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ECONOMIC ANALYSIS OF FLOOD CONTROL MEASURES ON THE VEDDER RIVER

R. Princic

September 1977

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

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SUMMARY

A. OBJECTIVE

The objective of this study is to assess the economic feasibility of providing set-back dykes along the Vedder River to protect Sumas Prairie and southwest Chilliwhack from flooding.

B. PROPOSED SOLUTION TO PROBLEM

The proposed solution to the problem calls for the construction of set-back dykes, able to withstand 200 year return winter floods, and periodic dredging of the Vedder River channel.

C. BASIC ASSUMPTIONS

Economic life of dyke is 35 years.
Discount rate is 7%.
Real dyke construction costs are appreciating at 2% per year.

D. RESULTS OF STUDY

Table 1 provides a summary of the results. For a more detailed analysis of benefits and costs see pages 34 - 38 in the report.

TABLE 1

Benefits, Costs, Benefit-Cost Ratios and Net Benefits - Vedder River*

	Benefits New Dykes	Project Costs	B/C Ratio	Net P.V. of Benefits
	$000	$000		$000
(1) Present Dykes Maintained	5,120.4	2,672.0	1.92	2,448.4
(2) Present Dykes not Maintained	5,844.7	2,493.0	2.34	3,351.7
(3) Present Dykes Removed	6,256.1	2,493.0	2.51	3,763.1

* Rate of discount 7% and project life 35 years. Most likely growth and price change (see text page 30).

E. CONCLUSION

Based on the results of this study it can be concluded that the construction of set-back dykes is justified.

RÉSUMÉ

A. BUT

Le but de cette étude est d'évaluer la possibilité économique de construire des endiguements en retrait le long de la rivière Vedder afin de protéger Sumas Prairie et le sud-ouest de Chilliwhack contre les inondations.

B. Solution Proposee

La solution proposée veut que l'on construise des endiguements en retrait qui pourraient résister à la pression des crues d'hiver de 1/200 ans et au dragage périodique effectué dans le canal de la rivière Vedder.

C. Prévisions Principales

La vie économique d'un endiguement est de 35 ans.
Le taux d'escompte est de 7%.
Le coût réel de la construction de digues augmente de 2% par année.

D. Résultats de l'étude

Le tableau 1 contient un résumé des résultats. Pour l'analyse détaillée des coûts et des bénéfices, veuillez vous référer aux pages 34 à 38 du rapport.

Tableau 1

Bénéfices, coûts, rapports bénéfice-coût et bénéfices nets - Rivière Vedder*

	Bénéfices-Nouveaux endiguements	Coûts du projet	Rapport B/C	Valeur nette présente des bénéfices
	$000	$000		$000
(1) Endiguements présente entretenus	5,120.4	2,672.0	1.92	2,448.4

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(2) Endiguements présents non entretenus	5,844.7	2,493.0	2.34	3,351.7
(3) Endiguements présents supprimés	6,256.1	2,493.0	2.51	3,763.1

*Taux d'escompte de 7% et vie du projet de 35 ans.
Ces chiffres comprennent le taux de croissance probable des coûts et des bénéfices.

E. Conclusion

Selon les résultats de cette étude, on peut conclure que la construction d'endiguements en retrait est justifiée.

A. INTRODUCTION

The Vedder River is a short fast flowing tributary of the Fraser River located about five miles south and west of Chilliwack City. The river leaves a steep mountain valley and enters the floodplain of the Fraser River about ten miles upstream from its junction with the Fraser River. The problems associated with the river occur at this point. Material transported by the river from its upper reaches by heavy flows is deposited on its alluvial fan because of reduced velocity. This aggradation has resulted in several changes in the rivers course throughout its history. The last such course change occurred in 1894 when the river shifted direction from a flow almost due north to one of west and then north-west.

Major flooding of the Vedder River has occurred on a number of separate occasions. The most recent and also the most serious occurred in December of 1975, when the river broke through the railway embankment on its south side and flooded parts of Yarrow and Sumas Prairie. In 1951 a flood almost identical in magnitude to the 1975 flood caused much less damage. High water levels also occurred in 1932 when the river is reported to have washed away some 1000 yards of railway track and 1948 and 1967 when no damages were reported.

Winter flooding by the Vedder River could cause severe damages to the surrounding area. A flood with a return period of 200 years could result in flooding of about 12,500 acres of agricultural land in Sumas-Yarrow and about 8,500 acres in Chilliwhack South. This would result in significant damage to future crop production and severe losses in other agricultural activities such as dairying, poultry and other animal production. A flood of this same magnitude would damage approximately 1690 houses and force the evacuation of over 6,000 people. It would also cause damage to commercial and industrial establishments in the area.

The Vedder River is also subject to a summer peak discharge. However, a 600 year return summer flood is only comparable in magnitude to a 10 year return winter flood (see Appendix 3). Therefore, damages associated with summer floods are significantly lower.

B. OBJECTIVE

The objective of this study is to assess the economic feasibility of providing set-back dykes to protect Sumas Prairie and southwest Chilliwhack against flooding from the Vedder River.

C. PROPOSED SOLUTION TO PROBLEM

This study examines a solution to the flooding problem which includes the construction of set-back dykes and the periodic removal of gravel to maintain channel capacity.

The set-back dykes are to be constructed approximately 500' on either side of the existing shoreline (see Map 2) and are designed to withstand a 200 year return winter discharge. Constructing dykes this way will allow the river some freedom to migrate within a confined corridor. This should provide greater flexibility in the management of the river (allow the removal of gravel from less sensitive areas) and enhancement of the fisheries resource.

D. BASIC ASSUMPTIONS

1. The expected economic life of the project is 35 years.
2. The discount rate used in the report is 7%[1/]. Sensitivity analysis is provided using 6% and 8% discount rates.

E. PROJECT COSTS

Appendix 2 outlines the expected project costs as prepared by

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

the Projects Division of the Water Planning and Management Branch. It provides an estimate of the cost of constructing the set-back dykes, the annual maintenance costs which the dykes would require to keep them to full standard and the costs of dreding the river[2/].

F. FLOOD FREQUENCIES, DURATION AND EXTENT

Data on river flows, frequency, duration and extent of flooding were prepared by the Projects Division, Water Planning and Management Branch. The information was based on a preliminary report, "Vedder River Flood Potential Study" by K. A. Morton prepared December 1975. River flows established in the report were updated and modified using a Log-Pearson plot. A summary of the information used in this report is provided in Appendix 3.

G. FLOOD DAMAGE CRITERIA

1. Residential and Associated Damages

a. Residential and Content Damage

Damages per housing unit were prepared using the procedure presented in the report "Estimating Flood Damages in the Fraser River Basin".[3/] The basic steps taken in the preparation of the stage damage functions are as follows: (1) create three average house classes A, B and C, using the British Columbia Appraisal Manual, (2) prepare an exterior stage-damage function for each house class by (a) identifying the structural characteristics of each house class (b) calculating the average perimeter areas of floors and walls, heights of main floors above ground level and length of exterior walls and (c) establishing the percentage of various building materials making up each house class, (3) estimate the content damage

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2/ The cost of dredging is included here for information purposes only. Since an equal amount of dredging would be required regardless of whether the set-back dykes are constructed or not this cost is not included in the analysis.

3/ Book, A.N., Princic, R., "Estimating Flood Damages in the Fraser River Basin", Dec. 1975, pages 41-55.

of each house class (in this case interior furnishing were assumed to have a value of 40% of the market value of the building (excluding property))[4/], (4) estimate the content damage of basements of each house class (content of basements was assumed to have a value of 10% of the furnishings of each house), (5) prepare a stage damage curve for content damage for each house class by multiplying content damage times the potential percentage damage at various flood depths, (6) determine the stage damage function for each house class by combining interior structural and content damage with exterior damage functions, (7) create a single stage damage function by combining the stage damage functions of A, B and C class houses weighted according to the ratio of these houses in each area (see Appendix 4).

Since stage damage functions for this area were prepared in 1971 it was necessary only to update these to 1975 dollars.[5/] Estimates of the number of houses likely to suffer damages at each flood stage were obtained by using air photographs. This was followed up by a field survey to update the information to 1975. The number of houses affected at each flood stage and the associated dollar damage is provided in Appendix 5.

b. Loss of Use of Dwelling

Evacuation of houses as a result of flooding represents a direct loss to the occupant. Loss of use of dwelling in the report was estimated as outlined in the report, "Estimating Flood Damages in the Fraser River Basin".[6/]

In general, the procedure was to take the number of houses inundated at each river stage and multiply this by the total

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4/ The 40% figure for content value was used for calculating 1971 content damages. A rough estimate of the value of interior contents and market value of buildings of an average B class house in 1975 showed that this figure has not changed.

5/ Statistics Canada, Construction Price Statistics, Residential Building Construction Input Price Indexes, British Columbia Total, Catalogue No. 62-007, page 18.

6/ Op. Cit., Book, A.N., Princic, R., page 98-99.

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.

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

Calculation of the loss of use of dwellings for any area and flood stage is summarized as follows:

$U = h \times (f + d) \times r$

where U = Loss of Use of Dwellings

h = number of houses flooded

f = duration of flood

d = additional evacuation to allow for repairs etc.

r = monthly rental value of average house in the area

The monthly rental value of dwellings was taken to be 1% of the market value of an average home in that area. An estimate of the total loss of use of houses is provided in Appendices 5A - 5C.

c. Extra Food Costs

Persons that lose their normal place of residence were expected to incur some additional expense for food. This would occur because they would be buying food in smaller quantities than usual. The extra cost was assumed to be

one-third higher than what a person would normally spend.[7/]

The procedure used to calculate depth damage functions for extra food cost is similar to that used in calculating "Loss of Use of Dwelling" which is described much more fully 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 multiply this by the period of evacuation and finally this total by the estimated extra food cost per person per day. This is summarized as follows:

$V = h \times p \times (f + d) \times b$

where V = Extra Food Cost

h = number of houses flooded

p = average persons per household for that area

f = duration of flood

d = additional evacuation to allow for repairs etc.

b = extra food cost per person per day

The extra cost of food in 1971 was estimated to be $.38 per person per day. In 1975 this additional cost was $.62 per person per day some 60% higher than in 1971.[9/] An estimate of the extra food costs for each flood stage is provided in Appendices 5A - 5C.

2. Commercial Damages

Commercial damages were estimated using the techniques and the unit damage curves outlined in the report "Estimating Flood

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7/ Ibid, page 100.

8/ Ibid, pages 98-99.

9/ Statistics Canada, Prices and Prices Indexes, Consumer Price Indexes, Food, Regional Cities, Vancouver, Catalogue No. 62-002, page 57.

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. These 20 categories, then, had average dollar damage values calculated for each foot of flooding.[11/]

The basic steps involved in estimating commercial damages in this study were: (1) assign individual commercial establishments to their appropriate categories, (2) determine the elevation of each establishment by the use of topographic maps and air photographs, (3) determine the height of the main floor above ground level for each establishment by 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 flood stage is provided in Appendices 1A - 1F.

3. Industrial Damages

Industrial damages were estimated using the procedures and the unit-damage estimates outlined in the report "Estimating Flood Damages in the Fraser River Basin".[12/] The unit-damage curves were prepared from data obtained by a survey of all industries on the Lower Fraser Valley floodplain.[13/]

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

11/ Appendix 6A provides a list of the categories for which average stage damage relationships were determined. Appendix 6B shows the average square foot damage at intervals of one foot for each of the categories. These values were updated to 1975 dollars using the Non-Residential Construction Price Index found in the Statistics Canada publication Construction Price Statistics, Catalogue No. 62-007 (see Appendix 18).

12/ Op. Cit. Book, A.N., Princic, R., page 55-59.

13/ Appendix 7A shows the average unit-stage damage estimates for various industries. These values were updated to 1975 dollars using the Non-Residential Construction Price Index found in the Statistics Canada publication Construction Price Statistics, Catalogue No. 62-007 (see Appendix 18).

Industrial damages for the Vedder study were estimated using the following steps: (1) individual industrial establishments were assigned to their appropriate category, (2) the elevation of each establishment was determined by the use of topographic maps and air photographs, (3) the height of the main floor above ground was determined for each establishment by site inspection, (4) the acres of land occupied by each industry was estimated by using air photographs and by site inspection, and (5) a dollar damage was calculated for each industry by multiplying the acreage of each industry flooded times the appropriate unit-damage estimate.

Estimates of industrial damages are provided in Appendix 1A - 1F.

4. Agricultural Damage and Income Loss

Agricultural damages and income loss for Sumas-Yarrow and Chilliwhack dyking districts were analysed thoroughly in the report "Estimating Flood Damages in the Fraser River Basin".[14/] This study, therefore, relies rather heavily on the approach and results presented in above report.

a. Crop Damage and Income Loss

Since flooding from the Vedder River can occur at two different times of the year, winter and summer, two average per acre damage figures, each reflecting the unique conditions of the season, were prepared.

The average unit loss for the summer season, for both Sumas-Yarrow and Chilliwhack South, were taken directly from the report "Estimating Flood Damages in the Fraser River Basin".[15/]

14/ Op. Cit., Book, A.N., Princic, R., pages 62-72.

15/ Ibid., pages 51 - 59.

The per acre damage figures in the Fraser Study were prepared for the average crop mix prevailing in the various dyking districts (Sumas (including Yarrow) and Chilliwack) for flooding from the Fraser River. Since flooding from the Vedder River corresponds very closely with flooding from the Fraser River the per acre damage figures generated for one study were felt to be equally suitable for the other. All that was required, therefore, was to update the 1971 figures to 1975 dollars.[16/] The average per acre damage figures (1971) used for the two separate areas in this report (Sumas-Yarrow and Chilliwhack South) are provided in Appendices 8A - 8B.

In the case of winter flooding, conditions are very different requiring the preparation of substantially new average damage figures. Annual crops i.e. vegetables, grains, etc., which are subject to flooding during summer months are not present in the winter season. Furthermore, perennial plants i.e. pasture, hay and legume, other fodder species, cane fruit, strawberries, tree fruit, etc., are in a dormant stage and can tolerate some degree of flooding.

The average per acre damage figures for winter flooding, therefore, were prepared taking into account only the expected damage to perennial crops. Also since perennial crops were able to withstand some flooding the amount of damage was adjusted using the following data.[17/]

16/ Statistics Canada, Farm Prices of Agricultural Products, British Columbia, Catalogue No. 62-003.

17/ Prepared with the assistance of soil specialists at the B.C. Department of Agriculture Office at Cloverdale.

DURATION OF FLOODING	% OF CROP DAMAGE
0 - 5 Days	0
6 - 10 Days	20
11 - 18 Days	50
19 + Days	100

Total area flooded for each flood (see Appendix 2) was estimated by planimetering maps (scale 1" = 25,000 ft.) on which extent of flooding had been delineated. The proportion of agricultural acreage flooded relative to the total acreage flooded in each area was estimated by planimetering a number of air photographs (1" = 500 ft.) which were considered to have land use representative of the land use in the two areas. By use of this approach it was found that about 85% of the land area of Sumas, 70% of the area of Yarrow and 81% of the area of Chilliwhack South were in agricultural use. The rest of the land in each case was used for roads, buildings or some other non agricultural use. The total agricultural acreage for each area and each flood was obtained by multiplying the total acreage flooded for a flood times the appropriate percentage of agricultural acreage flooded.

Flood damages for each flood and area were generated by multiplying the appropriate average per acre damage figure times the expected agricultural acres flooded (see Appendix 9A - 9D).

b. Dairy Production Losses

This report assumed that for any flood sufficient warning would be given to evacuate all milk cows and their followers. Although cows themselves were not likely to be destroyed by the flooding, the disruption brought about by the evacuation along with the

associated crowding and lack of alternate facilities was expected to cause considerable loss in milk production. It was assumed, therefore, that cows would not produce milk during the period of the flood plus an additional 30 days thereafter (B.C. Department of Agriculture, Dairy Division, Cloverdale).

Average daily production per milk cow in the Fraser Valley was estimated to be 33 pounds per day (annual production per milk cow in the Fraser Valley in 1971 was 12,000 pounds). The weighted average price of bulk milk in the Fraser Valley in 1971 was reported to be $6.10 per hundredweight (B.C. Milk Board). This was increased by 93% to $11.77 to update the figure to 1975 dollars.[18/]

The number of dairy cows in the flood area was based on the per acre distribution derived from the report "Estimating Flood Damages in the Fraser River Basin".[19/] A ratio of cows per acre was obtained for each area by dividing the total number of milk cows in that area by the agricultural acreage flooded. The number of milk cows affected, per flood, in the Vedder Study was obtained by multiplying the appropriate per acre ratio times the agricultural acreage flooded.

Total milk production losses were obtained for each area and flood stage as follows:

$P = m \times (f + e) \times 33 \text{ lbs.} \times \$.1177$

where P = Total Production Losses

m = number of milk cows evacuated

f = duration of flood

e = additional time when milk cows not productive

18/ Statistics Canada, Dairy Statistics, Average Farm Value of Milk Sold by Farmers, Average Price of total sales, British Columbia Total, Catalogue 23-201.

19/ Op. Cit., Book, A.N., Princic, R.

Estimates of milk production losses are presented in Appendices 9A - 9C.

c. Beef Cattle Production Losses

A key assumption concerning beef cattle production losses was that sufficient warning would be given to evacuate all cattle from the flooded area. However, although no animals would actually be destroyed the cattle were expected to fail to gain 1.5 pounds of weight per day while absent from their normal feeding area. The time during which losses would occur was taken to be the duration of flooding plus two weeks to allow for the movement of stock and post-flood preparation of fields.

The number of beef cattle in the flood area was obtained from background data used to estimate similar losses in the report "Estimating Flood Damages in the Fraser River Basin".[20/] A ratio of cows per acre was calculated for each relevant dyking district (Sumas (including Yarrow) and Chilliwhack) by dividing the total number of beef cattle flooded by the total agricultural acreage flooded. These ratios were then multiplied by the estimated agricultural acreage flooded in the Vedder River study to obtain the number of beef cattle flooded.

The 1971 dollar losses were estimated to be $.48 per head per day. In 1975 these losses were $.65 per head per day an increase of 35% over the 1971 price.[21/]

Total beef cattle production losses were obtained for each area and flood stage as follows:

20/ Ibid, pages 66-67.

21/ Statistics Canada, Livestock and Animal Products Statistics, Average Price of Steer, Dressed at Principal Stockyards, Annual, Calgary. Catalogue 23-203.

$C = m \times (f + d) \times 1.5$ lbs. x $.43

where C = Total Beef Cattle Production Losses

m = number of beef cattle evacuated

f = duration of flood

d = additional time to allow for field preparation

Estimates of beef cattle production losses are presented in Appendices 9A - 9D.

d. Hog Production Losses

The assumption concerning evacuation used in the preparation of dairy and beef cattle losses also applied to hogs. However, unlike beef cattle which would fail to gain weight during the entire evacuation period hogs would only fail to gain weight when they were being transported to and from their farms. Hogs, therefore, were assumed to fail to gain 17 lbs. during the initial removal and return journey.[22/]

The actual number of hogs in the flood area was obtained from data supplied by the British Columbia, Department of Agriculture, Livestock Branch at Cloverdale.[23/]

The 1971 loss per pound was estimated to be $.30 (Canada, Department of Agriculture, Livestock Division). In 1975 the per pound loss was $.98 an increase of 228% over the 1971 price.[24/]

Total hog production losses were obtained for each area and flood stage as follows:

$H = m \times 17$ lbs. x $.98

where H = Total Hog Production Losses

m = number of hogs evacuated

22/ Op. Cit. page 67.

23/ From background data used to estimate similar losses in the report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, Dec. 1975.

24/ Statistics Canada, Livestock and Animal Products Statistics, Average Price of Hogs, Dressed at Principal Public Stockyards, Annual, Calgary. Catalogue No. 23-003.

Estimates of hog production losses are presented in Appendices 9A - 9D.

e. Turkey Production Losses

Because of the nature of the turkey business, farmers raise turkeys primarily for special seasons such as Thanksgiving and Christmas, there are periods of the year (in particular the time just after Christmas) when they have very few or none on hand. In addition, floods occurring in the late fall of the year would cause minimal damages because many birds would be almost mature.[25/]

Winter floods, therefore, were expected to result in the least possible loss in turkey production since the birds would be near maturity and recoverable or farmers would not have yet started their operations. Summer floods would result in the greatest loss since farmers would be in the early stages of their operations. The expected months of production loss for the various floods for both summer and winter floods is provided below.

Return Period	Loss of Production (Months)	
	Winter Floods	Summer Floods
3 Years	-	-
10 Years	-	-
25 Years	1.0	1.5
75 Years	1.5	3.0
200 Years	1.5	3.0

25/ Poultry specialists with the B.C. Department of Agriculture, Poultry Division in Abbotsford indicated that turkeys 11 weeks or older could be slaughtered resulting in a partial recovery of the normal value.

The actual annual production for both Sumas-Yarrow and Chilliwhack South were estimated from data originally obtained from the B.C. Turkey Marketing Board.[26/]

Losses per turkey for 1971 were estimated to be $4.00 for heavy birds and $1.90 for light birds. Feed costs not incurred as a result of the floods were estimated to be $1.10 and $.70 for heavy and light turkeys respectively. Final unit losses in 1971 dollars were $2.90 for heavy birds and $1.20 for light birds. The 1975 gross turkey losses were expected to be $6.44 for large birds and $3.07 for small birds (an increase of 61% since 1971.[27/] Feed costs not incurred as a result of a flood in 1975 prices were $1.80 for large turkeys and $1.07 for small turkeys.[28/] Final unit losses per bird used to calculate turkey production losses for 1975 were $4.64 for large turkeys and $2.00 for light turkeys.

Total turkey production losses were obtained for each area and flood stage as follows:

$$T = (\frac{m}{12} \times d \times \$4.64) + (\frac{n}{12} \times d \times \$2.00)$$

where T = Total Turkey Production Losses

m = annual production of heavy turkeys in flood area

n = annual production of light turkeys in flood area

d = expected number of months of lost production

Estimates of turkey production losses for each area and flood stage are presented in Appendices 9A - 9D.

26/ From background data used to estimate similar losses in the report "Estimating Flood Damages in the Fraser River Basin", by A. N. Book and R. Princic, Dec. 1975

27/ Agriculture Canada, Poultry Market Review-Annual, Turkeys - Broilers and Toms, Average Price to Producers, British Columbia.

28/ Canadian Livestock Feed Board, Annual Report, Average Monthly Retail Prices of Mixed Feeds by Provinces, British Columbia, Crop Year 1970-71 to 1974-75, the average of Turkey Broiler starter and Turkey Broiler Finisher.

f. Broiler Production Losses

Floods were expected to cause only partial production losses because farmers would be able to salvage broilers which are 5 weeks old or older.[29/] Using statistics on Broiler growth provided by the B.C. Department of Agriculture, Poultry Division at Abbotsford, it was calculated that farmers would be able to recover about one-third of their normal production. Losses, therefore, were assumed to be two-thirds of the normal production over the period of the flood. In addition some losses in production were also expected to occur because of required clean-up time.[30/] The expected loss in production (in weeks) for the individual floods for both summer and winter floods is provided below.

Return Period	Loss of Production (In Weeks)	
	Sumas-Yarrow	Chilliwhack South
3 Years	-	-
10 Years	-	-
25 Years	3	-
75 Years	7	5
200 Years	11	10

The actual annual production in each of the flood areas was estimated from data obtained from the B.C. Broiler and Fryer Marketing Board.[31/]

Losses per bird in 1971 were estimated to be $.85. Feed costs not incurred as a result of the floods were estimated to be $.22 per bird. Unit loss per bird used to estimate broiler production losses in 1971 was $.63.[32/] The 1975 gross broiler

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29/ Broilers require only 8 weeks to reach market size.

30/ Clean-up time was assumed to vary with intensity of flood.

31/ From background data used to estimate similar losses in the report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, Dec. 1975.

32/ Op. Cit., Book, A. N., Princic, R.

losses were expected to be $1.41 per bird (an increase of 66% since 1971).[33/] Feed costs not incurred as a result of a flood in 1975 prices was calculated to be $.36 per bird.[34/] Final losses per bird used to calculate broiler production losses in 1975 were $1.05.

Total broiler production losses were obtained for each area and flood stage as follows:

$B = \frac{m}{52} \times d \times \$1.05$

where B = Total Broiler Production Losses

m = annual broiler production in flood area

d = loss of production in weeks

Estimates of broiler production losses for each area and flood stage are presented in Appendices 9A - 9D.

g. Egg Production Losses

A major disruption such as a flood would result in laying hens going into moulting and not producing eggs for a period of about 8 weeks. This, together with the flood duration and required clean-up and start-up time, would result in quite lengthy production losses.

In the case of the larger floods (returns of 75 and 200 years) where flood durations are long it was assumed that the evacuation of hens would be difficult and uneconomic. Therefore for these floods all hens in the inundated areas would be sent to the slaughter house. Because a farmer would have a good deal of investment tied up in his hens (hens require six months to reach productive age and produce for an average of only one

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33/ Agriculture Canada, Poultry Market Review-Annual, Chickens - Under 5 pounds, Average Price to Producers, British Columbia.

34/ Canadian Livestock Feed Board, Annual Report, Average Monthly Retail Prices of Mixed Feeds by Provinces, British Columbia, Crop Year 1970-71 to 1974-75, the average price of Broiler Starter and Broiler Finisher.

year) it was assumed that a farmer would lose about one half of his annual egg production. For the smaller floods (returns of 3, 10 and 25 years) where the durations are much shorter, some evacuation was considered possible and economic. Farmers in this case were expected to lose only one quarter of their annual production. The expected months of production loss for the various floods is provided below.

Return Period	Loss in Months of Production	
	Winter Floods	Summer Floods
3 years	-	-
10 years	3	3
25 years	3	3
75 years	6	6
200 years	6	6

The actual annual production in each of the dyking areas and various floods was estimated from past production records obtained from the B.C. Egg Marketing Board.[35/]

Egg prices to producers in 1971 were estimated to be $9.50 per case (30 doz. eggs per case). Feed costs not incurred as a result of a flood were estimated to be $5.90 per case. Unit loss of production used to estimate egg production losses was $3.60 per case. Similar analysis for 1975 showed that prices to producers were $16.90[36], feed costs not incurred were $10.30[37] and final unit losses per case used to calculate egg production losses in 1975 were $6.60.

Total egg production losses were obtained for each area and flood stage as follows:

35/ From background data used to estimate similar losses in the report "Estimating Flood Damages in the Fraser River Basin", by A. N. Book and R. Princic, Dec. 1975.

36/ Agriculture Canada, Poultry Market Review-Annual, Eggs - All Grades, Weighted Price to Producers, British Columbia.

37/ Canadian Livestock Feed Board, Annual Report, Average Monthly Retail Prices of Mixed Feeds by Provinces, British Columbia, Crop Year 1970-1971 to 1974-75, Laying Mach.

$$E = \frac{m}{12} \times d \times \$6.60$$

where E = Loss in Egg Production

m = annual egg production in flood area (cases)

d = loss of production in months

Estimates of egg production losses for each area and flood stage are presented in Appendices 9A-9D.

h. Livestock Evacuation Costs

The cost of livestock evacuation was taken from the report "Estimating Flood Damages in the Fraser River Basin".[38] In the report it was assumed that all livestock would be safely evacuated to a nearby safe area. The 1971 evacuation costs per animal were $6.00 for dairy cows, $1.60 for beef cattle and $1.00 for hogs. These figures were updated by 27% to $7.60 for dairy cows, $2.00 for beef cattle and $1.25 for hogs to reflect the increase in the cost of transportation since 1971.[39]

The number of animals affected at each flood was estimated elsewhere in the report. In the case of milk cows, however, it was assumed that an equal number of followers (non-producing milk cows) would also have to be evacuated.

An estimate of the costs associated with the evacuation of livestock for each area and flood stage is provided in Appendices 9A - 9D.

38/ Op. Cit., Book, A.N., Princic, R., page 71.

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

i. Damage to Milking Equipment

Damage to milking equipment was taken from the report "Estimating Flood Damages in the Fraser River Basin".[40/] The 1971 unit damage in the report was $20 per milk cow. The 1975 unit loss was $28 an increase of 39% over the 1971 price.[41/]

Estimates of milking equipment damages for each area and flood stage are presented in Appendices 9A - 9D.

j. Extra Feed Costs

The basic assumption in this report was that flooding of land for any length of time would destroy its capacity to produce fodder for one season as well as destroying stored feed. Since additional feed would have to be imported (the Lower Mainland is a net importer of feed) farmers were expected to require to pay $20 more per ton (1971) for the imported feed.[42/] The $20 per ton represents an extra feed cost in 1971 dollars. The 1975 extra feed cost was $44 an increase of 122% over the 1971 price.[43/]

The quantity of fodder losses were computed by combining the acreage under various crops times the hay equivalents for these crops (see below).

Annual "Hay Equivalent" Yields of Various Fodder Crops
(Tons/Acre)

Crop	Hay Equivalent
Grains, Pasture	3 tons
Tame Hay, Legumes	4 tons
Corn	6 tons
Rough Pasture	2 tons

40/ Op. Cit., Book, A.N., Princic, R., page 70.

41/ Statistics Canada, Farm Input Price Index, Power Machinery, Western Canada, Catalogue No. 62-004.

42/ Op. Cit, Book, A.N., Princic, R.

43/ Statistics Canada, Farm Input Price Index, Feed, Western Canada, Catalogue No. 62-004.

Estimates of extra feed cost for each area and flood stage are provided in Appendices 9A - 9D.

5. Miscellaneous Damages

a. Damage to Roads

Because of numerous variables it was impossible to prepare one single estimate which would adequately represent average flood damage per road mile. Therefore, two different sets of values were used to estimate damages in the Vedder River area. A value of $3,900 per mile of road was used to calculate damages for floods of short duration, less than 7 days of flooding, and $17,700 per mile was used to calculate damages to roads flooded for periods longer than one week.[44]

For an estimate of the total miles of road flooded and the resulting damages for each flood see Appendix 10.

b. Damage to Railways

Railway damages were prepared using actual data from the December 1975 flood and with the aid of B.C. Hydro railway officials. Damage estimates for the December 1975 flood (discharge of 25,000 cfs) were $30,000 for the repair of a major breach (180 feet) on the Sumas-Yarrow side of the Vedder River and $10,000 for the repair of minor washout (100 feet) of the railway bed on the Chilliwhack side of the river. Based on the above estimates the repairs to major breaching and the less costly washout of railway bed works out to be $170 and $100 per foot of railway track respectively.

44/ These values are updates of values used in the report "Estimating Flood Damages in the Fraser River Basin". The updates were prepared using the Statistics Canada publication Construction Price Statistics and table entitled Highway Construction Price Index, B.C., Catalogue No. 62-007. The highway index is presently only complete for the period 1971-74. The 1974-75 is preliminary and is based on the Washington State Highway Bid Price Index, found in the publication Engineering News Record.

B.C. Hydro railway officials felt that there would be little damage from lower level floods (discharge of 22,100 cfs or less) since these floods would not result in overtopping of the railway track.[45/] Higher level floods, on the other hand, which have greater volumes of water, would likely cause more severe damage than the December 1975 flood.[46/]

In the case of a 35,300 cfs flood it was assumed that a major railway breach would occur on either side of the river. The Sumas-Yarrow side was expected to have a 200 foot breach while the Chilliwhack side a 150 foot breach. In addition another 150 feet of railway track on either side of the river would suffer less severe washout. In the case of a 42,500 cfs flood the railway breach on the Sumas-Yarrow was assumed to be 250 feet wide and the breach on the Chilliwhack side 200 feet. Furthermore, an additional 250 feet of track on the Sumas-Yarrow side and 500 feet on the Chilliwhack side would be subject to minor washout.

For an estimate of damages associated with the various floods see Appendix 11.

c. Damage to Utilities

(1) Sewage Systems

This report assumes that any lengthy flooding of sewage systems would require them to be cleaned. The costs associated with the cleaning were taken from the report "Estimating Flood Damages in the Fraser River Basin".[47/] The costs prepared for the year 1971 are as follows:

45/ From discussion with Mr. Friedel of the B.C. Hydro and Power Authority, Railway Department.

46/ The breach of the December 1975 flood was caused by water flowing over the top of the railway embankment and not from seepage.

47/ Op. Cit., Book, A.N., Princic, R., page 95.

Duration of Flood	$ Damages per Serviced Acre
0 - 7 Days	-
8 - 30 Days	$2.30
+ 31 Days	$4.50

These were updated to $3.43 per serviced acre for flood duration of 8-30 days and $6.72 per serviced acre for floods having durations greater than 30 days to convert them to 1975 dollars.[48]

For an estimate of the damages to the sewage systems for each area and flood stage see Appendix 12.

(2) Water Supply Systems

No attempt was made to investigate damages to water supply systems these were merely taken from the report "Estimating Flood Damages in the Fraser River Basin".[49] The dollar damage figure used in the report for the year 1971 was $1.40 per acre of serviced land. This figure was updated to $2.10 (1975 price) to reflect the increase in prices since 1971.[50]

An estimate of the damages to the water supply systems for each area and flood stage is provided in Appendix 12.

(3) Electrical Installations

B. C. Hydro and Power Authorities indicated that cleaning and repairing of substations in the Sumas-Yarrow and Chilliwhack South areas would amount to about $76,000

48/ Statistics Canada, Employment Earnings and Hours, Employment Earnings and Hours by Industry for Urban Areas, Vancouver, Average Weekly Earnings all Employees (Construction SIC.400-421), Catalogue No. 72-002.

49/ Op. Cit., Book, A.N., Princic, R., pages 95.

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

(1971 prices) for a flood discharge of 42,500 cfs.[51] The 1975 losses were estimated to be $120,000 an increase of 59% since 1971.[52]

An estimate of the damages to electrical installations in each area and flood stage is provided in Appendix 12.

(4) Gas Distribution Systems

B. C. Hydro and Power Authorities in 1971 indicated that gas distribution facilities would require clean-up and restarting procedures costing $30 per gas using household flooded.[53] This was updated to $45 an increase of 49% to bring it to 1975 dollars.[54]

An estimate of the damages to gas distribution facilities in each area and flood stage is provided in Appendix 12.

(5) Telephone Facilities

B. C. Telephone Co., provided an estimate of the potential damages to its installations at Sumas-Yarrow and Chilliwhack South in 1971 for flooding from the Fraser River.[55] This information was merely updated to 1975 dollars (increased by 49% and used in this report.[56]

51/ Values 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, Dec. 1975.

52/ Statistics Canada, Construction Price Statistics, Price Indexes of Electric Utility Construction, Transformer Stations - Total, Catalogue No. 62-007.

53/ 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, Dec. 1975. This report assumes that 50% of households in the Vedder River area use gas.

54/ Op. Cit., Statistics Canada, Employment Earnings and Hours, Cat.No. 72-002.

55/ Values 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, Dec. 1975.

56/ Op. Cit., Statistics Canada, Employment Earnings and Hours, Cat. No. 72-002.

An estimate of the damages to major telephone facilities in each area and flood stage is provided in Appendix 12.

d. 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".[57] 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.[58] 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 1975.[59]

School damages for the Vedder River flooding were estimated as follows: (1) Schools were identified by type (primary and secondary) and size, (2) Depth of flooding was determined for each school, (3) damages were calculated for each school by multiplying the appropriate percentage per foot of flooding times the corresponding market value, (4) total damages were obtained for each flood stage by adding the individual school damages.

Estimates of school damages for each area and flood stage are provided in Appendix 13.

e. Damage to Barns and Outbuildings

Damage to barns and outbuildings was estimated using the same procedure established in the 1971 report "Estimating Flood

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57/ Op. Cit., Book A.N., Princic, R., pages 96 - 98.

58/ See Appendix 13.

59/ See Appendix 13.

Damages in the Fraser River Basin".[60] The report assumed that barns and outbuildings would have to be repaired and painted at a cost of $140 per barn and $40 per outbuilding. These figures were updated to $200 per barn and $70 per outbuilding to reflect the increase in building repair costs from 1971 to 1975.[61]

The number of buildings flooded were identified by using enlarged air photographs size 1 in. = 500 ft. and verified by a field survey. Damages were estimated for each stage by multiplying the number of buildings flooded times the appropriate unit loss.

An estimate of the number of buildings flooded at each area and flood stage is provided in Appendix 14.

f. Cost of Evacuating People

The report "Estimating Flood Damages in the Fraser River Basin",[62] used $1.30 per person as the cost of moving residents from their flooded homes and back again. This value was updated by 25% to $1.63 to reflect the increase in transportation costs between 1971 and 1975.[63]

The number of people evacuated for each of the two flood areas was obtained by multiplying the number of houses flooded at each stage times the average number of persons per family for the relevant District Municipality. The Municipal District of Chilliwhack had 3.8 persons per family and the Municipal District of Sumas 3.6 persons per family.[64]

60/ Op. Cit., Book, A.N., Princic, R., page 96.

61/ Statistics Canada, Farm Input Prices Index, Building Repairs, Catalogue 62-004.

62/ Op. Cit., Book, A.N., Princic, R., page 100.

63/ Statistics Canada, Prices and Price Indexes, Consumer Price Indexes, Regional Cities, Vancouver, Transportation, Catalogue 62-002.

64/ Statistics Canada, 1971 Census of Canada, Families, Families by Size and Type, Catalogue 93-714, Vol 2 - Part 3, June 1973, pages 3-5, 4-4 and 4-5.

An estimate of the number of people evacuated for each area and flood stage and the associated dollar loss is provided in Appendix 15.

6. Secondary Income Losses

a. Secondary Effects of Agricultural Crop Damage

(1) Backward Linkages

Damage to crops was expected to result in a reduction in the purchase of equipment and material. Certain fertilizers, insecticides, sacking, boxes and crates would not be purchased in the year of the flood. As a result suppliers of these goods would suffer losses. The income portion of these reduced purchases represent the secondary losses to B.C.

Secondary losses were estimated for both summer and winter flooding. In each case an average per acre material loss was calculated for the crop mix in the area using the approach described in the report "Estimating Flood Damages in the Fraser River Basin".[65/] Since the information in the Fraser River study was in 1971 dollars it was updated by 85.5% to bring it to 1975 dollars.[66/] This per acre loss was then multiplied by the total agricultural acres flooded at each stage to obtain secondary agricultural income losses (backward linkages).

Estimates of secondary losses (backward linkages) are provided in Appendices 8 and 16.

65/ Op. Cit., Book, A.N., Princic, R., pages 82-83.

66/ Statistics Canada, Prices and Price Indexes, Farm Input Price Indexes, Other Materials and Services, Catalogue No. 62-002.

(2) Forward Linkages

Secondary income losses resulting from the loss of crops to canning and processing firms were estimated to be $344 per acre (summer of 1971) in the report "Estimating Flood Damages in the Fraser River Basin".[67/] This figure was updated to $540 (1975 dollars) and used in the present study to estimate current secondary losses for the summer floods.[68/]

Since winter flooding will affect significantly less land in relevant crops (vegetables and other annual crops would not yet be planted) the summer figure was adjusted in accordance with the percentage of crop which would be affected (Sumas-Yarrow area 16% in perennial crops Chilliwhack 28% in perennial crops).

Estimates of secondary losses (forward linkages) are provided in Appendix 16.

b. Egg Processing

Since wholesalers are able to import eggs in the event of any shortages local production losses would cause only income losses at grading stations and some extra freight and handling costs. The report, "Estimating Flood Damages in the Fraser River Basin",[69/] assumed that secondary losses associated with reduction in the local egg supply were $.03 per dozen or $.90 per case. This figure was updated to $1.41 per case an increase of 57% to reflect the increase in price of eggs from 1971 to 1975.[70/]

67/ OP. Cit. pages 82 - 84.

68/ Statistics Canada, Industry Selling Price Indexes, Manufacturing, Fruit and Vegetable Canners and Preservers, Catalogue No. 62-543.

69/ Op. Cit., Book, A.N., Princic, R., page 85.

70/ Statistics Canada, Prices and Price Indexes, Wholesale Price Indexes of Selected Primary Commodities, Eggs, Catalogue No. 62-002, page 48.

Secondary losses in egg processing were calculated by multiplying the total cases of production lost at each flood (as calculated in Section 4g and provided in Appendix 9) times the expected dollar loss ($1.41 per case).

An estimate of the secondary losses, to egg processing, is provided in Appendix 17.

c. Milk Processing

Losses in the production of milk were expected to result in secondary losses to milk processors. The report, "Estimating Flood Damages in the Fraser River Basin",[71/] found that secondary losses of milk production amounted to about 40% of the primary income loss or $2.44 per cwt. This figure was updated to $4.12 to reflect the increase in the price of milk since 1971.[72/]

Secondary losses in milk processing were estimated by calculating the expected milk production losses per cow (see Section 4b for details on how this was calculated and Appendix 9 for results) and multiplying this times the number of cows affected per flood.

An estimate of the secondary milk production losses is provided in Appendix 17.

71/ Op. Cit., Book, A.N., Princic, R., page 85.

72/ Statistics Canada, Prices and Price Indexes, Industry Selling Price Indexes by Industry and Selected Commodities, Foods and Beverages Industries, milk sold to Households, Stores, etc., Catalogue No. 62-002.

7. Future Damages

a. General

This study examined four alternative projections of future flood damages. The first and most comprehensive is referred to as the "most likely" pattern of growth. This estimate was based on the best prediction of probable growth and productivity change and the most likely change in the real value of floodplain activity (see Appendix 19, 20 and 21). The second projection or "absolute minimum" was based on the assumption that there would be no growth or real price increase over time. The third projection was designed to examine the sensitivity of damage estimates of small errors in projections. This was done merely by increasing the "most likely" rate of change for each damage category by 1% per year. A fourth projection, the "absolute maximum" was designed to examine the sensitivity of damage estimates of major errors in projections. This was done by increasing the "most likely" rate of change for each damage category by 3% per year.

The growth projections prepared in this study were assumed to continue over the period 1975-2000. No changes in either growth or real prices were predicted for the period beyond the year 2000. It was felt that projections into the distant future were subject to too many uncertainties and would be completely arbitrary. Therefore, holding annual damages constant after the year 2000 was felt to be as realistic as predicting change.

b. Real Growth

The Vedder River floodplain is primarily rural and agricultural. Since most of the area is zoned for agricultural use (the notable exception is the area of Yarrow) growth in population

is expected to be low.

Projections of population growth in the report "Estimating Flood Damages in the Fraser River Basin" showed that the Yarrow area was expected to grow at a rate of 2% per year, the dyking district of Sumas 0% per year and the dyking district of Chilliwack 3% per year.[73/] Since Vedder River flooding corresponds very closely with Fraser River flooding in the case of Yarrow and Sumas, the growth figures presented for these areas in the latter report were felt to be reasonable and are used in this study.[74/] The growth projection estimated for Chilliwack, however, is an average for a much larger area (Chilliwhack District) and is not believed to be representative of the Chilliwhack South area. A more realistic assumption of expected growth for the Chilliwhack South area is 1% per year.

Future expansion of commercial, residential and associated damage categories such as, loss of use of dwelling, extra food cost, damage to utilities, damage to roads, damage to schools, damage to barns and outbuildings and evacuation of people are assumed to grow at the same rate as the growth in population.[75/]

Because of the small amount of industrial land subject to Vedder River flooding and the Provincial Government agricultural land freeze, which does not permit the zoning of additional land for industrial use, growth in the areas industry is expected to be negligible.

73/ Op. Cit., Book, A. N., Princic, R., pages 105-109.

74/ A weighted average for Sumas-Yarrow (based on the number of residences flooded in each area assuming a 200 year return flood) was calculated to be 1.3% per year.

75/ Projections of growth were not made beyond the year 2000. Because of many uncertainties projections into the distant future were felt to be completely arbitrary and of questionable value.

An analysis of agricultural growth in the Fraser River floodplain in the study, "Estimating Flood Damages in the Fraser River Basin" showed that productivity changes would occur in the agricultural sector in the Vedder River floodplain area.[76/] Because the two problems are rather similar the present study relies heavily on the findings and techniques outlined in the Fraser River report.

Annual growth rate figures for agricultural groups such as dairying, beef production and swine production were taken directly from the Fraser River report.[77/] Growth rates for agricultural groups such as poultry and eggs, for which information was not available in the Fraser River report were estimated using other sources.[78/]

Although annual rates of growth in agricultural crop production were prepared in the Fraser River report because of differences in the nature of flooding of the Vedder River (the most serious occur in the winter season when agricultural activity is at its lowest) these rates were not used in the present study. Calculation of annual rate of growth using the approach outlined in the Fraser River report and taking into account the conditions unique to the Vedder River resulted in an annual rate of appreciation of zero.

A table listing the expected annual rates of growth for each of the damage categories is provided in Appendix 19.

c. Real Price Changes Over Time

Real price changes over time are very difficult to predict with any degree of accuracy.[79/] A look at Appendix 20 shows what has

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76/ Op. Cit., Book, A.N., Princic, R., pages 121-125.

77/ Ibid., Book, A.N., Princic, R., page 123.

78/ Carne, I.C., et. al., Second Approximation Report, Agriculture in the Fraser Valley, 1964-1965-1974-1989, B.C. Department of Agriculture, Victoria, B.C.

79/ "Real price changes" can be defined as the increase or decrease in the value of a damageable good relative to all other goods in the economy (ie. relative to the consumer price index).

happened to real prices during various periods since 1955. Note particularly the changes in the average annual index between the years 1966-71 and 1971-75. Some of the components, agriculture for example, showed negative average annual price change during the period 1966-71 and high positive rates of growth, relative to the consumer price index, during the period 1971-75. Because of the extreme variability in the historic prices the projected real price increases adopted in this study are rather general and are not based on any kind of calculated average.[80/] Past prices are used only as a crude guide to future prices.

A list of the expected annual rates of real price increases for each damage category is provided in Appendix 20.

80/ Projections of real price increases were terminated at the year 2000. Because of many uncertainties the projection of prices into the distant future was felt to be highly arbitrary and of questionable value.

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 five river discharges ranging from 14,800 cfs to 42,500 cfs for both summer and winter floods (see Appendices 1A-1F). This provided estimates for five possible floods and established the stages (discharges) for calculating total potential damages.

Because of the complexity of the data, growth rates and real price changes varied for each damage category, a computer program "Flodam" was used to generate the present value of damages.[81/] This program was developed so that it could systematically compound each of the damage categories by its projected growth rate and discount these back to the base year. Then by summing all categories for any one discharge "Fodam" provided a present value of damages for that discharge.

Total damages (available benefits) were calculated using a modified version of another computer program "C$PRØB".[82/] This program was developed so it could calculate total potential damages by measuring the area under the damage-frequency curve created from the five discharge (stage) damage points. An estimate of the total potential damages is provided in column (1) of Appendix 24.

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.

81/ "Flodam" was developed by N.A. Dowds and A.N. Book in order to calculate the present value of flood damages for the Fraser River Upstream Storage Study (for reference see Bibliography).

82/ "C$PRØB" was originally developed by R.O.Lyons and N.A.Dowds to calculate flood damages for the Fraser River Upstream Storage Study.

At capacities of 32,000 cfs to 42,500 cfs (a dyke capacity of 32,000 cfs represents a dyke level equivalent to 2 ft. below the dyke design) set-back dykes were assumed capable of capturing only 50% of the available benefits.[83/] An estimate of these benefits and the residual benefits available for dykes is provided in columns (2) and (3) of Appendix 24.

Because there are dykes in the area at the present time, a further adjustment was necessary to estimate benefits to set-back dykes. Benefits captured by existing dykes had to be calculated and deducted from total available benefits. Two cases were established with respect to the present dykes. Case one assumed that dykes would be maintained at their present standards (existing dykes were assumed to have a probability of failure curve as plotted in Appendix 22). Case two assumed that the existing dykes would not be maintained and would gradually deteriorate over time (existing dykes were assumed to have a probability of failure curve as plotted in Appendix 23). A third case, based on the assumption that existing dykes would be removed was also analysed. Benefits for all three cases were calculated using the "C$PRØB" program. An estimate of the benefits captured by existing dykes is provided in Table 3 and column (4) of Appendix 24A, B & C.[84/]

Benefits to set-back dykes were then obtained by taking the difference between the available benefits and the benefits captured by the existing dykes. Table 3 gives a summary of the total available benefits, the benefits captured by the existing dykes and the benefits which are attributed to the proposed set-back dykes.[85/]

83/ 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.

84/ All of the necessary modifications to the "C$PRØB" program and the generation of flood benefits was carried out by R.O. Lyons and N.A. Dowds of the Water Planning & Management Branch, IWD, Pacific and Yukon Region.

85/ Obtaining total benefits by adding winter and summer floods is not entirely correct and leads to an overestimate of benefits. The correct procedure is to produce a combined annual damage-frequency curve for winter and summer floods and compute benefits from this curve. Since in this case summer benefits are small relative to winter benefits (only 2%) the error resulting from the straight addition of winter and summer benefits is negligible.

Table 3

Dyke Benefits (1976-2010) - Vedder River*

Case	Total Available Benefits ($1,000)	Benefits to Existing Dykes ($1,000)	Benefits to New Dykes ($1,000)
(1) Present Dykes Maintained			
- Winter	6,114.8	1,064.0	5,050.8
- Summer	141.3	71.7	69.6
TOTAL	6,256.1	1,135.7	5,120.4
(2) Present Dykes not Maintained			
- Winter	6,114.8	371.9	5,742.9
- Summer	141.3	39.5	101.8
TOTAL	6,256.1	411.4	5,844.7
(3) Present Dykes Removed			
- Winter	6,114.8	--	6,114.8
- Summer	141.3	--	141.3
	6,256.1	--	6,256.1

* Most likely growth and price change. 7% rate of discount.

Estimates of future flood benefits in this study were made assuming the most likely real price change and most likely change in floodplain development. However, because of numerous uncertainties with respect to future prices and floodplain activity and to provide some sensitivity analysis benefits were calculated using three other projections. Besides the most likely growth and price change also considered were zero growth and price change, growth and price change 1% higher than the most likely and growth and price change 3% higher than the most likely. Appendix 24A & B shows the effect of the various rates of growth on the benefits.

2. Costs

Appendix 2 provides an estimate of the capital costs, right of way costs and the annual maintenance costs of the set-back dykes.[86/] The Appendix also gives an estimate of the annual maintenance costs of the existing dykes.

The present value of the maintenance costs were calculated assuming a real cost appreciation rate of 2% per year and using a discount rate of 7% per year.[87/] In order to conduct sensitivity analysis future maintenance costs were calculated using two other rates of appreciation, 0% and 4% (Appendix 25).

A project cost figure which could be used to compare with the estimated dyke benefits was obtained in the following manner. The calculated present value of the maintenance costs of the set-back dykes were added to the capital and right of way costs of these dykes. Then the present value of the maintenance costs of the existing dykes were added to the total cost of the set-back dykes to arrive at project costs (see Table 4).[88/]

Table 4

Project Costs - Vedder R.*

Case	Capital Costs New Dykes	Right of Way Costs New Dykes	Maintenance Costs (1976-2010) New Dykes	Maintenance Costs (1976-2010) Present Dykes	Project Costs
(1) Present Dykes Maintained	$2,173,000	$78,000	$242,000	$179,000	$2,672,000
(2) Present Dykes Not Maintained	$2,173,000	$78,000	$242,000	-	$2,493,000
(3) Present Dykes Removed	$2,173,000	$78,000	$242,000	-	$2,493,000

* 7% rate of discount, 2% real rate of appreciation

86/ See Section 3, Land Purchase Costs, for an explanation of right of way costs.

87/ Although real dyke construction costs have increased much more rapidly in the recent past this rate was not expected to continue into the future.

88/ It is assumed that the existing dykes would be maintained at their present condition in order to protect property which is located between the river and the set-back dykes and to help stabilize the river channel by preventing river bank erosion.

3. Land Purchase Costs

During the course of this study there was considerable discussion about what should be done with the land which lies between the set-back dykes and the existing dykes. Several suggestions were put forward including, leaving the land under present ownership and its existing land use, to outright purchase of the land and taking it out of its present use. Since costs, particularly of the latter, would be significant this immediately raised the question of who should pay for the land and what costs should be included in the benefit-cost analysis. This section, therefore, attempts to analyse the various options and hopefully answer the questions.

The most straightforward solution, from both an economic and financial point of view, would appear to be merely to purchase the dyke right of way from the farmers and leave the rest of the land in their hands.[89] If the farmers then continued to maintain their present land use practices the only real costs which would result from the project are the actual capitalized future losses in agricultural production of the strip of land purchased for the dyke right of way (in a perfect market situation the purchase cost of the right of way would be equal to the present value of the net contribution of the land).[90]

Another solution would be for someone, preferably a government agency, to purchase all of the land between the present and proposed dykes. In this case the one who bears the costs of the land purchase is obviously the new owner of the land.

89/ Financial or private cost represents the actual dollar outlay which a purchaser must pay for land in order to obtain rights to that land. Economic or social cost is the opportunity cost of using the land for right-of-way or whatever instead of maintaining it in its present use.

90/ See Appendix 2 for the calculation of right of way costs.

If the provincial government purchases the land the monetary transaction is merely a transfer payment from the taxpayers of the province (who become the new owners of the land) to the land owners in exchange for their land. If the government then continues to maintain the land in its present use, the real costs to the project are the same as in the non purchase case (costs of right of way only). However, if land use of the area is changed, either to more intensive or less intensive use, the change may result in either a benefit or a cost to the project. For example, if the purchased land, which is presently in agricultural use, is taken out of production entirely and is left vacant, the loss chargeable to the project would amount to the present value of the future net income generated by agricultural production in the area. If, on the other hand, the purchased land is converted to higher valued recreation land (area is turned into a park) the project may result in benefits which should be credited to the project.

In this report it is assumed that regardless of whether the land is purchased outright by a government agency, or is left with the existing owners, it will continue to be used for agriculture or it will be converted to some other use (park, recreation area) which will make its value at least equal to its present value. Therefore, land costs to the project are assumed to be zero.

4. Benefit-Cost Ratios and Net Benefits

Once benefits and costs of the set-back dykes were estimated it was possible to calculate the benefit-cost ratios and the net benefits for each of the cases. These are summarized in Table 5.

Table 5

Benefits, Costs, Benefit-Cost Ratios and Net Benefits - Vedder R.*

Case	Benefits of New Dyke	Project Costs	B/C Ratio	Net Benefits
(1) Present Dykes Maintained	$5,120,400	$2,672,000	1.92	$2,448,400
(2) Present Dykes not Maintained	$5,844,700	$2,493,000	2.34	$3,351,700
(3) Present Dykes Removed	$6,256,100	$2,493,000	2.51	$3,763,100

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

5. Sensitivity Analysis

Appendix 26 provides benefit-cost ratios for the Vedder River Project under various assumptions of growth and real price change for both benefits and dyke construction costs and different discount rates (6%, 7% and 8%). Note that although there is some variation in the benefit cost ratios, at no time (even at zero growth and zero price change and 4% dyke cost appreciation) does the ratio ever drop below unity. In the case where existing dykes are removed, the benefit-cost ratios are even more favourable to set-back dykes. dykes.

I. GENERAL COMMENTS

This report examines all of the potential benefits of the set-back dykes which are directly related to the flooding problem. It does not examine other benefits, such as recreations and fisheries benefits which might result from the set-back dykes. For a preliminary analysis of this nature it was felt best not to attempt to assess these benefits.

If it had turned out that flood benefits were very close to project costs (ie. the B/C ratios were close to unity) then a more thorough analysis of benefits, this time including recreation and fisheries benefits, would have been warranted. As it turns out, flood benefits are sufficient to justify the project, therefore, analysis of recreation and fisheries benefits are not required.

J. CONCLUSION

Based on the results produced by this study, it can be concluded that the construction of set-back dykes is justified. This conclusion is arrived at in spite of the fact that this study did not analyse recreation and fisheries benefits which would in all probability lend even further support to the project.

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APPENDICES

APPENDIX 1

FLOOD DAMAGES - SUMMARY

AREA:

TYPE OF DAMAGE	$000's DAMAGES				
(1) Residential and Associated					
(a) Residential and content					
(b) Loss of use of dwelling					
(c) Extra Food Cost					
(2) Commercial					
(3) Industrial					
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss					
(b) Dairy production					
(c) Beef Cattle production					
(d) Hog production					
(e) Turkey production					
(f) Broiler production					
(g) Egg production					
(h) Livestock evacuation					
(i) Milking equipment					
(j) Extra feed					
(5) Miscellaneous					
(a) Roads					
(b) Railways					
(c) Utilities					
(1) Sewage systems					
(2) Water supply systems					
(3) Electrical installations					
(4) Gas distribution systems					
(5) Telephone facilities					
(d) Schools					
(e) Barns and outbuildings					
(f) Evacuating people					
TOTAL PRIMARY DAMAGES					
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages					
(2) Forward Linkages					
(b) Egg processing					
(c) Milk processing					
TOTAL SECONDARY DAMAGES					
TOTAL DAMAGES					

APPENDIX 1A

FLOOD DAMAGES - SUMMARY

AREA: VEDDER RIVER TOTAL (Winter Floods)

TYPE OF DAMAGE	$000's DAMAGES PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	10.0	218.3	1,199.0	6,534.9	15,373.2
(b) Loss of use of dwelling	.1	6.8	44.7	285.8	968.3
(c) Extra Food Cost	-	2.2	14.6	85.5	271.5
(2) Commercial	-	-	-	370.7	1,187.2
(3) Industrial	-	-	-	-	123.7
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	-	157.1	2,720.9	5,285.3
(b) Dairy production	-	18.7	180.3	1,099.0	2,431.5
(c) Beef Cattle production	-	-	.1	1.1	5.6
(d) Hog production	-	18.4	18.4	18.4	21.1
(e) Turkey production	-	-	24.7	37.1	37.1
(f) Broiler production	-	-	3.8	23.3	58.0
(g) Egg production	-	-	19.6	299.5	373.5
(h) Livestock evacuation	-	3.4	20.8	80.8	126.9
(i) Milking equipment	-	3.7	35.6	146.1	229.9
(j) Extra feed	-	-	51.6	877.3	1,515.6
(5) Miscellaneous					
(a) Roads	1.2	15.1	202.9	933.2	1,891.5
(b) Railways	-	-	40.6	89.5	151.5
(c) Utilities					
(1) Sewage systems	-	-	9.6	45.5	95.0
(2) Water supply systems	-	1.0	9.3	36.1	53.2
(3) Electrical installations	-	-	-	-	240.0
(4) Gas distribution systems	-	.9	4.6	20.8	38.1
(5) Telephone facilities	-	-	-	-	447.0
(d) Schools	-	-	-	561.1	1,865.2
(e) Barns and outbuildings	1.7	13.4	52.0	217.4	416.8
(f) Evacuating people	-	.3	1.2	5.6	10.4
TOTAL PRIMARY DAMAGES	13.0	302.2	2,090.5	14,378.3	33,079.4
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	-	3.1	13.6	27.3
(2) Forward Linkages	-	-	21.4	387.0	828.7
(b) Egg processing	-	-	4.2	40.3	50.1
(c) Milk processing	-	6.5	63.5	339.8	522.8
TOTAL SECONDARY DAMAGES	-	6.5	92.2	780.7	1,428.9
TOTAL DAMAGES	13.0	308.7	2,182.7	15,159.0	34,508.3

APPENDIX 1 B

FLOOD DAMAGES - SUMMARY

AREA: VEDDER RIVER TOTAL (Summer Floods)

TYPE OF DAMAGE	$000's DAMAGES PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	10.0	218.3	1,199.0	6,534.9	15,373.2
(b) Loss of use of dwelling	.1	6.8	44.7	285.8	968.3
(c) Extra Food Cost	-	2.2	14.6	85.5	271.5
(2) Commercial	-	-	-	370.7	1,187.2
(3) Industrial	-	-	-	-	123.7
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	37.8	1,059.1	4,831.4	8,496.4
(b) Dairy production	-	18.7	180.3	1,099.0	2,431.5
(c) Beef Cattle production	-	-	.1	1.1	5.6
(d) Hog production	-	18.4	18.4	18.4	21.1
(e) Turkey production	-	-	24.7	37.1	37.1
(f) Broiler production	-	-	3.8	23.3	58.0
(g) Egg production	-	-	19.6	299.5	373.5
(h) Livestock evacuation	-	3.4	20.8	80.8	126.9
(i) Milking equipment	-	3.7	35.6	146.1	229.9
(j) Extra feed	-	-	51.6	877.3	1,515.6
(5) Miscellaneous					
(a) Roads	1.2	15.1	202.9	933.2	1,891.5
(b) Railways	-	-	40.6	89.5	151.5
(c) Utilities					
(1) Sewage systems	-	-	9.6	45.5	95.0
(2) Water supply systems	-	1.0	9.3	36.1	53.2
(3) Electrical installations	-	-	-	-	240.0
(4) Gas distribution systems	-	.9	4.6	20.8	38.1
(5) Telephone facilities	-	-	-	-	447.0
(d) Schools	-	-	-	561.1	1,865.2
(e) Barns and outbuildings	1.7	13.4	52.0	217.4	416.8
(f) Evacuating people	-	.3	1.2	5.6	10.4
TOTAL PRIMARY DAMAGES	13.0	340.0	2,992.5	16,488.8	36,290.5
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	3.1	87.4	355.3	519.6
(2) Forward Linkages	-	45.9	359.8	1,500.0	2,294.8
(b) Egg processing	-	-	4.2	40.3	50.1
(c) Milk processing	-	6.5	63.5	339.8	522.8
TOTAL SECONDARY DAMAGES	-	55.5	514.9	2,235.4	3,387.3
TOTAL DAMAGES	13.0	395.5	3,507.4	18,724.2	39,677.8

APPENDIX 1C

FLOOD DAMAGES - SUMMARY

AREA: SUMAS-YARROW (Winter Floods)

TYPE OF DAMAGE	$000's DAMAGES (1975) PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	10.0	209.3	1,082.6	4,601.3	6,876.6
(b) Loss of use of dwelling	.1	6.5	40.8	217.3	382.8
(c) Extra Food Cost	-	2.1	13.4	65.5	108.0
(2) Commercial	-	-	-	354.9	448.6
(3) Industrial	-	-	-	-	-
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	-	157.1	2,466.2	3,236.5
(b) Dairy production	-	16.9	154.8	863.7	1,470.1
(c) Beef Cattle production	-	-	-	-	-
(d) Hog production	-	18.4	18.4	18.4	18.4
(e) Turkey production	-	-	24.7	37.1	37.1
(f) Broiler production	-	-	3.8	21.7	34.0
(g) Egg production	-	-	14.4	96.7	100.3
(h) Livestock evacuation	-	3.2	17.8	58.3	67.5
(i) Milking equipment	-	3.3	30.2	104.9	121.5
(j) Extra feed	-	-	51.6	754.5	1,004.0
(5) Miscellaneous					
(a) Roads	1.2	15.1	200.6	798.3	1,326.1
(b) Railways	-	-	30.6	49.0	67.5
(c) Utilities					
(1) Sewage systems	-	-	9.6	41.2	63.2
(2) Water supply systems	-	1.0	8.0	27.3	31.1
(3) Electrical installations	-	-	-	-	120.0
(4) Gas distribution systems	-	.9	4.1	14.5	16.7
(5) Telephone facilities	-	-	-	-	447.0
(d) Schools	-	-	-	433.3	612.7
(e) Barns and outbuildings	1.7	13.4	48.7	146.0	175.0
(f) Evacuating people	-	.3	1.1	3.9	4.5
TOTAL PRIMARY DAMAGES	13.0	290.4	1,912.3	11,174.0	16,769.2
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	-	3.1	11.1	14.3
(2) Forward Linkages	-	-	21.4	334.2	438.7
(b) Egg processing	-	-	3.1	20.7	21.4
(c) Milk processing	-	5.9	54.6	302.8	471.3
TOTAL SECONDARY DAMAGES	-	5.9	82.2	668.8	945.7
TOTAL DAMAGES	13.0	296.3	1,994.5	11,842.8	17,774.4

APPENDIX 1D

FLOOD DAMAGES - SUMMARY

AREA: CHILLIWHACK SOUTH (Winter Floods)

TYPE OF DAMAGE	$000's DAMAGES (1975) PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	-	9.0	116.4	1,933.6	8,496.6
(b) Loss of use of dwelling	-	.3	3.9	68.5	586.5
(c) Extra Food Cost	-	.1	1.2	20.0	163.5
(2) Commercial	-	-	-	15.8	738.6
(3) Industrial	-	-	-	-	123.7
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	-	-	254.7	2,048.8
(b) Dairy production	-	1.8	25.5	235.3	961.4
(c) Beef Cattle production	-	-	.1	1.1	5.6
(d) Hog production	-	-	-	-	2.7
(e) Turkey production	-	-	-	-	-
(f) Broiler production	-	-	-	1.6	24.0
(g) Egg production	-	-	5.2	91.5	134.5
(h) Livestock evacuation	-	.2	3.0	22.5	59.4
(i) Milking equipment	-	.4	5.4	41.2	108.4
(j) Extra feed	-	-	-	122.8	511.6
(5) Miscellaneous					
(a) Roads	-	-	2.3	134.9	565.4
(b) Railways	-	-	10.0	40.5	84.0
(c) Utilities					
(1) Sewage systems	-	-	-	4.3	31.8
(2) Water supply systems	-	-	1.3	8.8	22.1
(3) Electrical installations	-	-	-	-	120.0
(4) Gas distribution systems	-	-	.5	6.3	21.4
(5) Telephone facilities	-	-	-	-	-
(d) Schools	-	-	-	127.8	1,252.5
(e) Barns and outbuildings	-	-	3.3	71.4	241.8
(f) Evacuating people	-	-	.1	1.7	5.9
TOTAL PRIMARY DAMAGES	-	11.8	178.2	3,204.3	16,310.2
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	-	-	2.5	13.0
(2) Forward Linkages	-	-	-	52.8	390.0
(b) Egg processing	-	-	1.1	19.6	28.7
(c) Milk processing	-	.6	8.9	37.0	51.5
TOTAL SECONDARY DAMAGES	-	.6	10.0	111.9	483.2
TOTAL DAMAGES	-	12.4	188.2	3,316.2	16,793.4

APPENDIX 1 E

FLOOD DAMAGES - SUMMARY

AREA: SUMAS-YARROW (Summer Floods)

TYPE OF DAMAGE	$000's DAMAGES (1975) PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	10.0	209.3	1,082.6	4,601.3	6,876.6
(b) Loss of use of dwelling	.1	6.5	40.8	217.3	382.8
(c) Extra Food Cost	-	2.1	13.4	65.5	108.0
(2) Commercial	-	-	-	354.9	448.6
(3) Industrial	-	-	-	-	-
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	37.8	1,059.1	4,047.3	5,219.4
(b) Dairy production	-	16.9	154.8	863.7	1,470.1
(c) Beef Cattle production	-	-	-	-	-
(d) Hog production	-	18.4	18.4	18.4	18.4
(e) Turkey production	-	-	24.7	37.1	37.1
(f) Broiler production	-	-	3.8	21.7	34.0
(g) Egg production	-	-	14.4	96.7	100.3
(h) Livestock evacuation	-	3.2	17.8	58.3	67.5
(i) Milking equipment	-	3.3	30.2	104.9	121.5
(j) Extra feed	-	-	51.6	754.5	1,004.0
(5) Miscellaneous					
(a) Roads	1.2	15.1	200.6	798.3	1,326.1
(b) Railways	-	-	30.6	49.0	67.5
(c) Utilities					
(1) Sewage systems	-	-	9.6	41.2	63.2
(2) Water supply systems	-	1.0	8.0	27.3	31.1
(3) Electrical installations	-	-	-	-	120.0
(4) Gas distribution systems	-	.9	4.1	14.5	16.7
(5) Telephone facilities	-	-	-	-	447.0
(d) Schools	-	-	-	433.3	612.7
(e) Barns and outbuildings	1.7	13.4	48.7	146.0	175.0
(f) Evacuating people	-	.3	1.1	3.9	4.5
TOTAL PRIMARY DAMAGES	13.0	328.2	2,814.3	12,755.1	18,752.1
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	3.1	87.4	334.1	430.8
(2) Forward Linkages	-	45.9	359.8	1,375.2	1,773.4
(b) Egg processing	-	-	3.1	20.7	21.4
(c) Milk processing	-	5.9	54.6	302.8	471.3
TOTAL SECONDARY DAMAGES	-	54.9	504.9	2,032.8	2,696.9
TOTAL DAMAGES	13.0	383.1	3,319.2	14,787.9	21,449.0

APPENDIX 1F

FLOOD DAMAGES - SUMMARY

AREA: CHILLIWHACK SOUTH (Summer Floods)

TYPE OF DAMAGE	$000's DAMAGES (1975) PEAK FLOW (cfs) 14,800	22,100	28,000	35,300	42,500
(1) Residential and Associated					
(a) Residential and content	-	9.0	116.4	1,933.6	8,496.6
(b) Loss of use of dwelling	-	.3	3.9	68.5	586.5
(c) Extra Food Cost		.1	1.2	20.0	163.5
(2) Commercial	-	-	-	15.8	738.6
(3) Industrial	-	-	-	-	123.7
(4) Agricultural Damage and Income Loss					
(a) Crop damage and income loss	-	-	-	784.1	3,277.0
(b) Dairy production	-	1.8	25.5	235.3	961.4
(c) Beef Cattle production	-	-	.1	1.1	5.6
(d) Hog production	-	-	-	-	2.7
(e) Turkey production	-	-	-	-	-
(f) Broiler production	-	-	-	1.6	24.0
(g) Egg production	-	-	5.2	91.5	134.5
(h) Livestock evacuation	-	.2	3.0	22.5	59.4
(i) Milking equipment	-	.4	5.4	41.2	108.4
(j) Extra feed	-	-	-	122.8	511.6
(5) Miscellaneous					
(a) Roads	-	-	2.3	134.9	565.4
(b) Railways	-	-	10.0	40.5	84.0
(c) Utilities					
(1) Sewage systems	-	-	-	4.3	31.8
(2) Water supply systems	-	-	1.3	8.8	22.1
(3) Electrical installations	-	-	-	-	120.0
(4) Gas distribution systems	-	-	.5	6.3	21.4
(5) Telephone facilities	-	-	-	-	-
(d) Schools	-	-	-	127.8	1,252.5
(e) Barns and outbuildings	-	-	3.3	71.4	241.8
(f) Evacuating people	-	-	.1	1.7	5.9
TOTAL PRIMARY DAMAGES	-	11.8	178.2	3,733.7	17,538.4
(6) Secondary Income Loss					
(a) Effects of agriculture crop damage					
(1) Backward Linkages	-	-	-	27.2	88.8
(2) Forward Linkages	-	-	-	124.8	521.4
(b) Egg processing	-	-	1.1	19.6	28.7
(c) Milk processing	-	.6	8.9	37.0	51.5
TOTAL SECONDARY DAMAGES	-	.6	10.0	202.6	690.4
TOTAL DAMAGES	-	12.4	188.2	3,936.3	18,228.8

APPENDIX 2

VEDDER RIVER

A. Estimated Schedule of Quantity, unit prices and total cost of setback dyke (Phase III) *

Item	Unit	Quantity	Rate $	Amount
1. Clearing and Grubbing	Acre	42	1,700.00	71,400.
2. Stripping	SY	203,000	.25	50,800.
3. Bulkfill	CY	268,400	1.70	456,300
4. Impervious fill	CY	63,709	3.40	216,600.
5. Trench and toe drain	CY	16,787	3.80	63,800.
6. Trench excavation	LF	23,000	3.00	69,000.
7. Gravel surfacing	CY	6,953	4.25	29,600.
8. Floodboxes	each	10	21,000.00	210,000.
9. Ripraps	CY	20,800	5.00	104,000.
10. Filter for ripraps	CY	5,200	4.25	22,100.
11. Fences	LF	26,200	1.70	44,500.
12. Gates	each	10	4.30	4,300.
13. General requirement	LS			75,000.
Subtotal direct construction				1,417,000
Contingency 25%				354,000
Engineering Supervision 15%				213,000
Subtotal Construction cost (1975)				1,984,000
Engineering design @ 8% of construction				159,000
Legal Survey @ $6000./mile				30,000.
Total Cost (1975)				2,173,000

* Prepared by the Projects Division of the Water Planning and Management Branch, Inland Waters Directorate.

B. The annual cost of maintaining and repairing the setback dykes are as follows:*

0-15 years	0.5% per year	$10,865
16-50 years	1.0% per year	$21,173
51-200 years	2.0% per year	$43,460

C. Cost of gravel removal from the main channel.*

The estimated bedload deposition from 1972 to 1976 for the river section between Vedder Crossing and the upper end of Vedder Canal is 450,000 cubic yards or 112,500 cubic yards per year. For the period between 1935 to 1959 the estimated deposit at the mouth of Sumas River was 139,000 cubic yards per year. Assuming future bedload deposit at an annual rate of 100,000 cubic yards in the area below the British Columbia Hydro and Power Authority railway bridge, the cost of such work at a unit rate of $1.00 per cubic yard would amount to $100,000. per year.

D. The annual cost of maintaining the present dykes at existing standard based on the estimated phase I capital cost of $360,000 for dykes, B.P. and culverts are as follows:*

Annual Maintenance @ 3% of $360,000 = $10,800

E. Economic cost of right of way.

About half of the 34 acres of land required for dyke right of way is located on non-agricultural land. Much of the other half is located on low intensive agricultural use such as hay and pasture. Assuming an average net value of agricultural production of $120. per acre**, an intensification factor of 2% per year and using a discount rate of 7% per year, one acre of right of way land in this area is worth $2300. The economic cost of the 34 acres of right of way is equal to $78,000.

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* Prepared by the Projects Division of the Water Planning and Management Branch, Inland Waters Directorate.

** Assuming that production per acre is equivalent to 4 tons of hay which sells for $100 per ton and net income is equal to 30% of gross.

APPENDIX 3

VEDDER RIVER - AREA FLOODED AND DURATION*

AREA AND NATURE OF FLOODING		RETURN PERIOD (YRS)				
	Winter Floods	3	10	25	75	200
	Summer Floods	27	600	-	-	-
	Peak Flow (cfs)	14,800	22,100	28,000	35,300	42,500
CHILLIWACK						
a) Total area flooded (acres)						
	ponded	-	-	-	1700	7100
	overland	-	45	600	2500	3400
b) Duration of flood (days)						
	ponded	-	-	-	20	55**
	overland	-	3	4	4	5
SUMAS						
a) Total area Flooded (acres)						
	ponded	50	100	3500	10700	13800
	overland	100	400	1000	2300	1000
b) Duration of flood (days)						
	ponded	1	1	8	34	60
	overland	1	3	4	4	5

* Prepared by the Projects Division of the Water Planning and Management Branch, Inland Waters Directorate.

** East of Chilliwack Creek - Duration = 8 days
- Area flooded 1400 acres

APPENDIX 4A

AVERAGE DAMAGE - PER FOOT OF FLOODING

Data used to calculate damages to houses and contents in the Vedder River area.

Flooding Feet above Ground	DAMAGE 1975 DOLLARS *	
	SUMAS- YARROW	CHILLIWHACK SOUTH
1	2560	2560
2	5680	6390
3	7380	7950
4	9940	10370
5	11220	11790
6	11930	12500
7	13200	13770
8	13350	14060
9	13920	14630
10	14060	14770
10 +	21000	22400

* From stage-damage curves prepared for areas 10B Chilliwack and 11 and 12 Sumas and Yarrow for the year 1971 in the report, "Estimating Flood Damages in the Fraser River Basin" by A.N. Book and R. Princic, Dec. 1975 Appendix A. Table A,7.2 Page 31.
The 1971 curves were multiplied by 1.42 to update them to 1975 dollars. The 1.42 factor was obtained from the "Residential Building Construction Input Price Index, B.C. Total", found in the Statistics Canada publication Construction Price Statistics, Catalogue No. 62-007.

APPENDIX 4B

Critical Characteristics of Houses by Area[1]

Area	% of Houses in Each Class			% of Houses With Basements			Main Floor Level Above Ground (St) HWB*			HWOB**		
	A	B	C	A	B	C	A	B	C	A	B	C
SUMAS & YARROW	-	48	52	-	50	23	-	3	3	-	1	1
CHILLIWHACK	3	50	47	100	33	20	3	3	3	-	1	1

* Houses with Basements

** Houses without Basements

[1]Source: Estimating Flood Damages in the Fraser River Basin, by A. N. Book & R. Prince, Dec. 1975, Appendix A, Page 30.

APPENDIX 5A

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - SUMAS AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
14,800								
22,100								
28,000	1	8	$2560	2	$54/$18	$ 108	$ 5,120	$ 36
	2		$5680	10	$239/$78	$ 2390	$56,800	$ 780
	3		$7380	6	$239/$78	$ 1434	$44,280	$ 468
	4		$9940	8	$430/$133	$ 3440	$79,520	$ 1064
	5		$11220	4	$430/$133	$ 1720	$44,880	$ 532
			TOTAL	30		$ 9092	$230,600	$ 2880
35,300	1	34	$2560	13	$237/$72	$ 3081	$ 33,280	$ 936
	2		5680	37	420/134	15540	210,160	4958
	3		7380	20	420/134	8400	147,600	2680
	4		9940	19	612/189	11628	188,860	3591
	5		11220	22	612/189	13464	246,840	4158
	6		11930	20	656/200	13120	238,600	4000
	7		13200	25	656/200	16400	330,000	5000
	8		13350	9	656/200	5904	120,150	1800
	9		13920	9	656/200	5904	125,280	1800
	10		14060	6	656/200	3936	84,360	1200
	10 +		21900	12	656/200	7872	252,000	2400
			TOTAL	192		$105,249	$1,977,130	$32,523

APPENDIX 5A

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - SUMAS AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
	1	60	$ 2560	22	$414/$128	$ 9117	$ 56,320	$ 2816
	2		$ 5680	29	$595/189	$ 17255	$164,720	$ 5475
	3		$ 7380	20	$595/189	$ 11900	$147,600	$ 3776
	4		$ 9940	4	$784/243	$ 3136	$ 39,760	$ 973
42,500	5		$11220	10	$784/243	$ 7840	$112,200	$ 2430
	6		$11930	39	$826/256	$ 32214	$465,270	$ 9980
	7		$13200	20	$826/256	$ 16520	$264,000	$ 5120
	8		$13350	19	$826/256	$ 15694	$253,650	$ 4864
	9		$13920	25	$826/256	$ 20650	$348,000	$ 6400
	10		$14060	25	$826/256	$ 20650	$351,500	$ 6400
	10 +		$21000	62	$826/256	$ 51212	$1302,000	$15872
			TOTAL	275		$206,188	$3,505,020	$64,106

*$210 per month

APPENDIX 5B

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - YARROW AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
14,800	1	3	$2560	4	$21/$6	$84	$10,240	$ 24
			TOTAL	4		$84	$10,240	$ 24
22,100	1	4	$2560	15	$40/$8	$600	$38,400	$ 120
	2		$5680	21	$211/70	$4431	$119,280	$ 1470
	3		$7380	7	$211/70	$1480	$51,660	$ 493
			TOTAL	43		$6511	$209,340	$ 2083
28,000	2	4	$5680	150	$211/$70	$31,737	$852,000	$ 10,500
			TOTAL	150		$31,737	$852,000	$ 10,500
35,300	3	34	$7380	5	$420/134	$2100	$36,900	$ 670
	4		$9940	3	$612/189	$1836	$29,820	$ 567
	5		$11220	2	$612/189	$1224	$22,440	$ 378
	6		$11930	3	$656/200	$1968	$35,790	$ 600
			TOTAL	13		$7128	$124,950	$ 2,215
	2	4	$5680	440	$238/$70	$104,966	$2,499,200	$30,800
			TOTAL	440		$104,966	$2,499,200	$30,800
		GRAND	TOTAL	453		$112,094	$2,624,150	$33,015

APPENDIX 5B

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - YARROW AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
42,500	3	60	$7380	125	$603/$118	$73,375	$922,500	$ 14,750
	4		9940	35	$795/152	$27,825	$347,900	$ 5,320
	5		11220	1	$795/152	$ 795	$ 11,220	$ 152
	6		11930	1	$838/160	$ 838	$ 11,930	$ 160
	7		13200	1	$838/160	$ 838	$ 13,200	$ 160
	8		13350	2	$838/160	$ 1,676	$ 26,750	$ 320
	9		13920	3	$838/160	$ 2,514	$ 41,760	$ 480
			TOTAL	168		$107,861	$1,375,260	$ 21,342
	2	5	$5680	151	$217/$72	$ 32,767	$ 857,680	$ 10,872
	3		$7380	126	$217/72	$ 27,342	$ 929,880	$ 9,072
	4		$9940	21	$410/126	$ 8,610	$ 208,740	$ 2,646
			TOTAL	298		$ 68,719	$1,996,300	$ 22,590
		GRAND TOTAL		466		$176,580	$3,371,560	$ 43,932

* $210 per month

APPENDIX 5C

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - CHILLIWACK SOUTH AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
14,800								
22,100	1	4	$2560	1	$30/$10	$ 30	$ 2,560	$ 10
	2		$6390	1	$250/78	$ 250	$ 6,390	$ 78
			TOTAL	2		$ 280	$ 8,950	$ 88
28,000	1	4	$2560	9	$30/$10	$ 270	$ 23,040	$ 90
	2		$6390	7	$250/78	$ 1750	$ 44,730	$ 546
	5		$11790	2	$443/131	$ 886	$ 23,580	$ 262
	6		$12500	2	$483/141	$ 966	$ 25,000	$ 282
			TOTAL	20		$ 3872	$116,350	$ 1180
35,300	1	20	$2560	20	$150/$43	$3000	$ 51,200	$ 860
	2		$6390	41	$373/110	$15293	$261,990	$ 4,510
	3		$7950	19	$373/110	$7087	$151,050	$ 2,090
	4		$10370	6	$514/162	$3084	$ 62,220	$ 972
	5		$11790	2	$514/162	$1028	$ 23,580	$ 324
	6		$12500	3	$603/171	$1809	$ 37,500	$ 513
	7		$13770	4	$603/171	$2412	$ 55,080	$ 684
	8		$14060	0	$603/171	$ -	-	-
	9		$14630	8	$603/171	$4824	$117,040	$ 1,368
	10		$14,770	17	$603/171	$10251	$251,090	$ 2,907
	10 +		$22400	26	$603/171	$15678	$582,400	$ 4,446
			TOTAL	146		$64,466	$1,593,150	$ 18,674
	1	4	$2560	133	$30/$10	$3,990	$340,480	$ 1,330
			TOTAL	133		$3,990	$340,480	$ 1,330
		GRAND	TOTAL	279		$68,456	$1,933,630	$ 20,004

APPENDIX 5C

LOSS OF USE - DAMAGE - EXTRA FOOD COSTS - CHILLIWACK SOUTH AREA

Peak Flow (cfs)	Level of Flooding Above Ground Level	Length of Evacuation Period (DAYS)	Damage Per House	Number of Houses	Loss of Use per House * / Extra Food Cost	Total Loss of Use	Damage To Houses	Extra Food Costs
42,500	1	55	$2560	131	$453/$120	$59,343	$335,360	$ 15,720
	2		$6390	165	$675/190	$111,375	$1,054,350	$ 31,350
	3		$7950	103	$675/190	$69,525	$818,850	$ 19,570
	4		$10370	69	$866/243	$59,754	$715,530	$ 16,767
	5		$11790	43	$866/243	$37,238	$506,970	$ 10,449
	6		$12500	24	$906/253	$21,744	$300,000	$ 6,072
	7		$13770	45	$906/253	$40,770	$619,650	$ 11,385
	8		$14060	50	$906/253	$45,300	$703,000	$ 12,650
	9		$14,630	20	$906/253	$18,120	$292,600	$ 5,060
	10		$14770	23	$906/253	$20,838	$339,710	$ 5,819
	10 +		$22400	106	$906/253	$96,036	$2,374,440	$ 26,818
			TOTAL	779		$580,043	$8,060,420	$ 161,660
	1	5	$2560	170	$38/$11	$ 6,460	$ 435,200	$ 1,870
			TOTAL	170		$ 6,460	$ 435,200	$ 1,870
		GRAND	TOTAL	949		$586,503	$8,495,620	$ 163,530

* $224 per month

APPENDIX 6A

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 (e.g. Buckerfields), and variety stores.
6. Small Retail Trade - jewellers, stationery, music stores, photographic, florists, needlework, sporting goods, book shops, fabric, bicycle and mower stores, etc.
7. Mechanical Retail - machine shop, (i.e. wreckers, parts, body shop, retail - air cooled engines).
8. Building Supplies - lumber yard (when associated with "do-it-yourself" type stores), sash and door, glass - often included mirrors.
9. Personal Services - beauty salon, barbers, laundromat, dry cleaners, and funeral homes.
10. Hotel-Motel Services - hotels, motels, autocourts.
11. Transportation and Communication Services - printing, newspaper, publishers trucking and freight services.
12. Institutional Aspects - Courthouse, post office, hospital.
13. Food Services - restaurant, drive-in, coffee shop, cafe, delicatessen, specialty foods, butchers, bakers, and similar.

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

APPENDIX 6 B

AVERAGE DOLLAR DAMAGE PER SQUARE FOOT OF COMMERCIAL BUILDING AREA AT ONE FOOT FLOOD DEPTH INTERVALS*

CATEGORY OF ESTABLISHMENT	Cumulative Damage ($) per foot of Flooding									
	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
1. Petroleum Services	2.6	3.5	4.2	5.0	5.1	5.1	5.1	5.1	5.1	5.1
2. Financial Services	2.3	3.2	5.3	5.8	5.9	5.9	5.9	5.9	5.9	5.9
3. Grocery Retail	2.3	5.6	7.5	8.5	9.2	9.8	10.1	10.1	10.1	10.1
4. Hardware	1.9	3.1	5.2	6.4	7.6	8.7	9.9	10.3	10.3	10.3
5. General Stores	2.2	4.5	5.9	7.0	8.1	9.2	10.0	10.1	10.1	10.2
6. Small Retail Trade	3.9	6.5	9.5	14.4	17.3	20.0	21.1	21.5	21.5	21.5
7. Mechanical Retail	2.1	3.1	4.7	6.6	8.0	9.0	10.1	10.1	10.1	10.1
8. Building Supplies	4.4	4.8	5.3	5.7	6.2	6.7	7.2	7.3	7.3	7.3
9. Personal Services	3.3	6.6	9.7	10.7	11.3	11.4	11.4	11.4	11.4	11.4
10. Hotel-Motel Services	2.3	2.8	3.5	4.3	4.5	4.6	4.6	4.6	4.6	4.6
11. Transp & Communic. Services	3.4	5.5	7.6	9.6	11.5	13.3	13.3	13.3	13.3	13.3
12. Institutional Services	1.8	5.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8
13. Food Services	1.7	3.7	7.0	9.6	10.5	10.5	11.5	11.5	11.5	11.5

SOURCE: Field Survey, Lower Fraser 1971

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

APPENDIX 7

Average Unit Stage Damage Estimates for Selected Industrial Categories*

INDUSTRIAL CATEGORY NUMBER	Damage per Acre of Land Used ($1000)[a] Flood Depth in Feet[b] 1'	2'	3'	4'	5'	6'	Acres of Land Used per Employee	Acres of Land Used per Sq. Ft. of Plant Area
17. Fruit and Vegetable Canners	47	50	55	391	393	395	.0284	.00005
51. Misc. Wood Industries	1	1	6	-	-	-	.6725	.00020
72. Other Metal Fabricating	6	12	12	13	19	22	.0546	.00010

a **Note:** These figures are presented only to illustrate the relative magnitudes of the damages estimated for various industries; their usefulness is severely limited due to extreme fluctuations in changes observed from firm to firm.

b Flood Depth refers to feet above floor level except for industry No. 48 in which case it refers to feet above ground level.

* From report "Estimating Flood Damages in the Fraser River Basin", by A.N. Book and R. Princic, page 50 of the appendix.

APPENDIX 8A

Average per Acre Crop Damage - Dyking District

Sumas (Including Yarrow) - Summer Floods

Type of Crop or Crop Group	Avg. per * Acre Dmg. ($)	Tot. Acres in Crop (A)	% ea. Crop Total Acres (%)	Wgt. Value Each Crop ($)
A. Perennial Crops				
1) Tame Hay, Legume & other Fodder Crops	180	8,093	38.2	68.76
2) Pasture	160	5,375	25.4	40.64
3) Strawberries	2050	30	.1	2.05
4) Raspberries	2850	423	2.0	57.00
5) Other Small Fruit	1500	27	.1	1.50
6) Tree Fruit	2900	68	.3	8.70
7) Nursery Products				
a)Christmas Tree	2400	-	-	-
b)Mixed Varieties	5000	87	.4	20.00
8) Hops	2600	-	-	-
B. Annual Crops				
1) Greenhouse Products	43,560	.0344	-	.07
2) Grain Crops	125	513	2.4	3.00
3) Oats for Hay	115	682	3.2	3.68
4) Corn for Ensilage	270	401	1.9	5.13
C. Vegetables				
1) Potatoes	600	-	-	-
2) Green Beans	270	400	1.9	5.13
3) Wax Beans	240	65	.3	.72
4) Broccoli	400	400	1.9	7.60
5) BrusselSprouts	450	150	.7	3.15
6) Cauliflower	680	143	.7	4.76
7) Sweet Corn	150	2657	12.6	18.90
8) Peas	200	1650	7.8	15.60
9) Rhubarb (Field)	1300	-	-	-
TOTAL		21,164	100.00	266.39*

* Average per acre crop damage is in 1971 dollars. The final value used in the report was updated to $444.87 (1975 dollars) by multiplying by price index 1.67. This price index was obtained from Catalogue No. 62-003, Statistics Canada, Farm Prices of Agricultural Products - B.C.

APPENDIX 8B

Average per Acre Crop Damage - Dyking District

Chilliwhack - Summer Floods

Type of Crop or Crop Group	Avg. Per* Acre Dmg. ($)	Tot. Acres in Crop (A)	% ea. Crop Tot. Acres (%)	Wgt. Value Each Crop ($)
A. Perennial Crops				
1) Tame Hay, Legume & Other Fodder Crops	180	9,067	37.7	67.86
2) Pasture	160	9,019	37.5	60.00
3) Strawberries	2050	10	.04	.82
4) Raspberries	2850	388	1.6	45.60
5) Other Small Fruits	1500	18	.07	1.05
6) Tree Fruit	2900	160	.7	20.30
7) Nursery Products				
a) Christmas Trees	2400	30	.12	2.88
b) Mixed Varieties	5000	5	.02	1.00
8) Hops	2600	750	3.1	80.60
B. Annual Crops				
1) Greenhouse Products	43,560	1.17	-	2.12
2) Grain Crops	125	448	1.9	2.37
3) Oats for Hay	115	689	2.9	3.33
4) Corn for Ensilage	270	1,037	4.3	11.61
C. Vegetables				
1) Potatoes	600	300	1.2	7.20
2) Green Beans	270	150	.6	1.62
3) Wax Beans	240	-	-	-
4) Broccoli	400	75	.3	1.20
5) Brussel Sprouts	450	-	-	-
6) Cauliflower	680	20	.1	.68
7) Sweet Corn	150	524	2.2	3.30
8) Peas	200	1,350	5.6	11.20
9) Rhubarb(Field)	1,300	13	.05	.65
TOTAL		24,053	100.00	325.39*

* Average per acre crop damage is in 1971 dollars. The final value used in the report was updated to $543.40 (1975 dollars) by multiplying by price index 1.67 This price index was obtained from Catalogue No. 62-003, Statistics Canada Farm Prices of Agricultural Products - B.C.

APPENDIX 8C

Average per Acre Crop Damage * - Dyking District

Sumas (Including Yarrow) - Winter Floods

Type of Crop of Crop Group	Avg. per Acre Dmg ($) **	Tot. Acres in Crop (A)	% ea. Crop Tot. Acres (%)	Wgt. Value Ea. Crop ($)
A. Perennial Crops				
1) Tame Hay, Legumes & Other Fodder Crops	180	8,093	38.2	68.76
2) Pasture	160	5,375	25.4	40.64
3) Strawberries	2,050	30	.1	2.05
4) Raspberries	2,850	423	2.0	57.00
5) Other Small Fruit	1,500	27	.1	1.50
6) Tree Fruit	2,900	68	.3	8.70
7) Nursery Products				
a) Christmas Trees	2,400	-	-	-
b) Mixed Varieties	5,000	87	.4	20.00
8) Hops	2,600	-	-	-
B. Annual Crops	-	7,061	33.4	-
TOTAL		21,164	100.00	198.65 **

* (1) Damages for 75 & 200 year return floods are 100% of crop damages.

(2) Damages for 20 year return floods are 20% of crop damages.

(3) Damages for 10 year return floods or lower are 0% of crop damages.

** Average per acre crop damage is in 1971 dollars. The final value used in the report was updated to $332 (1975 dollars) by multiplying by price index 1.67. This price index was obtained from Catalogue No. 62-003, Statistics Canada, Farm Prices of Agricultural products, B.C.

APPENDIX 8D

Average per Acre Crop Damage* - Dyking District

Chilliwhack - Winter Floods

Type of Crop or Crop Group	Avg. Per ** Acre Dmg.	Tot. Acres in Crop	% ea. Crop Tot. Acres	Wgt. Value Each Crop
A. Perennial Crops				
1) Tame Hay, Legumes & Other Fodder Crops	180	9,067	37.7	67.86
2) Pasture	160	9,019	37.5	60.00
3) Strawberries	2,050	10	.04	.82
4) Raspberries	2,850	388	1.6	45.60
5) Other Small Fruit	1,500	18	.07	1.05
6) Tree Fruit	2,900	160	.7	20.30
7) Nursery Products				
a) Christmas Trees	2,400	30	.12	2.88
b) Mixed Varieties	5,000	5	.02	1.00
8) Hops	2,600	750	3.1	80.60
B. Annual Crops		4,606	19.1	-
TOTAL		24,053	100.00	280.11**

* (1) Damages for 75 & 100 year return floods are 100% of crop damages

(2) Damages for 20 year return floods or lower are 0% of crop damages.

** Average per acre crop damage is in 1971 dollars. The final value used in the report was updated to $468 (1975 dollars) by multiplying by price index 1.67. This price index was obtained from Catalogue No. 62-003, Statistics Canada, Farm Prices of Agricultural Products, B.C.

APPENDIX 9A

AGRICULTURAL DAMAGES

Dyking Area - Sumas-Yarrow (Winter Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(1) Total Area Flooded					
Ponded 0 - 5 Days	50A	100A		700A	8850A
6 - 10 Days			2800A	700A	850A
11 - 18 Days				1400A	1600A
19+ Days				7900A	10500A
Total Ponded	50A	100A	2800A	10700A	13800A
Overland	100A	400A	1000A	2300A	1000A
(2) Crop Damages					
Area in Crops					
Ponded 0 - 5 Days	40A	85A		595A	722A
(Area X .85) 6 - 10 Days			2380A	595A	722A
11 - 18 Days				1190A	1360A
19+ Days				6715A	8925A
Total Ponded	40A	85A	2380A	9095A	11729A
Overland (Area X .70)	70A	280A	700A	1610A	700A
Per Acre Crop Damage					
Ponded 0 - 5 Days					
6 - 10 Days			$66	$66	$66
11 - 18 Days				$166	$166
19 + Days				$332	$332
Overland					
Total Crop Damages					
Ponded 0 - 5 Days					
6 - 10 Days			$157,080	$39,270	$47,652
11 - 18 Days				$197,540	$225,760
19+ Days				$2229,380	$2963,100
Total Ponded			$157,080	$2466,190	$3236,512
Overland					
(3) Duration of Flood (Days)					
Ponded (Maximum)	3	4	8	34	60
Overland (Maximum)	3	4	4	4	5
(4) Dairy Production Losses					

APPENDIX 9A (Cont'd)

Agricultural Damages

Dyking Area - Sumas - Yarrow (Winter Flood) Con't.

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
Dairy Cows in Flood Area					
Ponded (.35 cows/Crop Acre)	-	30	833	3183	4105
Overland	-	98	245	563	245
TOTAL		118	1078	3746	4350
Losses per milk cow					
Ponded ($)	-	132	147	248	350
Overland ($)	-	132	132	132	136
Total Daily Losses					
Ponded ($)	-	3960	122,451	789,384	1,436,750
Overland ($)	-	12,936	32,340	74,316	33,320
TOTAL $		16,896	154,791	863,700	1,470,070
(5) Hog Production Losses					
Hog in Flood Area	-	1,105	1,105	1,105	1,105
Losses Per Hog	-	$16.66	$16.66	$16.66	$16.66
Total Hog Losses		$18409	$18409	$18409	$18409
(6) Turkey Production Losses					
Turkeys in Flood Area					
Heavies	-	-	5063	7625	7625
Lights	-	-	581	875	875
Total Losses					
Heavies $4.64	-	-	$23492	$35,380	$35,380
Lights $2.00	-	-	$1,162	$ 1,750	$ 1,750
TOTAL			$24654	$37,130	$37,130

APPENDIX 9A (Cont'd)

AGRICULTURAL DAMAGES

Dyking Area - Sumas - Yarrow (Winter Flood) Cont'd

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
7) Broiler Production Losses					
Annual Production in Flood Area	-	-	93,800	229,800	229,800
Weekly Production in Flood Area	-	-	1,800	4,420	4,420
Weeks of Production Lost			3	7	11
Total Birds Lost by Flood	-	-	3,600	20,626	32,413
Poultry Losses ($1.05 per bird)	-	-	$3,780	$21,657	$34,034
8) Losses in Egg Production					
Annual Production in Flood Area	-	-	8,696cs	29,310c	30,403 c
Monthly Production in Flood Area	-	-	725c	2,443c	2,534 c
Loss of Production (Months)	-	-	3	6	6
Total Losses by Flood (Cases'c')	-	-	2,175	14,658	15,204
Egg Production Losses ($6.60/case)	-	-	$14,355	$96,743	$100,346
9) Livestock Evacuation Costs					
Dairy Cattle					
No. of Dairy Cows	-	236	2,156	7,492	8,700
Cost of Evacuation ($7.60/cow)	-	$1,794	$16,386	$56,939	$66,120
Hogs					
No. of Hogs	-	1,105	1,105	1,105	1,105
Cost of Evacuation ($1.25/hog)		$1,381	$1,381	$1,381	$1,381
TOTAL EVACUATION		$3,175	$17,767	$58,320	$67,501
10) Damage to Milking Equipment					
No. of Producing Dairy Cows	-	118	1,078	3,746	4,350
Losses by flood ($28 per cow)		$3,304	$30,184	$104,888	$121,500
11) Extra Feed Costs					
Acreage in Crops					
Grains & Pasture	-	-	148	1,932	2,530
Tame Hay	-	-	182	2,838	3,807

APPENDIX 9A (Cont'd)

AGRICULTURAL DAMAGES

Dyking Area - Sumas Yarrow (Winter Flood) Cont'd.

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
Hay Equivalents					
Grains & Pastures (3T./acre)	-	-	444	5,796	7,590
Tame Hay (4T./acre)	-	-	728	11,352	15,228
TOTAL			1,172	17,148	22,818
Extra Cost of Feed @ $44/T.	-	-	$51,568	$754,512	$1,003,992

APPENDIX 9B

AGRICULTURAL DAMAGES

Dyking Area - Sumas-Yarrow (Summer Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(1) Total Area Flooded					
Ponded	50A	100A	2800A	10700A	13800
Overland	100A	400A	1000A	2300A	1000
(2) Crop Damages					
Area in Crops					
Ponded (Area x .85)	40A	85A	2380A	9095A	11729A
Overland (Area x .70)	70A	280A	700A	1610A	700A
Per Acre Crop Damage					
Ponded	-	$445	$445	$445	$445
Overland	-	-	-	-	-
Total Crop Damage					
Ponded		$37,825	$1,059,100	$4,047,275	$5,219,405
Overland		-	-	-	-
TOTAL		$37,825	$1,059,100	$4,047,275	$5,219,405

Damages to other agricultural categories are similar to Sumas-Yarrow (Winter Floods).

APPENDIX 9C

AGRICULTURAL DAMAGES

Dyking Area - Chilliwhack South (Winter Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(1) Total Area Flooded					
Ponded 0 - 5 Days	-	-	-	450A	500A
6 - 10 Days	-	-	-	450A	500A
11 - 18 Days	-	-	-	500A	700A
19+ Days	-	-	-	300A	4000A
Total Ponded	-	-	-	1700A	5700A
East of Chilliwack Creek	-	-	-	-	1400A
Overland	-	45A	600A	2500A	3400A
(2) Crop Damage					
Area in Crops					
Ponded 0 - 5 Days	-	-	-	382A	425A
(Area X.85) 6 - 10 Days	-	-	-	382A	425A
11 - 18 Days	-	-	-	425A	595A
19+ Days	-	-	-	255A	3400A
Total Ponded	-	-	-	1444A	4845A
East of Chilliwack Creek	-	-	-	-	1190A
Overland (Area X.70)	-	31A	420A	1750A	2380A
Per Acre Crop Damage					
Ponded 0 - 5 Days	-	-	-	-	-
6 - 10 Days	-	-	-	$ 94	$ 94
11 - 18 Days	-	-	-	$234	$234
19+ Days	-	-	-	$468	$468
East of Chilliwhack Creek	-	-	-	-	$234
Overland	-	-	-	-	-
Total Crop Damages					
Ponded 0 - 5 Days	-	-	-	-	-
6 - 10 Days	-	-	-	$35,908	$39,950
11 - 18 Days	-	-	-	$99,450	$139,230
19+ Days	-	-	-	$119,340	$1,591,200
East of Chilliwhack Creek	-	-	-	-	$278,460
Overland	-	-	-	-	-
Total	-	-	-	$254,698	$2,048,840

APPENDIX 9C (Cont'd)

AGRICULTURAL DAMAGES

Dyking Area - Chilliwhack South (Winter Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(3) Duration of Flood (Days)					
Ponded (Maximum)	-	-	-	20	55
East of Chilliwhack Creek	-	-	-	-	8
Overland	3	4	4	4	5
(4) Dairy Production Losses					
Dairy Cows in Flood Area					
Ponded (.46 cows/Crop Acre)	-	-	-	665	2230
East of Chilliwhack Creek	-	-	-	-	547
Overland	-	14	193	805	1095
Losses Per Milk Cow					
Ponded	-	-	-	$194	$330
East of Chilliwhack Creek	-	-	-	-	$148
Overland	-	$132	$132	$132	$136
Total Dairy Losses					
Ponded	-	-	-	$129,010	$735,900
East of Chilliwhack Creek	-	-	-	-	$ 80,956
Overland	-	$1,848	$25,476	$106,260	$ 144,540
Total	-	$1,848	$25,476	$235,270	$961,396
(5) Beef Cattle Losses					
Beef Cattle in Flood Area (.021 Per Acre					
Ponded	-	-	-	30	102
East of Chilliwhack Creek	-	-	-	-	25
Overland	-	-	9	37	50
Losses Per Animal					
Ponded	-	-	-	$22	$45
East of Chilliwhack Creek	-	-	-	-	$14
Overland	-	-	$11.70	$11.70	$12.35
Total Beef Cattle Losses					
Ponded	-	-	-	$660	$4590
East of Chilliwhack Creek	-	-	-	-	$350
Overland	-	-	$105	$433	$ 618
TOTAL	-	-	$105	$1093	$5558

APPENDIX 9C (Cont'd)

AGRICULTURAL DAMAGES

Dyking Area - Chilliwhack South (Winter Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(6) Hog Losses					
Hogs in Flood Area	-	-	-	-	160
Losses Per Hog	-	-	-	-	$ 16.66
Total Hog Losses	-	-	-	-	$ 2666
(7) Broiler Production Losses					
Annual Production in Flood Area	-	-	-	24,000	178,400
Weekly Production in Flood Area	-	-	-	462	3430
Production Loss in Flood Area (Weekly Production X.667)	-	-	-	308	2287
Weeks of Production Lost	-	-	-	5	10
Total Birds Lost by Flood				1540	22,867
Poultry Losses ($1.05 per bird)				$1617	$24,010
(8) Losses in Egg Production					
Annual Production in Flood Area (Cases)	-	-	3133	27,733	40,750
Monthly Production in Flood Area (Cases)	-	-	261	2,311	3,396
Months of Production Lost	-	-	3	6	6
Total Losses by Flood (Cases)	-	-	783	13,866	20,376
Egg Production Losses ($6.60/ Case)	-	-	$5,168	$91,516	$ 134,482
(9) Livestock Evacuation Losts					
Dairy Cattle					
No. of Dairy Cows	-	28	386	2940	7744
Cost of Evacuation ($7.60 per cow)		$213	$ 2934	$ 22,344	$58,854
Beef Cattle					
No. of Beef Cattle	-	-	9	67	177
Cost of Evacuation ($2.00 per cow)	-	-	$18	$134	$ 354
Hogs					
No. of Hogs	-	-	-	-	160
Cost of Evacuation ($1.25 per hog)	-	-	-	-	$200
Total Evacuation	-	$213	$2,952	$22,478	$59,408

APPENDIX 9C (Cont'd)

AGRICULTURAL DAMAGES

Dyking Area - Chilliwhack South (Winter Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(10) Damage to Milking Equipment					
No. of Producing Cows	-	14	193	1470	3872
Losses by Flood ($28 per cow)		$392	$5404	$41,160	$108,416
(11) Extra Feed Cost					
Acreage in Crops					
Grains and Pasture	-	-	-	400	1,666
Tame Hay	-	-	-	398	1,657
Hay Equivalents					
Grains and Pasture (3T. per Acre)	-	-	-	1200	4998
Tame Hay (4T. per Acre)	-	-	-	1592	6628
Total				2792	11626
Extra Cost of Feed @ $44 per ton	-	-	-	$122,848	$511,632

APPENDIX 9D

AGRICULTURAL DAMAGES

Dyking Area - Chilliwhack South (Summer Flood)

	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(1) Total Area Flooded					
Ponded	-	-	-	1700A	5700A
East of Chilliwhack Cr.	-	-	-	-	1400A
Overland	-	45A	600A	2500A	3400A
(2) Crop Damage					
Area in Crops					
Ponded (Area x .85)	-	-	-	1444A	4845A
East of Chilliwhack Cr. (Area x .85)	-	-	-	-	1190A
Overland (Area x .70)	-	31A	420A	1750A	2380A
Per Acre Crop Damage					
Ponded	-	-	-	$543	$543
East of Chilliwhack Cr.	-	-	-	-	$543
Overland	-	-	-	-	-
Total Crop Damage					
Ponded	-	-	-	$784,092	$2,630,835
East of Chilliwhack Cr.	-	-	-	-	$ 646,170
Overland	-	-	-	-	-
Total $	-	-	-	$784,092	$3,277,005

Damages to other agricultural categories are similar to Chilliwhack South (Winter Flood).

APPENDIX 10

Damage to Roads

SUMAS - YARROW

Peak Flow (cfs)	Flood Duration	Damage Per Mile	Total Miles Flooded	Road Damages
14,800	3 Days	$ 3,900	.3	$1170
22,100	3 Days	3,900	2.5	9,750
	8 Days	17,700	.3	5,310
				$15,060
28,000	4 Days	3,900	4.7	18,330
	8 Days	17,700	10.3	182,310
				$200,640
35,300	4 Days	3,900	12.4	48,360
	34 Days	17,700	45.1	798,270
				$846,630
42,500	5 Days	3,900	6.00	23,400
	60 Days	17,700	73.6	1,302,720
				$1,326,120

CHILLIWHACK SOUTH

14,800				NIL
22,100				NIL
28,000	4 Days	$3,900	.6	$ 2,340
35,300	4 Days	$3,900	7.8	30,420
	20 Days	$17,700	5.9	104,430
				$134,850
42,500	5 Days	3,900	12.0	46,800
	55 Days	17,700	29.3	518,610
				$565,410

APPENDIX 11

Damage to Railways

SUMAS - YARROW

Peak Flow (cfs)	Breaching	Damage Per Foot	Size of Breach	Railway Damage
14,800	-	-	-	-
22,100	-	-	-	-
28,000	Major	$170	180 ft.	$30,600
35,300	Major	$170	200 ft.	$34,000
	Minor	$100	150 ft.	$15,000
				$49,000
42,500	Major	$170	250 ft.	$42,500
	Minor	$100	250 ft.	$25,000
				$67,500

CHILLIWACK SOUTH

14,800	-	-	-	-
22,100	-	-	-	-
28,000	Minor	$100	100 ft.	$10,000
35,300	Major	$170	150 ft.	$25,500
	Minor	$100	150 ft.	$15,000
				$40,500
42,500	Major	$170	200 ft.	$34,000
	Minor	$100	500 ft.	$50,000
				$84,000

APPENDIX 12

Damage to Utilities

UTILITY	Sumas - Yarrow Damage in 1975 Dollars Peak Flow (cfs) 14,800	22,100	28,000	35,300	42,500	Chilliwhack South Damage in 1975 Dollars Peak Flow (cfs) 14,800	22,100	28,000	35,300	42,000
(1) Sewage Systems	-	-	9,600	41,200	63,200	-	-	-	4,300	31,800
(2) Water Supply Systems	-	1,050	7,980	27,300	31,080	-	-	1,260	8,820	22,050
(3) Electrical Installations	-	-	-	-	120,000	-	-	-	-	120,000
(4) Gas Distribution Systems	-	945	4,050	14,490	16,650	-	-	450	6,300	21,375
(5) Telephone Installations	-	-	-	-	447,000	-	-	-	-	-
TOTAL	-	1,995	21,630	82,990	677,930	-	-	1,710	19,420	195,225

APPENDIX 13

Damage to Schools *

Table showing the percentage flood damages at various levels of flooding used to calculate school damages.

Flood Depth Above Floor	Per Cent of Market Value Damaged
1	18
2	37
3	44
4	50
5	58
6	65
7	71
8	77
9	86
10	95

Source: Robertson, 1963: Table D-1

Table showing the average market values (1971 + 1975) of schools by number of classrooms and type of school (primary, secondary) in the Lower Mainland.

Primary Schools			Secondary Schools				
No. of Classrooms	Market Value Per Classroom		No. of Classrooms	Market Value Per Classroom			
				Jr. Secondary		Sr. Secondary	
	$ 1971	$1975**		$ 1971	$ 1975**	$ 1971	$1975**
4	45,000	63,900	10	80,000	113,600	96,000	136,300
8	37,000	52,500	13	71,000	100,800	85,000	120,700
9	43,000	61,000	17+	65,000	92,300	78,000	110,700
16	37,000	52,500					
23	31,000	44,000					

* Information from report "Estimating Flood Damages in the Fraser River Basin" by A.N. Book and R. Princic, Dec. 1975; page 97.

** The 1975 values were obtained by mutiplying the 1971 values by 1.42. The figure 1.42 represents the change in the Residential Building Construction Input Price Index, B.C. Total, found in the Statistics Canada Catalogue No. 62 - 007.

DAMAGE TO SCHOOLS

NO.	NAME OF SCHOOL	TYPE OF SCHOOL	MAIN FLOOR ABOVE GROUND (ft.)	NO. OF CLASSROOMS		DEPTH OF FLOODING			MARKET VALUE PER CLASS ROOM OF AFFECTED CLASSROOM	DAMAGE ($1975) (000's)		
				TOTAL	GROUND FLOOR	PEAK FLOW (1000 cfs) 28.0	35.3	42.5		PEAK FLOW (1000 cfs) 28.0	35.3	42.5
SUMAS-YARROW												
1.	Yarrow	Elem.Jun.	-2	24	8	-	4	5	$42,600	-	170.4	197.7
2.	John Calvin	Elem.	-1	12	6	-	3	5	$56,800	-	150.0	197.7
3.	Barrowtown	Elem.	1	5	5	-	2	7	$61,000	-	112.9	217.3
									TOTAL	-	433.3	612.7
CHILLIWHACK SOUTH												
1.	Greendale	Elem.	-2	12	6	-	-	10	$56,800	-	-	323.8
2.	Chadsey	Elem.	1	4	4	-	4	13	63,900	-	127.8	255.6
3.	Rundle Jr.Sec.	Jun.Sec.	0	16	16	-	-	1	95,100	-	-	274.1
4.	Fraser Valley Col.	Jr. Col.	1	24	24	-	-	1	92,300	-	-	39.90
									TOTAL	-	127.8	1252.5

APPENDIX 14

DAMAGE TO BARNS AND OUTBUILDINGS

NUMBER OF BARNS AND OUTBUILDINGS FLOODED

AREA	PEAK FLOW (cfs)									
	14,800		22,100		28,000		35,300		42,500	
	B*	O**	B	O	B	O	B	O	B	O
YARROW	4	13	37	85	92	240	182	580	182	580
SUMAS	0	0	0	0	49	53	237	309	339	431
TOTAL	4	13	37	85	141	293	419	889	521	1011
CHILLIWHACK SOUTH	-	-	-	-	11	15	210	420	710	1425
GRAND TOTAL	4	13	37	85	152	308	629	1309	1231	2436

* Barns ** Outbuildings

DAMAGE TO BARNS AND OUTBUILDINGS

AREA	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
(1) SUMAS-YARROW					
(a) Barns ($200 per Barn)	$ 800	$ 7400	$ 28,200	$ 83,800	$ 104,200
(b) Outbuildings ($70 per Building)	$910	$ 5950	$ 20,510	$ 62,230	$ 70,770
TOTAL	$1710	$13,350	$ 48,710	$146,030	$ 174,970
(2) CHILLIWHACK SOUTH					
(a) Barns ($200 per Barn)	-	-	$ 2,200	$ 42,000	$ 142,000
(b) Outbuildings ($70 per Building)	-	-	$ 1,050	$ 29,400	$ 99,750
TOTAL	-	-	$ 3,250	$ 71,400	$ 241,750

APPENDIX 15

NUMBER OF PEOPLE EVACUATED

AREA	Persons Per Family	PEAK FLOW (cfs)									
		14,800		22,100		28,000		35,300		42,500	
		H*	P**	H	P	H	P	H	P	H	P
SUMAS	3.6	-	-	-	-	30	108	192	691	275	990
YARROW	3.8	4	15	43	163	150	570	453	1721	466	1771
TOTAL	-	4	15	43	163	180	678	645	2412	741	2761
CHILLIWHACK SOUTH	3.8	-	-	2	8	20	76	279	1060	949	3606
GRAND TOTAL	-	4	15	45	171	200	754	924	3472	1690	6367

* Houses **People

COST OF EVACUATING PEOPLE

AREA	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
SUMAS ($1.63/Person)	-	-	$176.04	$1,126.33	$ 1,613.70
YARROW ($1.63 /Person)	$ 24.45	$265.69	$929.10	$2,805.23	$ 2,886.73
TOTAL	$ 24.45	$265.69	$1105.14	$3,931.56	$ 4,500.43
CHILLIWHACK SOUTH ($1.63/Person)	-	$13.04	$123.88	$1,727.8	$ 5,877.78

APPENDIX 16

Secondary Income Losses

(1) Backward Linkages

AREA	Loss Per Acre		PEAK FLOW (cfs) 14,800		22,100		28,000		35,300		42,500	
	W*	S**	W	S	W	S	W	S	W	S	W	S
	$	$				$	$		$		$	
SUMAS- YARROW	1.30	36.73	-	-	-	3122	3094	-	11,050	-	14,309	-
CHILLIWHACK SOUTH	2.32	14.71	-	-	-	-	-	-	2464	-	13,015	-
TOTAL												

* Winter ** Summer

(2) Forward Linkages

AREA	Loss Per Acre		PEAK FLOW (cfs) 14,800		22,100		28,000		35,300		42,500	
	W*	S**	W	S	W	S	W	S	W	S	W	S
	$	$				$	$		$		$	
SUMAS - YARROW	49	540	-	-	-	45900	21420	-	334,205	-	438,723	-
CHILLIWHACK SOUTH	97	540	-	-	-	-	-	-	52,759	-	389,989	-
TOTAL	-	-										

*Winter **Summer

APPENDIX 17

Secondary Income Losses

(a) Egg Processing

AREA	PEAK FLOW (cfs)				
	14,800	22,100	28,000	35,300	42,500
SUMAS-YARROW	-	-	$3067	$20,668	$21,438
CHILLIWHACK SOUTH	-	-	$1104	$19,551	$28,730
TOTAL	-	-	$4,171	$40,219	$50,168

(b) Dairying

AREA	PEAK FLOW (cfs)									
	14,800		22,100		28,000		35,300		42,500	
	Loss Per Cow	Total Loss	Loss Per Cow	Total Loss	Loss Per Cow	Total Loss	Loss Per Cow	Total Loss	Loss Per Cow	Total Loss
SUMAS-YARROW			$	$	$	$	$	$	$	$
Ponded	-	-	46	1380	52	43,316	87	276,921	112	459,760
Overland	-	-	46	4508	46	11,270	46	25,898	47	11,515
TOTAL				5888		54,586		302,819		471,275
CHILLIWHACK SOUTH										
Ponded	-	-	-	-	-	-	68	45,220	116	258,868
East of Chil. Cr.	-	-	-	-	-	-	-	-	52	28,444
Overland	-	-	46	644	46	8878	46	37,030	47	51,465
				644		8878		82,250		338,777

APPENDIX 18

Price Indexes Used in the Study

Damage Category	Source of Index	% Price Change 1971 - 75
(1) Residential and Content	Statistics Canada, Construction Price Statistics, Residential Building Construction Input Price Indexes, B.C. Total, Catalogue No. 62-007, P.18.	42.0
(2) Loss of Use of Dwelling	Not required	-
(3) Extra Food Costs	Statistics Canada, Prices and Prices Indexes, Consumer Price Indexes, Food Regional Cities, Vancouver, Catalogue No. 62-002, P. 57.	65.6
(4) Commercial	Statistics Canada, Construction Price Statistics, Non-Residential Construction Price Indexes, Input, Index, Total, Catalogue No. 62-007 P. 24.	48.1
(5) Industrial	Statistics Canada Construction Price Statistics, Non-Residential Construction Price Indexes, Input Index, Total, Catalogue No. 62-007, P. 24.	48.1
(6) Crop Damage and Income Loss	Statistics Canada, Farm Prices of Agricultural Products, B.C., Catalogue No. 62-003.	67.2
(7) Dairy Production	Statistics Canada, Dairy Statistics, Average Farm Value of Milk sold by Farmers, Average Price of Total Sales, B.C. Total, Catalogue No. 23-201.	92.9
(8) Beef Cattle Production	Statistics Canada, Livestock and Animal Products Statistics, Average Price of Steer, Dressed at Principal Stockyards, Annual, Calgary, Catalogue No. 23-003.	35.1
(9) Hog Production	Statistics Canada, Livestock and Animal Products Statistics, Average Price of Hogs, Dressed at Principal Public Stockyards, Annual, Calgary, Catalogue No. 23-003.	228.4
(10) Turkey Production	Agriculture Canada, Poultry Market Review-Annual, Turkeys-Broilers and Toms, Average Price to Producers, B.C.	61.0
(11) Broiler Production	Agriculture Canada, Poultry Market Review - Annual, Chickens - Under 5 Pounds, Average Price to Producers, B.C.	65.9
(12) Egg Production	Agriculture Canada, Poultry Market Review - Annual, Eggs - All Grades, Weighted Price to Producers, B.C.	78.2

APPENDIX 18 (Cont.)

Price Indexes Used in the Study

Damage Category	Source of Index	% Price Change 1971 - 75
(13) Livestock Evacuation	Statistics Canada, Prices and Price Indexes, Consumer Price Indexes, Regional Cities, Transportation, Vancouver, Catalogue No. 62-002.	26.6
(14) Milking Equipment	Statistics Canada, Farm Input Price Index, Power Machinery - Western Canada, Catalogue No. 62-004.	38.5
(15) Extra Feed	Statistics Canada, Farm Input Price Index, Feed-Western Canada, Catalogue No. 62-004.	121.8
(16) Roads*	Statistics Canada, Construction Price Statistics, Highway Construction Price Index, B.C. Total, Catalogue No. 62-007.	97.4
(17) Sewage Systems	Statistics Canada, Employment Earnings and Hours by Industry for Urban Areas, Vancouver, Average Weekly Earnings all Employees (Construction SIC.400-421), Catalogue No. 72-002.	49.3
(18) Water Supply Systems	Statistics Canada, Employment Earnings and Hours by Industry for Urban Areas, Vancouver, Average Weekly Earnings All Employee (Construction SIC 400-421) Catalogue No. 72-002.	49.3
(19) Electrical Instalations	Statistics Canada Construction Price Statistics Price Indexes of Electric Utility Construction, Transformer Stations - Total, Catalogue No. 62-007.	57.4
(20) Gas Distribution	Statistics Canada Employment Earnings and Hours, Employment Earnings and hours by Industry for Urban Areas, Vancouver, Average Weekly Earnings All Employees (Construction SIC 400-421) Catalogue No. 72-002.	49.3
(21) Telephone Facilities	Statistics Canada, Employment Earnings and Hours, Employment Earnings and Hours by Industry for Urban Areas, Vancouver, Average Weekly Earnings All Employees (Construction SIC 400-421), Catalogue No. 72-002.	49.3
(22) Schools	Statistics Canada, Construction Price Statistics, Residential Building Construction Input Price Indexes, B.C. Total, Catalogue No. 62-007, P. 18.	42.0

APPENDIX 18 (Cont.)

Price Indexes Used in the Study

Damage Category	Source of Index	% Price Change 1971 - 75
(23) Barns and Out-Buildings	Statistics Canada, Farm Input Price Index Building Repairs, Catalogue 62-004.	51.7
(24) Evacuating People	Statistics Canada, Prices and Price Indexes Consumer Price Indexes, Regional Cities, Vancouver, Transportation, Catalogue No. 62-002.	26.6
(25) Backward Linkages	Statistics Canada, Prices and Price Indexes, Other materials and Services, Catalogue No. 62-002.	85.5
(26) Forward Linkages	Statistics Canada, Industry Selling Price Indexes, Manufacturing, Fruit and Vegetable Canners and Preservers, Catalogue No. 62-543.	57.9
(27) Egg Processing	Statistics Canada, Prices and Price Indexes, Wholesale Price Indexes of Selected Primary Commodities, Eggs, Catalogue No. 62-002.	57.0
(28) Milk Processing	Statistics Canada, Prices and Price Indexes, Industry Selling Price Indexes by Industry and Selected Commodities, Foods and Beverages Industries, Milk Sold to Households, Stores, etc. Catalogue No. 62-002.	69.0
(29) Consumer Price Index	Statistics Canada, Consumer Prices and Price Indexes, Consumer Price Index for Regional Cities, Vancouver, All-Items, Catalogue No. 62-010.	37.7

* The 1974-75 Highway Construction Index is not available for B.C. Index for that period is based on the Washington State Highway Bid Price Index found in the publication Engineering News Record.

APPENDIX 19

GROWTH AND REAL PRICE CHANGE IN THE VEDDER RIVER AREA

TYPE OF DAMAGE	Sumas - Yarrow		Chilliwhack South	
	Growth 1975-2000	Price Change 1975-2000	Growth 1975-2000	Price Change 1975-2000
(1) Residential and Associated				
(a) Residential and Content	1.3	1.0	1.0	1.0
(b) Loss of Use of Dwelling	1.3	1.0	1.0	1.0
(c) Extra Food Cost	1.3	.5	1.0	.5
(2) Commercial	1.3	2.0	1.0	2.0
(3) Industrial	-	-	0	2.0
(4) Agricultural Damage and Income Loss				
(a) Crop Damage and Income Loss	0	1.0	0	1.0
(b) Dairy Production	2.4	1.0	2.4	1.0
(c) Beef Cattle Production	-	-	2.4	.5
(d) Hog Production	.8	.5	.8	.5
(e) Turkey Production	2.5	0	-	-
(f) Broiler Production	2.5	0	2.5	0
(g) Egg Production	2.5	0	2.5	0
(h) Livestock Evacuation	0	0	0	0
(i) Milking Equipment	0	0	0	0
(j) Extra Feed	0	1.0	0	1.0
(5) Miscellaneous				
(a) Roads	1.3	1.0	1.0	1.0
(b) Railways	0	1.0	0	1.0
(c) Utilities				
(1) Sewage Systems	1.3	1.5	1.0	1.5
(2) Water Supply Systems	1.3	1.5	1.0	1.5
(3) Electrical Instalations	0	1.5	0	1.5
(4) Gas Distribution Systems	1.3	1.5	1.0	1.5
(5) Telephone Facilities	0	1.5	0	1.5
(d) Schools	1.3	1.0	1.0	1.0
(e) Barns and Outbuildings	1.3	1.0	1.0	1.0
(f) Evacuating People	1.3	0	1.0	0
(6) Secondary Income Loss				
(a) Effects of Agriculture Crop Damage				
(1) Backward Linkages	0	2.0	0	2.0
(2) Forward Linkages	0	2.0	0	2.0
(b) Egg Processing	0	2.0	0	2.0
(c) Milk Processing	3.0	2.0	3.0	2.0

APPENDIX 20

AREA: RELATIVE RATES OF PRICE CHANGE 1955 - 1975

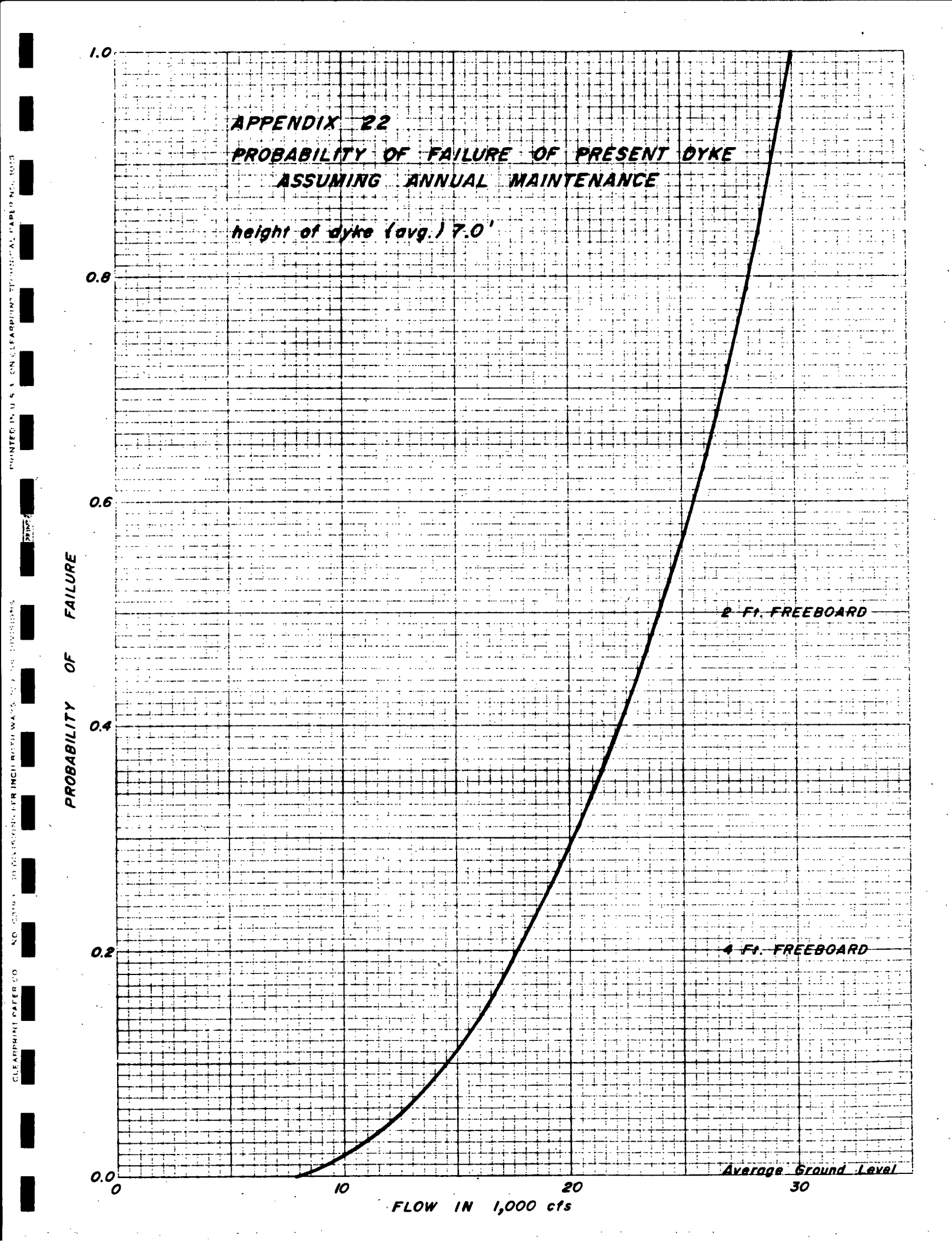
TYPE OF DAMAGE	Average Annual % Change in Real Value			Projected Real Price Change
	1955-71 *	1966-71*	1971-75	1975 - 2000
(1) Vancouver Consumer Price Index	2.1	3.5	8.4	
(2) Residential and Associated				
(a) Residential and Content	1.3	2.3	.8	1.0
(b) Loss of Use of Dwelling	1.3	2.3	.8	1.0
(c) Extra Food Cost	- 0.1	- 0.3	5.1	.5
(3) Commercial	2.0	3.8	1.9	2.0
(4) Industrial	2.0	3.8	1.9	2.0
(5) Agricultural Damage and Income Loss				
(a) Crop Damage and Income Loss	-.6	- 2.1	5.7	1.0
(b) Dairy Production	0.4	0.7	9.7	1.0
(c) Beef Cattle Production	1.1	0.5	.3	.5
(d) Hog Production	-	-	29.1	.5
(e) Turkey Production	- 3.4	- 3.9	5.5	0
(f) Broiler Production	- 3.4	- 3.9	5.8	0
(g) Egg Production	- 3.3	- 8.0	8.4	0
(h) Livestock Evacuation	-	-	- 2.3	0
(i) Milking Equipment	-	-	0.3	0
(j) Extra Feed	-	-	15.7	1.0
(6) Miscellaneous				
(a) Roads	-	-	12.2	1.0
(b) Railways	-	-	?	1.0
(c) Utilities				
(1) Sewage Systems	-	-	2.3	1.5
(2) Water Supply Systems	-	-	2.3	1.5
(3) Electrical Instalations	-	-	4.0	1.5
(4) Gas Distribution Systems	-	-	2.3	1.5
(5) Telephone Facilities	-	-	2.3	1.5
(d) Schools	1.3	2.3	.8	1.0
(e) Barns and Outbuildings	-	-	2.6	1.0
(f) Evacuating People	-	-	- 2.3	0
(7) Secondary Income Loss				
(a) Effects of Agriculture Crop Damage				
(1) Backward Linkages	-	-	11.7	2.0
(2) Forward Linkages	-	-	3.7	2.0
(b) Egg Processing	-	-	5.3	2.0
(c) Milk Processing	-	-	6.1	2.0

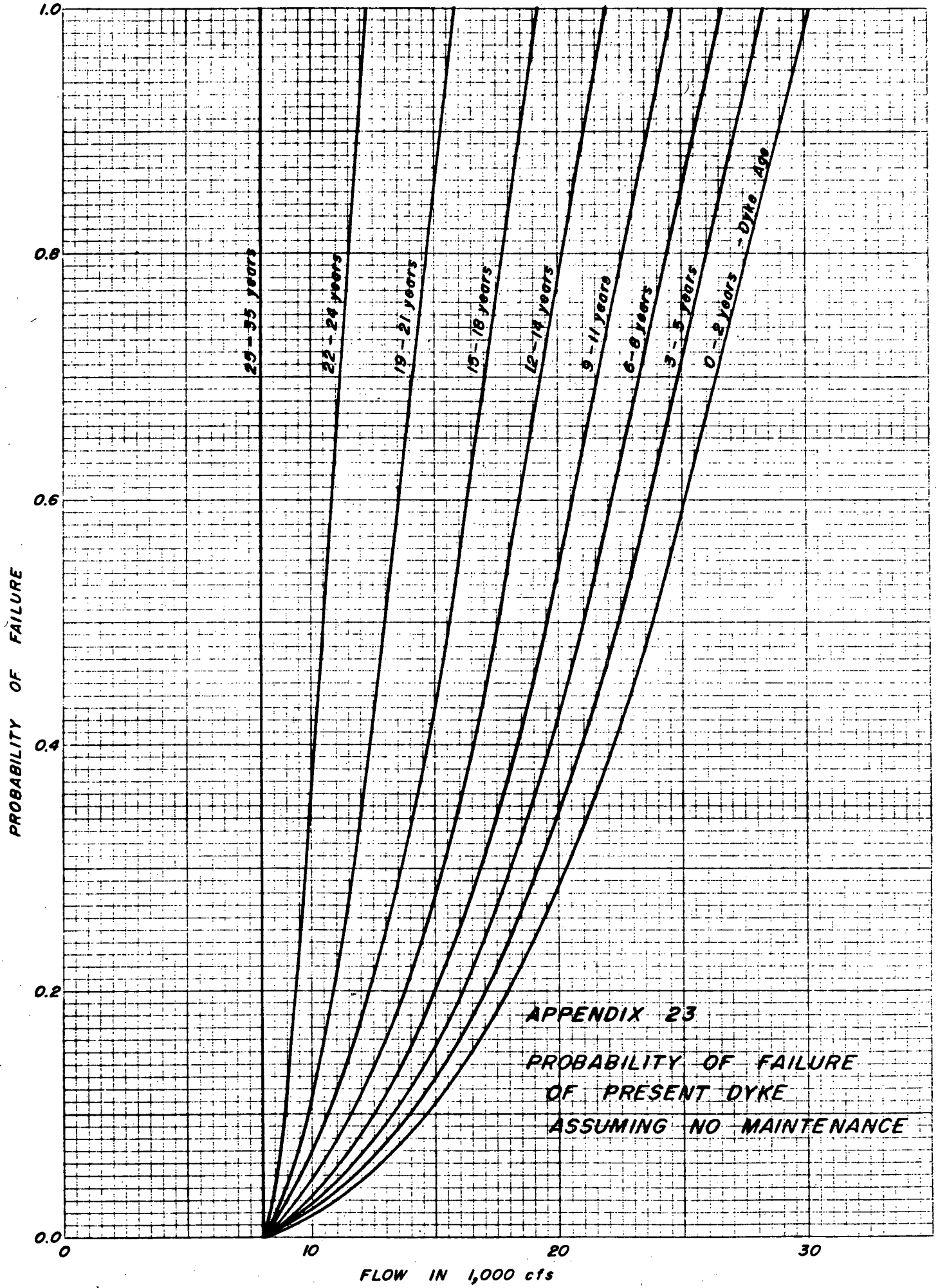
APPENDIX 21

AREA — GROWTH AND PRICE CHANGE - VEDDER RIVER TOTALS

1975 - 2000

TYPE OF DAMAGE	- Annual % Change in Damage - Category	
	Sumas - Yarrow 1975 - 2000	Chilliwhack South 1975 - 2000
(1) Residential and Associated		
(a) Residential and Content	2.3	2.0
(b) Loss of Use of Dwelling	2.3	2.0
(c) Extra Food Cost	1.8	1.5
(2) Commercial	3.3	3.0
(3) Industrial	-	2.0
(4) Agricultural Damage and Income Loss		
(a) Crop Damage and Income Loss	1.0	1.0
(b) Dairy Production	3.4	3.4
(c) Beef Cattle Production	-	2.9
(d) Hog Production	1.3	1.3
(e) Turkey Production	2.5	-
(f) Broiler Production	2.5	2.5
(g) Egg Production	2.5	2.5
(h) Livestock Evacuation	0	0
(i) Milking Equipment	0	0
(j) Extra Feed	1.0	1.0
(5) Miscellaneous		
(a) Roads	2.3	2.0
(b) Railways	1.0	1.0
(c) Utilities		
(1) Sewage Systems	2.8	2.5
(2) Water Supply Systems	2.8	2.5
(3) Electrical Instalations	1.5	1.5
(4) Gas Distribution Systems	2.8	2.5
(5) Telephone Facilities	1.5	1.5
(d) Schools	2.3	2.0
(e) Barns and Outbuildings	2.3	2.0
(f) Evacuating People	1.3	1.0
(6) Secondary Income Loss		
(a) Effects of Agriculture Crop Damage		
(1) Backward Linkages	2.0	2.0
(2) Forward Linkages	2.0	2.0
(b) Egg Processing	2.0	2.0
(c) Milk Processing	5.0	5.0


APPENDIX 22
PROBABILITY OF FAILURE OF PRESENT DYKE
ASSUMING ANNUAL MAINTENANCE
height of dyke (avg.) 7.0'
1.0
0.8
0.6
0.4
0.2
0.0
PROBABILITY OF FAILURE
2 Ft. FREEBOARD
4 Ft. FREEBOARD
Average Ground Level
0
10
20
30
FLOW IN 1,000 cfs



APPENDIX 24

Present Value of Flood Benefits ($1975) Under Different Assumptions of Future Growth and Real Price Change (1976-2010) -

Projection	Discount Rate		Total Available Benefits ($1,000)	Benefits Not Available Beyond 32,000 cfs* ($1,000)	Benefits Available For Dykes ($1,000)	Benefits Captured By Existing Dykes ($1,000)	Benefits Captured By Set-Back Dykes ($1,000)
1. Most Likely Growth and Price Change	6%	Winter					
		Summer					
		Total					
	7%	Winter					
		Summer					
		Total					
	8%	Winter					
		Summer					
		Total					
2. Zero Growth and Zero Price Change	7%	Winter					
		Summer					
		Total					
3. Growth 1% Higher Than Most Likely	7%	Winter					
		Summer					
		Total					
4. Growth 3% Higher Than Most Likely	7%	Winter					
		Summer					
		Total					

*Adjustment to take into account the Fraser River Program Committee criteria of crediting dykes with only 50% of the benefits between the point two feet below the dyke design level and the design level.

APPENDIX 24 A

Present Value of Flood Benefits ($1975) Under Different Assumptions of Future Growth and Real Price Change (1976-2010) - EXISTING DYKES MAINTAINED (Case 1)

Projection	Discount Rate		(1) Total Available Benefits ($1,000)	(2) Benefits Not Available Beyond 32,000 cfs* ($1,000)	(3) Benefits Available For Dykes ($1,000)	(4) Benefits Captured By Existing Dykes ($1,000)	(5) Benefits Captured By Set-Back Dykes ($1,000)
1. Most Likely Growth and Price Change	6%	Winter	9792.6	2840.2	6952.4	1210.8	5741.6
		Summer	167.6	6.9	160.7	86.1	74.6
		Total	9960.2	2847.1	7113.1	1296.9	5816.2
	7%	Winter	8614.8	2500.0	6114.8	1064.0	5050.8
		Summer	147.4	6.1	141.3	71.7	69.6
		Total	8762.2	2506.1	6256.1	1135.7	5120.4
	8%	Winter	7645.4	2219.4	5426.0	943.9	4482.1
		Summer	131.0	5.4	125.6	67.3	58.3
		Total	7776.4	2224.8	5551.6	1011.2	4540.4
2. Zero Growth and Zero Price Change	7%	Winter	6681.4	1952.4	4729.0	811.8	3917.2
		Summer	115.2	4.8	110.4	58.6	51.8
		Total	6796.6	1957.2	4839.4	870.4	3969.0
3. Growth 1% Higher Than Most Likely	7%	Winter	9767.6	2833.5	6934.1	1207.5	5726.6
		Summer	167.2	6.9	160.3	85.9	74.4
		Total	9934.8	2840.4	7094.4	1293.4	5801.0
4. Growth 3% Higher Than Most Likely	7%	Winter	12,744.7	3695.0	9049.7	1579.6	7470.1
		Summer	218.1	9.0	209.1	112.2	96.9
		Total	12,962.8	3704.0	9258.8	1691.8	7567.0

*Adjustment to take into account the Fraser River Program Committee criteria of crediting dykes with only 50% of the benefits between the point two feet below the dyke design level and the design level.

APPENDIX 24B

Present Value of Flood Benefits ($1975) Under Different Assumptions of Future Growth and Real Price Change (1976-2010) - EXISTING DYKES NOT MAINTAINED (Case 2)

Projection	Discount Rate		(1) Total Available Benefits ($1,000)	(2) Benefits Not Available Beyond 32,000 cfs* ($1,000)	(3) Benefits Available For Dykes ($1,000)	(4) Benefits Captured By Existing Dykes ($1,000)	(5) Benefits Captured By Set-Back Dykes ($1,000)
1. Most Likely Growth and Price Change	6%	Winter	9792.6	2840.2	6952.4	401.1	6551.3
		Summer	167.6	6.9	160.7	42.2	118.5
		Total	9960.2	2847.1	7113.1	443.3	6669.8
	7%	Winter	8614.8	2500.0	6114.8	371.9	5742.9
		Summer	147.4	6.1	141.3	39.5	101.8
		Total	8762.2	2506.1	6256.1	411.4	5844.7
	8%	Winter	7645.4	2219.4	5426.0	361.4	5064.6
		Summer	131.0	5.4	125.6	37.1	88.5
		Total	7776.4	2224.8	5551.6	398.5	5153.1
2. Zero Growth and Zero Price Change	7%	Winter	6681.4	1952.4	4729.0	341.9	4387.1
		Summer	115.2	4.8	110.4	35.0	75.4
		Total	6796.6	1957.2	4839.4	376.9	4462.5
3. Growth 1% Higher Than Most Likely	7%	Winter	9767.6	2833.5	6934.1	401.6	6532.5
		Summer	167.2	6.9	160.3	42.2	118.1
		Total	9934.8	2840.4	7094.4	443.8	6650.6
4. Growth 3% Higher Than Most Likely	7%	Winter	12744.7	3695.0	9049.7	449.5	8600.2
		Summer	218.1	9.0	209.1	48.7	160.4
		Total	12,962.8	3704.0	9258.8	498.2	8760.6

*Adjustment to take into account the Fraser River Program Committee criteria of crediting dykes with only 50% of the benefits between the point two feet below the dyke design level and the design level.

APPENDIX 24C

Present Value of Flood Benefits ($1975) Under Different Assumptions of Future Growth and Real Price Change (1976-2010) - EXISTING DYKES REMOVED (Case 3)

Projection	Discount Rate		(1) Total Available Benefits ($1,000)	(2) Benefits Not Available Beyond 32,000 cfs* ($1,000)	(3) Benefits Available For Dykes ($1,000)	(4) Benefits Captured By Existing Dykes ($1,000)	(5) Benefits Captured By Set-Back Dykes ($1,000)
1. Most Likely Growth and Price Change	6%	Winter	9792.6	2840.2	6952.4	--	6952.4
		Summer	167.6	6.9	160.7	--	160.7
		Total	9960.2	2847.1	7113.1	--	7113.1
	7%	Winter	8614.8	2500.0	6114.8	--	6114.8
		Summer	147.4	6.1	141.3	--	141.3
		Total	8762.2	2506.1	6256.1		6256.1
	8%	Winter	7645.4	2219.4	5426.0	--	5426.0
		Summer	131.0	5.4	125.6	--	125.6
		Total	7776.4	2224.8	5551.6		5551.6
2. Zero Growth and Zero Price Change	7%	Winter	6681.4	1952.4	4729.0	--	4729.0
		Summer	115.2	4.8	110.4	--	110.4
		Total	6796.6	1957.2	4839.4		4839.4
3. Growth 1% Higher Than Most Likely	7%	Winter	9767.6	2833.5	6934.1	--	6934.1
		Summer	167.2	6.9	160.3	--	160.3
		Total	9934.8	2840.4	7094.4		7094.4
4. Growth 3% Higher Than Most Likely	7%	Winter	12,744.7	3695.0	9049.7	--	9049.7
		Summer	218.1	9.0	209.1	--	209.1
		Total	12,962.8	3704.0	9258.8	--	9258.8

*Adjustment to take into account the Fraser River Program Committee criteria of crediting dykes with only 50% of the benefits between the point two feet below the dyke design level and the design level.

APPENDIX 25

Project Costs for Proposed Setback Dykes*

Case	Rate of Real Appreciation 0%	2%	4%
(1) Case 1 - Existing Dykes Maintained			
(a) Cost of New Dyke (Capital Cost)	$2,173,000	$2,173,000	$2,173,000
(b) Maintenance cost of New Dyke	$ 180,000	$ 242,000	$ 337,000
(c) Maintenance cost of existing Dyke	$ 140,000	$ 179,000	$ 236,000
(d) Cost of right of way	$ 78,000	$ 78,000	$ 78,000
Total Project Cost	$2,571,000	$2,672,000	$2,824,000
(2) Case 2 - Existing Dykes not Maintained			
(a) Cost of New Dyke (Capital Cost)	$2,173,000	$2,173,000	$2,173,000
(b) Maintenance Cost of New Dyke	$ 180,000	$ 242,000	$ 337,000
(c) Maintenance Cost of Existing Dyke	-	-	-
(d) Cost of right of way	$ 78,000	$ 78,000	$ 78,000
Total Project Cost	$2,431,000	$2,493,000	$2,588,000
(3) Case 3 - Existing Dykes Removed			
(a) Cost of New Dyke (Capital Cost)	$2,173,000	$2,173,000	$2,173,000
(b) Maintenance Cost of New Dyke	$ 180,000	$ 242,000	$ 337,000
(c) Cost of right of way	$ 78,000	$ 78,000	$ 78,000
Total Project Cost	$2,431,000	$2,493,000	$2,588,000

* 7% rate of discount
35 year project life

APPENDIX 26

Sensitivity Analysis of Benefit-Cost Ratios - Vedder River

(1) Case 1 - Existing Dykes Maintained

Projection	Cost of New Dyke $2,571,000 1/ Discount Rate 6%	7%	8%	Cost of New Dyke $2,672,000 1/ Discount Rate 6%	7%	8%	Cost of New Dyke $2,824,000 1/ Discount Rate 6%	7%	8%
1. Most Likely Growth and Price Change	2.26	1.99	1.77	2.18	1.92	1.70	2.06	1.81	1.61
2. Zero Growth and Zero Price Change		1.54			1.49			1.41	
3. Growth 1% Higher Than Most Likely		2.26			2.17			2.05	
4. Growth 3% Higher Than Most Likely		2.94			2.83			2.68	

(2) Case 2 - Existing Dykes Not Maintained

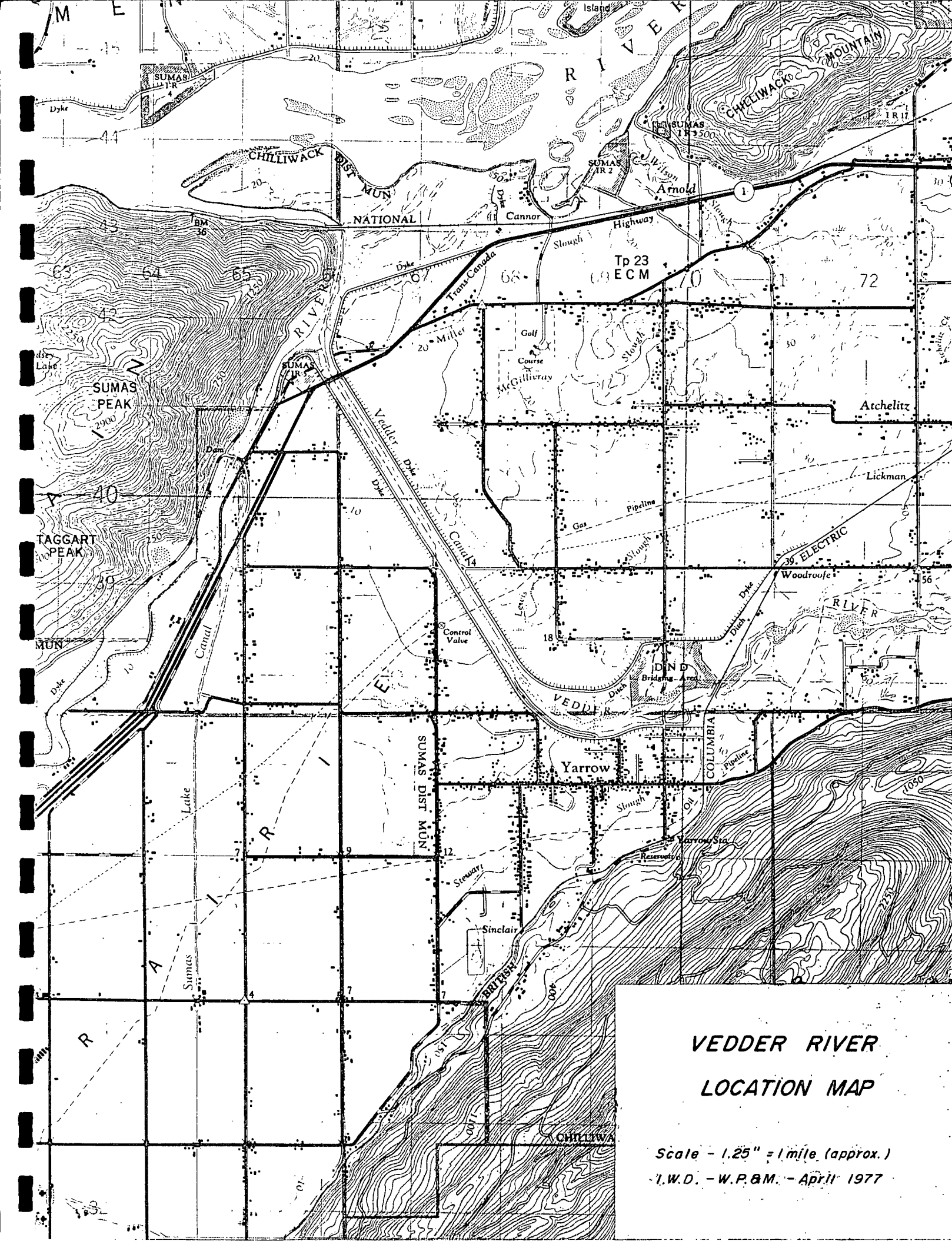
Projection	Cost of New Dyke $2,431,000 1/ Discount Rate 6%	7%	8%	Cost of New Dyke $2,493,000 1/ Discount Rate 6%	7%	8%	Cost of New Dyke $2,588,000 1/ Discount Rate 6%	7%	8%
1. Most Likely Growth and Price Change	2.74	2.40	2.12	2.68	2.34	2.07	2.58	2.26	1.99
2. Zero Growth and Zero Price Change		1.84			1.79			1.72	
3. Growth 1% Higher Than Most Likely		2.74			2.67			2.57	
4. Growth 3% Higher Than Most Likely		3.60			3.51			3.39	

Sensitivity Analysis of Benefit-Cost Ratios - Vedder River

(1) Case 1 - Existing Dykes Removed

Projection	Cost of New Dyke $2,431,000 1 / Discount Rate			Cost of New Dyke $2,493,000 1 / Discount Rate			Cost of New Dyke $2,588,000 1 / Discount Rate		
	6%	7%	8%	6%	7%	8%	6%	7%	8%
1. Most Likely Growth and Price Change	2.93	2.57	2.28	2.85	2.51	2.23	2.75	2.42	2.15
2. Zero Growth and Zero Price Change		1.99			1.94			1.87	
3. Growth 1% Higher Than Most Likely		2.92			2.85			2.74	
4. Growth 3% Higher Than Most Likely		3.81			3.71			3.58	

1 / See Appendix 25


VEDDER RIVER
LOCATION MAP
Scale - 1.25" = 1 mile (approx.)
I.W.D. - W.P.&M. - April 1977
SUMAS PEAK
TAGGART PEAK
Vedder Canal
Trans-Canada Highway
NATIONAL
Cannor
Arnold
Atchelitz
Lickman
Yarrow
Woodroofe
Sinclair
Stewart
Miller
McGillivray
Golf Course
Dam
Control Valve
Pipeline
Gas
Slough
Dyke
Ditch
DND
Bridging Area
Yarrow Sta. Reserve
COLUMBIA
ELECTRIC
BRITISH
CHILLIWACK MOUNTAIN
CHILLIWACK DIST MUN
SUMAS DIST MUN
SUMAS I.R. 1
SUMAS I.R. 2
SUMAS I.R. 3
SUMAS I.R. 4
SUMAS I.R. 5
Tp 23
ECM
Island
Lake
Creek

PROPOSED SETBACK DYKES

PROPOSED ROCK GROYNES

VEDDER RIVER

SETBACK DYKE ALIGNMENT

Scale ~ 2.54" = 1 mile (approx.)

I.W.D. — W.P.& M. — Sept. 26/77