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ECONOMIC ANALYSIS OF KAMLOOPS DYKING AREAS - NT1, T1 and T2

R. PRINCIC

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Inland Waters Directorate
Pacific and Yukon Region
Vancouver, B.C.

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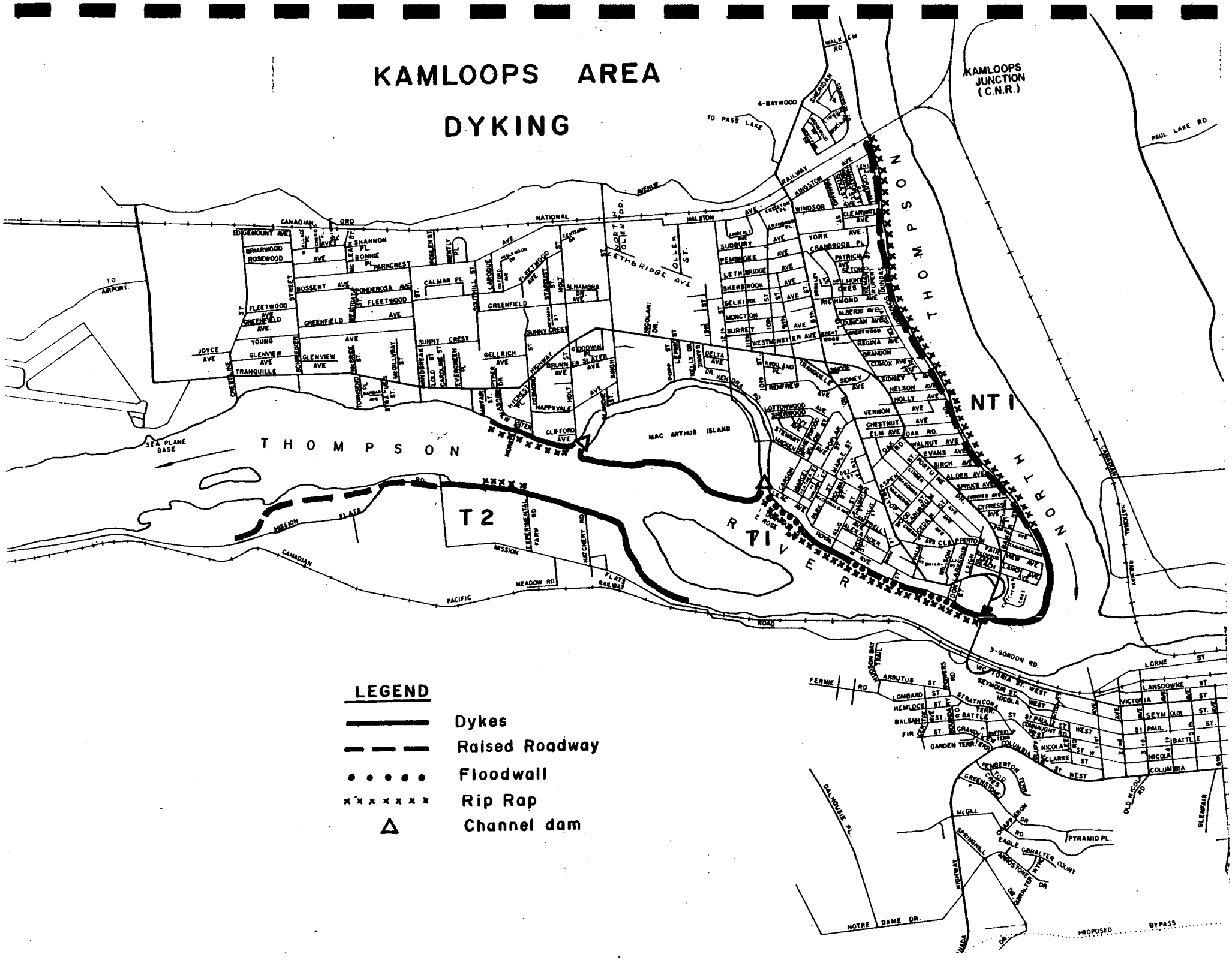
KAMLOOPS AREA
DYKING
KAMLOOPS JUNCTION (C.N.R.)
THOMPSON
RIVER
NORTH
MAC ARTHUR ISLAND
SEA PLANE BASE
T2
TO AIRPORT
TO PASS LAKE
4-BAYWOOD
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LEGEND
Dykes
Raised Roadway
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PROPOSED BYPASS

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SUMMARY

1. OBJECTIVE

The objective of this study is to assess the economic feasibility of providing dykes for three areas of Kamloops.

2. PROPOSED DYKES

The proposed dykes would protect areas NT1, T1, and T2 as shown in Figure (1).

3. BASIC ASSUMPTION

The basic assumptions used in the study are:

1. economic life of dykes is 35 years,
2. basic discount rate is 7%,
3. real dyke construction costs are appreciating at 1% per year,
4. base year is 1982.

4. RESULTS OF STUDY

Table 1 provides a summary of the results of the economic analysis of dyking areas NT1, T1, and T2 of Kamloops.

TABLE 1

Benefits, Costs, Benefit-Cost Ratio, and Net Benefits - Kamloops

	Dyking Areas	Benefits New Dykes	Project Costs	B/C Ratio	Net P.V of Benefits
		$ (000)	$ (000)		$ (000)
1)	NT1	2,922	4,445	.7	-1,523
2)	T1	7,787	7,836	1.0	- 49
3)	T2	1,218	1,856	.7	- 638
4)	NT1+T1	10,709	12,072	.9	-1,363

5. CONCLUSION

This study has quantified all of the economic benefits which could be obtained from the construction of dykes in three of the key dyking areas of Kamloops (NT1, T1 and T2). The study results show that the construction of dykes is marginally justified in only one area (T1) and that the other areas NT1 and T2 and a combined project (NT1 and T1) are not economically viable.

A. INTRODUCTION

An earlier study of benefits associated with flood protection, in the Kamloops area, showed that three dyking area NT1, T1 and T2 (see Map 1) had benefits and resulting benefit-cost ratios of any significance.[1/] The other four areas analysed by the study, T3, T4, NT2 and ST1, had insignificant benefits and resulting benefit-cost ratios. A reconnaissance of the Kamloops area floodplain in mid 1977 and again in the fall of 1981 showed that very little new development had occurred in any of the dyking areas. As a result it was concluded that only the three areas NT1, T1 and T2 were likely to show changes in their benefit-cost ratios. Therefore only these three dyking areas are examined in detail in this report.

There are several reasons why the benefits estimated in this study will differ from those prepared in the earlier report. First, since the earlier report, some new development and intensification of activity has occurred. Secondly, the river profile has been updated and refined. Thirdly, better topographic maps and air photographs are now available to enable analysts to identify more precisely the areas flooded and the degree of flooding. Finally, since this study examined a smaller area, a much more detailed and intensive analysis of benefits is possible.

This update makes some reliance on the data collected for the 1971 study. For the most part, however, the data used is new.

B. OBJECTIVE

The objective of this study is to assess the economic feasibility of providing dykes for three dyking areas NT1, T1 and T2 at Kamloops. Since areas NT1 and T1 can be joined to form one continuous dyke, therefore eliminating the need for the cost of the separation, an

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1/ Environment Canada, "Kamloops Area-Benefit Study," Inland Waters Directorate, Pacific and Yukon Region, Unpublished report, February 28, 1973.

assessment of benefits for a combined project (NT1 & T1) is also prepared.

C. PROPOSED DYKES

The proposed dykes to protect areas NT1, T1 and T2 are shown in Map (1).

D. BASIC ASSUMPTIONS

The basic assumptions used in this study are:

1. The economic life of the proposed engineering works is 35 years.
2. The discount rate is 7%.[2/] Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Real growth and price change is expected to be 1% per year. Sensitivity analysis is provided using 0% and 2% growth rates.
4. Real dyke construction costs will appreciate at 1% per year over the next 35 years. Sensitivity analysis is provided using 0% and 3% growth rates.
5. Base year is 1982.

E. PROJECT COSTS

Appendix 2 outlines the expected project costs. It provides an estimate of the costs of constructing each dyke alternative to Fraser River Program standards, and shows the annual maintenance costs which new dykes would require to keep them at full program standard. Wherever applicable, right-of-way costs are included in the analysis.

F. FLOOD DAMAGE CRITERIA

1. Residential and Associated Damages

a. Residential Structural and Content

1) Residential Structure

Houses in Kamloops were found to be generally similar

2/ A 7% discount rate is used in the study because the Fraser River Joint Advisory Board agreed to use this rate in all its studies. The Treasury Board of Canada recommends the use of a discount rate of 10% for the year 1975.

to those in the Lower Mainland. Minor differences were not expected to have significant effect on the damage estimates.

Unit damage curves for residential structures for three house classes (A, B and C) were prepared in the report "Estimating Flood Damages in the Fraser River Basin".[3/] These unit damage curves were used in the current study to prepare separate structural damage curves for houses, apartments, and condominiums.

Structural damage curves for houses were prepared by combining main floor, basement and exterior (Chilliwack) damage curves of A, B and C class houses in the appropriate mix in which they occur.

The mix of house classes (A, B and C) was obtained in the following way: (1) the 1971 average house value of A, B and C class houses was updated using the B.C. Assessment Authority residential price index,[4/] (2) the upper value of C and B houses was established by calculating an average of the updated C and B class houses and B and A houses (Appendix 4), (3) a complete list of the assessed values of all floodplain homes at Kamloops was obtained from the B.C. Assessment Authority office in Kamloops, (4) the mix of A, B and C class houses was established by placing each floodplain home into its appropriate class based on its assessed value.

3/ Book, A.N., Princic R., "Estimating Flood Damages in the Fraser River Basin," Water Planning and Management Branch, Fisheries and Environment Canada, December 1975, pp. 41-55.

4/ B.C. Assessment Authority, Appraisal Systems Division Composite Cost Indices. Residences, Frame Structure.

The percentage of houses with basements was obtained from a field survey. An indication of the mix of house classes (A, B and C) and percentage of houses with basements in each dyking district is displayed in Appendix 5.

A structural curve for apartments was obtained by using the main floor damage curves (structural damage only) of 50% C class houses and 50% B class houses without basements. A structural damage curve for condominiums was prepared using the main floor damage curves (structural damage only) for 50% C class houses and 50% B class houses without basements and the exterior damage curves for Chilliwack type houses.

2) Content

Unit damage curves for residential content were prepared for three house classes (A, B and C) in the report "Estimating Flood Damages in the Fraser River Basin".[5/] These curves were used in the current study to prepare content damage curves for houses, apartments and condominiums.

Content damage curves for houses were prepared for each dyking area by taking into account the mix of house classes (A, B and C) and the percentage of houses with basements in that area. The mix of house classes and the percentage with basements used in the study is described under Residential Structure.

A content damage curve for apartments and condominiums

5/ Op. Cit., Book, A.N., Princic, R., p. 40

was prepared using the main floor damage curves (content damage only) for 50% C class houses and 50% B class houses.

The content unit damage curves were prepared from data based on 1971 dollars. These were updated to 1982 dollars using the "Statistics Canada, Consumer Price Index for Canada".[6/] Since indices were available, residential content was divided into two categories; furniture and appliances. For the purpose of this study it was assumed that the value of residential content was made up of 1/3 appliances and 2/3 furniture. One index, weighted according to the assumed ratio of furniture to appliance, was generated for use to update the residential content damage curves to 1982 dollars (see Appendix 16).

3) Combined Structural and Content Damage

Residential damages at Kamloops were estimated using unit damage curves which combines both structural and content damages. Separate curves were prepared to calculate damages to houses, apartments and condominiums. For houses a combined unit damage curve (structural and content) was prepared for each of three dyking areas. For apartments and condominiums only one curve was prepared. This curve was intended to be used to calculate damages to apartments and condominiums in any of the dyking areas. The unit damage curves for houses, apartments and condominiums used in the Kamloops study are shown in Appendix 6.

6/ Statistics Canada, Consumer Price Index for Canada, Main Components, Sug-groups and Selected Items, Furniture, Appliances, Catalogue No. 62-010 p. 35.

Damage to mobile homes (both structural and content) was prepared using a different procedure. First an average market value of mobile homes was obtained by contacting various dealers in the Kamloops area. Then a unit damage curve was prepared by applying a percentage-damage curve used by the U.S. Federal Insurance Administration to the market value of mobile homes. The unit damage curve used to estimate damages to mobile homes in Kamloops is shown in Appendix 6.

The number of residential units likely to suffer damage at each flood stage and dyking area was obtained from air photographs and from field inspection. Appendix 7A - 7D provides an estimate of the residential units subject to flooding and the associated dollar damage at each flood stage and dyking area.

b. Loss of Use of Dwelling

Loss of use of dwelling was estimated using the procedure described in the report "Estimating Flood Damages in the Fraser River Basin".[7/] In general, the procedure was to take the number of houses inundated at each river stage and multiply this by the total number of days during which they could not be occupied times the rental value of the homes. To allow a reasonable period for the restoration of services (water, hydro, etc.), clean-up and repairs to houses, the following additional time was added to the duration of flooding to give the total evacuation period.

7/ Op. Cit., Book, A.N., Princic, R., pp. 98-99.

TABLE 2

Evacuation Period

Flood Depth Above Main Floor	Period of Evacuation
Less than 1 foot	Duration of flood only
1 and 2 feet	Duration of flood + 45 days
More than 2 feet	Duration of flood + 60 days

The monthly rental value of houses was taken to be 1% of the market value of an average house (excluding land) in the dyking area. The monthly rental value of apartments, mobile homes and condominiums was taken to be 1% of the damages at the +3.0 meter level. An estimate of the loss of use of residential dwellings is provided in Appendices 7A - 7D.

c. Extra Food Cost

It is generally felt that residents of flooded areas would have to pay slightly more for food than they normally do. This would be the case because they would be forced to buy food in smaller quantities than usual.

Extra food cost was estimated using the procedure described in the report "Estimating Flood Damages in the Fraser River Basin".[8/] In general, the approach was to take the number of houses inundated at each flood stage, multiply this by the appropriate average number of persons per house, then

8/ Ibid., p. 100

multiply this by the period of evacuation and finally this total by the estimated extra food cost per person per day.

The extra cost of food in 1971 was estimated to be $ .38 per person per day. For 1982 the extra food cost is assumed to be $1.14 per person per day.[9/] An estimate of the extra food costs for each flood stage and dyking area is provided in Appendices 7A - 7D.

2. Commercial Damages

Commercial damages were estimated using the techniques and the unit damage curves outlined in the report "Estimating Flood Damages in the Fraser River Basin".[10/] The report used a field survey to establish stage damage curves for 20 distinct groups of commercial categories. Average dollar damages were calculated per square meter of establishment for each .3 meter of flooding.[11/]

The damages for each of the commercial categories were updated in the following manner. The proportion of damage to structure, inventory, and furniture and equipment was identified for each category of establishment. Appropriate indices were selected (which reflect price changes between 1971 and 1982) for each of structure, inventory, and furniture and equipment for the various

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9/ Statistics Canada, Consumer Prices and Price Indexes, Consumer Price Indexes for Regional Cities, Vancouver, Food, Food Away From Home. Cat. No. 62-010.

10/ Op. Cit., Book, A.N., Princic, R., pp. 49-55.

11/ Appendix 8A provides a list of the categories for which average stage damage relationships were determined. Appendix 8B shows the average square meter damage at intervals of .3 of a meter for each category for 1971.

commercial categories. A weighted index was generated for each type of establishment by adding the three proportional damages.

The basic steps involved in estimating commercial damages in this study were: (1) identify and assign individual commercial establishments to their appropriate categories (Appendix 8A); (2) determine the elevation of each establishment by the use of topographic maps and site inspection; (3) determine the height of the main floor above ground level for each establishment by use of air photographs and site inspection; (4) estimate the floor area of each establishment by use of air photographs and site inspection; and (5) obtain the dollar damage for each establishment by multiplying its floor area times the appropriate unit damage estimate. An estimate of the potential commercial damages at each stage is provided in Appendices 1A - 1C.

3. Industrial Damages

Industrial damages, as a result of flooding, were prepared in an earlier report entitled "Kamloops Area - Benefit Study".[12/] These damages, were originally estimated by on-site inspection and discussion with plant management. Because of the difficulty of estimating industrial structural damages, the estimates prepared in the earlier report were updated to 1982 and were used in this report.[13/] To account for plant expansion, it was assumed that plants grew in direct proportion to the increase in the number of its employees. The number of emloyees employed by industries at Kamloops in 1982 was obtained from Employment and Immigration Canada, District Economist, for the area[14/]. An

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12/ Environment Canada, "Kamloops Area - Benefit Study", Inland Waters Directorate, Pacific and Yukon Region, Unpublished report, February 28, 1973.

13/ B.C. Assessment Authority, Appraisal Systems Division, Composite Cost Indices, Commercial and Industrial Structures.

14/ Mr. R. Smelser, District Economist, Employment and Immigration Canada.

estimate of potential industrial damages at each flood stage is provided in Appendices 1A - 1C.

4. Income Losses

Primary and secondary income losses include all returns to labour, land, capital and entrepreneurship which would be lost to the province as a result of a flood. Primary income losses refer to losses incurred by floodplain firms forced to shut down because of a flood. Secondary losses refer to losses by non-floodplain firms forces to reduce production when a flood destroys their markets or source of raw materials.

a. Primary Income Losses

Two methods were used to calculate primary income losses depending on whether production of floodplain firms could be deferred or transferred to other non-floodplain firms in British Columbia or not. If production could be deferred or transferred, the only losses to British Columbia would be frictional losses caused by delays and extra shipping costs. In this study, this cost was assumed to be 2% of the value of the transferred or deferred production.[15/] If production could not be deferred or recovered by some other British Columbia firm income losses were calculated in the following manner: (1) each firm's daily gross value of production was established either by contacting the firm directly or through secondary sources;[16/] (2) each firm's value added portion of its gross income was established by consulting the publication "The Input-Output Structure of

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15/ Book, A.N., Princic R., "Estimating Flood Damages in the Fraser River Basin," Water Planning and Management Branch, Fisheries and Environment Canada, December 1975, pp. 73-76.

16/ Ibid., pp. 77-78.

the Canadian Economy 1961";[17] and, (3) primary income loss was calculated by multiplying the firm's daily income (value added) by the total number of days out of production.[18]

It was assumed that no income losses would occur in the commercial sector. It was anticipated that income losses of floodplain establishments would be made up by gains by business located off the floodplain or by postponement of purchases to a later date.

b. Secondary Income Losses

Secondary income losses were estimated by identifying and examining the various forward and backward linkages between firms on and off the floodplain. The steps involved were as follows: (1) take the residual of the gross daily production (after deducting the firm's value added) calculated under primary income loss; (2) identify the portion of the residual production supplied by B.C. industries;[19] (3) estimate the value added portion of each of the supplying industries;[20] (4) calculate the weighted average income loss (value added portion only) of the supplying industries; and, (5) calculate the secondary income loss by multiplying the weighted average income loss times the residual gross daily income.[21]

17/ Dominion Bureau of Statistics, "The Input-Output Structure of the Canadian Economy", The Queen's Printer, Ottawa, Ontario, August 1969.

18/ For a more detailed explanation see the report "Estimating Flood Damages in the Fraser River Basin," by A.N. Book, and R. Princic.

19/ Ibid.

20/ Ibid.

21/ For a more detailed explanation see the report, "Estimating Flood Damages in the Fraser River Basin," by A.N. Book, and R. Princic, pp. 73-86.

5. Damage to Roads

Damage to roads were estimated using the data and the procedure described in the report "Estimating Flood Damages in the Fraser River Basin".[22/] Road damages were estimated using two sets of values; a value of $2,000 per mile ($1,240 per km) was used to estimate damages for floods of less than 7 days and $9,000 per mile ($5,590 per km) for floods longer than 7 days. These values were converted to damage per kilometer and were updated to $3,840 and $17,330 (1982 dollars) for flooding of less and more than 7 days respectively.[23/] Estimates of road damages at various flood stages and dyking areas are presented in Appendix 9.

6. Damage to Schools

Damage to schools was estimated using the procedure and unit losses prepared in the 1971 report, "Estimating Flood Damages in the Fraser River Basin".[24/] Unit losses were put together for each individual school by combining flood depth curves expressing the percentage loss per foot of flooding times the market value of the school.[25/] The market values for the various schools by size (number of classrooms) and level of education had originally been obtained from the Department of Education. Since market values used in the Fraser River report were for the year 1971, these had to be updated to 1982 dollars.[25/] Estimates of school damages for each area and flood stage are provided in Appendix 10.

22/ Op. Cit., Book, A.N., Princic, R., pp. 92-94.

23/ Statistics Canada, Construction Price Statistics, Highway Construction Price Index, B.C. Total, Catalogue No. 62-007, p. 24.

24/ Op. Cit., Book, A.N., Princic, R., pp. 96-98.

25/ See Appendix 16.

26/ See Appendix 16.

7. Damage to Utilities

a. Sewage Systems

This report assumes that any lengthly flooding of sewage systems would require them to be cleaned. Province of British Columbia engineers (Water Investigations Branch) estimated that it would cost $7,000-$8,000 (1978) to clean and repair the sewage system in North Kamloops. For the purpose of this analysis it was assumed that these costs would be incurred as a result of a 345.95 m flood. This figure was converted to damage per hectare ($44 in 1978) so it could be used to calculate damages for different flood stages. The 1978 unit damage ($44) was then increased to $77 per hectare to bring it to the base year 1982. Since cleaning of sewage systems involves mainly labour, the 74% increase reflects the change in labour costs between 1978 and 1982.[27/] An estimate of the damages to the sewage systems for each area and flood stage is provided in Appendix 11.

b. Water Supply Systems

Damages to the water supply system were felt to be similar to damages to the sewage system. The procedure used to estimate damages resulting from flooding of water supply lines was the same as that used for estimating damages to the sewage system.

c. Gas Distribution Systems

British Columbia Hydro and Power Authority, in 1971, indicated that gas distribution facilities would require cleanup and restarting procedures costing $30 per gas using

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27/ Statistics Canada, Employment Earnings and Hours by Industry for Provinces and Regions, British Columbia, Average Weekly Earnings, All Employees (Construction, Building s.i.c. 400-421), Vancouver, Catalogue No. 72-002.

household flooded.[28/] This was updated to $110 (1982 dollars) to reflect the increase in costs since 1971.[29/] An estimate of the damages to gas distribution facilities in each area and flood stage is provided in Appendix 12.

8. Miscellaneous Damages

a. Debris Removal and Cleanup Costs

Analysis of past floods have shown a sizeable expenditure for the removal of debris, sand and gravel from flooded areas. Flood damage claims following the Vedder River flood of December 1975 showed an average cost of $80 per acre ($198 per hectare) for the removal of debris and general cleanup of land.[30/] This figure was updated to $487 per hectare for 1982 and used in the current study. An estimate of the cost of debris removal and general clean-up for each area and flood stage is provided in Appendix 11.

b. Damage to Outbuildings

Damage to outbuildings was estimated using the same procedure established in the 1971 report "Estimating Flood Damages in the Fraser River Basin".[31/] The report assumed that outbuildings would have to be repaired and painted at a cost of $40 per outbuilding. This figure was updated to $108 per outbuilding to reflect the increase in building

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28/ Value taken from background data used in the preparation of the report "Estimating Flood Damages in the Fraser River Basin" by A.N. Book, R. Princic, December 1975.

29/ Op. Cit., Statistics Canada, Employment Earnings and Hours, Catalogue No. 72-002.

30/ From information supplied by the Province of British Columbia, Water Investigations Branch.

31/ Op. Cit., Book, A.N., Princic, R., p. 96.

repair costs from 1971 to 1982.[32/]

The number of buildings flooded were identified by using enlarged air photographs and verified by field inspection. Damages were estimated for each stage by multiplying the number of buildings flooded times the unit loss. An estimate of the number of buildings flooded at each area and flood stage is provided in Appendix 13.

c. Cost of Evacuating People

The report "Estimating Flood Damages in the Fraser River Basin", used $1.50 per person as the cost of moving residents from their flooded homes and back again.[33/] This value was updated to $4.30 to reflect the increase in transportaton costs between 1971 and 1982.[34/]

The number of people evacuated from each dyking area was obtained by multiplying the number of residences flooded at each stage times the average number of persons per family in Kamloops (3.6 persons per family).[35/] An estimate of the number of people evacuated at each dyking area and flood stage and the associated dollar loss is provided in Appendix 14.

d. Miscellaneous Structural

A hockey arena and other recreational facilities on McArthur

32/ Statistics Canada, Farm Input Prices Index, Building Repairs, Catalogue No. 62-004.

33/ Op. Cit. Book, A.N., Princic, R., p. 100.

34/ Statistics Canada, Prices and price Indexes, Consumer Price Indexes, Regional Cities, Vancouver, Transportation, Catalogue No. 62-002.

35/ Statistics Canada, 1971 Census of Canada, Families, Families by Size and type, Catalogue 93-714, Vol. 2 - Part 2, June 1973, pp. 1-7.

Island were expected to be flooded by a 200 year return flood. Damages to these facilities were estimated using data from Appendix 8B, Category 14, Recreation Services. An estimate of the damages is provided in Appendix 1B.

e. Park and Recreation Land

Damage to recreation land was based on a 1972 report by G.E. Crippen and Associates Ltd.[36/] The report estimated that recreation areas such as parks would suffer damages (cleanup, etc.) of about $145 per acre ($358 per ha.) of flooded land. This value was updated to $900 per hectare to reflect cost increases to 1982.[37/] An estimate of the hectares of recreation land flooded at each dyking area and for each flood stage and the associated dollar loss is provided in Appendix 15.

G. FUTURE DAMAGES

1. Real Growth

The three dyking areas vary considerably in their mix of commercial, industrial and residential establishments and the amount of land available for further development. Area NT1 is primarily residential, has no industrial development, a small amount of commercial development, and has no vacant land for any further expansion. Area T1 has no industrial development, considerable commercial development, and has no vacant land for residential development. Area T2 is primarily industrial, has a small amount of commercial development and has some land available for expansion.

Very little change has been observed in the commercial sector of

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36/ Crippen, G.E. and Associates Ltd., "Flood Control Study of Fraser River Below Hope", Vancouver, January 1972.

37/ Statistics Canada, Employment Earnings and Hours, Employment Earnings and Hours by Industry for Urban Areas. Average Weekly Earnings, Industrial Composite for Urban Areas, Kamloops Catalogue No. 72-002.

the three areas since the last study (1971). Based on this observation it was assumed that no large scale commercial development would occur in these areas. However, because of the large commercial component of area T1, it was assumed that some intensification of activity would occur.

Although there is substantial land available for industrial growth in area T2, most of it is owned by the existing industries. Any new development, therefore, is likely to be related to these industries. Since it appears that new industrial construction on the floodplain is complying with the provincial government requirement to flood proof to the 200 year return flood, new industrial development is not expected to result in significant increases in damages.

2. Real Price Change

"Real price changes" over time are increases or decreases in the value of damageable goods relative to all other goods in the economy (i.e. relative to the consumer price index). Real changes in the value of damageable commodities are normally forecast from the analysis of historic changes. Because of the extreme variability in these prices, however, no attempt is made to project real price changes over time for individual damage categories.

3. General

This study provides three alternative projections of future flood damages. A rate of 1% per year is used as the "most likely" pattern of growth. This estimate is based on the best prediction of probable growth and productivity change and the most likely change in the real value of floodplain activity. The second projection, or "absolute minimum", is based on the assumption that there would be no growth or real price increase over time. The third projection is designed to examine the sensitivity of

damage estimates of small errors in projections. This is done merely by increasing the "most likely" rate of change for each damage category by 1% per year. The growth projections in this study are assumed to continue over the period 1982-2017.

H. BENEFIT-COST ANALYSIS

1. Benefits

Using the physical parameters of depth, duration, and extent of flooding and the damage criteria described earlier in the report, potential damages were estimated for each of four river stages ranging from 344.12 M to 346.83 M (see Appendices 1A - 1C).

Next average annual damages were calculated for each of the dyke areas separately and for a combined area (NT1 & T1) using the frequencey data in Appendix 3 and the flood damage information in Appendices 1A - 1C (Figures 2-5). To make this analysis comparable with similar studies prepared for the Fraser River Flood Control Program and to some extent account for the reduced reliability of dykes at higher water elevations, an adjustment was made to the total available benefits. At flood elevations between 346.56 M and 346.83 M (1 ft. below dyke design) the new dykes were assumed capable of capturing only 50% of the available benefits.[38/] To show the effect of different confidence levels on benefits average annual damages are also calculated for dyke confidence up to the design level and for two feet below design level. Average annual damages for the dyking areas and various dyke confidence levels are displayed in Appendix 18.

Benefits were generated using the average annual damages and the appropriate discount factor for the three growth scenarios

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38/ In the Fraser Flood Control Study, the dyke design was 26 ft. (Mission gauge) and the 100% confidence level was established at 24 ft., 2 ft. below its design level. Upgraded dykes captured only 50% of the benefits between 24 ft. and 26 ft.

FIG. 2

KAMLOOPS – AREA NT I
AVERAGE ANNUAL DAMAGES

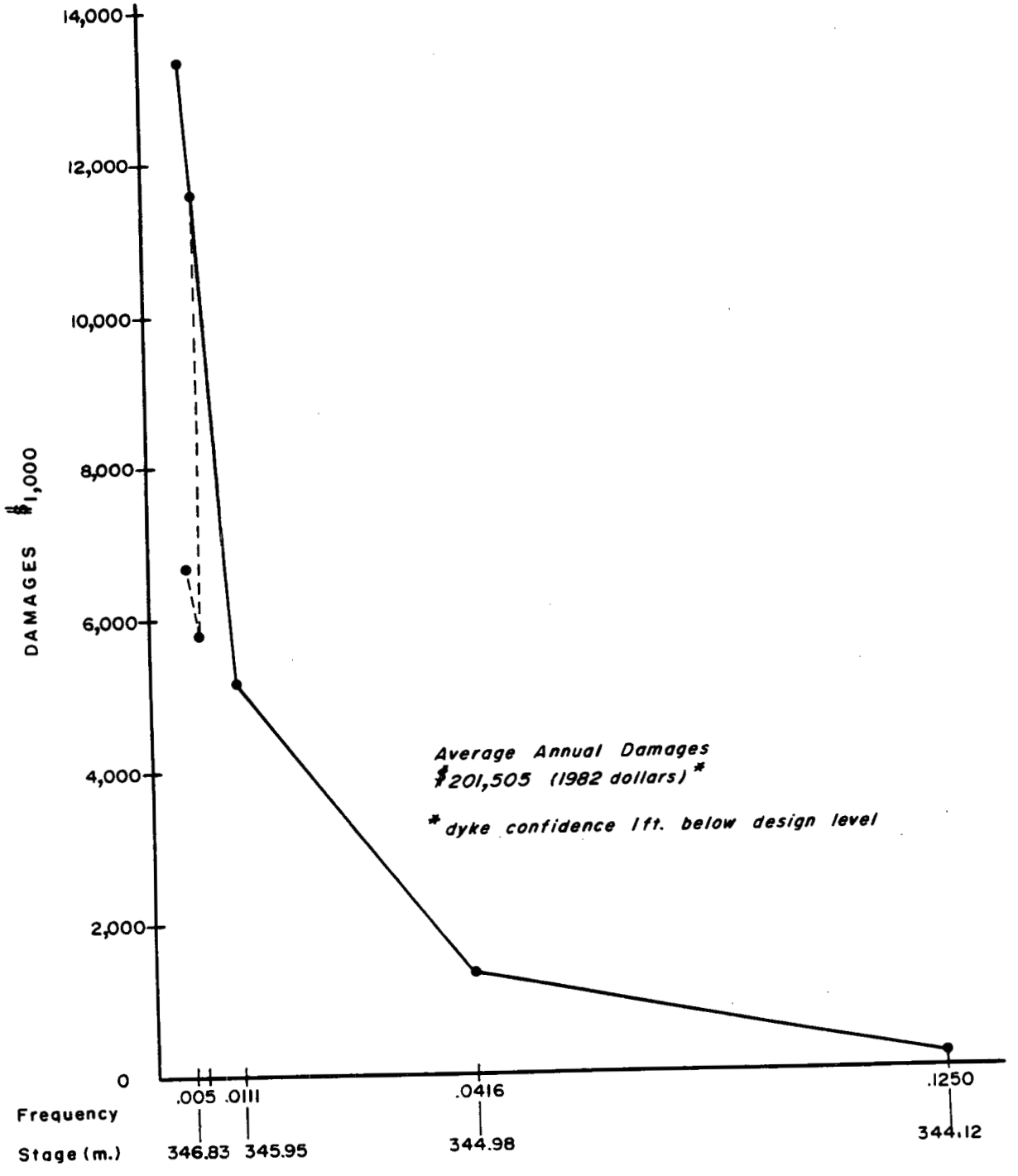


FIG. 3

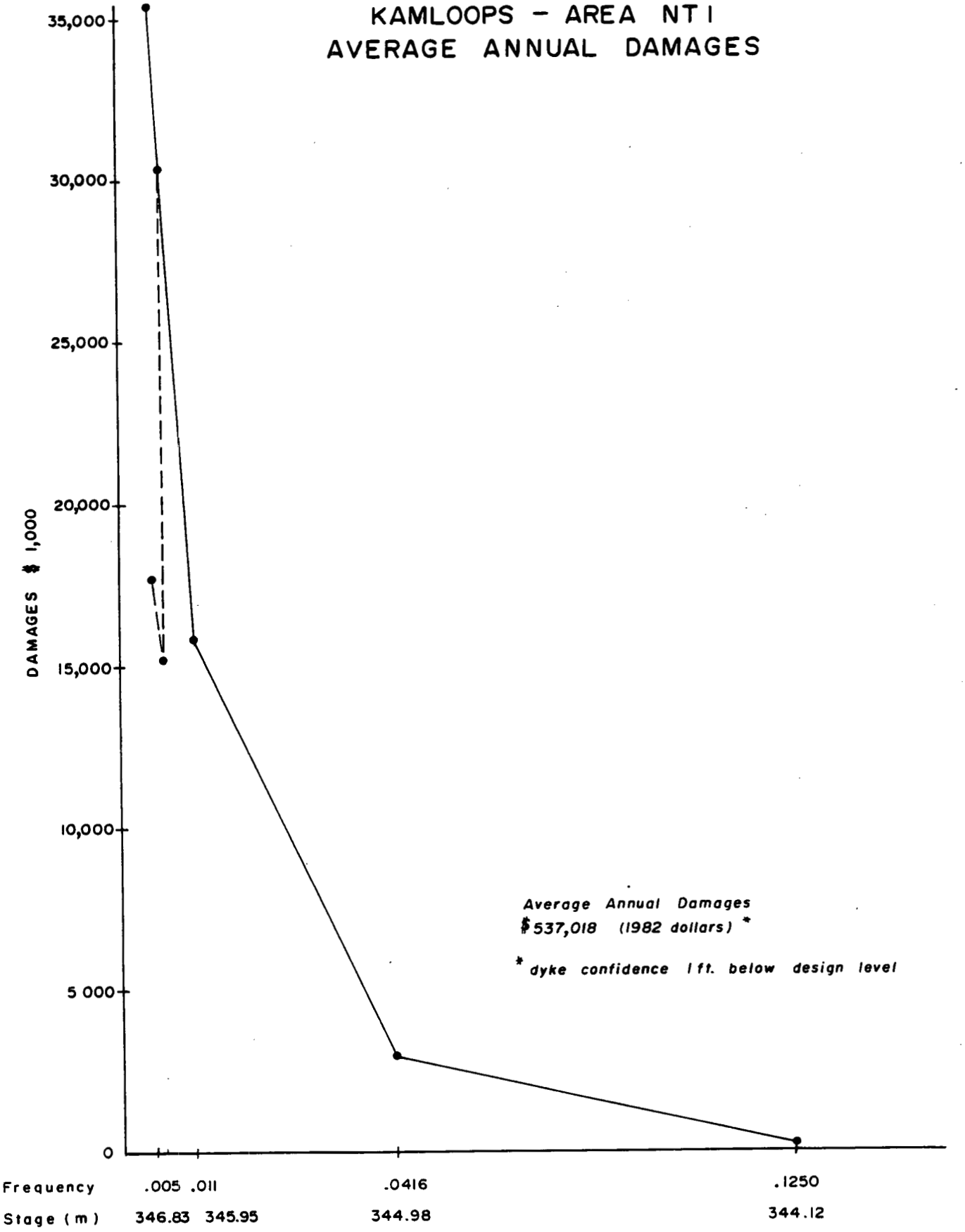

KAMLOOPS - AREA NT I
AVERAGE ANNUAL DAMAGES
35,000
30,000
25,000
20,000
15,000
10,000
5 000
0
DAMAGES $ 1,000
Average Annual Damages
$537,018 (1982 dollars) *
* dyke confidence 1 ft. below design level
Frequency .005 .011 .0416 .1250
Stage (m) 346.83 345.95 344.98 344.12

FIG . 4

KAMLOOPS - AREA NT I
AVERAGE ANNUAL DAMAGES

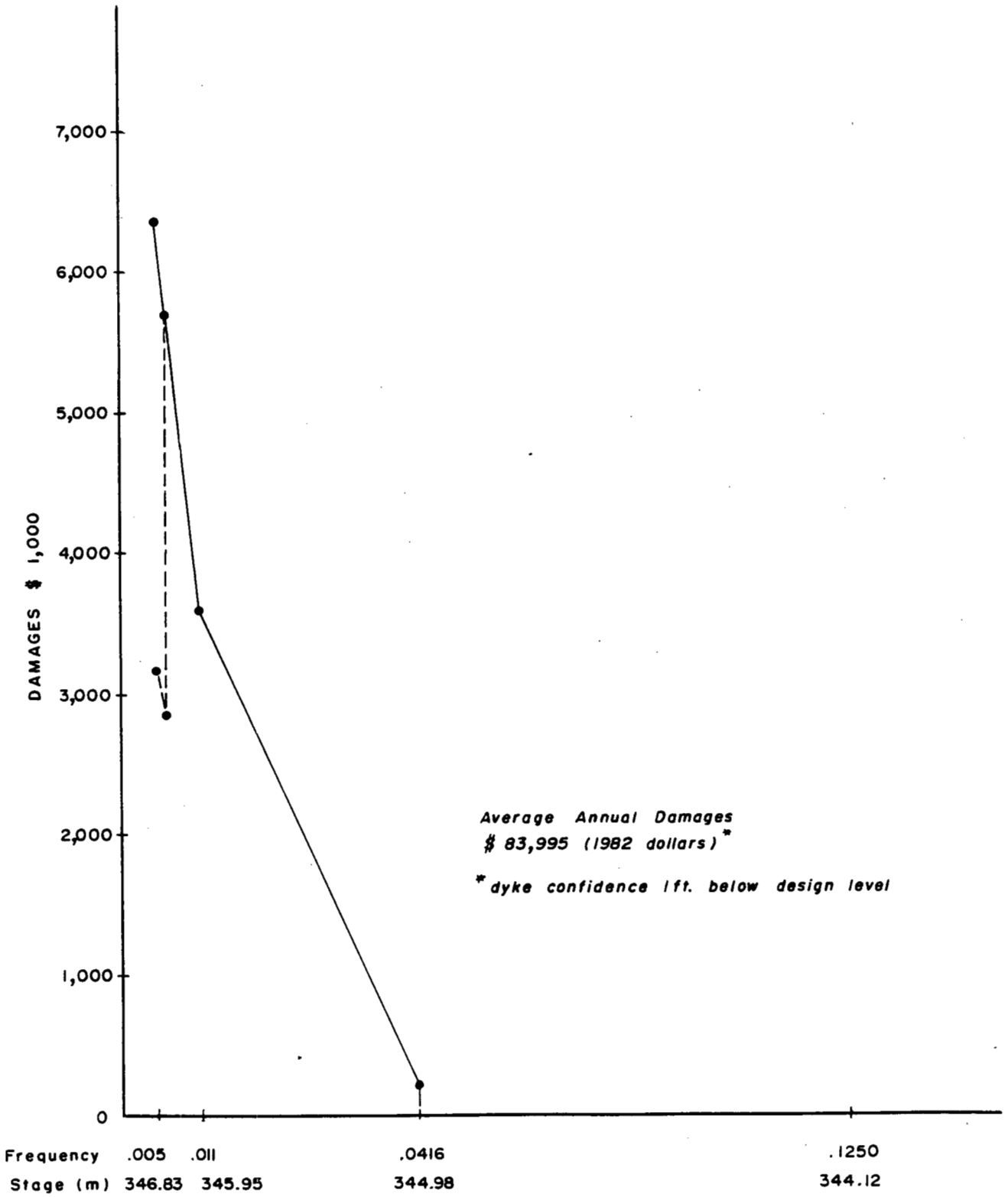
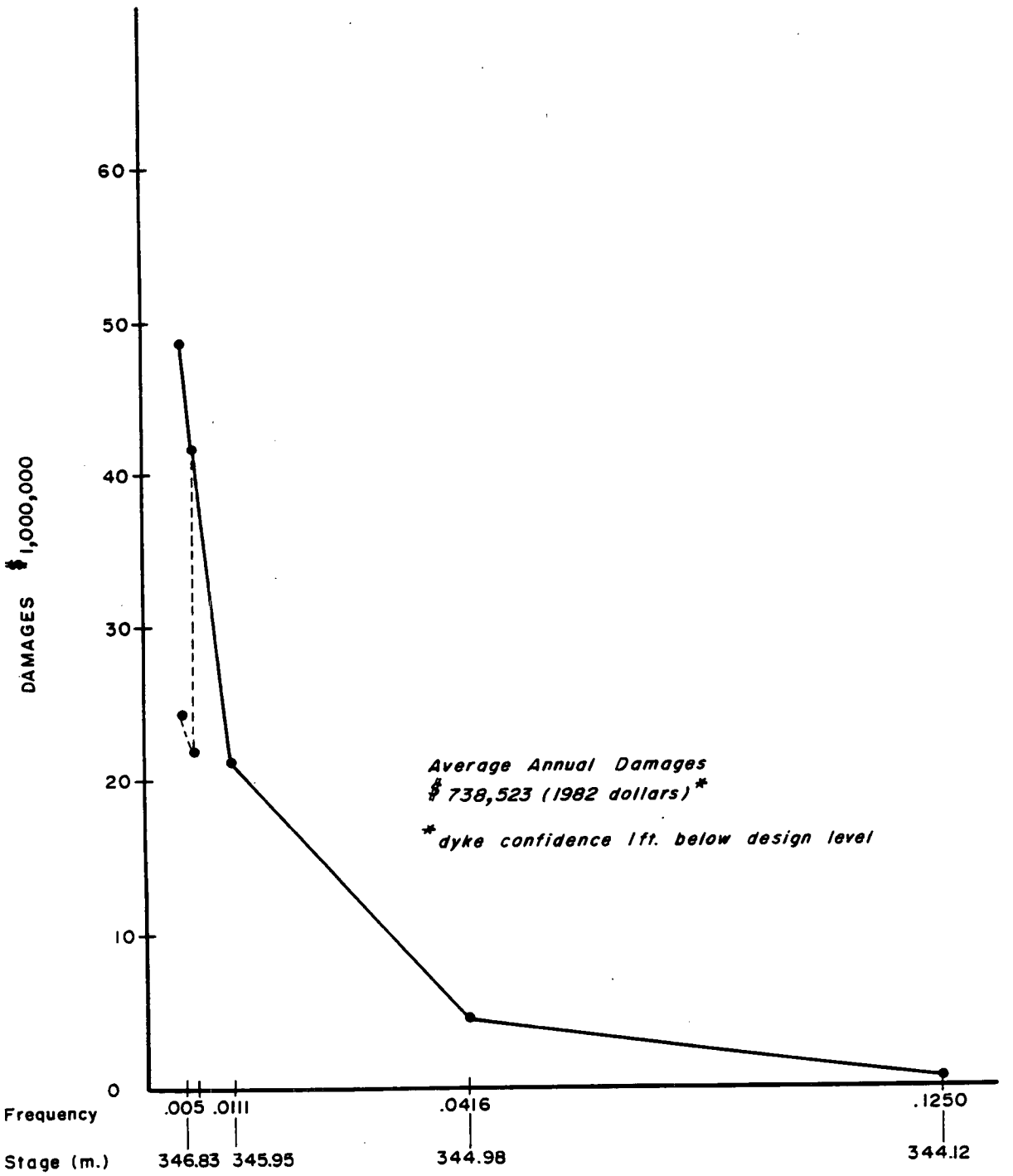


FIG. 5

KAMLOOPS - AREA (NTI + TI)
AVERAGE ANNUAL DAMAGES



outlined earlier. The present value of benefits for each of the dyking areas is shown in Appendix 19. A summary of the results is provided in Table 3.

Table 3
Present Value of Dyke Benefits (1982-2017)

Dyke Area	Benefits* ($000)
1) NT1	2,922
2) T1	7,787
3) T2	1,218
4) NT1 & T2	10,709

* Using 7% discount rate, 35 year project life and most likely growth rate and price change. Confidence level of new dyke 1 foot below design level.

2. Costs

Appendix 2 provides an estimate of the capital costs, right-of-way costs, and the annual maintenance costs of the Kamloops dykes.[39/]

The present value of the maintenance costs were calculated assuming a real cost appreciation rate of 1% per year and using a discount rate of 7% per year. In order to conduct sensitivity analysis, future maintenance costs were calculated using two other rates of appreciation; 0% and 3% (Appendix 17).

Project costs were obtained by adding the calculated present value of the maintenance costs of the dykes to the capital and right-of-way costs of these dykes (Table 4).

39/ See Appendix 2B, Right-of Way Costs, for an explanation of right-of-way costs.

TABLE 4

Project Costs - Kamloops

Area	Capital Cost of New Dyke	Maint. Cost of New Dyke	Right-of-Way Cost*	Project Cost
	($000)	($000)	($000)	($000)
(1) NT1	4,054	391	--	4,445
(2) T1	4,255	411	3,170	7,836
(3) T2	1,692	164	--	1,856
(4) NT1 & T2	8,119	783	3,170	12,072

* Preliminary estimate obtained from the Province of British columbia, Water Investigations Branch.

3. Benefit-Cost and Net Benefits

Table 5 summarizes the benefit-cost ratios and net benefits for each dyking area. These were calculated from the estimated benefits and costs derived during the study.

TABLE 5

Benefits, Costs, Benefit-Cost Ratios and Net Benefits

Kamloops

Dyke Area	Benefits of New Dykes	Project Costs	Benefit-Cost Ratios	Net Benefits
	($000)	($000)	($000)	($000)
(1) NT1	2,922	4,445	.7	-1,523
(2) T1	7,787	7,836	1.0	- 49
(3) T2	1,218	1,856	.7	- 638
(4) NT1 & T1	10,709	12,072	.9	-1,363

4. Sensitivity Analysis

Appendix 21A - 21D provides benefit-cost ratios for the three dyking areas of Kamloops (NT1, T1, T2 and NT1 & T1) under various assumptions of growth and real price change for both benefits and dyke construction costs at different discount rates (6%, 8% and 10%). Note that in only one dyking area, T1, is the benefit-cost

ratio almost equal to 1. For the same dyking area and more relaxed assumptions, most likely rate of growth and discount rate of 10%, the benefit-cost ratio is only .7. Furthermore, if a dyke confidence of two feet below dyke design is used (dyke confidence used to assess benefits of lower Fraser River dykes) the benefit cost ratio for T1 drops to .94.

I. GENERAL COMMENTS

The purpose of benefit-cost studies of dyking areas, carried out under the Fraser River Flood Control Program, has been to quantify the benefits available to any new dyke construction and to rank projects in order of priority. A methodology for estimating damages and calculating dyke benefits was established in the early part of the program. An approach for updating flood damages was also established early on in the program and had been applied in most instances without alteration. To satisfy the second part of the study objective, ranking of projects, it is necessary to maintain consistency in the method of analysis and approach used to update damages. This has been done for the most part.

A major change has been made in the calculation of benefits at Kamloops which has made these benefits larger and makes it difficult to compare them with other studies elsewhere. This change involves the use of a higher confidence level for the reconstructed dykes in that area.

Changing the confidence level of improved dykes in the Kamloops area has the effect of making benefits in this area larger. In the case of all Lower Fraser river dykes the 100% confidence level of improved dykes was established at 2 feet below their design level. At Kamloops the 100% confidence level was established at 1 foot below the design level. This change makes benefits at Kamloops about 5-7% higher than they would be if the 2 foot confidence level had been used.

A change such as that introduced in the Kamloops study can bias the analysis in favour of less justifiable projects. In order to maximize the return on the available funds for dyke construction all projects should be evaluated using the same techniques and methods of analysis, unless there is a justified reason for making the particular changes, i.e. the confidence level of dykes at Kamloops is higher because the material used for their construciton is superior to that used elsewhere.

J. CONCLUSION

This study has quantified all of the economic benefits which could be obtained from the constructon of dykes in three of the key dyking areas of Kamloops (NT1, T1 and T2). The study results, show that the construction of dykes is marginally justified in only one area (T1) and that the two other areas NT1 and T2 and a combined project (NT1 & T1) are not economically viable.

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APPENDICES

APPENDIX 1A

FLOOD DAMAGES - SUMMARY

AREA: KAMLOOPS NT1

TYPE OF DAMAGE	1982 DAMAGES ($000) FLOOD STAGE (M) 344.12	344.98	345.95	346.83
1) Residential and Associated				
a) Structural and content	157.6	1,109.4	4,219.9	9,948.6
b) Loss of use of dwelling	11.6	89.8	238.9	529.6
c) Extra food cost	3.3	25.4	67.5	149.5
2) Apartment and Condominiums				
a) Structural and content	-	-	266.0	1,755.7
b) Loss of use	-	-	20.4	109.9
c) Extra food cost	-	-	11.8	57.7
3) Mobile Homes				
a) Structural and content	-	-	-	-
b) Loss of use	-	-	-	-
c) Extra food cost	-	-		-
4) Commercial	-	-	91.2	205.6
5) Industrial	-	-	-	-
a) Structural and Inventory	-	-	-	-
b) Income (primary)	-	-	-	-
6) Roads	13.9	55.5	75.4	172.1
7) Schools	-	-	114.7	318.1
8) Utilities				
a) Sewage systems	.5	1.8	3.5	5.4
b) Water supply systems	.5	1.8	3.5	5.4
c) Gas distribution systems	2.6	10.3	33.2	63.5
9) Miscellaneous				
a) Clean-up costs	3.4	11.7	21.9	34.1
b) Outbuildings	.4	1.8	5.4	6.9
c) Evacuating people	.4	2.7	6.5	11.4
d) Structural	-	-	-	-
e) Parks and recreation land	-	2.2	2.8	4.0
TOTAL PRIMARY DAMAGES	194.2	1,312.4	5,182.6	13,377.5
7) Secondary Income Loss				
a) Industrial	-	-	-	-
TOTAL SECONDARY DAMAGES	-	-	-	-
TOTAL DAMAGES	194.2	1,312.4	5,182.6	13,377.5

APPENDIX 1B

FLOOD DAMAGES - SUMMARY

AREA: KAMLOOPS T1

TYPE OF DAMAGE	1982 DAMAGES ($000) FLOOD STAGE (M) 344.12	344.98	345.95	346.83
1) Residential and Associated				
a) Structural and content	131.5	1,678.6	8,957.2	21,211.1
b) Loss of use of dwelling	22.7	156.8	407.6	1,053.6
c) Extra food cost	7.0	48.8	168.4	326.1
2) Apartment and Condominiums				
a) Structural and content	-	162.4	1,774.2	3,565.2
b) Loss of use	-	18.5	116.3	207.0
c) Extra food cost	-	7.8	65.4	121.4
3) Mobile Homes				
a) Structural and content	15.0	442.8	1,710.3	3,745.5
b) Loss of use	5.7	33.4	84.0	129.7
c) Extra food cost	3.4	20.0	50.4	77.8
4) Commercial	-	257.2	2,067.2	3,913.4
5) Industrial	-	-	-	-
a) Structural and Inventory	-	-	-	-
b) Income (primary)	-	-	-	-
6) Roads	15.6	79.7	107.4	219.1
7) Schools	-	-	114.7	318.5
8) Utilities				
a) Sewage systems	1.7	5.2	10.4	11.6
b) Water supply systems	1.7	5.2	10.4	11.6
c) Gas distribution systems	6.3	32.7	90.2	112.9
9) Miscellaneous				
a) Clean-up costs	10.7	32.6	65.7	73.1
b) Outbuildings	.8	3.5	12.6	14.3
c) Evacuating people	1.2	8.1	17.3	22.2
d) Structural	-	-	-	234.7
e) Parks and recreation land	-	1.1	48.4	48.8
TOTAL PRIMARY DAMAGES	223.3	2,994.4	15,878.1	35,417.6
7) Secondary Income Loss				
a) Industrial	-	-	-	-
TOTAL SECONDARY DAMAGES	-	-	-	-
TOTAL DAMAGES	223.3	2,994.4	15,878.1	35,417.6

APPENDIX 1C

FLOOD DAMAGES - SUMMARY

AREA: KAMLOOPS T2

TYPE OF DAMAGE	1982 DAMAGES ($000) FLOOD STAGE (M) 344.12	344.98	345.95	346.83
1) Residential and Associated				
a) Structural and content	-	-	-	-
b) Loss of use of dwelling	-	-	-	-
c) Extra food cost	-	-	-	-
2) Apartment and Condominiums				
a) Structural and content	-	-	-	-
b) Loss of use	-	-	-	-
c) Extra food cost	-	-	-	-
3) Mobile Homes				
a) Structural and content	-	-	-	-
b) Loss of use	-	-	-	-
c) Extra food cost	-	-	-	-
4) Commercial	-		206.3	287.4
5) Industrial				
a) Structural and Inventory	-	93.3	333.7	424.3
b) Income (primary)	-		2,259.7	4,236.9
6) Roads		6.9	26.5	97.2
7) Schools	-	-	-	-
8) Utilities				
a) Sewage systems		2.7	10.8	13.5
b) Water supply systems		2.7	10.8	13.5
c) Gas distribution systems	-	-	-	-
9) Miscellaneous				
a) Clean-up costs		17.0	68.2	85.2
b) Outbuildings	-	-	-	-
c) Evacuating people	-	-	-	-
d) Structural	-	-	-	-
e) Parks and recreation land	-	-	-	-
TOTAL PRIMARY DAMAGES	-	122.6	2,916.0	5,158.0
7) Secondary Income Loss				
a) Industrial	-	84.5	684.9	1,225.4
TOTAL SECONDARY DAMAGES	-	84.5	684.9	1,225.4
TOTAL DAMAGES	-	207.1	3,600.9	6,383.4

APPENDIX 2

Cost Associated With Dyke Construction - Kamloops

A. Dyke Construction and Maintenance Costs

Dyke Area	Dyke Costs* (1982) $	Annual Maintenance 0-15 Yrs $	Cost (1982)** 16-35 yrs $
1) NT1	4,054,000+	20,300+	40,500+
2) T1	4,255,000+	21,300+	42,600+
3) T2	1,692,000+	8,500+	17,200+
4) NT1+T1	8,119,000	40,600	81,200

* Dyke costs were provided by the Water Investigations Branch, B.C. Ministry of Environment.

** Maintenance costs were estimated to be 0.5 percent for the first 15 years and 1.0 percent for the next 20 years of the dyke costs.

\+ Includes the cost of separating dykes NT1 and T1, estimated to be $132,000 and maintenance costs $700 for first 15 years and $1,300 for subsequent 20 years.

B. Right-of-Way Costs

Of the three dyking areas under consideration only area T1 would be required to have any amount of land purchased for right-of-way. Most of the dyke in area NT1 would either be constructed on the existing road right-of-way or on municipal owned land. Project right-of-way costs for this area are estimated to be zero. The dyke in area T2 would also be constructed primarily on the existing alignment. The additional land which would be required would probably be obtained from the existing owners at no cost. Project right-of-way costs for area T2 are also assumed to be zero. The situation in area T1 is very different. For about two-thirds of its length, the dyke would cross private residential property. As a result, right-of-way would have to be purchased from the property owners. Preliminary estimates by Kamloops City authorities put the cost of purchase of right-of-way at $1.9 million for 1976.*** This cost is updated to $3.17 million (1982 dollars) using the residential price index (Appendix 16).

*** Preliminary estimate from B.C. Water Investigations Branch

APPENDIX 3

Physical Characteristics of Flooding

	Flood					
Return Period	8	24	90	115	154	200
Elevation (M)	344.12	344.98	345.95	346.22	346.56	346.83
Elevation (Ft)	1129.0	1132.4	1135.0	1135.9	1137.0	1137.9
Discharge (cfs)	122,400	141,600	159,000	163,900	170,000	175,600
Frequency	.1250	.0416	.0111	.0087	.0065	.0050
Area Flooded (Ha)						
NT1	7	24	45	-	-	70
T1	22	67	135	-	-	150
T2	-	35	140	-	-	175

APPENDIX 4

House Values at Kamloops

- Data used to classify houses at Kamloops

Average Value of Houses in Kamloops by class, 1971 and 1982

YEAR	HOUSE CLASS A	B	C
1971	28,506	15,100	6,456
1982*	79,817	42,280	18,077

* B.C. Assessment Authority residential price index

Limits established for the purpose of classifying houses

A	62,625	B	31,060	C
	low limit of A		low limit of B	

APPENDIX 5

Critical Characteristics of Houses by Area - Kamloops

Area	% of Houses In Each Class			% of Houses With Basements			Main Floor Level Above Ground (M) Houses With Basements			Houses Without Basements		
	A	B	C	A	B	C	A	B	C	A	B	C
NT1	3	80	17	100	86	77	.9	.9	.9	0	.6	.6
T1	7	55	38	100	92	48	.9	.9.	.6	0	.3	.3

APPENDIX 6

Average Damage - Various Levels of Flooding

Flooding Meters Above Ground	DAMAGE BY AREA - 1982 DOLLARS				
	Houses		Apt.'s*	Condo.'s**	Mobiles***
	NT1	T1	NT1 & T1	NT1 & T1	NT1 & T1
0	0	0	2,800	2,800	0
.3	5,460	5,300	11,700	13,570	0
.6	7,020	8,270	13,600	16,220	1,150
.9	11,700	12,170	15,000	18,100	10,350
1.2	22,150	20,440	16,500	19,800	14,950
1.5	25,100	23,240	16,800	21,060	17,940
1.8	27,300	25,120	17,300	22,000	19,550
2.1	30,730	27,920	17,500	23,240	20,120
2.4	31,500	28,550	18,700	24,800	20,700
2.7	32,300	29,330	-	24,960	21,280
3.0	32,600	29,640	-	25,120	23,000
+3.0	48,830	44,460	-	38,380	23,000

* From report, "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, December 1975, Appendix A, page 29. Curve put together using main floor damage curves for 50 percent C class houses without basements and 50 percent B class houses without basements. This was updated to 1982 dollars using the B.C. Assessment Authority Residential Price Index.

** From report, "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, December 1975, Appendix A, page 21 and 29. Curve put together using main floor damage curves for 50 percent C class houses and 50 percent B class houses without basements plus exterior damages for Chilliwack type houses. This was updated to 1982 dollars using the B.C. Assessment Authority Residential Price Index.

*** Based on Percent-damage curve used by the U.S. Federal Insurance Administration. Total value per mobile home in the Kamloops area in 1982 was estimated to be $23,000.

APPENDIX 7A1

KAMLOOPS - NT1 — Houses

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evac-uation period (DAYS)	Damage per House $	No. of Houses	Loss of use per House * / Extra Food Cost	Total Loss of Use $	Damage to Houses $	Extra food Costs $
	0	14	-	25	228/64	5,700		1,600
344.12	.3	14	5,460	16	228/64	3,648	87,360	1,024
	.6	14	7,020	5	228/64	1,140	35,100	320
	.9	23	11,700	3	374/106	1,122	35,100	318
				49		11,610	157,560	3,262
	0	25	-	82	407/115	33,374	-	9,430
	.3	25	5,460	39	407/115	15,873	212,940	4,485
	.6	25	7,020	6	407/115	2,442	42,120	690
344.98	.9	34	11,700	25	554/156	13,850	292,500	3,900
	1.2	55	22,150	16	895/253	14,320	354,400	4,048
	1.5	73	25,100	5	1189/336	5,945	125,500	1,680
	1.8	81	27,300	3	1318/373	3,954	81,900	1,119
				176		89,758	1,109,360	25,352
	0	28	-	41	456/129	18,696	-	5,289
	.3	28	5,460	43	456/129	19,608	234,780	5,547
	.6	28	7,020	83	456/129	37,848	582,660	10,707
	.9	37	11,700	82	602/170	49,364	959,400	13,940
	1.2	59	22,150	39	961/271	37,379	863,850	10,569
345.95	1.5	75	25,100	6	1221/345	7,326	150,600	2,070
	1.8	84	27,300	25	1367/386	34,175	682,500	9,650
	2.1	88	30,730	16	1432/405	22,912	491,680	6,480
	2.4	88	31,500	5	1432/405	7,160	157,500	2,025
	2.7	88	32,300	3	1432/405	4,296	96,900	1,215
				343		238,864	4,219,870	67,492
	0	32	-	-	-	-	-	-
	.3	32	5,460	95	521/147	49,495	518,700	13,965
	.6	32	7,020	81	521/147	42,201	568,620	11,907
	.9	42	11,700	41	683/193	28,003	479,700	7,913
	1.2	64	22,150	43	1042/294	44,805	952,450	12,642
346.83	1.5	80	25,100	83	1303/368	108,149	2,083,300	30,544
	1.8	87	27,300	82	1416/400	116,112	2,238,600	32,800
	2.1	92	30,730	39	1498/423	58,422	1,198,470	16,497
	2.4	92	31,500	6	1498/423	8,988	189,000	2,538
	2.7	92	32,300	25	1498/423	37,450	807,500	10,575
	3.0	92	32,600	16	1498/423	23,968	521,600	6,768
	+3.0	92	48,830	8	1498/423	11,984	390,640	3,384
				519		529,577	9,948,580	149,533

* Monthly rental value - $488.

APPENDIX 7A2

KAMLOOPS - T1 — Houses

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per House $	No. of Houses	Loss of use per House * / Extra Food Cost	Total Loss of Use $	Damage to Houses $	Extra food Costs $
	0	14	-	81	207/64	16,770	-	5,180
344.12	.3	14	5,300	17	207/64	3,520	90,100	1,090
	.6	33	8,270	5	490/152	2,450	41,350	760
				103		22,740	131,450	7,030
	0	25	-	110	370/115	40,700	-	12,650
	.3	25	5,300	132	370/115	48,840	699,600	15,180
344.98	.6	43	8,270	81	636/198	51,520	669,870	16,040
	.9	43	12,170	17	636/198	10,810	206,890	3,370
	1.2	66	20,440	5	978/304	4,890	102,200	1,520
				345		156,760	1,678,560	48,760
	0	28	-	51	415/129	21,170	-	6,580
	.3	28	5,300	123	415/129	51,040	651,900	15,870
	.6	46	8,270	220	682/212	150,040	1,819,400	46,640
345.95	.9	46	12,170	110	682/212	75,020	1,338,700	23,320
	1.2	69	20,440	132	1023/317	135,040	2,698,080	41,840
	1.5	69	23,240	81	1023/317	82,860	1,882,440	25,680
	1.8	84	25,120	17	1245/386	21,160	427,040	6,560
	2.1	84	27,920	5	1245/386	6,220	139,600	1,930
				639		407,550	8,957,160	168,420
	0	32	-	-	-	-	-	-
	.3	32	5,300	10	741/147	7,410	53,000	1,470
	.6	50	8,270	35	741/230	25,940	289,450	8,050
	.9	50	12,170	51	741/230	37,790	620,670	11,730
	1.2	72	20,440	94	1067/331	100,300	1,921,360	31,114
	1.5	72	23,240	123	1067/331	131,240	2,858,520	40,713
346.83	1.8	88	25,120	220	1304/405	286,880	5,526,400	89,100
	2.1	88	27,920	110	1304/405	143,440	3,071,200	44,550
	2.4	92	28,550	132	1365/423	180,180	3,768,600	55,836
	2.7	92	29,330	81	1363/423	110,400	2,375,730	34,263
	3.0	92	29,640	17	1363/423	23,170	503,880	7,191
	+3.0	92	44,460	5	1363/423	6,820	222,300	2,115
				784		1,053,570	21,211,110	326,132

* Monthly rental value - $445.

APPENDIX 7B

KAMLOOPS - T1 — Mobile Homes

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per Home $	No. of Homes	Loss of use per Home * / Extra Food Cost	Total Loss of Use $	Damage to Homes $	Extra food Costs $
	0	14	-	18	107/64	1,930	-	1,150
344.12	.3	14	0	22	107/64	2,350	-	1,410
	.6	14	1,150	13	107/64	1,390	14,950	830
				53		5,670	14,950	3,390
	0	25	-	49	192/115	9,410	-	5,640
	.3	25	0	9	192/115	1,730	-	1,040
344.98	.6	25	1,150	18	192/115	3,460	20,700	2,070
	.9	70	10,350	22	537/322	11,810	227,700	7,080
	1.2	70	14,950	13	537/322	6,980	194,350	4,190
				111		33,390	442,750	20,020
	0	28	-	-	215/129	-	-	-
	.3	28	0	26	215/129	5,590	-	3,350
	.6	28	1,150	47	560/336	10,100	54,050	6,060
345.95	.9	73	10,350	49	560/336	27,440	507,150	16,460
	1.2	73	14,950	9	560/336	5,040	134,550	3,020
	1.5	88	17,940	18	675/405	12,150	322,920	7,290
	1.8	88	19,550	22	675/405	14,850	430,100	8,910
	2.1	88	20,120	13	675/405	8,780	261,150	5,260
				184		83,950	1,710,330	50,350
	0	32	-	-	-	-	-	-
	.3	32	0	-	-	-	-	-
346.83	.6	32	1,150	-	-	-	-	-
	.9	77	10,350	-	-	-	-	-
	1.2	77	14,950	-	-	-	-	-
	1.5	92	17,940	26	705/423	18,330	466,440	11,000
	1.8	92	19,550	47	705/423	33,140	918,850	19,880
	2.1	92	20,120	49	705/423	34,540	985,880	20,730
	2.4	92	20,700	9	705/423	6,340	186,300	3,810
	2.7	92	21,280	18	705/423	12,690	383,040	7,610
	3.0	92	23,000	22	705/423	15,510	506,000	9,310
	+3.0	92	23,000	13	705/423	9,160	299,000	5,500
				184		129,710	3,745,510	77,840

* Monthly rental value - $230.

APPENDIX 7C1

KAMLOOPS - T1 — Apartments

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per Apt. $	No. of Apt. Units	Loss of use per Apt. * / Extra Food Cost	Total Loss of Use $	Damage to Apts. $	Extra food Costs $
344.98	-	-	-	-	-	-	-	-
	0	28	2,800	3 (6)**	175/129	530	8,400	390
345.95	.3	73	11,700	-	-	-	-	-
	.6	73	13,600	14	455/336	6,370	190,400	4,700
				(28)	175/(129)	4,900		3,610
				17 (34)		11,800	198,800	8,700
	0	32	-	-	-	-	-	-
	.3	77	0	-	-	-	-	-
	.6	77	13,600	36	480/354	17,280	489,600	12,740
				(72)	200/(147)	14,400		10,580
	.9	92	15,000	3	573/423	1,720	45,000	1,270
				(6)	200/(147)	1,200		880
346.83	1.2	92	16,500	-	-	-	-	-
	1.5	92	16,800	14	573/423	8,020	235,200	5,920
				(28)	200/(147)	5,600		4,120
				53 (106)		48,220	769,800	35,510

*Monthly rental value $187.
**( ) shows other apartment units evacuated.

APPENDIX 7C2

KAMLOOPS - T1 — Apartments

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per Apt. $	No. of Apts. Units	Loss of use per Apts.* / Extra Food Cost	Total Loss of Use $	Damage to Apts. $	Extra food Costs $
	0	25	2,800	10	156/115	1,560	28,000	1,150
				(10)**		1,560		1,150
344.98	.3	-	-	-	-	-	-	-
				10				
				(10)		3,120	28,000	2,300
	0	28	2,800	36	175/129	6,300	100,800	4,640
				(72)		12,600		9,290
	.3	73	11,700	42	455/336	19,110	491,400	14,110
				(42)	(175)/(129)	7,350		5,420
345.95	.6	73	13,600	12	455/336	5,460	163,200	4,030
				(24)	(175)/(129)	4,200		3,100
	.9	88	15,000	10	549/405	5,490	150,000	4,050
				(10)	(175)/(129)	1,750		1,290
				100				
				(148)		62,260	905,400	45,930
	0	32	2,800	8	200/147	1,600	22,400	1,180
				(8)		1,600		1,180
	.3	77	11,700	12	480/354	5,760	140,400	4,250
				(12)	(200)/(147)	2,400		1,760
	.6	77	13,600	-	-	-	-	-
	.9	92	15,000	26	573/423	14,900	390,000	11,000
				(56)	(200)/(147)	11,200		8,230
	1.2	92	16,500	36	573/423	20,630	594,000	15,230
				(72)	(200)/(147)	14,400		10,580
346.83	1.5	92	16,800	42	573/423	24,070	705,600	17,770
				(42)	(200)/(147)	8,400		6,170
	1.8	92	17,300	12	573/423	6,880	207,600	5,080
				(24)	(200)/(147)	4,800		3,530
	2.1	92	17,500	10	573/423	5,730	175,000	4,230
				(10)	(200)/(147)	2,000		1,470
				146				
				(224)		124,370	2,235,000	91,660

*Monthly rental value $187.
**( ) shows other apartment units evacuated.

APPENDIX 7D1

KAMLOOPS - T1 — Condominiums

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per Cond. $	No. of Conds.	Loss of use per Cond.* / Extra Food Cost	Total Loss of Use $	Damage to Condominiums $	Extra food Costs $
345.95	0	28	2,800	24	359/129	8,620	67,200	3,100
				24		8,620	67,200	3,100
	0	32	2,800	-	-	-	-	-
346.83	.3	77	13,570	-	-	-	-	-
	.6	77	16,220	34	984/354	33,460	551,480	12,040
	.9	92	18,100	24	1176/423	28,220	434,400	10,150
				58		61,680	985,880	22,190

*Monthly rental value - $384.

APPENDIX 7D2

KAMLOOPS - T1

Condominiums

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - 1982 DOLLARS

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evacuation period (DAYS)	Damage per Cond. $	No. of Conds.	Loss of use per Cond.* / Extra Food Cost	Total Loss of Use $	Damage to Condominiums $	Extra food Costs $
344.98	0	25	2,800	48	320/115	15,360	134,400	5,520
	.3	-	-	-	-	-	-	-
				48		15,360	134,400	5,520
	0	28	-	-	-	-	-	-
	.3	-	-	-	-	-	-	-
345.95	.6	-	-	-	-	-	-	-
	.9	88	18,100	48	1126/405	54,050	868,800	19,440
				48		54,050	868,800	19,440
	0	32	2,800	40	409/147	16,360	112,000	5,880
	.3	-	-	-	-	-	-	-
	.6	77	16,220	10	984/354	9,840	162,200	3,540
346.83	.9	-	-	-	-	-	-	-
	1.2	-	-	-	-	-	-	-
	1.5	-	-	-	-	-	-	-
	1.8	92	22,000	48	1176/423	56,450	1,056,000	20,300
				98		82,650	1,330,200	29,720

*Monthly rental value - $384.

APPENDIX 8A

Categories for Which Average Stage-Damage Relationships Were Determined*

1. Petroleum Services - service stations, bulk oil plant.
2. Financial Services - banks, trust companies, finance companies.
3. Grocery Retail - supermarkets, medium-sized grocery store, corner store, grocery wholesale, confectionery and liquor stores.
4. Hardware Stores -
5. General Stores - dry goods, feedstuffs (eg. Buckerfields), and variety stores.
6. Retail Stores - essentially large retail establishments.
7. Furniture and Furnishings - furniture, appliances, carpets, draperies; also includes paints, television.
8. Small Retail Trade - jewellers, stationery, music stores, photographic, florist, needlework, sporting goods, book shops, fabric, bicycle and mower stores, etc.
9. Retail Apparel - men's wear, ladies' wear and footwear.
10. Mechanical Retail - machine shop, (i.e. wreckers, parts, body shop, retail - air-cooled engines).
11. Building Supplies - lumber yard (when associated with "do-it-yourself" type stores), sash and door, glass - often included mirrors.
12. Contractor Services (small) - electrical, plumbing, upholstery.
13. Personal Services - beauty salon, barbers, laundromat, dry cleaners, and funeral homes.
14. Recreation Services - theatres, billiard halls, bowling alleys, ice rinks, bars, etc.
15. Hotel-Motel Services - hotels, motels, autocourts.
16. Transportation and Communication Services - printing, newspaper, publishers, trucking and freight services.
17. Profesional Services - doctors, dental surgeons, lawyers and solicitors, veterinarians, optometrists and realtors.
18. Institutional Aspects - courthouse post office, hospital.

19 Food Services - restaurant, drive-in, coffee shops, cafes, delecatessens, specialty foods, butchers, bakers, and similar.

20. Drug Stores - all types and sizes ranging from the very large to quite small.

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* From report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, December 1975, pp. 50-51.

APPENDIX 8B

AVERAGE DOLLAR DAMAGE PER SQUARE METER OF COMMERCIAL BUILDING AREA AT .3 METER FLOOD DEPTH INTERVALS*

Category of Establishment:	Cumulative Damage ($) Various Levels of Flooding ($1971) meters									
	.3	.6	.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
1. Petroleum Services	28.0	37.7	45.2	53.8	54.9	54.9	54.9	54.9	54.9	54.9
2. Financial Services	24.7	34.4	57.0	62.4	63.5	63.5	63.5	63.5	63.5	63.5
3. Grocery Retail	24.7	60.3	80.7	91.5	99.0	105.5	108.7	108.7	108.7	108.7
4. Hardware	20.4	33.4	56.0	68.9	81.8	93.6	106.6	110.9	110.9	110.9
5. General	23.7	48.4	63.5	75.3	87.2	99.0	107.6	108.7	108.7	109.8
6. Retail Stores	53.8	109.8	139.9	198.3	208.8	227.1	241.1	248.6	248.6	248.6
7. Furniture & Furnishings	121.6	153.9	201.3	220.6	232.5	243.3	249.7	250.8	251.9	252.9
8. Small Retail Trade	42.0	70.0	102.2	155.0	186.2	215.3	227.1	231.4	231.4	231.4
9. Retail Apparel	99.0	227.1	260.5	336.9	357.4	374.6	389.6	402.6	402.6	402.6
10. Mechanical Retail	22.6	33.4	50.6	71.0	86.1	96.9	108.7	108.7	108.7	108.7
11. Building Supplies	47.4	51.7	57.0	61.3	66.7	72.1	77.5	78.6	78.6	78.6
12. Contractor Services	21.5	29.1	37.7	48.4	61.3	67.8	71.0	74.3	76.4	76.4
13. Personal Services	35.5	71.0	104.4	115.2	121.6	122.7	122.7	122.7	122.7	122.7
14. Recreation Services	14.0	19.4	36.6	38.7	39.8	39.8	40.9	40.9	40.9	40.9
15. Hotel-Motel Services	24.7	30.1	37.7	46.3	48.4	49.5	49.5	49.5	49.5	49.5
16. Trans;. & Communic. Services	36.6	59.2	81.8	103.3	123.8	143.2	143.2	143.2	143.2	143.2
17. Professional Services	28.0	40.9	52.7	63.5	65.6	67.8	68.9	68.9	68.9	68.9
18. Institutional Services	19.4	61.3	82.9	84.0	84.0	84.0	84.0	84.0	84.0	84.0
19. Food Services	18.3	39.8	75.3	103.3	113.0	113.0	123.8	123.8	123.8	123.8
20. Drug Stores	14.0	42.0	74.3	107.6	152.8	160.4	167.0	167.9	167.9	167.9

* From report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, December 1975, p. 54.

APPENDIX 9

Road Damages - Kamloops ($1982)

Less than 7 day flood; $ 3,840 damage per Kilometer
More than 7 day flood; $17,330 damage per Kilometer

	Elevation												
	344.12			344.98			345.95			346.83			
Flood Stage	Flood (Km)	Flood Duration (Days)	($) Damage	Flood (Km)	Flood Duration (Days)	($) Damage	Flood (Km)	Flood Duration (Days)	($) Damage	Flood (Km)	Flood Duration (Days)	($) Damage	TOTAL DAMAGES
AREA NT1													
344.12	.8	15	13,860										13,860
344.98	.8	20	13,860	2.4	10	41,590							55,450
345.95	.8	22	13,860	2.4	16	41,590	5.2	5	19,970				75,420
346.83	.8	26	13,860	2.4	20	41,590	5.2	11	90,120	6.9	4	26,500	172,070
AREA T1													
344.12	.9	15	15,600										15,600
344.98	.9	20	15,600	3.7	10	64,120							79,720
345.95	.9	22	15,600	3.7	16	64,120	7.2	5	27,650				107,370
346.83	.9	26	15,600	3.7	20	64,120	7.2	11	124,780	3.8	4	14,590	219,090
AREA T2													
344.12													
344.98				.4	20	6,930							6,930
345.95				.4	22	6,930	5.1	5	19,580				26,510
346.83				.4	26	6,930	5.1	11	88,380	.5	4	1,920	97,230

APPENDIX 10

Damage to Schools

Name of School	Type	No of Rooms	Level Above Ground (M)	Dept of Flooding Flood Stage 345.95	Dept of Flooding Flood Stage 346.83	Market Value Per Classroom*	Damage (1982) Flood Stage 345.95	Damage (1982) Flood Stage 346.83
AREA NT1								
1. Arthur Hatton	Elementary	18	.3	-	-	-	-	-
2. Overlander	Elementary	7	.3	.3	1.2	91,000	114,660	318,500
AREA T1								
1. Happyvale	Elementary	7	0	.3	1.2	91,000	114,660	318,500

* Information from report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, December 1975; page 97. The 1982 values were obtained by multiplying the 1971 value by 2.46, the B.C. Asessment Authority, Commercial and Industrial Structures (Frame) price index.

Flood Damage as a Percentage of Assessed Value of Schools

Floor Depth Above Floor (M)	Per cent of Market Value Damaged
.3	18
.6	37
.9	44
1.2	50
1.5	58

APPENDIX 11

Damage to Sewage System and Water Supply System and Cost of Clean-up

Area	Damage Category	Damage Per Ha	FLOOD STAGE 344.12 Ha	344.12 Damages	344.98 Ha	344.98 Damages	345.95 Ha	345.95 Damages	346.83 Ha	346.83 Damages
NT1	1) Sewage System	$ 77	7	$ 539	24	$ 1,848	45	$ 3,465	70	$ 5,390
	2) Water Supply	77	7	539	24	1,848	45	3,465	70	5,390
	3) Clean-up	487	7	3,409	24	11,688	45	21,915	70	34,090
T1	1) Sewage System	$ 77	22	$ 1,694	67	$ 5,159	135	$10,395	150	$11,550
	2) Water Supply	77	22	$ 1,694	67	$ 5,159	135	$10,395	150	$11,550
	3) Clean-up	487	22	$10,714	67	$32,629	135	$65,745	150	$73,050
T2	1) Sewage System	$ 77	-	-	35	$ 2,695	140	$10,780	175	$13,475
	2) Water Supply	77	-	-	35	$ 2,695	140	$10,780	175	$13,475
	3) Clean-up	487	-	-	35	$17,045	140	$68,180	175	$85,225

APPENDIX 12

Damage to Gas Distribution - $1982

damages per unit = $110

AREA		FLOOD STAGE 344.12 Units	344.12 Damages	344.98 Units	344.98 Damages	345.95 Units	345.95 Damages	346.83 Units	346.83 Damages
NT1									
	Houses	24	$2,640	94	$10,340	302	$33,220	519	$57,090
	Condominiums	-	-	-	-	-	-	58	6,380
	TOTAL		2,640		10,340		33,220		63,470
T1									
	Houses	22	$2,420	235	$25,850	588	$64,680	784	$86,240
	Condominiums	-	-	-	-	48	5,280	58	6,380
	Mobile Homes	35	3,850	62	6,820	184	20,240	184	20,240
	TOTAL		6,270		32,670		90,200		112,860

APPENDIX 13

Damage to Outbuildings - Kamloops $1982

Damage per outbuilding is $108.

	Flood Stage							
	344.12		344.98		345.95		346.83	
Area	No.	Damage	No.	Damage	No.	Damage	No.	Damage
NT1	4	$432	17	$1,836	50	$ 5,400	64	$ 6,912
T1	7	756	32	3,456	117	12,636	132	14,256

APPENDIX 14

Cost of Evacuating People - Kamloops $1982

Area	Flood Stage 344.12 House holds*	People*	($) Damage**	344.98 House-holds*	People*	($) Damage**	345.95 House-holds*	People*	($) Damage**	346.83 House-holds*	People*	($) Damage**
NT1	24	86	370	176	634	2,726	418	1,505	6,472	736	2,650	11,395
T1	75	270	1,161	524	1,886	8,110	1,119	4,028	17,320	1,436	5,170	22,231

* Housholds include houses, apartments, condomimiums and mobile houses.

*

* Persons per family in Kamloops is 3.6.

*

** Cost of evacuating each person is $4.30.

APPENDIX 15

Parks and Recreation Land

Area	Damage Per Ha.	Flood Stage 344.12 No.	344.12 Damage	344.98 No.	344.98 Damage	345.95 No.	345.95 Damage	346.83 No.	346.83 Damage
NT1	$900	-	-	2.4	$2,160	3.5	$ 2,880	4.4	$ 3,960
T1	$900	-	-	1.2	1,080	53.8	48,420	54.2	48,780
T1	$900	-	-	-	-	-	-	-	-

APPENDIX 16

Price Indexes Used in the Study

	Source of Index	Damage Category	Price Change 1971-82 (1971 = 100)
1)	Residences, Frame Structure	Residential	
	B.C. Assessment Authority Appraisal Systems Division Composite Cost Indices.	Structural	280[1]
2)	Consumer Price Index for Canada, Main Components, Sub-groups and Selected Items, Furniture, Major Household Appliances.	Residential Content Furniture	202[2,3]
	Statistics Canada Consumer Prices and Price Indexes, Cat. No. 62-010, Table 8.	Appliances	173[2,3]
3)	Consumer Price Indexes for Regional Cities, Vancouver, Food, Food away from home.	Extra Food Costs	301[2,3]
	Statistics Canada Consumer Prices and Price Indexes, Cat. No. 62-010, Table 9.		
4)	Commercial and Industrial Structures (Frame)	Commercial (structural)	246[1]
	B.C. Assessment Authority, Appraisal	Industrial (structural)	246[1]
	Systems Division, Composite Cost Indices.	Schools	246[1]
5)	Farm Building Repairs - B.C.	Out-Buildings	270[3,4]
	Statistics Canada, Farm Input Price Index, Cat. No. 62-004, Table 3.		
6)	Highway Construction Price Index, B.C. Total.	Roads	310[5]
	Statistics Canada, Construction Price Statistics, Cat. No. 62-007, Table 17.		
7)	Employment Earnings and Hours by Industry for Provinces and Regions, British Columbia, Average Weekly Earnings all Employees (Construction S.I.C. 400-421), Vancouver.	Sewage Systems	174[2,3,6]
		Water Supply Systems	174[2,3,6]
	Statistics Canada, Employemnt Earnings and Hours, Catalogue No. 72-002.	Gas Distribution	367[2,3]

APPENDIX 16 (Cont'd)

Price Indexes Used in the Study

Source of Index	Damage Category	Price Change 1971-82 (1971 = 100)
	Debris Removal & Clean Up Costs	246[2,3,7]
8) Consumer Price Indexes for Regional Cities Vancouver, Transportation. Statistics Canada Consumer Prices and Price Indexes, Cat. No. 62-010, Table 9.	Evacuating People	286[2,3]
9) Consumer Price Index for Regional Cities All Items, Vancouver. Statistics Canada Consumer Prices and Price Indexes, Cat. No. 62-010, Table 9.	Consumer Price Index	263[2,3]
10) Employment Earnings and Hours of Industry for Urban areas, Average Weekly Earnings, Industrial Composite for Urban Areas, Kamloops. (page 98)	Primary Income	292[2,3]
Statistics Canada, Employemnt Earnings and Hours, Catalogue No. 72-002.	Parks and Recreation land	252[2,3,8]

1. The price index for 1982 is based on the past four year average (1978-81).
2. The price index for June 1981 is assumed to represent the average for 1981.
3. The price index for 1982 is based on the past three year average (1979-81).
4. The price index for the 2nd quarter is assumed to represent the average for 1981.
5. The price index for 1981 and 1982 are based on the past two year average (1978-79).
6. Price index is for period 1978-82 only.
7. Price index is for period 1975-82 only.
8. Price index is for period 1972-82 only.

APPENDIX 17

Project Costs for Kamloops Dykes $1982*

Dyke Area		Rate of Real Appreciation 0%	1%	3%
		$(000)	$(000)	$(000)
(1) NT1				
(a)	Cost of New Dyke (Capital Cost)	4,054	4,054	4,054
(b)	Maintenance Cost of New Dyke	340	391	531
(c)	Cost of Right-of-way	-	-	-
	Total Project Cost	4,394	4,445	4,585
(2) T1				
(a)	Cost of New Dyke (Capital Cost)	4,255	4,255	4,255
(b)	Maintenance Cost of New Dyke	358	411	558
(c)	Cost of Right-of-way	3,170	3,170	3,170
	Total Project Cost	7,783	7,836	7,983
(3) T2				
(a)	Cost of New Dyke (Capital Cost)	1,692	1,692	1,692
(b)	Maintenance Cost of New Dyke	143	164	223
(c)	Cost of Right-of-way	-	-	-
	Total Project Cost	1,835	1,856	1,915
(2) NT1 + T1				
(a)	Cost of New Dyke (Capital Cost)	8,119	8,119	8,119
(b)	Maintenance Cost of New Dyke	682	783	1,064
(c)	Cost of Right-of-way	3,170	3,170	3,170
	Total Project Cost	11,971	12,072	12,353

* Using 7% discount rate and 35 year project life.

APPENDIX 18

Average Annual Damages

Dyke Confidence	Average Annual Damages NT1	T1	T2	NT1+T1
a) Design Level	$210,949	$562,348	$88,524	$773,297
b) One Foot Below Design Level	201,505	537,018	83,995	738,523
b) Two Feet Below Design Level	190,554	507,302	78,284	697,856

APPENDIX 19

Present Value of Flood Benefits ($1982) Under Different Assumption of Future Growth and Real Price Change (1972 - 2017)*

Area		Total Available Benefits ($1,000) Discount Rate 6%	7%	8%	10%
NT1					
(1)	Most likely Growth and Price Change	3,300	2,922	2,610	2,129
(2)	Zero Growth and Price Change	2,922	2,610	2,349	1,943
(3)	Growth 1% Higher than Most Likely	3,761	3,300	2,922	2,349
T1					
(1)	Most likely Growth and Price Change	8,793	7,787	6,954	5,675
(2)	Zero Growth and Price Change	7,787	6,954	6,259	5,179
(3)	Growth 1% Higher than Most Likely	10,023	8,793	7,787	6,259
T2					
(1)	Most likely Growth and Price Change	1,375	1,218	1,088	888
(2)	Zero Growth and Price Change	1,218	1,088	979	810
(3)	Growth 1% Higher than Most Likely	1,568	1,375	1,218	979
NT1 + T1					
(1)	Most likely Growth and Price Change	12,093	10,709	9,564	7,804
(2)	Zero Growth and Price Change	10,709	9,564	8,608	7,122
(3)	Growth 1% Higher than Most Likely	13,785	12,093	10,709	8,608

* Confidence level of new dyke is 1 foot below design level.

APPENDIX 20

Present Value of Flood Benefits ($1982) Under Different Levels of Dyke Confidence*

Dyke Confidence	Present Value of Benefits ($1,000) NT1	T1	T2	NT1+T1
a) Design Level	$3,059	$8,154	$1,284	$11,213
b) One Foot Below Design Level	2,922	7,787	1,218	10,709
b) Two Feet Below Design Level	2,763	7,356	1,135	10,119

* Using 7% discount rate and 35 year project life.
Most likely growth rate and price change.

APPENDIX 21A

Sensitivity Analysis of Benefit-Cost Ratios Under Various Growth Projections Discount Rates and Dyke Costs

A. DYKE AREA NT1

Confidence level of new dyke is 1 foot below design level.

Projection	Cost of New Dyke $4,394,000* Discount Rate				Cost of New Dyke $4,445,000** Discount Rate				Cost of New Dyke $4,585,000*** Discount Rate			
	6%	7%	8%	10%	6%	7%	8%	10%	6%	7%	8%	10%
(1) Most Likely Growth	.75	.67	.59	.48	.74	.66	.59	.48	.72	.64	.57	.46
(2) Zero Growth and Price Change	.67	.59	.53	.44	.66	.59	.53	.44	.64	.57	.51	.42
(3) Growth 1% Higher Than Most Likely	.86	.75	.67	.53	.85	.74	.66	.53	.82	.72	.64	.51

* Real Appreciation of dyke maintenance costs is 0% per year.
** Real Appreciation of dyke maintenance costs is 1% per year.
*** Real Appreciation of dyke maintenance costs is 3% per year.

APPENDIX 21B

Sensitivity Analysis of Benefit-Cost Ratios Under Various Growth Projections Discount Rates and Dyke Costs

A. DYKE AREA T1

Confidence level of new dyke is 1 foot below design level.

Projection	Cost of New Dyke $7,783,000* Discount Rate				Cost of New Dyke $7,836,000** Discount Rate				Cost of New Dyke $7,983,000*** Discount Rate			
	6%	7%	8%	10%	6%	7%	8%	10%	6%	7%	8%	10%
(1) Most Likely Growth	1.13	1.00	.89	.73	1.12	.99	.89	.72	1.10	.98	.87	.71
(2) Zero Growth and Price Change	1.00	.89	.80	.67	.99	.89	.80	.66	.98	.87	.78	.65
(3) Growth 1% Higher Than Most Likely	1.29	1.13	1.00	.80	1.28	1.12	.99	.80	1.26	1.10	.98	.78

* Real Appreciation of dyke maintenance costs is 0% per year.
** Real Appreciation of dyke maintenance costs is 1% per year.
*** Real Appreciation of dyke maintenance costs is 3% per year.

APPENDIX 21C

Sensitivity Analysis of Benefit-Cost Ratios Under Various Growth Projections Discount Rates and Dyke Costs

A. DYKE AREA T2

Confidence level of new dyke is 1 foot below design level.

Projection	Cost of New Dyke $1,835,000* Discount Rate				Cost of New Dyke $1,856,000** Discount Rate				Cost of New Dyke $1,915,000*** Discount Rate			
	6%	7%	8%	10%	6%	7%	8%	10%	6%	7%	8%	10%
(1) Most Likely Growth	.75	.66	.59	.48	.74	.66	.59	.48	.72	.64	.57	.46
(2) Zero Growth and Price Change	.66	.59	.53	.44	.66	.59	.53	.44	.64	.57	.51	.42
(3) Growth 1% Higher Than Most Likely	.85	.75	.66	.53	.84	.74	.66	.53	.82	.72	.64	.51

* Real Appreciation of dyke maintenance costs is 0% per year.
** Real Appreciation of dyke maintenance costs is 1% per year.
*** Real Appreciation of dyke maintenance costs is 3% per year.

APPENDIX 21D

Sensitivity Analysis of Benefit-Cost Ratios Under Various Growth Projections Discount Rates and Dyke Costs

A. DYKE AREA NT1 + T1

Confidence level of new dyke is 1 foot below design level.

Projection	Cost of New Dyke $11,971,000* Discount Rate 6%	7%	8%	10%	Cost of New Dyke $12,072,000** Discount Rate 6%	7%	8%	10%	Cost of New Dyke $12,353,000*** Discount Rate 6%	7%	8%	10%
(1) Most Likely Growth	1.01	.89	.80	.65	1.00	.89	.79	.65	.98	.87	.77	.63
(2) Zero Growth and Price Change	.89	.80	.72	.59	.89	.79	.71	.59	.87	.77	.70	.58
(3) Growth 1% Higher Than Most Likely	1.15	1.01	.89	.72	1.14	1.00	.89	.71	1.12	.98	.87	.70

* Real Appreciation of dyke maintenance costs is 0% per year.
** Real Appreciation of dyke maintenance costs is 1% per year.
*** Real Appreciation of dyke maintenance costs is 3% per year.

APPENDIX 22

Sensitivity Analysis of Benefits-Cost Ratios
Under Different Levels of Dyke Confidence*

Dyke Confidence	Benefit Cost Ratios NT1	T1	T2	NT1+T1
a) Design Level	.69	1.04	.69	.93
b) One Foot Below Design Level	.66	.99	.66	.89
b) Two Feet Below Design Level	.62	.94	.61	.84

* Benefits using most likely growth and price change.
Maintenance costs of dykes are assumed to appreciate at 1% per year.
Using 7% discount rate and 35 year project lift.