, no damage to structures would be recorded unless the water level exceeded the height of the wall. In this case, an estimate of damage to the retaining wall itself would be included on the inventory form. Boat docks may or may not be damaged by high water levels, although it was considered inconvenient if the water rose over top of the dock or if there was less than one foot of water at the end of the dock.

With reference to the hypothetical example (see Figure l), it is evident that the foundations of the house and garage would be affected by the 1,5 foot increment (1125.3 feet) and that the main floors would be flooded at the 2 foot increment. Boat dock operation would be inconvenienced if the lake rose to 1124.3 feet (0.5 foot increment) or dropped below 1120.0 feet (within the normal operating range).

When structural damage was recorded for a property, a legal description was obtained together with a reference number to locate the property in the filing system and on aerial photos of the area. With these data, information on the cost of structural damage could be obtained from assessment rolls. Structural damage occurring to properties other than residential was assessed by drawing a field sketch and checking on damage estimates with follow-up interviews.

For evaluation purposes, property damage was also classified according to land use category and as such was recorded on the inventory form. The land use categories chosen were as follows;

1. Residential
2. Commercial
3. Industrial
4. Recreational
5. Agricultural
6. Transportation

Land exposed at low water levels was measured at approximately one-half mile increments along the shore or at selected reference points and recorded on air photos. This information was transferred to maps at a later date (see Maps 2 and 3). Two measurements were recorded; the distance from high water mark (ll23.8 ft.) to low water nark (1119.8 ft) and from low water to 3.0' below this level (lll6.8' ft.).

3-2 DAMAGE ESTIMATION

The previous section outlined the method of data inventory. The next step was to determine ways of measuring the extent of this damage. Interviews were conducted with landscape contractors and insurance adjusters to determine damage estimation procedures. For the purpose of this task, it was assumed that estimates within about a 25 per cent level of accuracy were appropriate. Time constraints did not permit detailed tabulations so a uniform damage estimation procedure was established.

Property damage was analysed in two ways. Flooding of unimproved land (sand, scrub) was considered an inconvenience but not an economic loss and was measured in acres. Flooding of improved land (lawns, flower beds) was evaluated in dollar terms - the cost of replacing the damage. Based on interviews with landscape architects, a value of 25 cents per square foot was chosen as average replacement cost of improved property.[1]

Assessment of damage to structures involved a complex procedure. If foundations only were affected and there was no basement then no economic damage was assessed, only an inconvenience factor. Total number of structures affected in this manner were tabulated. If the structure had a basement, damage could occur both to the basement structure and its contents. Similarly, at higher lake elevations, damage could occur to main building structures and contents.

1/ Information on cost figures was obtained from Keans Landscaping, Penticton, B.C.

In the case of structural damage, insurance adjusters calculate this on the basis of market value of the building. The market value is determined from the assessed value which was available from municipal assessment offices in Penticton, Summerland, Peachland, Kelowna and rural assessment rolls for Vernon Assessment District and Kettle River Assessment District (Table 1 and Map l).

The formula for converting assessed values into market values varied between Assessment Districts. In some offices, the assessed values were 50 per cent of market values but over all, the range of conversion factors varied between 50 and 90 per cent. For each area, district assessors provided the appropriate conversion factor. The following formulae were then used to determine economic damage to structures and contents:

<u>Structural Damage</u>

Basement	- 6% of market value
Main Floor	- 30% of market value
Contents Value	- 40% of market value of building
Up to 6" of Water	- 30% of contents value
Over 6" of Water	- 100% of contents value
Basement	- average of $800 - Total Loss

TABLE 1

ASSESSMENT DISTRICTS AND ASSESSMENT ZONES [2/]

A. Penticton

B. Summerland

1. Trout Creek
2. Lower Summerland

C. Peachland

D. Kelowna

1. South Kelowna
2. North Kelowna

E. Kettle River

1. West Bench
2. North Beach
3. Naramata

F. Vernon District

1. Gellatly
2. Green Bay
3. Westbank
4. Westside
5. Fintry
6. Whiteman
7. Okanagan Landing
8. Okanagan Centre
9. Mission

G. Osoyoos Lake

Assessment data for the summer cottages built on the Indian Reserve at the north end of Okanagan Lake were generally not available. Only a small percentage had ever been assessed and, in all cases, there was no legal description for the properties. This problem was overcome by talking to the assessor of

[2/] These subdivisions provided the basis of filing and retrieving data. Final calculations were first of all made by assessment zones, next by assessment areas, and finally, totals were derived for each lake and each land use category (see Appendix B and C).

the Vernon District and checking the assessment files of these properties that had been assessed. In most cases, the buildings were no more than shacks which were used a few weekends each summer. Three types of structures were identified and an average value attached to each: Type I - a shack with a value of $800; Type II - a cabin, but well constructed with a value of $1,500; and Type III - a small permanent home with a value of $6,000. Based on a qualitative judgement, the structure was placed in one of the categories and recorded on the inventory form. These figures were then used as market values for damage estimation.

An average garage (or boat house) was valued at $2,000 and approximately $350 damage would occur if the water levels exceeded the height of foundation walls. Boat docks would not receive any economic damage, but the owner would be inconvenienced if he could not use his dock. In this case, the total number of docks affected at each increment was recorded. Damage to public boat ramps was recorded in a similar manner.

Retaining walls could be damaged due to wave action and ground swelling. It was assumed that this would occur if the water overtopped the wall. Under these circumstances, the total length of the wall was recorded and a replacement cost of $7/ft. was estimated (assuming an average wall is 8 inches thick and two feet high).

Special problems for determining economic damage to railway docks, the bridge at Kelowna and the lumber mill at Kelowna were encountered. The B.C. Water Investigations Branch requested damage information on these structures. No information was available from the Kelowna Lumber Mill and the B.C. Department of Highways indicated that damage estimates of low water levels to Kelowna Bridge would require detailed studies. Thus, the economic damage data presented in the next section do not include data on these structures. Additional information on the C.P.R. and C.N.R. operations were obtained by Dr. J. 0'Riordan in September (see letter in Appendix D), and these damage data were incorporated into the economic damage calculations.

There could be potential loss of revenue to commercial operations (marinas and campgrounds) in the event of extreme lake level fluctuations. Marinas could lose revenue through the sale of gas and the rental of dock space at both high and low water levels. Interviews were carried out at each location where damage occurred to determine total loss of gas sales per season and the rental charge/month for docks. The field survey determined the increment where it would be impossible to use the gas pumps or rent mooring space. Campgrounds would lose revenue if some of their sites were flooded. The field survey indicated the number of sites flooded at each increment and the interview determined the charge per day and the period of operation. The charge multiplied by the number of days gave a seasonal loss figure, which is a maximum estimate as it is assumed that campsites would be occupied if no flooding occurred.[3/]

[3/] These assumptions may be revised as a result of investigating the consequences of the 1972 flood on Osoyoos Lake. It appears that some tourists cancelled bookings for July and August when they heard of flooding problems on Osoyoos Lake in June. If these tourists do not come to the Okanagan at all, their potential expenditures should be accounted as costs to flooding.

3-3 SURVEY TECHNIQUES

Field survey techniques for both on-shore and off-shore areas had to be devised to provide an acceptable level of accuracy within the specified time constraints. Following a period of experimentation, the field survey methods described below were determined with the co-operation of a surveyor from the B.C. Water Resources Service.

On-shore surveying involved the determination of 0,5' contours up to two feet above high water mark of 1123.8'. The lake level was checked daily and used as a datum point for the survey. The survey method involved using a hand level rod and pacing to determine contours and distances. Property widths were determined from property plans where available. The field survey involved 3 people; one to operate the hand level, one as rod man and for pacing, and one for completing the inventory forms, including sketching where necessary.

Off-shore surveying was required to determine the amount of land exposed at low water levels and point out which boat docks became inoperable. The depth of water off the end of a dock was determined by rod soundings. Distances of land exposed were found by using a boat and rod sounding (using the lake level as datum) to determine low water level (1119.8') and 3.0' below this level (1116.8'). At each of these points, a range finder was used to determine the distance from shore. Only the two points were located as the slope of beach was found to be constant in most cases and because it was difficult to obtain accurate soundings at 0.5 foot increments. This information was recorded on air photos and later transferred onto a map (see Map 2).

3-4 EVALUATION PROCEDURES

Final calculations of shoreline damage were measured in terms of the multiple objectives of economic growth, environmental quality and social well-being. Damage under the economic growth objective was accounted in dollar terms and any impact that could properly be assessed in dollars was included in this category. Damage occurring under the environmental and social objectives were accounted in quantitative but non-monetary units on the following basis. Any impact on the recreational and aesthetic qualities of the shoreline that were affecting the public at large rather than the individual property owners were accounted under the environmental objective. If the results of this summer's work on the impacts of high water levels on recreation indicate that tourists do in fact avoid the valley, their potential expenditures foregone will be included in the economic objective. Any effects on the loss of opportunities by private property owners due to fluctuating lake levels were accounted under the social well-being objective. On this basis, final calculations resulted in damage being included in the following categories.

A. Environmental

1. Number of public boat ramps inconvenienced.
2. Area of public recreation sites flooded.
3. Distance exposed at low water.

B. Social

1. Area of private property flooded (improved and unimproved),
2. Number of private boat docks inconvenienced.
3. Number of buildings affected.

C. Economic

1. Potential direct damage to property and structures.
2. Potential loss of revenue.

Damage accounted for under the environmental and social objectives were primarily inconvenience factors in which society at large or individual property owners would suffer a loss of opportunity in the use of certain facilities. Care was taken in final calculations to avoid the possibility of double counting. However, in some cases it was felt that two distinct types of damage could occur from the same data base. For example, the flooding of private property has an inconvenience factor but, if one property owner has landscaped part of his property, then he would incur an additional economic damage associated with replacement costs.

3-5 LIMITATIONS AND ASSUMPTIONS

The actual estimates of damage presented in this preliminary report should be treated with some care, as they depend on a number of assumptions. First, it is assumed that under flooding conditions, no precautions will be undertaken by shoreline residents to protect their property. In the case of the Osoyoos flood during June, 1972, many property owners placed sandbags around their property, thus considerably reducing structural damage. Furthermore, additional precautions such as removing furniture to higher levels in the house, or in some cases evacuating the house completely would reduce damage to contents. Second, the economic and social costs of these emergency actions were also not accounted, though presumably they are less than the reduction in flood damage otherwise they would not be undertaken. The re-survey of Osoyoos Lake this summer will assess the costs of all emergency and protective measures.

Third, the recreational costs were simply based on potential loss of revenue during the actual flood period. If tourists go elsewhere in the Okanagan valley, there is no net economic loss to the valley as a whole. But if tourists decide to avoid the valley completely on account of either high or low lake levels, then their total potential expenditures plus the multiplier impacts of these expenditures within the Okanagan economy should be accounted as a cost. During the survey of 1971, no data were available to assess the total recreational impacts, but this summer, the socio-economic group will attempt to determine in more detail the recreational impacts of high water on Okanagan and Osoyoos Lakes. Fourthly, loss of revenue was based on an estimate of the number of units (campsite or motel) flooded. Experience from the 1972 Osoyoos Lake flooding indicated that this assumption may have to be revised to account for other factors such as loss of access to an entire campsite or seepage into sewage systems which creates a health hazard.

This report only covers indentifiable damage and thus omits certain aspects of potential inconvenience. For example, seepage into basements, crawl-spaces and septic tanks will undoubtedly occur with high lake levels, but actually properties that could be affected were difficult to identify in a field survey. Economic costs will likely be small, but social inconvenience could be significant and attempts will be made this summer to assess the consequences of such damage. Costs of adjustments to the Kelowna Floating Bridge also have not been included in this report. In June, 1972, water was pumped into tanks on the bridge which enabled it to operate successfully at Okanagan lake levels of 1124.5 feet.

Finally, all damage was based on calm water levels. Additional damage could result from wave action during storms, but as the extent of such damage would be almost impossible to assess from a field survey, it has been omitted from this report.

RESULTS

Tabulations for each landuse category for Okanagan and Osoyoos Lakes can be found in Appendix B & C at the end of this report. These tabulations were interpreted according to the evaluation procedures described in the previous section. The results are shown both in tabular form and graphically in the form of stage-damage curves (incremental and cumulative) for each category.

4-1 OKANAGAN LAKE

The results for Okanagan Lake include damage that will occur at both high and low water levels.

4-1.1 Environmental Damage

In terms of public boat docks affected (see Table 2 and Figures 2 and 3), there appears to be a linear relationship between the number of ramps affected and the water level at both high and low areas. The major inconvenience would occur during the period March to November.

A similar linear relationship between water depths and damage is evident for areas of public recreation sites flooded (Table 3 and Figures 4 and 5) due to the regular slope of the foreshore. Most of the recreational sites are sandy beaches (see tabulation sheet for recreation areas in Appendix B) and, as the beaches at Penticton and Kelowna are already crowded during July and August, if the lake were to exceed the maximum range during these months, recreation values could be significantly reduced.

TABLE 2

PUBLIC BOAT RAMPS INCONVENIENCED (OKANAGAN LAKE)

(i) Cumulative		(ii) Incremental
Increment	No.	No.
High		
1.5' - 2.0'	15	3
1.0' - 1.5'	12	5
0.5' - 1.0'	7	4
0.0' - 0.5'	3	3
4' Fluctuation	0	0
0.0' - 0.5'	5	5
0.5' - 1.0'	11	6
1.0' - 1.5'	17	6
1.5' - 2.0'	22	5
2.0' - 2.5'	22	0
2.5' - 3.0'	22	0
Low		

TABLE 3

AREA OF PUBLIC RECREATION SITES FLOODED (OKANAGAN LAKE)

(i) Cumulative			(ii) Incremental	
Increment	Sq. Ft.	Acres	Sq. Ft.	Acres
0.0' - 0.5'	299,910	6.885	299,910	6.885
0.5' - 1.0'	623,555	14.315	323,645	7.430
1.0' - 1.5'	923,470	21.199	309,915	6.884
1.5' - 2.0'	1,271,990	29.201	348,520	8.002

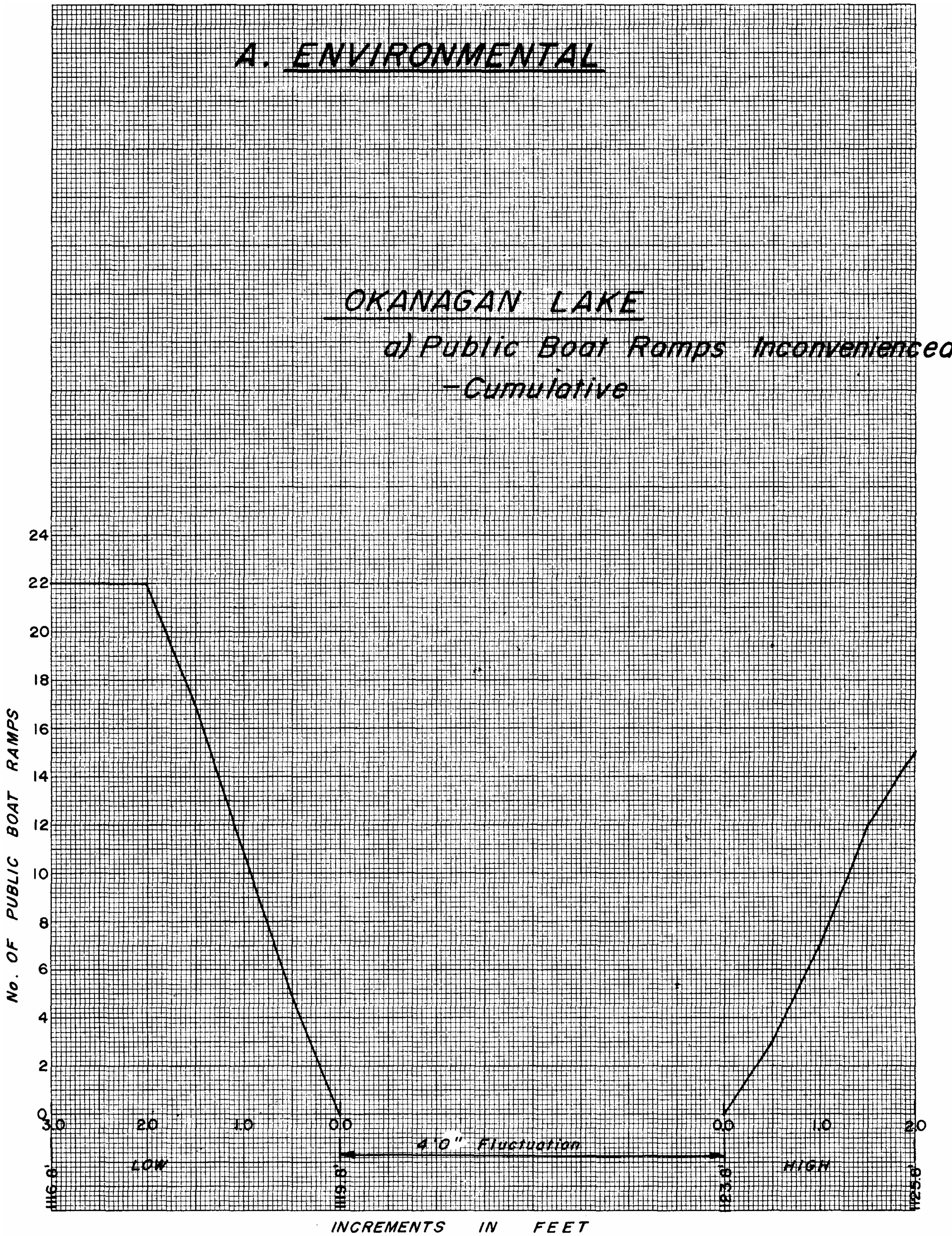

A. ENVIRONMENTAL
OKANAGAN LAKE
a) Public Boat Ramps Inconvenienced
—Cumulative
No. OF PUBLIC BOAT RAMPS
24
22
20
18
16
14
12
10
8
6
4
2
0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
4'0" Fluctuation
LOW
HIGH
INCREMENTS IN FEET

FIGURE 2

A. ENVIRONMENTAL

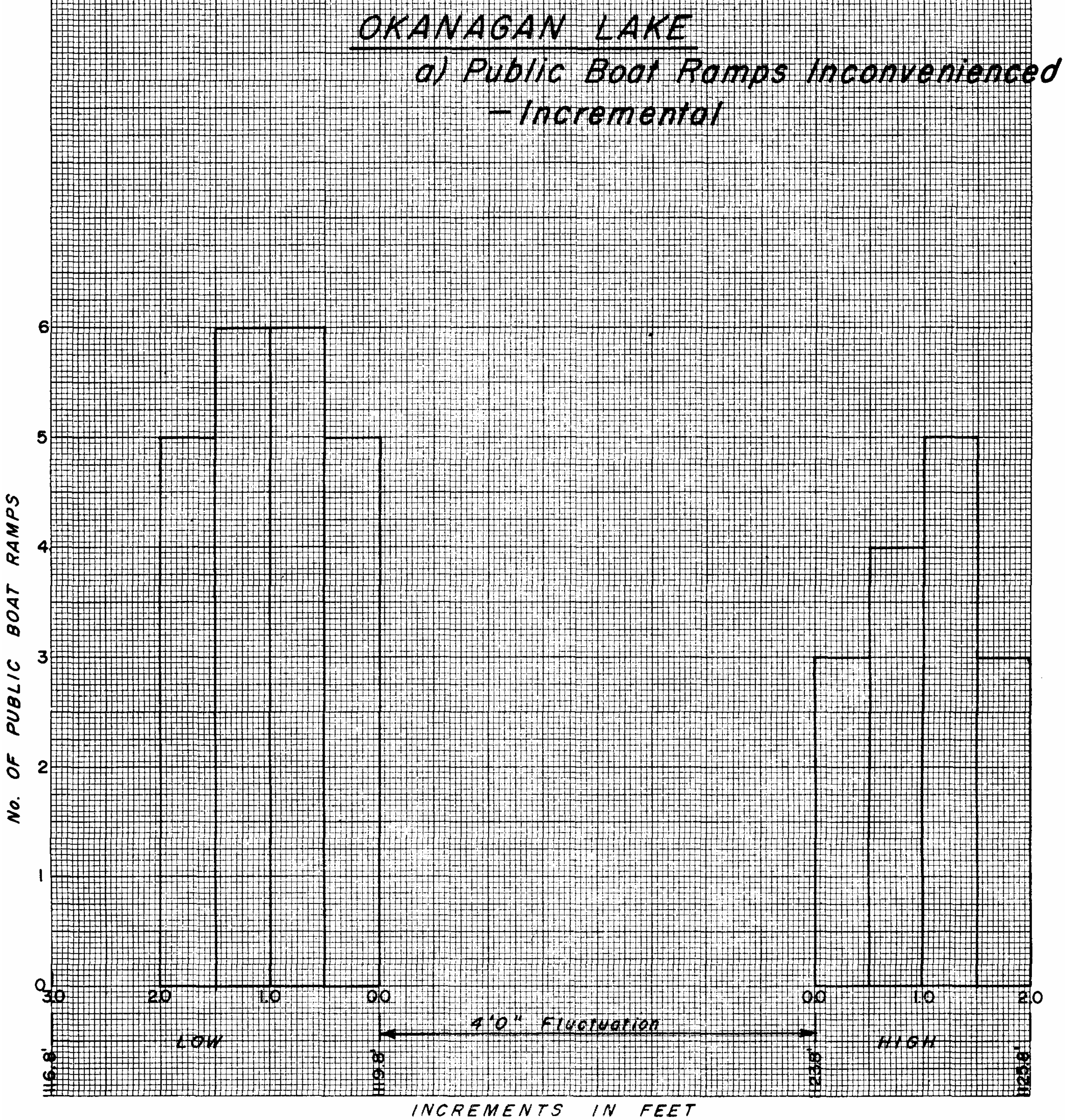


FIGURE 3

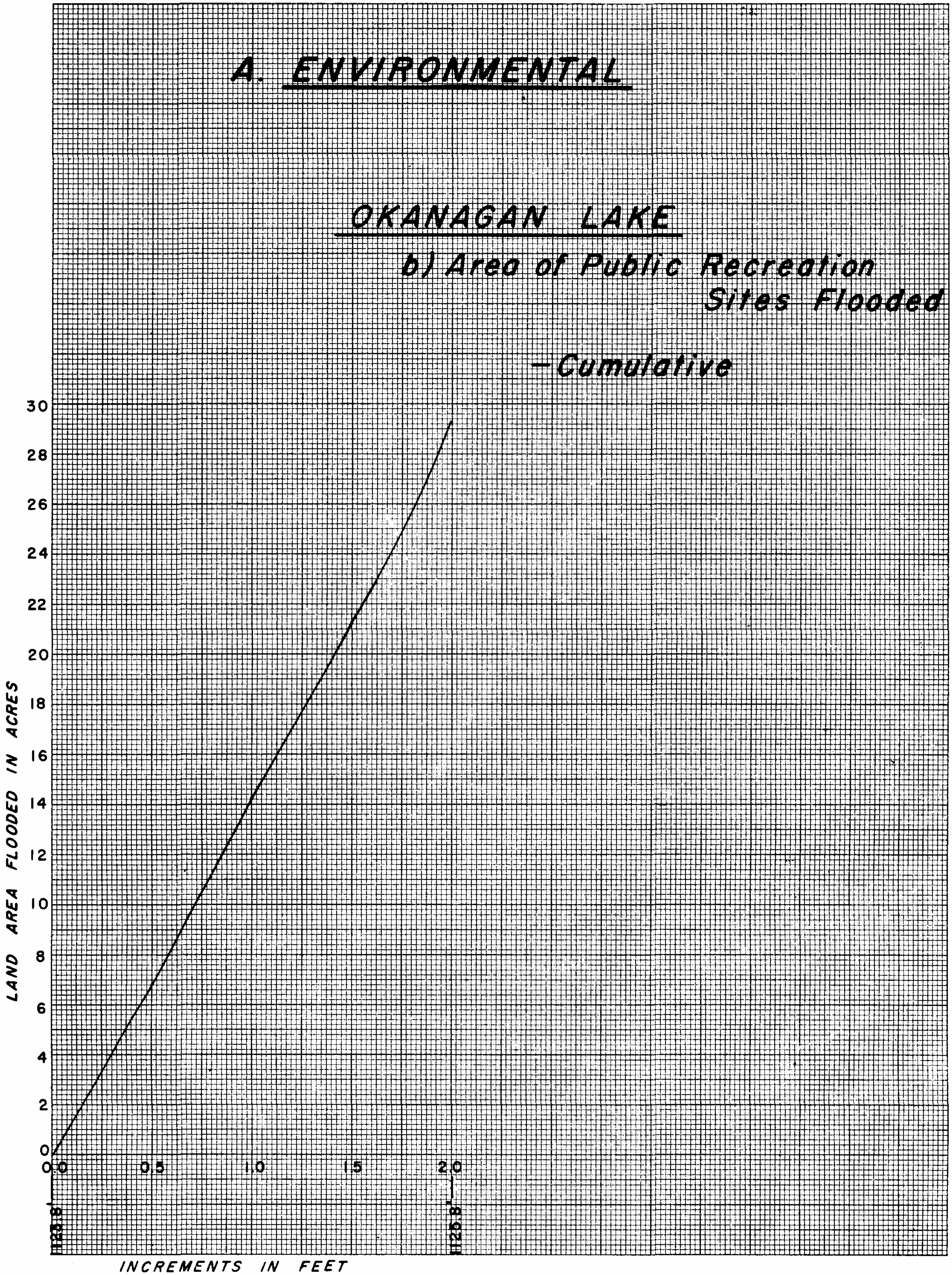

A. ENVIRONMENTAL
OKANAGAN LAKE
b) Area of Public Recreation Sites Flooded
- Cumulative
LAND AREA FLOODED IN ACRES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
0.0
0.5
1.0
1.5
2.0
1123.8'
1125.8'
INCREMENTS IN FEET

FIGURE 4

A. ENVIRONMENTAL

OKANAGAN LAKE

b) Area of Public Recreation Sites Flooded

-Incremental

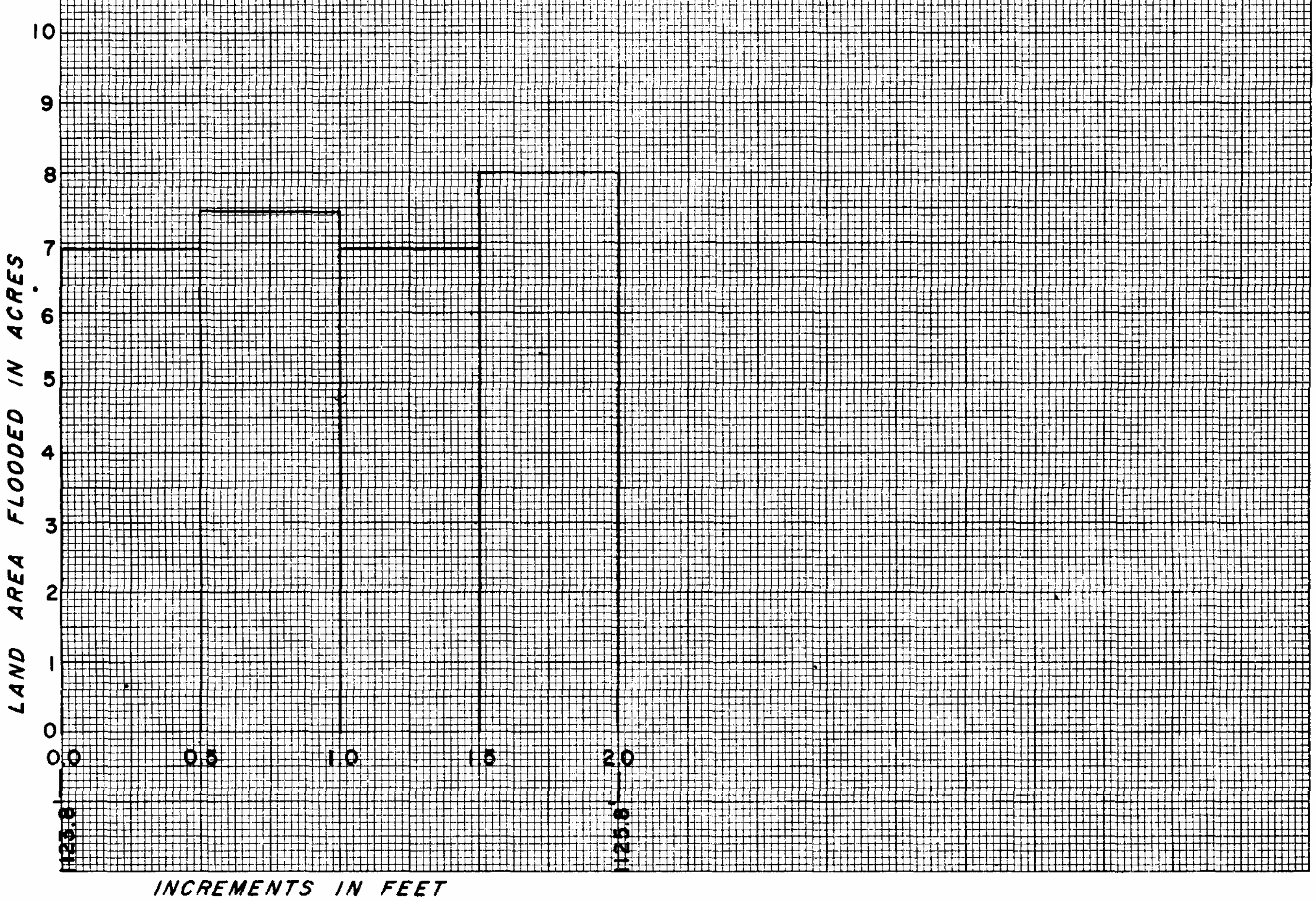


FIGURE 5

Survey methods showed a linear relationship between water levels and exposure of shoreline (Figure 6). The data gathered in the survey are more relevant when associated with specific locations than for the lake as a whole. Therefore the graph shows the relationship using arbitrary units of distance, while Maps 2 and 3 indicate the spatial distribution of various categories of exposed shoreline.

If water levels drop below the low water mark (1119.8') the lake bottom will be exposed which, in many areas, consists of mud and weeds. The negative aesthetic value associated with the exposed areas could have detrimental effects on the community and upon the tourism industry, especially if these lake levels occurred during the summer months.

Exposures of less than 100 feet between 1119.8 feet and 1116.8 feet were generally restricted to undeveloped sections of the shoreline. For the more developed sections, especially south of Kelowna at Okanagan Mission and in the North Arm, exposures of 500 and even 1000 feet were indicated when lake levels reached 1116.8 feet. Because of their association with developed areas, shoreline exposures would likely represent a significant 'cost' within the environmental value objective.

4-1.2 Social Damage

The area of private property inundated again displays a linear relationship which is due to the regular topography of the shoreline (Table 4, Figures 7 and 8). The acreage is relatively large as many dwellers have property lines extending to the high water mark (1123.8 feet).

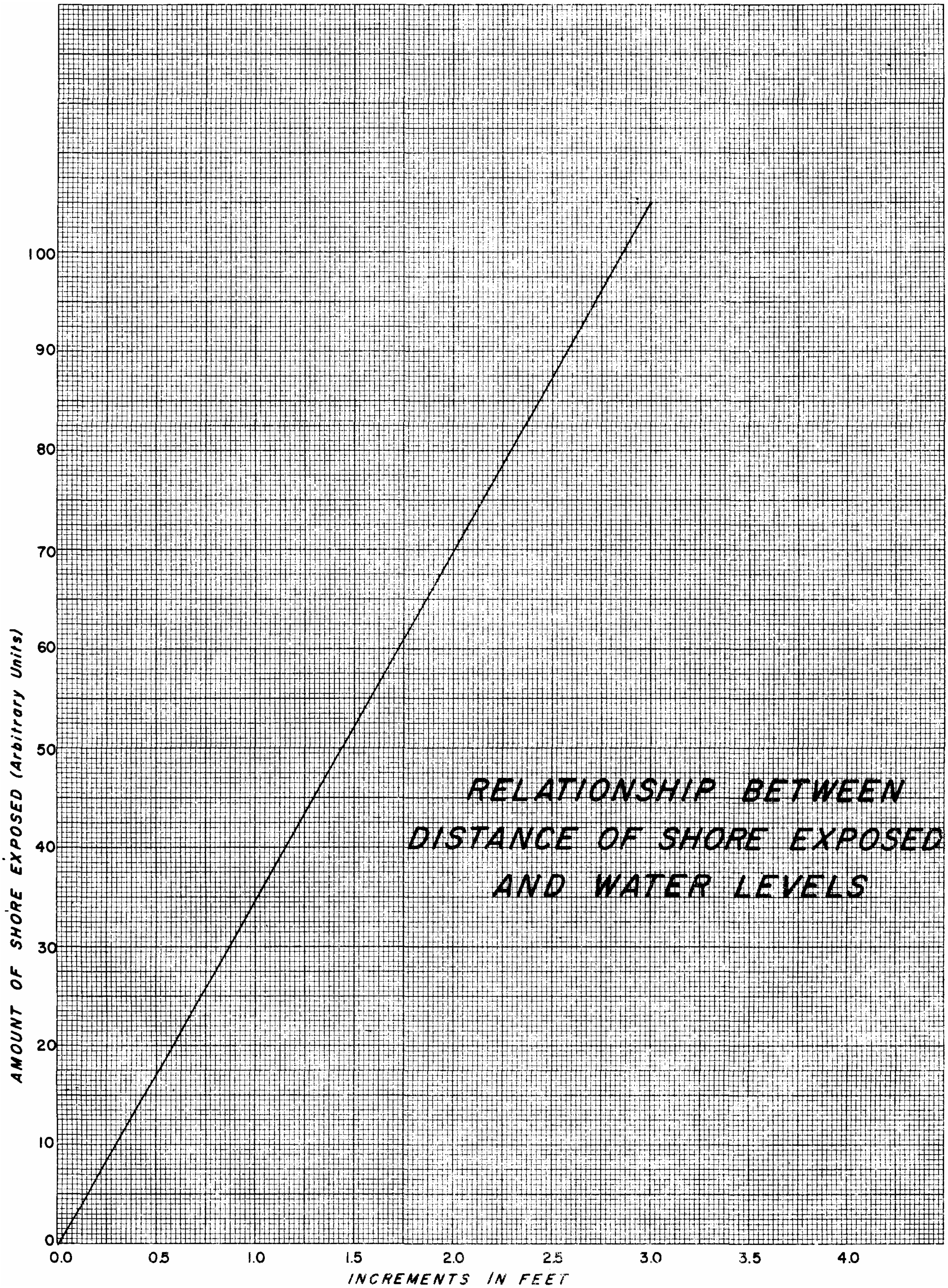
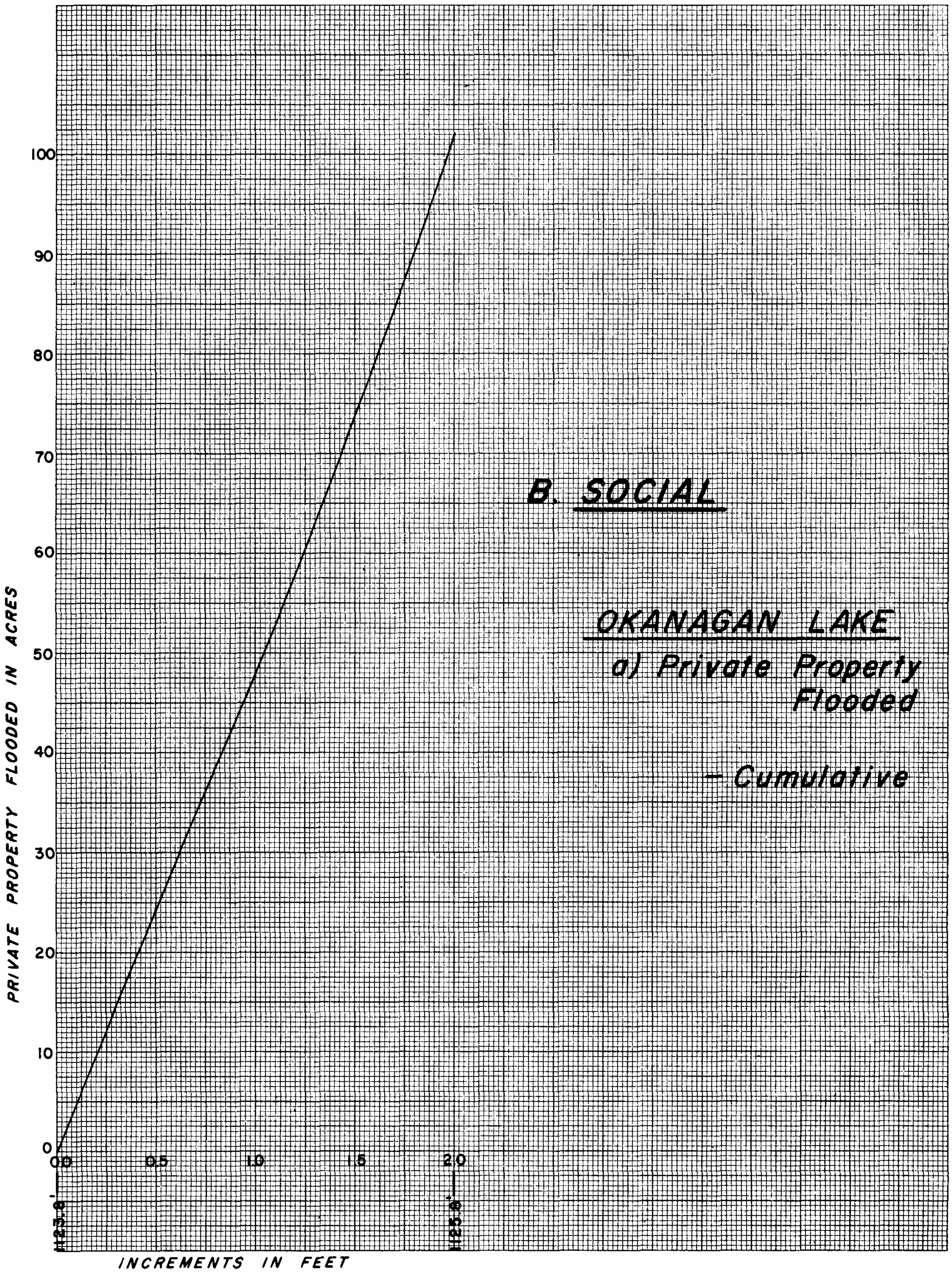

RELATIONSHIP BETWEEN
DISTANCE OF SHORE EXPOSED
AND WATER LEVELS
AMOUNT OF SHORE EXPOSED (Arbitrary Units)
INCREMENTS IN FEET
0
10
20
30
40
50
60
70
80
90
100
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

FIGURE 6



PRIVATE PROPERTY FLOODED IN ACRES
100
90
80
70
60
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
INCREMENTS IN FEET
B. SOCIAL
OKANAGAN LAKE
a) Private Property Flooded
– Cumulative

FIGURE 7

B. SOCIAL

OKANAGAN LAKE

a) Private Property Flooded
—Incremental

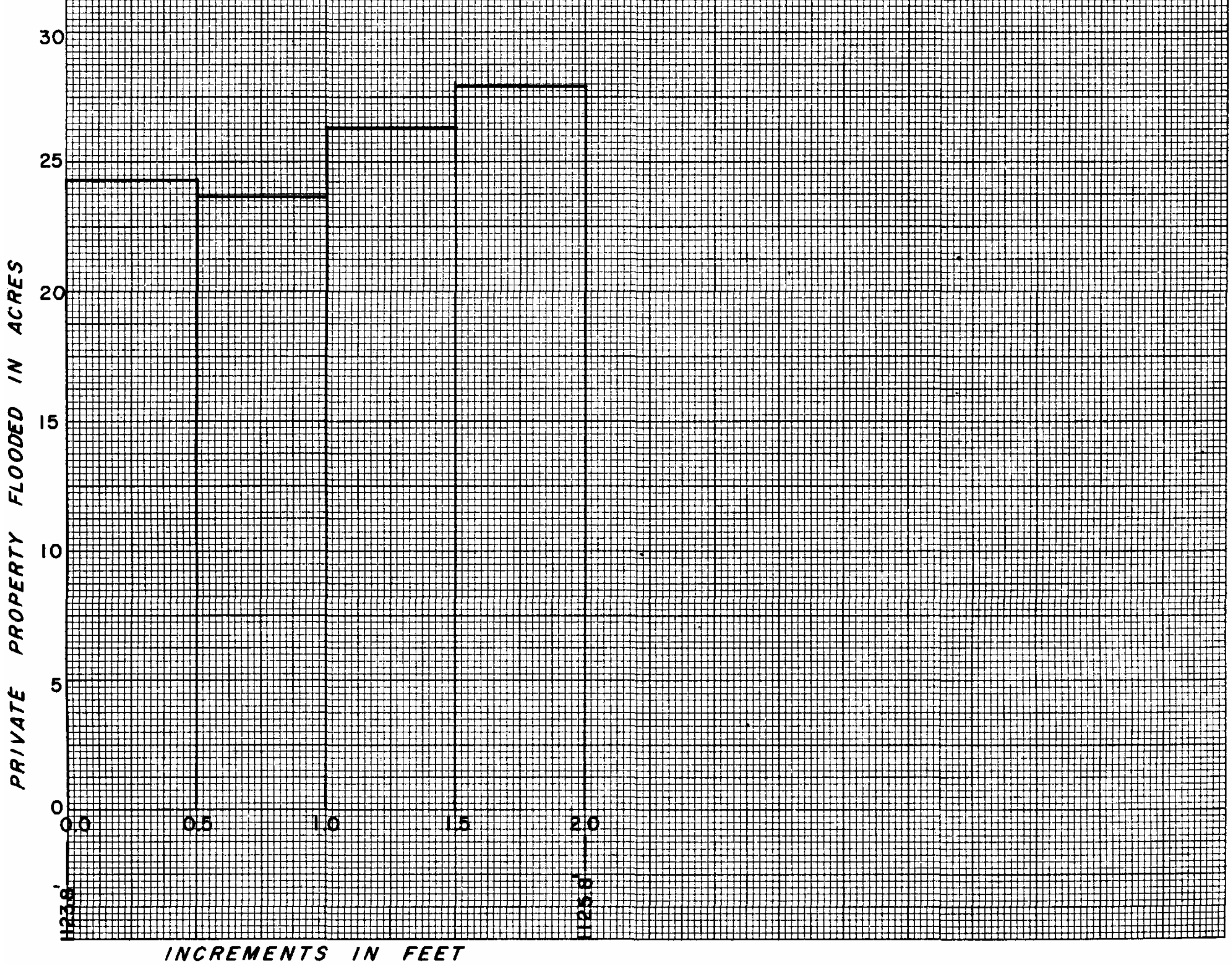


FIGURE 8

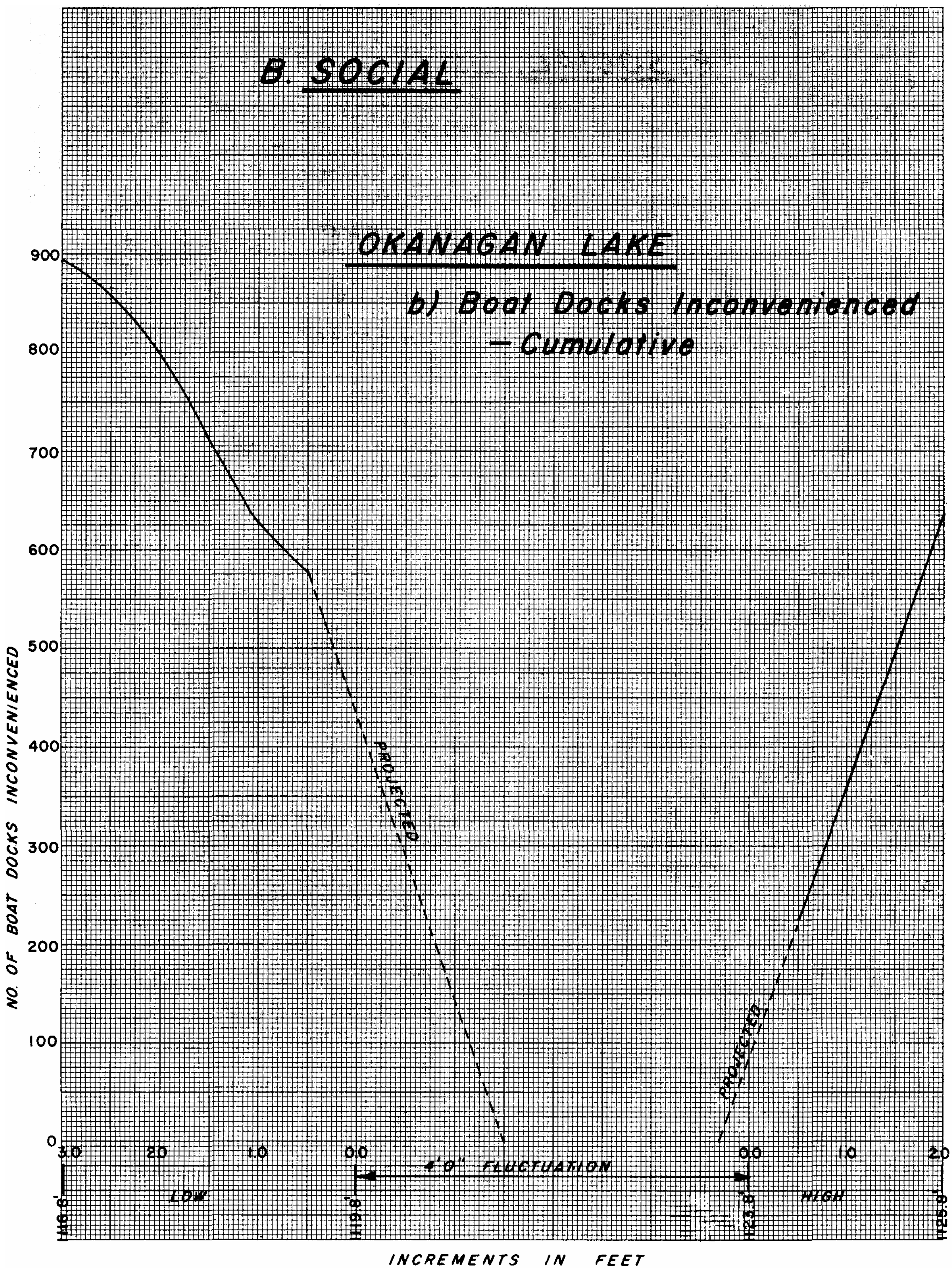
TABLE 4

AREA OF PRIVATE PROPERTY FLOODED (IMP. & UNIMP.) OKANAGAN LAKE

	(i) Cumulative		(ii) Incremental	
Increment	Sq. Ft.	Acres	Sq. Ft.	Acres
0.0' - 0.5'	1,055,294	24.226	1,055,294	24.226
0.5' - 1.0'	2,079,723	47.774	1,024,429	23.548
1.0' - 1.5'	3,226,413	74.068	1,146,690	26.294
1.5' - 2.0'	4,439,925	101.927	1,213,512	27.859

During the field survey, it was obvious that a large number of private boat docks would be inoperable within the present fluctuation range (Figures 9 & 10) Because the graph could not be constructed on the assumption that no damage would occur within the normal fluctuation range, it was adjusted according to the following assumptions. Low water levels have occurred historically during the winter and in early spring before there is much use of boat docks but, by June, the level is usually within two feet of the maximum (1123.8 feet). People appear to have adjusted to the rhythm of lake level fluctuations and tend to build to high water levels rather than low water levels. The field survey indicated that there was about a 2-foot range (1123.0 to 1121.0 feet) within which all docks would operate effectively. The projections shown are a qualitative assessment of what would occur within the fluctuation range.

The information presented does not indicate that people will be unable to use their boats but rather that they will suffer inconveniences in doing so.



B. SOCIAL
OKANAGAN LAKE
b) Boat Docks Inconvenienced
— Cumulative
NO. OF BOAT DOCKS INCONVENIENCED
900
800
700
600
500
400
300
200
100
0
PROJECTED
PROJECTED
3.0
2.0
1.0
0.0
4'0" FLUCTUATION
0.0
1.0
2.0
LOW
HIGH
1116.8
1119.8
1123.8
1125.8
INCREMENTS IN FEET

FIGURE 9

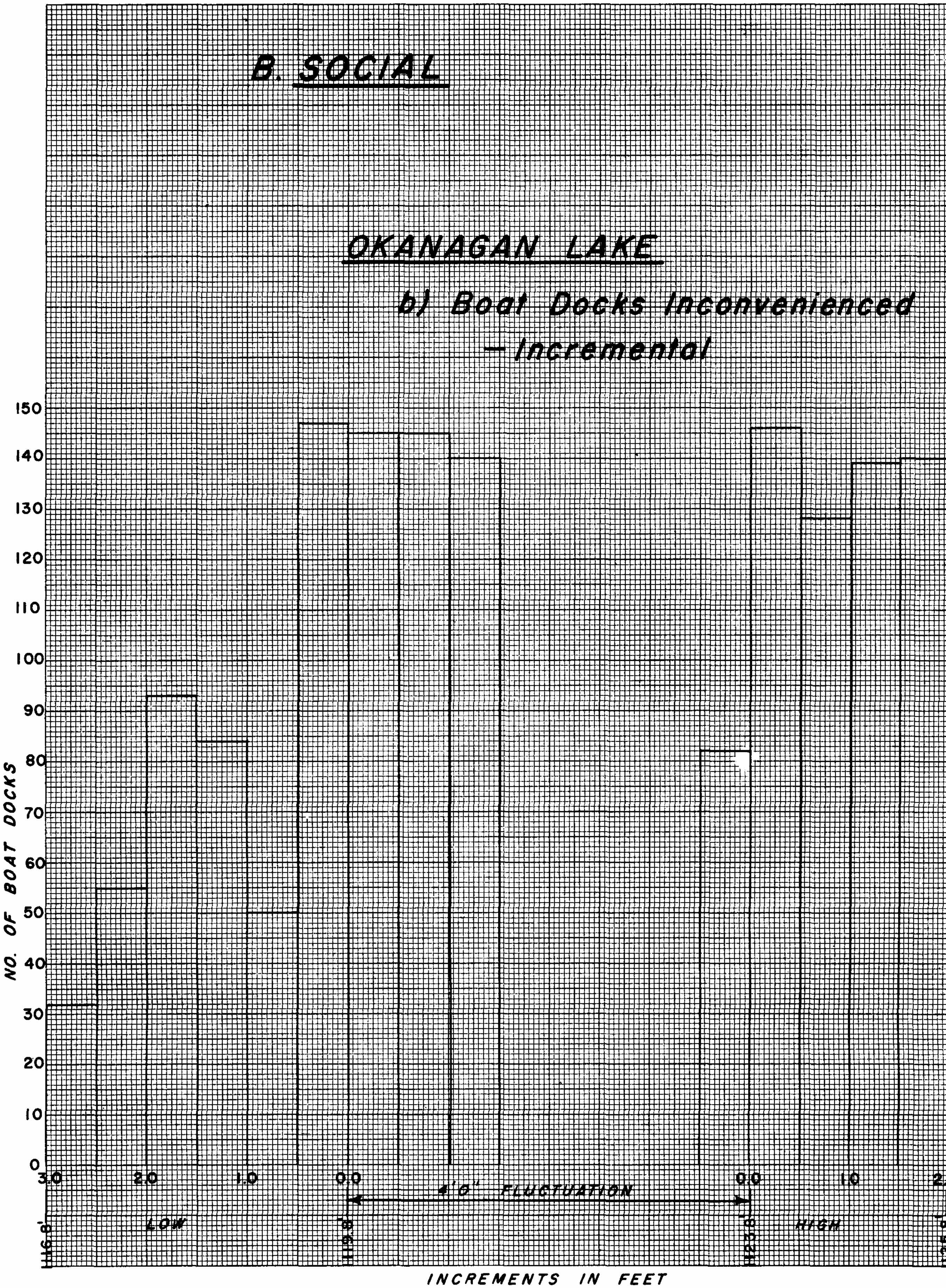

B. SOCIAL
OKANAGAN LAKE
b) Boat Docks Inconvenienced
—Incremental
NO. OF BOAT DOCKS
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
3.0
2.0
1.0
0.0
4'0' FLUCTUATION
0.0
1.0
2.0
LOW
HIGH
1116.8'
1119.8'
1123.8'
1125.8'
INCREMENTS IN FEET

FIGURE 10

TABLE 5

BOAT DOCKS INCONVENIENCED (OKANAGAN LAKE)

(i) Cumulative Increment	No.	(ii) Incremental No.
High		
1.5' - 2.0'	635	140
1.0' - 1.5'	495	139
0.5' - 1.0'	356	128
0.0' - 0.5'	228	143
4' Fluctuation	473	473
0.0' - 0.5'	577	147
0.5' - 1.0'	627	50
1.0' - 1.5'	711	84
1.5' - 2.0'	804	93
2.0' - 2.5'	859	55
2.5' - 3.0'	891	32
Low		

TABLE 6

NO. OF BUILDINGS AFFECTED - HOUSES, MOTELS, GARAGES, ETC.

(OKANAGAN LAKE)

(i) Cumulative Increment	No.	(ii) Incremental No.
0.0' - 0.5'	79	79
0.5' - 1.0'	160	81
1.0' - 1.5'	247	87
1.5' - 2.0'	393	146

Table 6 shows the relationship between the number of buildings affected at various high water levels. Again, a linear relationship is indicated up to 1.5 feet above maximum level at which point the relationship becomes exponential. There would obviously be considerable amount of inconvenience to lakeshore dwellers if the lake level was to rise more than a foot above present high water. The curve (Figure 11 and 12) shows quite clearly how residents feel safe at developing property close to the high water.

TABLE 7

POTENTIAL DIRECT DAMAGE (OKANAGAN LAKE)

(i) Cumulative		(ii) Incremental
Increment	Damage	Damage
0.0' - 0.5'	$ 38,732.75	$ 38,732.75
0.5' - 1.0'	99,265.25	60,532.50
1.0' - 1.5'	229,804.50	130,539.25
1.5' - 2.0'	575,286.50	345,482.00
4' Fluctuation		
0.0' - 0.5'	4,000.00	4,000.00
0.5' - 1.0'	4,000.00	0
1.0' - 1.5'	6,000.00	6,000.00
1.5' - 2.0'	6,000.00	0
2.0' - 2.5'	6,000.00	0
2.5' - 3.0'	6,000.00	0

4-1.3 Economic Damage

Previous stage-damage curves for the social and environmental value functions have tended to be linear in form. In the case of economic damage to property and structures (Table 7 and Figures 13-15), the stage-damage curve is exponential, a relatively small amount of flood damage (less than $100,000) occurring at levels below 1124.8 feet but rising rapidly to $600,000 at 1125.8 feet.

The main reason for the exponential curve in the economic value function is that most property owners have not improved their land below 1124.3 feet (6 inches above maximum lake levels) and,

B. SOCIAL

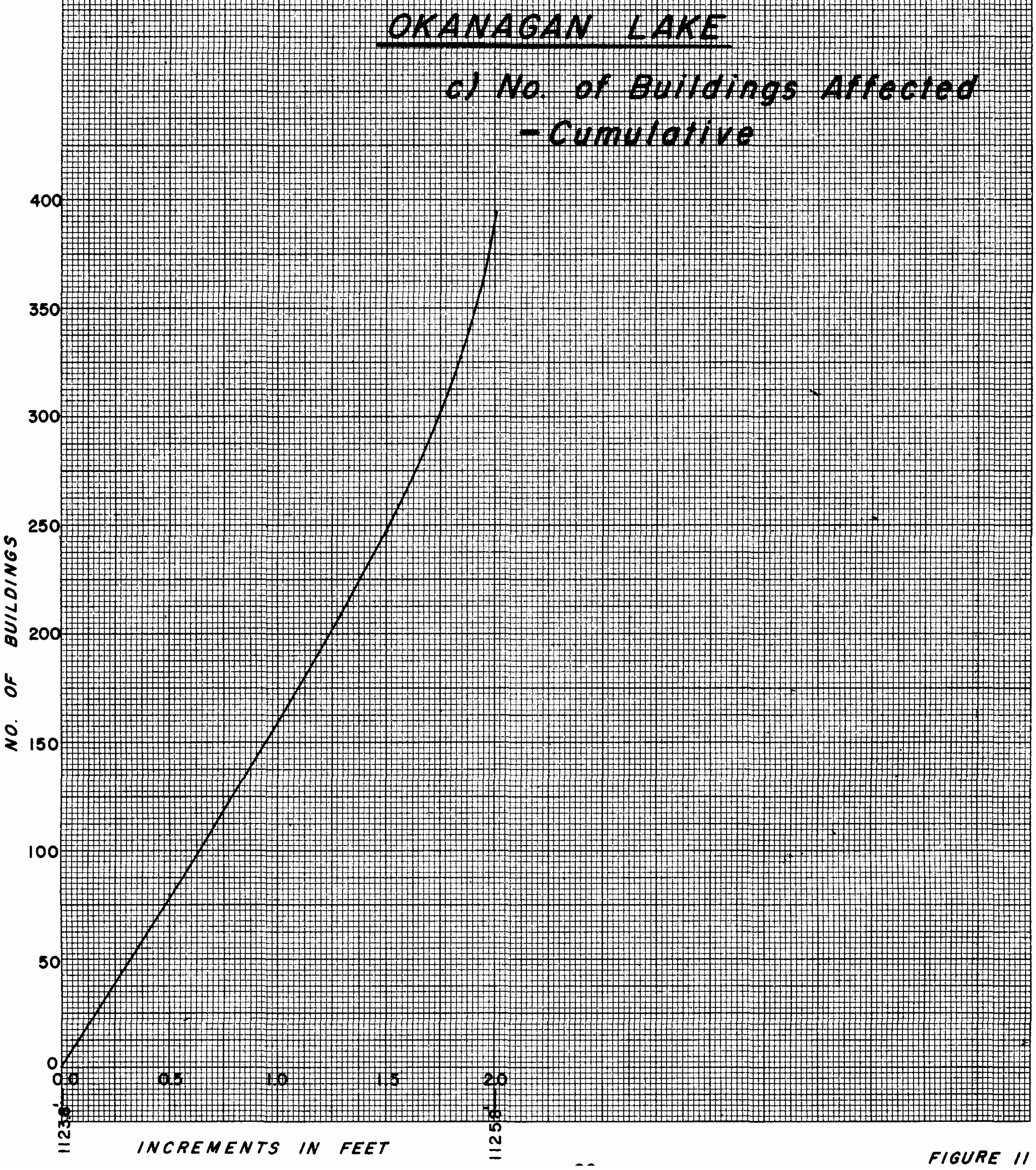


FIGURE 11

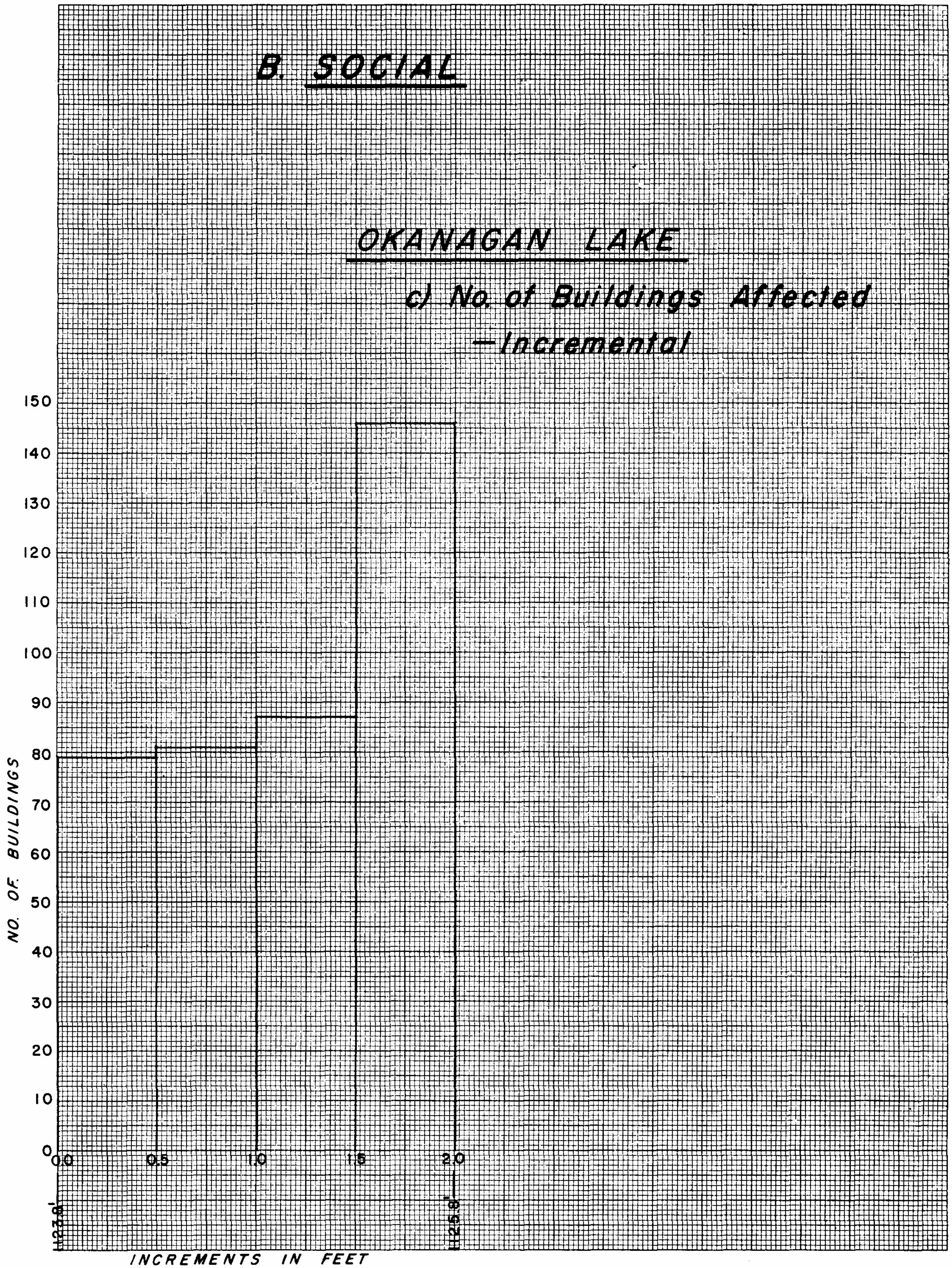
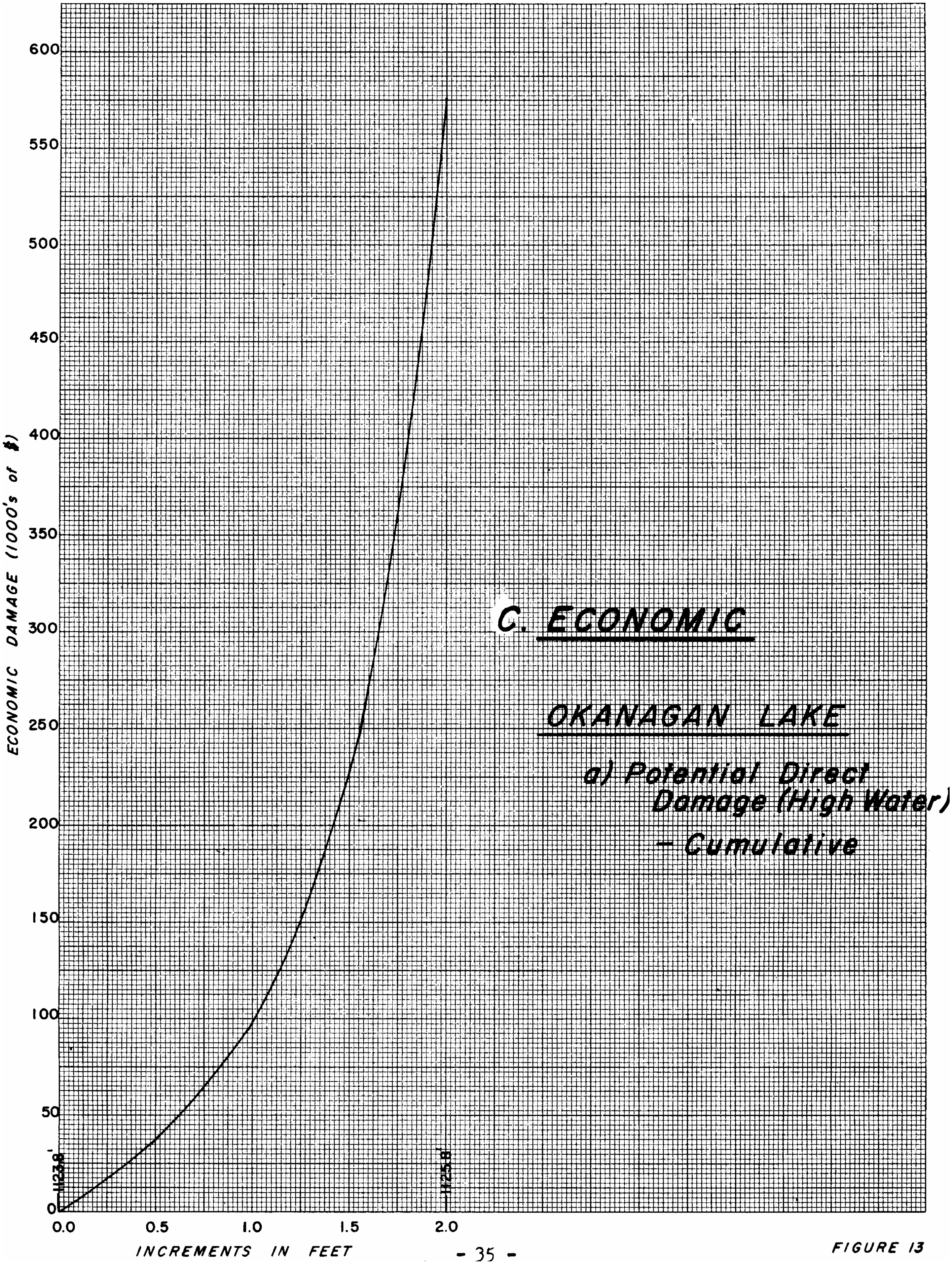

B. SOCIAL
OKANAGAN LAKE
c) No. of Buildings Affected
—Incremental
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
NO. OF BUILDINGS
0.0
0.5
1.0
1.5
2.0
1123.8'
1125.8'
INCREMENTS IN FEET

FIGURE 12



C. ECONOMIC
OKANAGAN LAKE
a) Potential Direct Damage (High Water) – Cumulative
ECONOMIC DAMAGE (1000's of $)
600
550
500
450
400
350
300
250
200
150
100
50
0
0.0
0.5
1.0
1.5
2.0
INCREMENTS IN FEET
1123.8'
1125.8

FIGURE 13

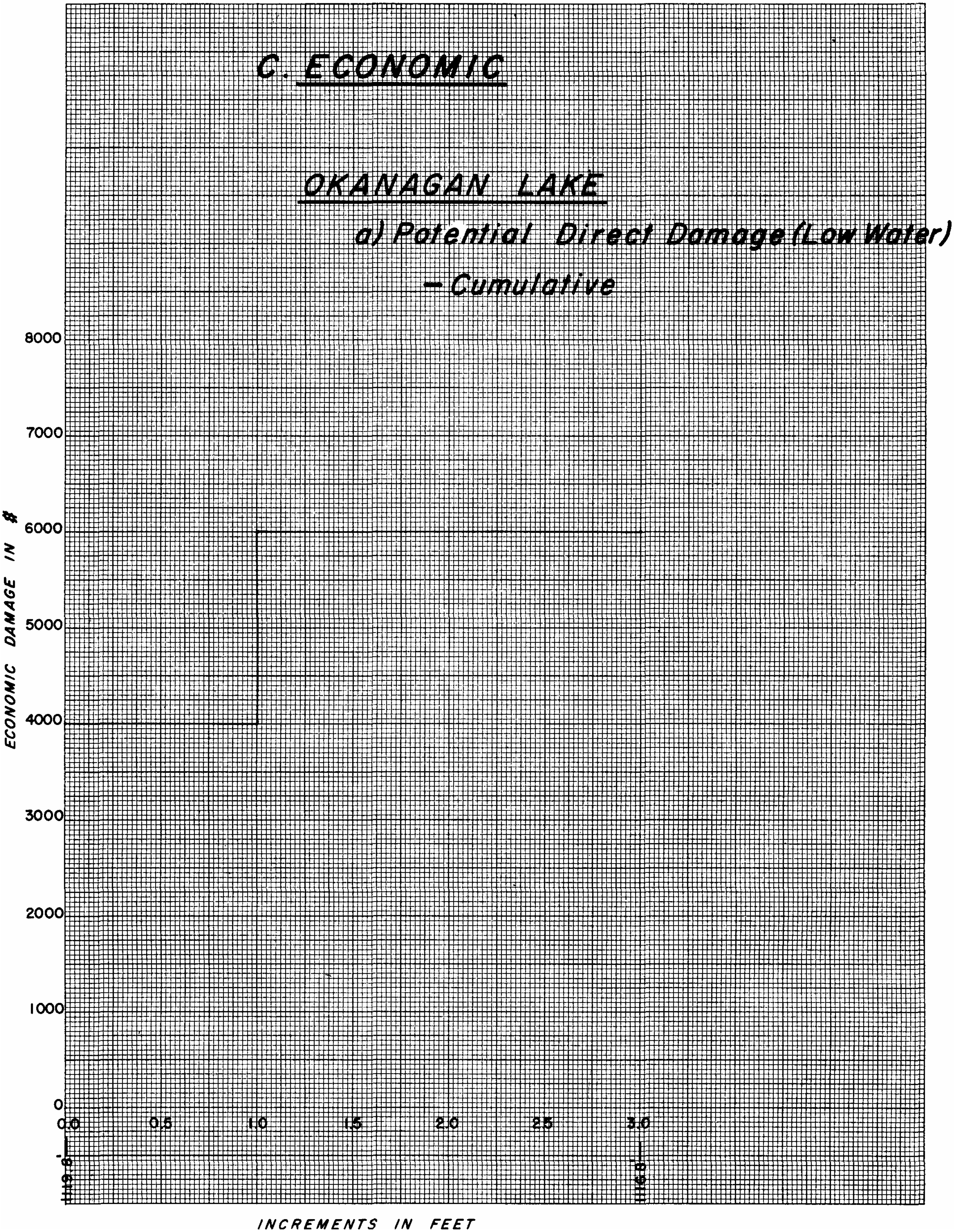

C. ECONOMIC
OKANAGAN LAKE
a) Potential Direct Damage (Low Water)
— Cumulative
ECONOMIC DAMAGE IN $
8000
7000
6000
5000
4000
3000
2000
1000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
INCREMENTS IN FEET

FIGURE 14

C. ECONOMIC

OKANAGAN LAKE
a) Potential Direct Damage
— Incremental

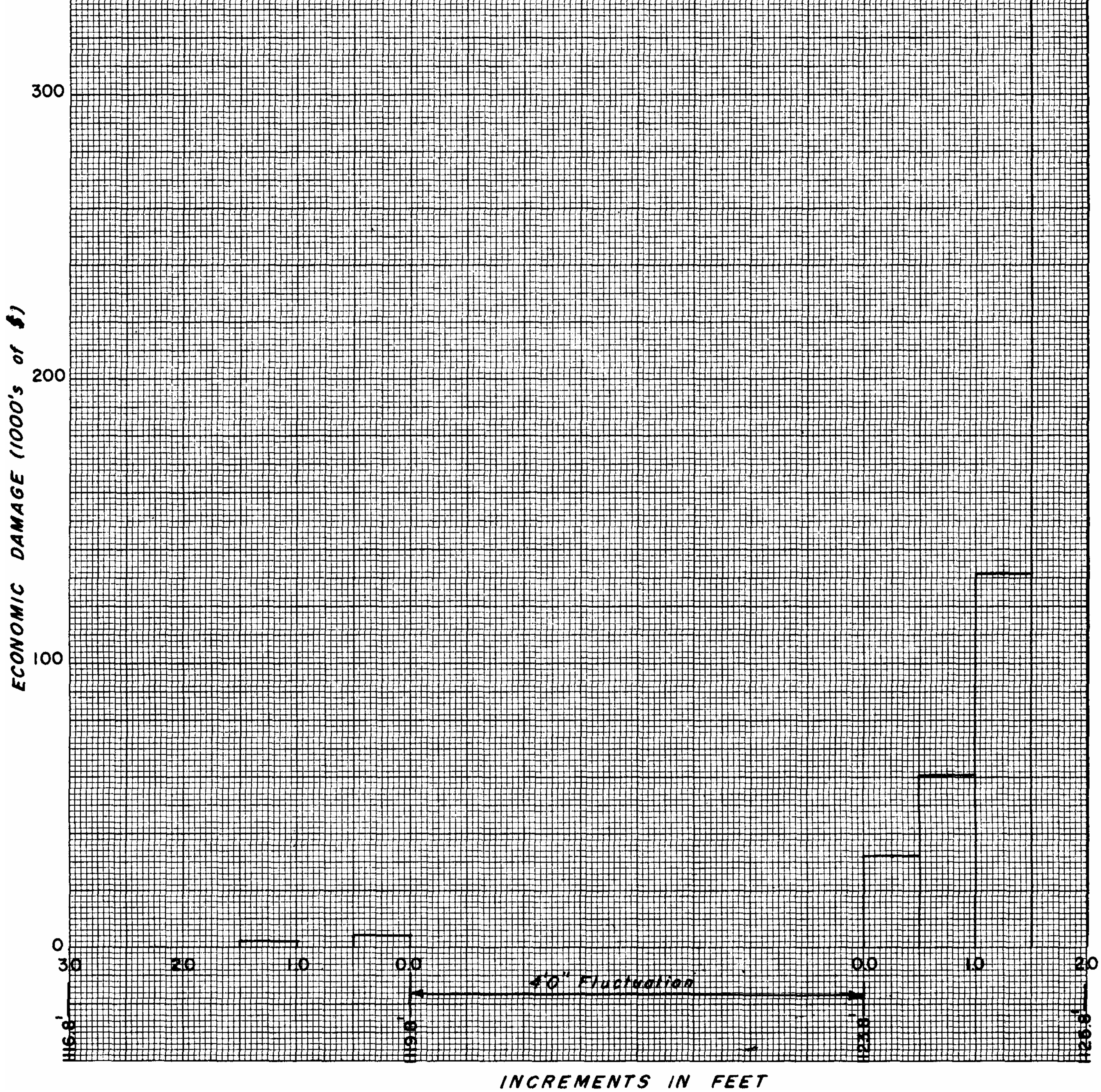


FIGURE 15

although such flooding would be an inconvenience, it would not give rise to large economic losses. Because there are numerous improved property and structural developments above 1124.8 feet (one foot above maximum), potential flood damage at these elevations increases significantly.

Because railway barge traffic is gradually disappearing from Okanagan Lake, the economic implications of both high and low lake levels on such resources would be minimal (see Fig. 14) On May 31, 1972 C.P.R. ceased its lake barge traffic so only C.N.R. operates on the lake, and the Company can adjust its tracks with shims whenever the lake fluctuates outside the normal four-foot range. Costs of shimming are estimated at $1,000 per dock per season and because of low traffic volumes at Westbank, Peachland and Naramata only the docks at Penticton and Kelowna would be adjusted.[4/] In the event of a prolonged drawdown, the shims would remain in the tracks all the time, thus reducing operational costs. Thus, no large-scale structural changes to warfing facilities have been considered, (see Appendix D). As barge traffic appears to be an economically marginal enterprise, alternative transportation by truck during extremely low drawdown would not appear to be a large additional cost.

The most important potential cost of low water levels on Okanagan Lake involves possible structural adjustments to the Kelowna Floating Bridge. It is understood that the bridge is presently designed to withstand lake levels down to 1118.8 feet, but that detailed analysis would be required to estimate the extent of possible structural alterations which would enable the bridge to withstand lake levels down to 1117.0 feet.

[4/] Figure 14 which shows costs of short-term adjustments to railway warfs should be reduced so that total costs are $2,000.

Extreme lake level fluctuations also result in economic costs to certain commercial operations due to potential loss of revenue. Some commercial marinas will not operate effectively at extremely high and low water levels and, consequently, potential loss of revenue from rentals and gas sales is quite sensitive to such lake level fluctuations (Table 8 and Figures 16-20). Actual gas sales foregone will likely be similar to potential losses, but actual rental losses will likely be small because stalls are usually rented before freshet occurs.

Few campsites are developed below 1124.8 feet but, if lake levels rise above this elevation, there will be a considerable potential revenue loss. Because the few campgrounds are crowded in early summer (when maximum flood probabilities occur), the actual loss of revenue may be significantly less than the potential as campers could easily move to dry sites. As mentioned earlier, studies this summer should improve the accuracy of economic costs to tourism associated with high water levels.

4-1.4 Annual Damage

During the summer of 1971, a preliminary evaluation of a number of alternative ways of operating the main-stem system was undertaken. Included in this evaluation procedure was the existing or "null" operation procedure. A mathematical model for simulating lake level fluctuations over the 50 years of record (1921-1970) was developed at the University of British Columbia [5/] and the number of occasions when the lake would have fluctuated beyond its normal four-foot operating range were noted.

[5/] Russell, S.O. and McNeill, K.Y. "Output from U.B.C. Mathematical Model of the Operation of the Main-Stem Okanagan River", University of British Columbia, July 1971.

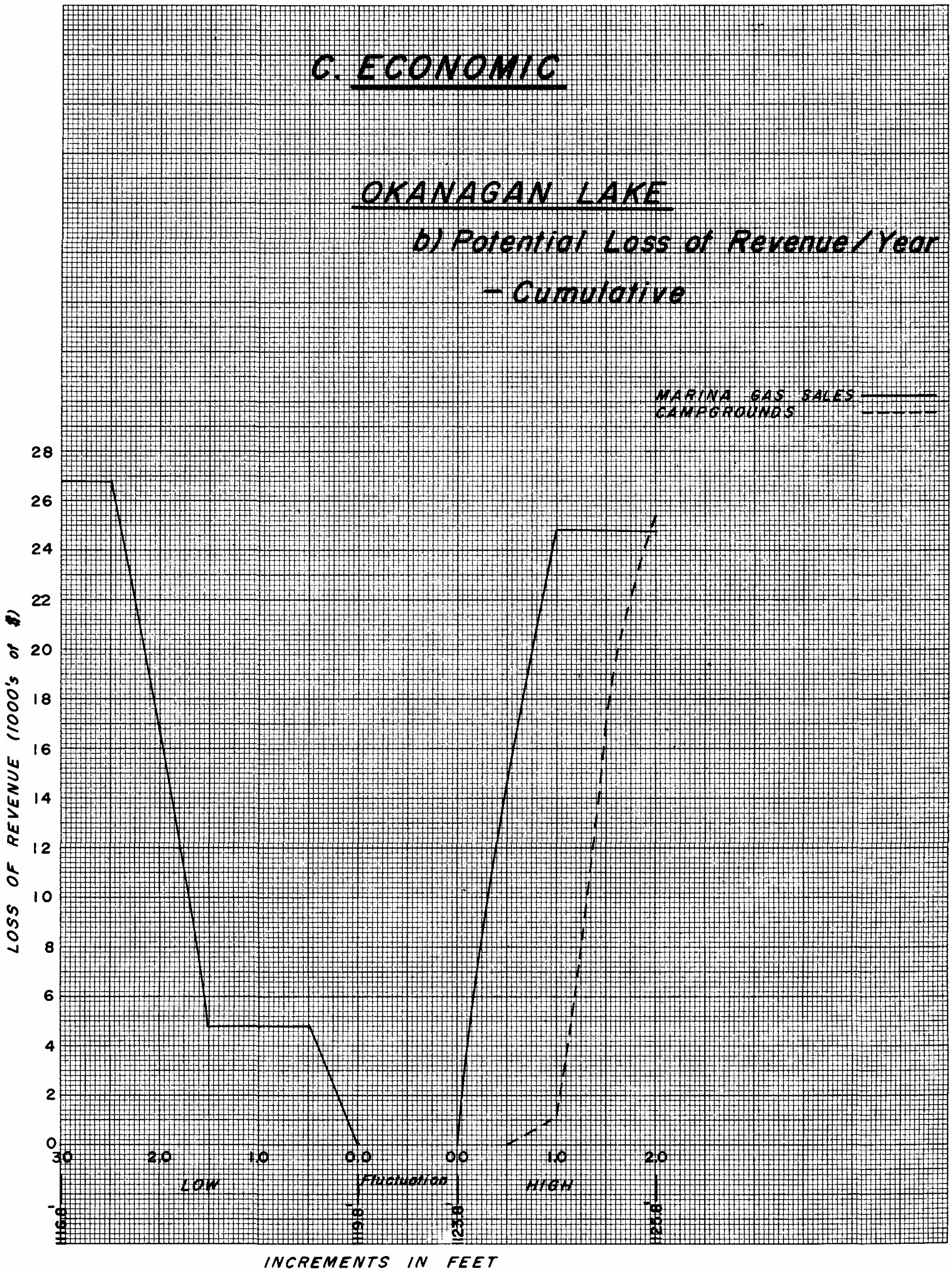

C. ECONOMIC
OKANAGAN LAKE
b) Potential Loss of Revenue/Year
– Cumulative
MARINA GAS SALES
CAMPGROUNDS
LOSS OF REVENUE (1000's of $)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
3.0
2.0
1.0
0.0
0.0
1.0
2.0
LOW
Fluctuation
HIGH
1116.8
1119.8
1123.8
1125.8
INCREMENTS IN FEET

FIGURE 16

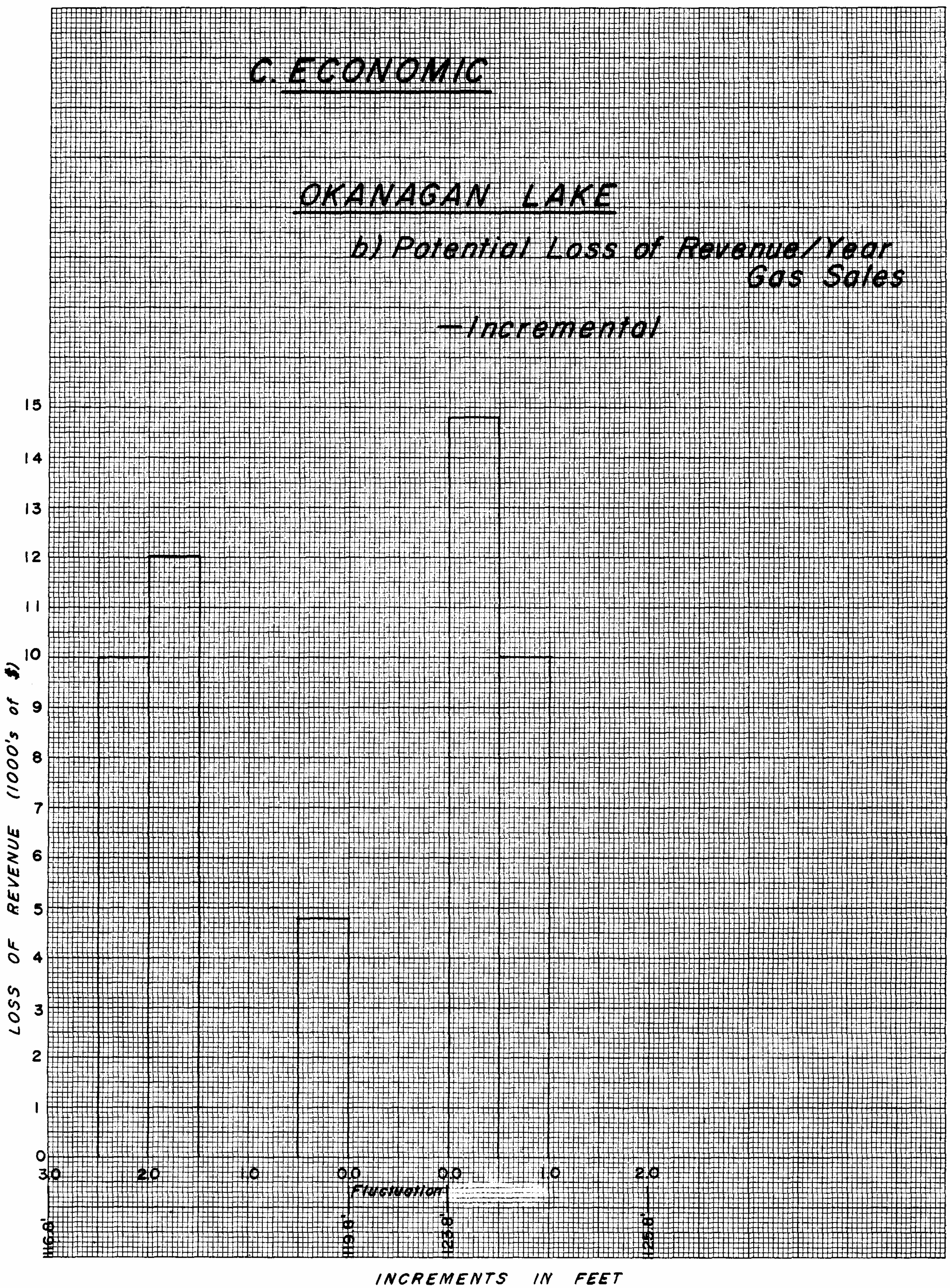

C. ECONOMIC
OKANAGAN LAKE
b) Potential Loss of Revenue/Year Gas Sales
— Incremental
LOSS OF REVENUE (1000's of $)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
Fluctuation
116.8'
119.8'
123.8'
125.8'
INCREMENTS IN FEET

FIGURE 17

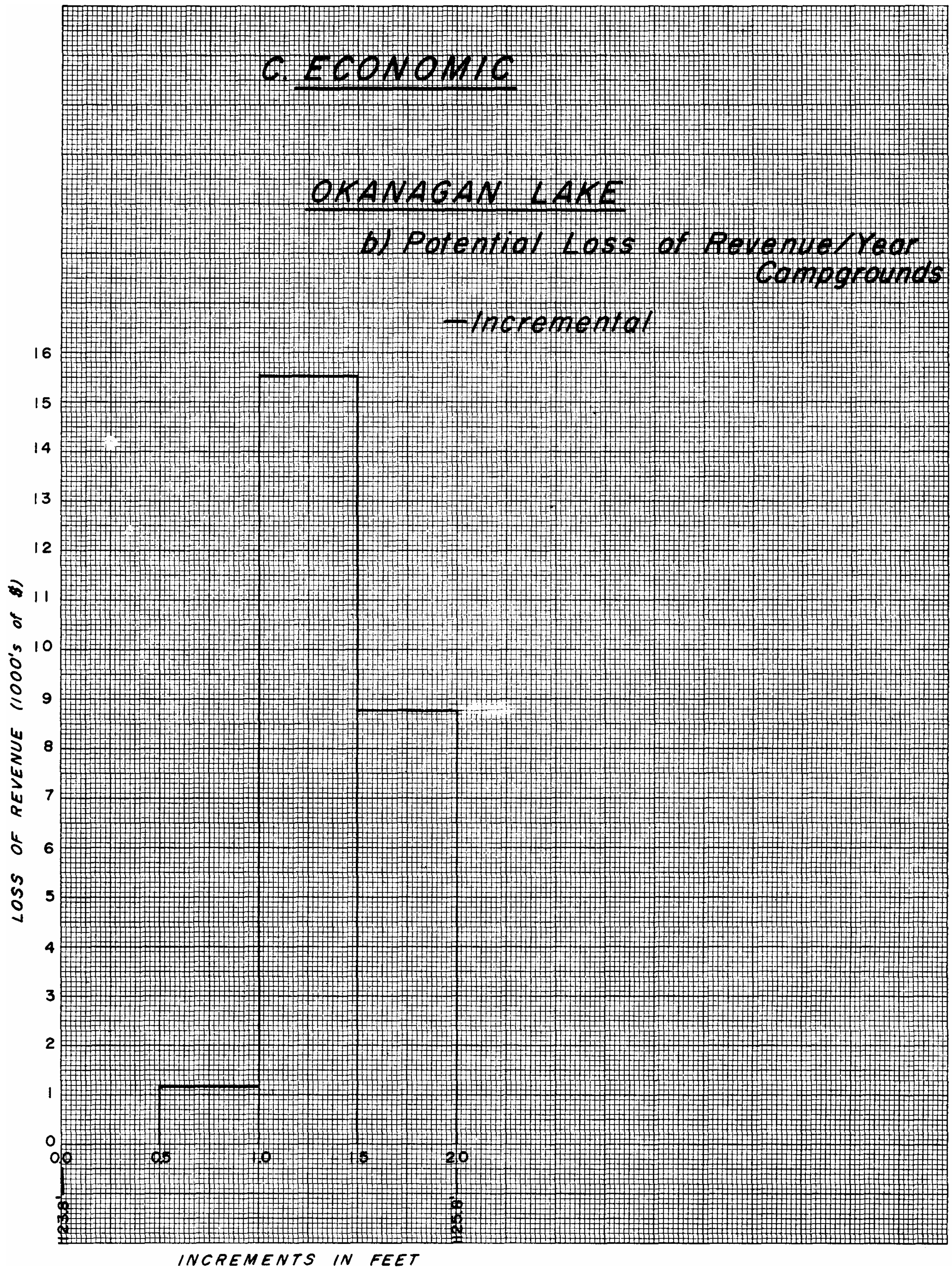

C. ECONOMIC
OKANAGAN LAKE
b) Potential Loss of Revenue/Year
Campgrounds
—Incremental
LOSS OF REVENUE (1000's of $)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.0
0.5
1.0
1.5
2.0
123.8'
125.8'
INCREMENTS IN FEET

FIGURE 18

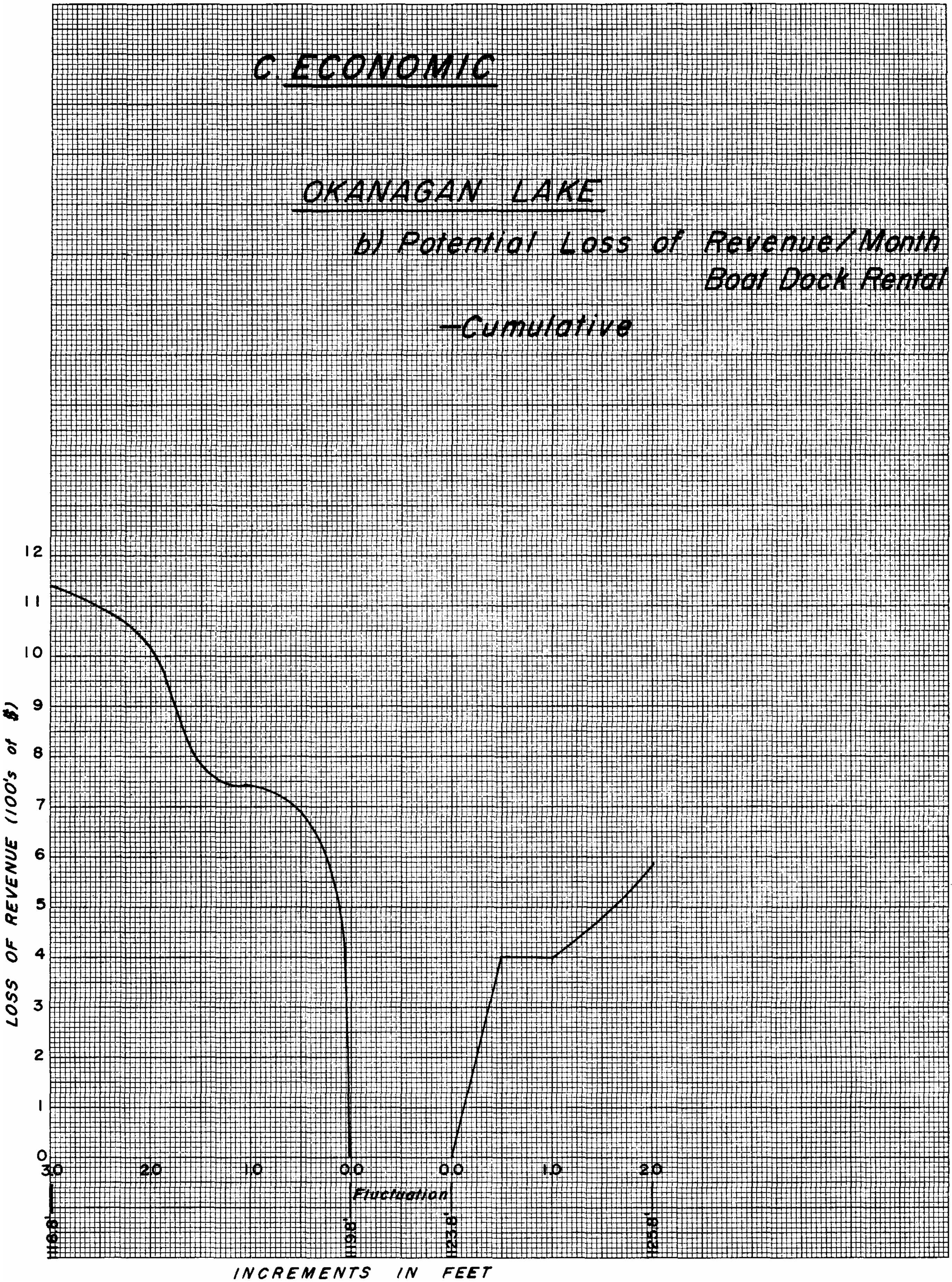

C. ECONOMIC
OKANAGAN LAKE
b) Potential Loss of Revenue/Month
Boat Dock Rental
—Cumulative
LOSS OF REVENUE (100's of $)
0
1
2
3
4
5
6
7
8
9
10
11
12
3.0
2.0
1.0
0.0
0.0
1.0
2.0
Fluctuation
116.8'
119.8'
123.8'
125.8'
INCREMENTS IN FEET

FIGURE 19

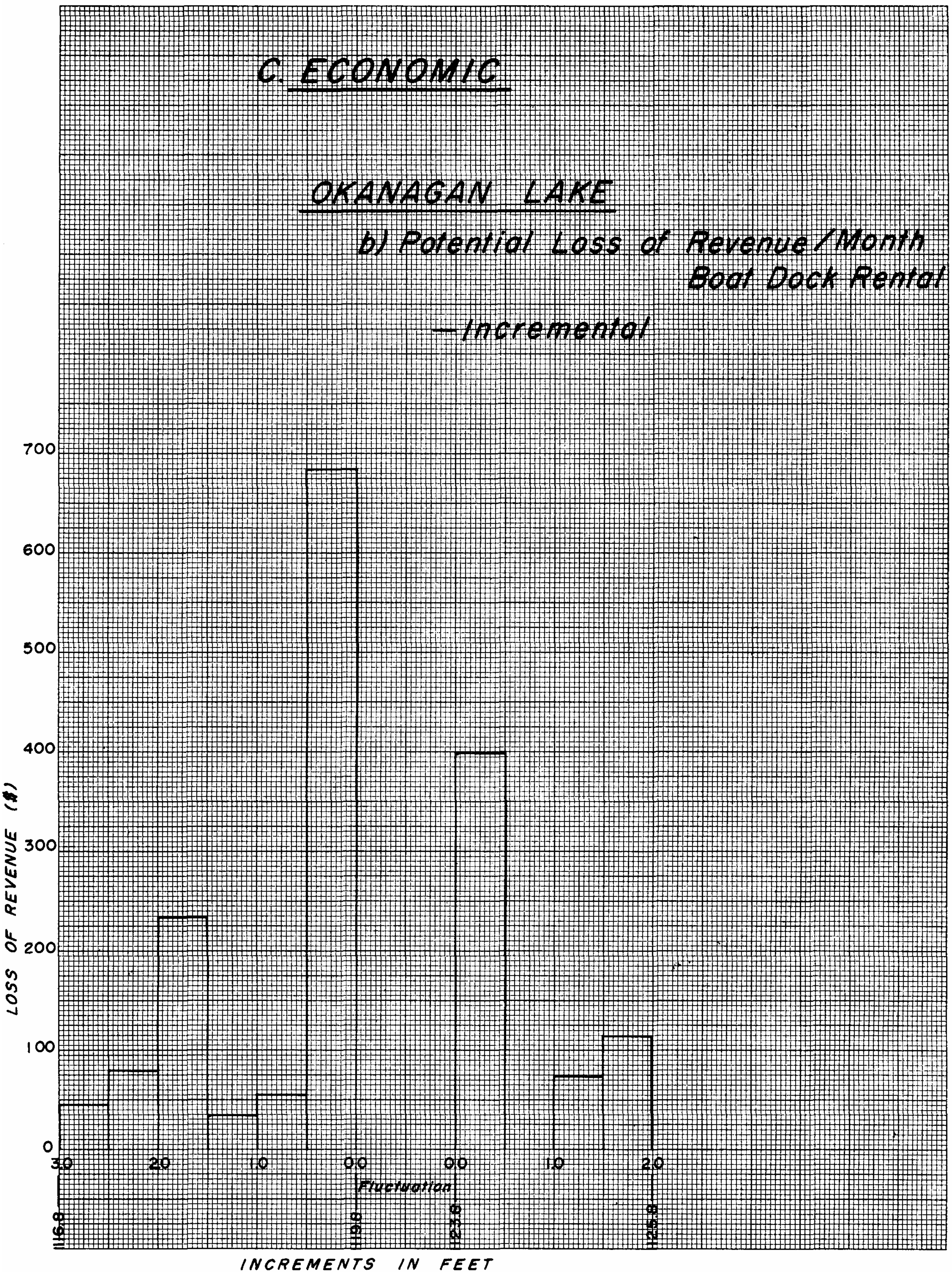

C. ECONOMIC
OKANAGAN LAKE
b) Potential Loss of Revenue/Month
Boat Dock Rental
—Incremental
700
600
500
400
300
200
100
0
LOSS OF REVENUE ($)
3.0
2.0
1.0
0.0
0.0
1.0
2.0
Fluctuation
1116.8
1119.8
1123.8
1125.8
INCREMENTS IN FEET

FIGURE 20

TABLE 8

POTENTIAL LOSS OF REVENUE (OKANAGAN LAKE)

Increment High	(i) Cumulative Gas Sales (Loss/Season)	(i) Cumulative Campgrounds (Loss/Season)	(i) Cumulative Boat Dock Rental (Per Month)	(ii) Incremental Gas Sales (Loss/Season)	(ii) Incremental Campgrounds (Loss/Season)	(ii) Incremental Boat Dock Rental (Per Month)
1.5' - 2.0'	$24,800	$25,460	$ 590	$ 0	$ 8,740	$ 115
1.0' - 1.5'	24,800	16,720	475	0	15,580	75
0.5' - 1.0'	24,800	1,140	400	10,000	1,140	0
0.0' - 0.5'	14,800	0	400	14,800	0	400
4' Fluctuation	0	0	0	0	0	0
0.0' - 0.5'	4,800	0	685	4,800	0	685
0.5' - 1.0'	4,800	0	740	0	0	55
1.0' - 1.5'	4,800	0	775	0	0	35
1.5' - 2.0'	16,800	0	1,010	12,000	0	235
2.0' - 2.5'	26,800	0	1,090	10,000	0	80
2.5' - 3.0'	26,800	0	1,135	0	0	45

This mathematical model assumed that the present (1970) water consumptive needs on the main-stem system would be met for each year of record.

The results of this mathematical simulation are shown in Table 9, which presents the percentage of occasions that Okanagan Lake would fluctuate outside its normal operating range. In fact, flooding would have occurred on two occasions [6/] while low levels would basically be restricted to the simulation of the 1930-33 drought, when the lake levels would remain below the minimum operating range for 30 months. Because of the importance of this drought, its implications are discussed in more detail in Appendix K.

6/ This model assumed that Okanagan Lake could be drawn down below its minimum operating level of 1119.8 feet during high runoff years to accommodate the freshet. This assumption may be revised in later runs of the model and the implications on flood damage assessed.

TABLE 9

PERCENTAGE OF OCCASIONS WHEN OKANAGAN LAKE WOULD FLUCTUATE IN THE RANGE INDICATED-

SIMULATED OPERATION OF THE LAKE_ FROM 1921-1970

Range in Feet	Comments	J.	F	M	A	M	J	J	A	S	O	N	D	Year
1116.8-1119.8	Below	8.0	8.0	10.2	14.4	4.0	2.0	2.0	6.0	6.0	8.0	8.0	8.0	7.0
1119.8-1123.8	Normal	92.0	92.0	89.8	85.6	94.8	94.6	97.6	94.0	94.0	92.0	92.0	92.0	92.0
1123.8-1124.8	Above	0.0	0.0	0.0	0.0	1.2	3.4	C.4	0.0	0.0	0.0	0.0	0.0	0.4

Table 9 indicates the relatively small proportion of occasions when Okanagan Lake would have fluctuated beyond its present range. Consequently, total socio-economic damage when averaged over the 50 year period is considered to be small. Actual annual, damage estimates were made by interpolating costs of each occurrence of extreme lake level fluctuation against the stage-damage curves for each selected landuse category discussed earlier in the paper.

In the case of the landuse types accounted under the environmental and social goals, damage was estimated in unit-days which represented the total opportunity lost in days during the period of extreme high or low water levels. Thus, if 10 private boat docks were rendered inoperable by high water for two months (60 days), a total of 600 boat-dock-days would be lost. To account for seasonal variations in use (for example, boat docks are mainly used during the summer months), each social and environmental landuse category was adjusted by a monthly weighting factor (Table 10).

The total damage in dollars (economic objective) and unit-days (social and environmental objectives) for all extreme events in the 50 years of record was summed and the total divided by 50 to obtain annual damage values (Table II). Although the total damage would be relatively large, because such extreme events occur so infrequently, the annual damage is considerably reduced in size and impact. [7/]

[7/] For a more detailed discussion of the impact of a preliminary selection of alternatives on shoreline landuse see O'Riordan J. "Preliminary Evaluation of Shoreline Damage Around Okanagan Lake", Water Management Service, Department of the Environment, Vancouver, B.C.

TABLE 10

MONTHLY WEIGHTINGS IN DAYS FOR SHORELINE DAMAGE

(Maximum 31)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Public Boat Access Ramps	0	0	5	10	15	25	31	31	20	10	5	0
Private Boat Docks	0	0	5	10	15	25	31	31	20	10	5	0
Public Recreation Beaches	0	0	0	0	5	15	31	31	10	0	0	0
Marinas	0	0	0	0	20	30	31	31	20	10	0	0
Campgrounds	0	0	0	0	10	20	31	31	10	0	0	0

TABLE 11

TOTAL AND ANNUAL DAMAGES FOR SELECTED LANDUSE CATEGORIES AROUND OKANAGAN LAKE FOR SIMULATED OPERATION 1921-1970

	Total Damage	Annual Damage
Economic Costs		
Property Damage ($)	117,000	2,340
Loss of Revenue	38,750	775
Total Economic Costs	155,750	3,115
Environmental Costs		
Public Boat Ramps(Ramp days)	3,920	78.4
Public Recreation Sites(Acre days)	345	6.9
Land Exposed(Area days)	42,165	843.3
Social Costs		
Private Property Flooded(Acre days)	2,642	52.8
Private Structures Flooded(Structure days)	8,540	170.8
Private Boat Docks(Boat dock days)	253,430	5068.6

In light of a reassessment of assumptions in damage evaluation procedures (see section 3.2.1), some of the Figures in Table 11 may be revised. It appears that economic damage to property and structures could be over-estimated as emergency protective measures would likely be undertaken. Similarly, total boat-dock days is represented as a maximum figure, as few residents use their boats every day during the summer. The costs of fluctuating lake levels to the tourist industry may be underestimated and improved figures will be available after this summer's field work.