

F1-B.5

ANALYSES OF BENEFITS OF FRASER RIVER  
FLOOD CONTROL PROGRAM DYKING PROJECTS

Prepared for the determination of  
priorities for miscellaneous work

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April, 1982

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February 5, 1982

DEWDNEY AREA IMPROVEMENT DISTRICT  
ANALYSIS OF BENEFITS

A. Introduction

The Dewdney Area Improvement District is located on the north bank of the Fraser River some 75 km east of Vancouver. The total area which would be protected by the rehabilitated dykes is 1,760 hectares of rural, residential and agricultural land. The area also has a population of about 1,000 people and some 250 houses.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Dewdney Area Improvement District dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1971.

E. Future Damages

The Dewdney area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in population and

associated activity are expected to be low. Real price changes over time are also expected to be low. It was felt therefore, that a 1% rate of growth would be used to reflect both expected real growth and real price changes over time.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated only 50% of damages. Average annual damages for Dewdney Dyking District were estimated to be \$1,478,600.

2. Benefits

Benefits were calculated for the Dewdney Dyking District by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

Table 1  
Benefit - Dewdney Dykes

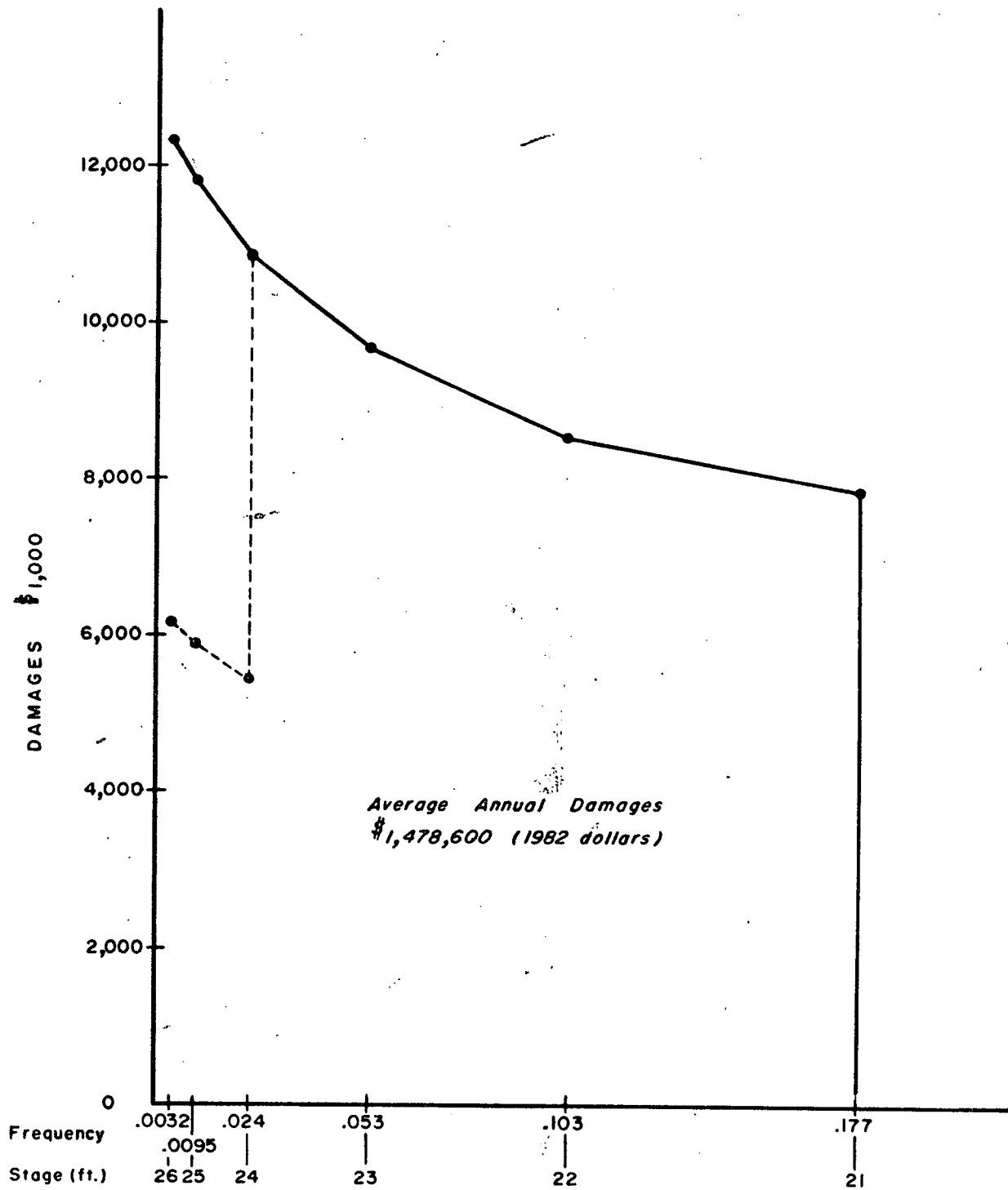
DISCOUNT RATE	BENEFITS (\$000)
7%	21,437
6%	24,211
8%	19,144
10%	15,624

G. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures. If these changes were taken into account, benefits would likely be higher.

FIG. 1

DEWDNEY AREA IMPROVEMENT DISTRICT  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: DEWDNEY

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	1,224	1,401	1,619	1,838	2,057	2,215
(b) Loss of use of dwelling	65	78	90	96	103	105
(c) Extra Food Cost	26	29	33	35	37	39
(2) Commercial	4	5	7	8	9	9
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	697	715	733	749	767	773
(b) Dairy production	145	154	163	178	193	193
(c) Beef Cattle production	9	9	9	9	10	10
(d) Livestock evacuation	-	7	16	16	16	16
(e) Milking equipment	-	11	22	24	26	26
(f) Extra feed	212	219	224	229	234	236
(5) Miscellaneous						
(a) Roads	169	169	169	169	172	178
(b) Railways		-	-	22	59	59
(c) Schools	31	34	64	91	101	122
(d) Barns and outbuildings	8	8	8	8	8	8
TOTAL PRIMARY DAMAGES	2,590	2,839	3,155	3,472	3,792	3,989
(6) Secondary Income Loss						
(a) From severance of rail- way transport	-	-	-	75	75	75
(b) From severance of road transport	-	-	-	11	11	11
(c) Effects of agriculture crop damage						
(1) Backward Linkages	-	-	3	3	3	3
(2) Forward Linkages	-	-	18	18	19	19
(d) Milk processing	-	-	65	72	77	77
TOTAL SECONDARY DAMAGES	-	-	86	179	185	185
TOTAL DAMAGES	2,590	2,839	3,241	3,651	3,977	4,174

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: DEWDNEY

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	3427.2	3922.8	4533.2	5146.4	5759.6	6202.0
(b) Loss of use of dwelling	162.5	195.0	225.0	240.0	257.5	262.5
(c) Extra Food Cost	78.3	87.3	99.3	105.4	111.4	117.4
(2) Commercial	10.2	12.9	17.9	20.4	23.0	23.0
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	2070.1	2123.6	2177.0	2224.5	2278.0	2295.8
(b) Dairy production	494.5	525.1	555.8	607.0	658.1	658.1
(c) Beef Cattle production	49.3	49.3	49.3	49.3	54.8	54.8
(d) Livestock evacuation	-	20.0	40.0	45.8	45.8	45.8
(e) Milking equipment	-	33.0	66.0	72.0	78.0	78.0
(f) Extra feed	903.1	932.9	954.2	975.5	996.8	1005.4
(5) Miscellaneous						
(a) Roads	523.9	523.9	523.9	523.9	533.2	551.8
(b) Railways	-	-	-	68.2	182.9	182.9
(c) Schools	76.3	83.6	157.4	223.9	248.5	300.1
(d) Barns and outbuildings	21.6	21.6	21.6	21.6	21.6	21.6
TOTAL PRIMARY DAMAGES	7,817.0	8,531.0	9,420.6	10,323.9	11,249.2	11,799.1
(6) Secondary Income Loss						
(a) From severance of rail- way transport	-	-	-	233.3	233.3	233.3
(b) From severance of road transport	-	-	-	34.2	34.2	34.2
(c) Effects of agriculture crop damage						
(1) Backward Linkages	-	-	8.0	8.0	8.0	8.0
(2) Forward Linkages	-	-	41.8	41.8	44.1	44.1
(d) Milk processing	-	-	210.6	233.3	249.5	249.5
TOTAL SECONDARY DAMAGES	-	-	260.4	550.6	569.1	569.1
TOTAL DAMAGES	7817.0	8531.0	9681.0	10874.5	11818.3	12368.3



### APPENDIX 3

#### Price Indexes Used in the Study

Damage Category	Source of Index	Price Change 1971-82 (1971 = 100)
1) Residential	British Columbia Assessment Authority, Appraisal, Systems Division, Composite Cost Indices, Residences Frame Structure.	280
2) Loss of Use of Dwelling	Statistics Canada, Consumer Price and Price Indexes, Consumer Price Indexes for Regional Cities, Vancouver, Housing Cat. No. 62-010.	250
3) Extra Food Cost	Statistics Canada, Consumer Prices and Price Indexes, Consumer Price Indexes for Regional Cities, Vancouver, Food Catalogue No. 62 - 010.	301
4) Commercial	British Columbia Assessment Authority Appraisal Systems Division, Composite Cost Indices, Commercial and Industrial Structures, Frame.	255
5) Agricultural Crop Damages	Statistics Canada, Farm Prices, Farm Prices of Agricultural Products, B.C. Cat. No. 62-003	297
6) Dairy Production	The Milk Board Annual Report, Province of British Columbia, Table VI - Producer Prices for Qualifying Milk (before adjustment).	341
7) Beef Production	Statistics Canada, Livestock and Animal Products, Cattle: Farm Value per Head, B.C., All Cattle, Cat. No. 23-203.	548
8) Livestock Evacuation	Statistics Canada, Consumer Prices and Price Indexes, Consumer Price Indexes for Regional Cities, Vancouver, Transportation Cat. No. 62-010.	286
9) Damage to Milking Equipment	Statistics Canada, Farm Input Price Index, Power Machinery - Western Canada, Cat. No. 62-004.	300

# APPENDIX 3

## Price Indexes Used in the Study

Damage Category	Source of Index	Price Change 1971-1982 (1971 = 100)
10) Extra Feed Cost	Statistics Canada, Farm Input Price Index, Feed-Western Canada, Cat. No. 62-004.	426
11) Road Damage Railway Damage	Statistics Canada, Construction Price Statistics, Highway Construction Price Index, B.C. Total, Catalogue No. 62-007.	310
12) Schools	British Columbia Assessment Authority, Appraisal Systems Division, Composite Cost Indices, Commercial and Industrial Structures, Frame.	246
13) Barns and Out-buildings	Statistics Canada, Farm Input Price Index, Farm Building Repairs - B.C. Cat. No. 62-004.	270
14) Secondary Agriculture - Forward Linkage	Statistics Canada, Consumer Prices and Price Indexes, Consumer Price, Indexes for Regional Cities, Fruit and Vegetables, Vancouver, Cat. No. 62-010.	232
15) Secondary Agricultural - Backward Linkage	Statistics Canada, Farm Input Price Index, Supplies and Services, Western Canada, Cat. No. 62-004.	266
16) Secondary Dairy	Statistics Canada, Industry Price Indexes, Industry Selling Price Indexes by Major Groups, Industries and Selected Commodities, Dairy Products Industry, Cat. No. 62-011.	324
17) Severance of Rail Severance of Roads	Statistics Canada, Industry Price Indexes, Industry Selling Price Index by Major Groups, Industries and Selected Commodities, Industry Selling Price Indexes: Manufacturing, Cat. No. 62-011.	311

DYKING DISTRICT OF SALMON RIVER  
ANALYSIS OF BENEFITS

A. Introduction

The Dyking District of Salmon River is located on the south bank of the Fraser River some 40 kms. east of Vancouver. The area is primarily agricultural. An estimated 400 hectares of agricultural land would be flooded by a 200 year return flood. Only a few residences and a small number of people would be affected by the flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Salmon River dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1971.

E. Future Damages

The Salmon River area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in

population and associated activity are expected to be low. Real price changes over time are also expected to be low. It was felt therefore, that no real growth and real price changes would occur in this area over the next 35 years.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for Salmon River were estimated to be \$85,817.

2. Benefits

Benefits were calculated for Salmon River by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1  
Benefits - Salmon River Dykes

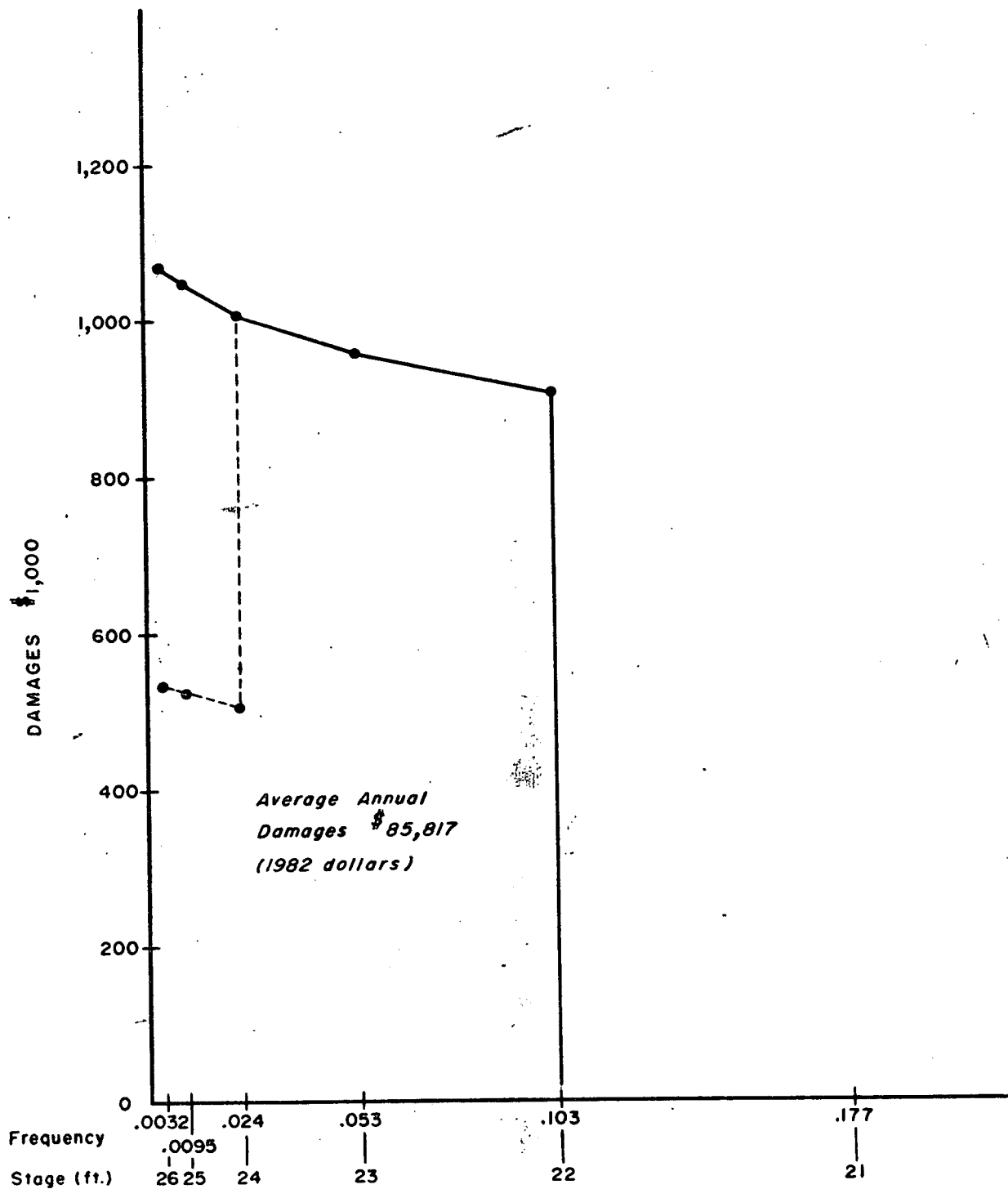
<u>DISCOUNT RATE</u>	<u>BENEFITS (\$1,000)</u>
7%	1,111
6%	1,244
8%	1,000
10%	828

G. Conclusion

This analysis provides an estimate of benefits which relies on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures.

FIG. 1

DYKING DISTRICT OF SALMON RIVER  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: SALMON RIVER

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and Content	-	8	11	19	27	31
(b) Loss of use of dwelling	-	1	1	2	2	2
(c) Extra Food Cost	-	-	-	-	2	2
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	185	194	200	203	205
(b) Dairy production	-	-	-	-	-	-
(c) Beef Cattle production	-	2	3	3	3	3
(d) Livestock evacuation	-	-	-	-	-	-
(e) Milking equipment	-	-	-	-	-	-
(f) Extra feed	-	61	64	66	67	68
(5) Miscellaneous						
(a) Roads	-	18	18	18	18	18
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	-	-	-	-
TOTAL PRIMARY DAMAGES	-	275	291	308	322	329
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages	-	1	1	1	1	1
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES	-	1	1	1	1	1
TOTAL DAMAGES	-	276	292	309	323	330

APPENDIX 2  
FLOOD DAMAGES -- SUMMARY 1982

AREA: SALMON RIVER

TYPE OF DAMAGE	<u>\$000's DAMAGES</u> <u>FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	22.4	30.8	53.2	75.6	86.8
(b) Loss of use of dwelling	-	2.5	2.5	5.0	5.0	5.0
(c) Extra Food Cost	-	-	-	-	6.0	6.0
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	549.5	576.2	594.0	602.9	608.9
(b) Dairy production	-	-	-	-	-	-
(c) Beef Cattle production	-	11.0	16.4	16.4	16.4	16.4
(d) Livestock evacuation	-	-	-	-	-	-
(e) Milking equipment	-	-	-	-	-	-
(f) Extra feed	-	259.9	272.6	281.2	285.4	289.7
(5) Miscellaneous						
(a) Roads	-	55.8	55.8	55.8	55.8	55.8
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	-	-	-	-
TOTAL PRIMARY DAMAGES	-	901.1	954.3	1005.6	1047.1	1068.6
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages	-	2.7	2.7	2.7	2.7	2.7
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES	-	2.7	2.7	2.7	2.7	2.7
TOTAL DAMAGES	-	903.8	957.0	1008.3	1049.8	1071.3



WESTHAM AND REIFEL ISLANDS

ANALYSIS OF BENEFITS

A. Introduction

Westham and Reifel Islands are located about 30 kms south of Vancouver at the northwest corner of the Municipality of Delta. Westham Island is a very productive agricultural area with 700 hectares of the island's total of 760 hectares in crops. Reifel Island is a very important bird sanctuary. The islands have about 40 houses, 30 barns and some 60 other outbuildings. There is a permanent population of about 140 residents on Westham Island. In addition an estimated 20 people work at the Alaksen Wildlife Area.

- B. The purpose of this analysis is to provide an update of economic benefits of reconstructing the Westham and Reifel Island dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Examination of damages for Westham and Reifel Islands estimated for 1975 shows that the bulk of the damages are associated with agriculture. In the majority of stages, agricultural damages account for well over 90% of total damages. The price index used to update benefits in this analysis therefore, is the Farm Prices of Agricultural Products Index for B.C. from Statistics Canada. Since the price index for agriculture has risen by a higher rate than most of the other damage categories only a small error (on the high side) will occur in the estimates of benefits as a result of using this index.

E. Future Damages

Westham Island is primarily rural and agricultural. Since the area is zoned for agricultural use, real growth in population and associated activity are expected to be minimal. However, because this area is such a suitable area for agriculture some intensification of activity could take place. Real price changes in agriculture are expected to remain relatively low. This analysis examines two different growth scenarios 0 and 2% rates of growth for this area.

F. Analysis of Benefits

The procedure to estimate benefits for 1982 was to update 1975 benefits calculated in the report "Economic Analysis of Dyke Improvement for Westham and Reifel Islands" by R. Princic prepared in 1977. The index, Farm Prices of Agricultural Products for B.C. by Statistics Canada used to update benefits, shows that prices have changed by a factor of 1.77 between 1975 and 1982. Updated benefits are provided in Table 1.

TABLE 1  
Benefits - Westham and Reifel Island Dykes

Proposed Projects	Rates of Growth (%)	<u>1982 Benefits (\$1000)</u>			
		6%	7%	8%	10%
1) Westham and Reifel Islands	0	1,276	1,140	1,027	850
	2	1,644	1,443	1,276	1,027
2) Westham Island	0	1,198	1,071	963	798
	2	1,543	1,354	1,198	963
3) Reifel Island	0	89	80	71	58
	2	115	101	89	71

G. Conclusion

The update of benefits prepared in this analysis is for the conditions which prevailed in the area in 1975. Benefits generated for 1982 reflect only increases in the price index. No attempt has been made to incorporate agricultural enhancement or other land use changes into the analyses. If these changes were taken into account, benefits would likely be higher. However, it is felt that the benefits incorporating the 2% rate of growth, shown in Table 1, more than compensate for any real growth and price change likely to occur in the area over the next 35 years.

Dyking District of West Langley  
Analysis of Benefits

A. Introduction

The Dyking District of West Langley is located on the south bank of of the Fraser River some 40 kms. east of Vancouver. The total area which would be protected by the rehabilitated dykes is 170 hectares of rural agricultural land. A 200 year level flood would only affect a small number of houses and its residents.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the West Langley dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1971.

E. Future Damages

The West Langley area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in population

and associated activity are expected to be low. Real price changes over time are also expected to be low. It was felt therefore, that there would be no real growth and real price changes in benefits over time in the area during the next 35 years.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated only 50% of damages. Average annual damages for West Langley Dyking District were estimated to be \$ 37,700.

2. Benefits

Benefits were calculated for the West Langley District by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1

Benefits - Dyking District of West Langley

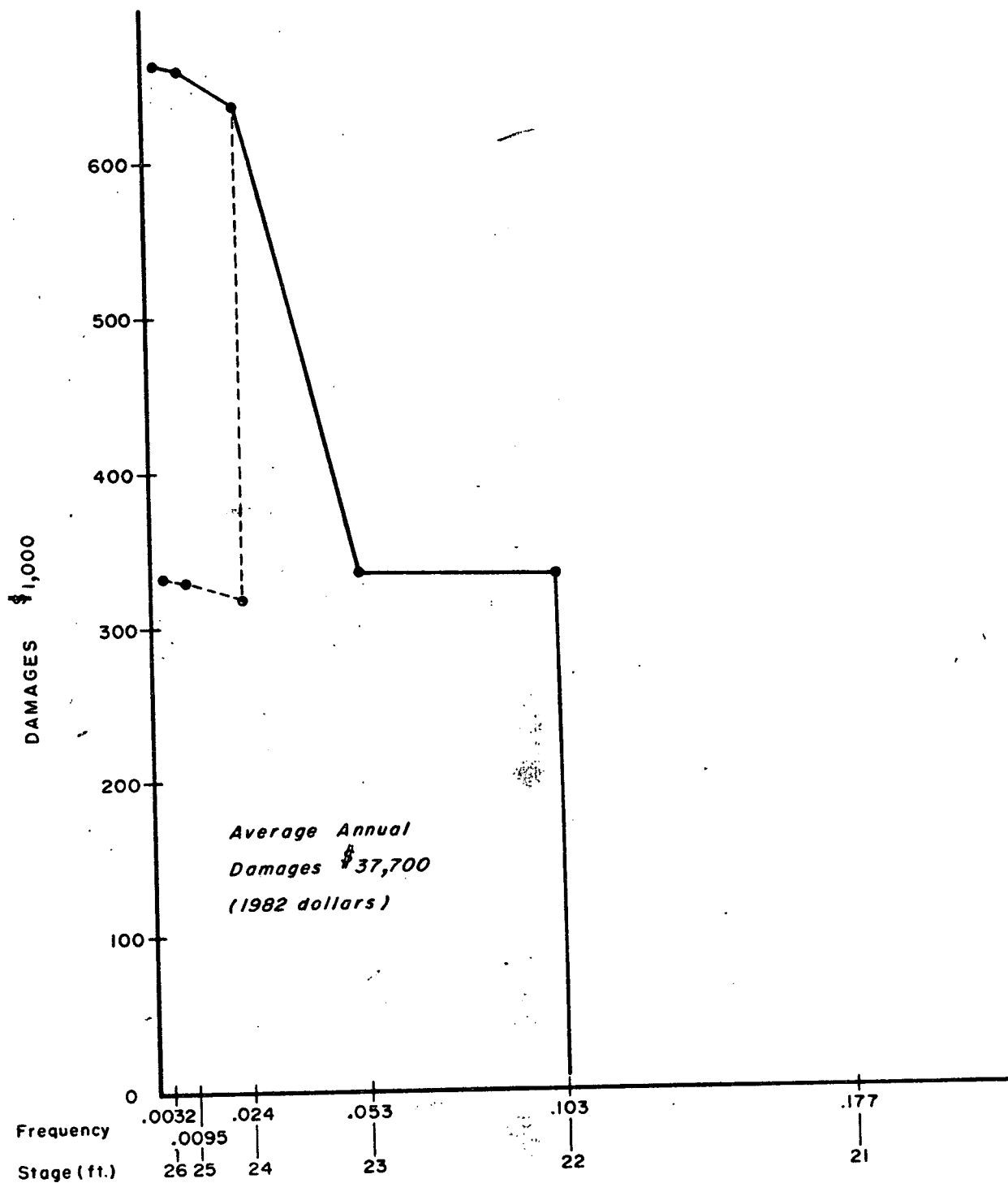
DISCOUNT RATE	BENEFITS (\$1,000)
7%	488
6%	547
8%	439
10%	364

G. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increased in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures.

FIG. 1

DYKING DISTRICT OF WEST LANGLEY  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: WEST LANGLEY

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	5	5	6	7	7
(b) Loss of use of dwelling	-					
(c) Extra Food Cost	-					
(2) Commercial	-	-	-	-	-	-
(3) Industrial						
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	61	61	64	66	67
(b) Dairy production	-	-	-	8	8	8
(c) Beef Cattle production	-	1	1	1	2	2
(d) Livestock evacuation	-	-	-	-	1	1
(e) Milking equipment	-	-	-	1	1	1
(f) Extra feed	-	24	24	25	26	26
(5) Miscellaneous						
(a) Roads	-	10	11	11	11	11
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	-	-	-	-
TOTAL PRIMARY DAMAGES	-	101	102	116	122	123
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing	-	-	-	3	3	3
TOTAL SECONDARY DAMAGES	-	-	-	3	3	3
TOTAL DAMAGES	-	101	102	119	125	126



APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: WEST LANGLEY

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	14.0	14.0	16.8	19.6	19.6
(b) Loss of use of dwelling	-	-	-	-	-	-
(c) Extra Food Cost	-	-	-	-	-	-
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	181.2	181.2	190.1	196.0	199.0
(b) Dairy production	-	-	-	272.8	272.8	272.8
(c) Beef Cattle production	-	5.5	5.5	5.5	11.0	11.0
(d) Livestock evacuation	-	-	-	-	2.9	2.9
(e) Milking equipment	-	-	-	3.0	3.0	3.0
(f) Extra feed	-	102.2	102.2	106.5	110.8	110.8
(5) Miscellaneous						
(a) Roads	-	31.0	34.1	34.1	34.1	34.1
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	-	-	-	-
TOTAL PRIMARY DAMAGES	-	333.9	337.0	628.8	650.2	653.2
(6) Secondary Income Loss						
(a) From severance of rail- way transport	-	-	-	-	-	-
(b) From severance of road transport	-	-	-	-	-	-
(c) Effects of agriculture crop damage	-	-	-	-	-	-
(1) Backward Linkages	-	-	-	-	-	-
(2) Forward Linkages	-	-	-	-	-	-
(d) Milk processing	-	-	-	9.7	9.7	9.7
TOTAL SECONDARY DAMAGES	-	-	-	9.7	9.7	9.7
TOTAL DAMAGES	-	333.9	337.0	638.5	659.9	662.9

Dyking District of Pitt Meadows No. 2  
Analysis of Benefits

A. Introduction

The Dyking District of Pitt Meadows No. 2 is located on the east bank of the Pitt River some 40 Kms. east of Vancouver. The area is primarily agricultural with about 322 hectares out of the District's total area of 430 hectares in agricultural production. There are a total of 68 houses, 38 barns and some 114 other out-buildings which would be flooded by a 200 year return flood. The area also has a permanent population of about 270 people.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Pitt Meadows No. 2 dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rate.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1974 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1974.

E. Future Damages

The original report prepared in 1974 had calculated the present value of damages for each stage with a growth factor incorporated into the calculation (Appendix 3). The 1982 updated damages (Appendix 4) contain the same growth factor. To determine the significance of the growth, benefits are also generated for a zero growth option. Both of these options are shown in Table 1.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for Pitt Meadows No. 2 were estimated to be \$419,740.

2. Benefits

Benefits for the zero growth option were calculated by multiplying average annual damages times the appropriate present worth factor. For this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. For the growth option the present value of damages had already been calculated for each stage (Appendix 4). Therefore, it was necessary merely to calculate the area under the curve (Figure 2) to obtain benefits. Estimates of benefits for the two options are provided in Table 1.

Table 1  
Benefits - Pitt Meadows No. 2 Dykes

Discount Rates	<u>1982 Benefits (\$1,000)</u>	
	Growth Rate 0%	Growth Rate Used in Original Study
7%	5,435	7,322
6%	6,085	8,270
8%	4,892	6,532
10%	4,048	5,453

G. Conclusion

This analysis provides an estimate of benefits which relies on data generated in 1974. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1974. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures. It is felt that the benefits incorporating the growth rate used in the original report, shown in Table 1, more than compensates for any real growth and price change between 1974 and the year 2000.

FIG. 1

DYKING DISTRICT OF PITT MEADOWS No.2  
AVERAGE ANNUAL DAMAGES

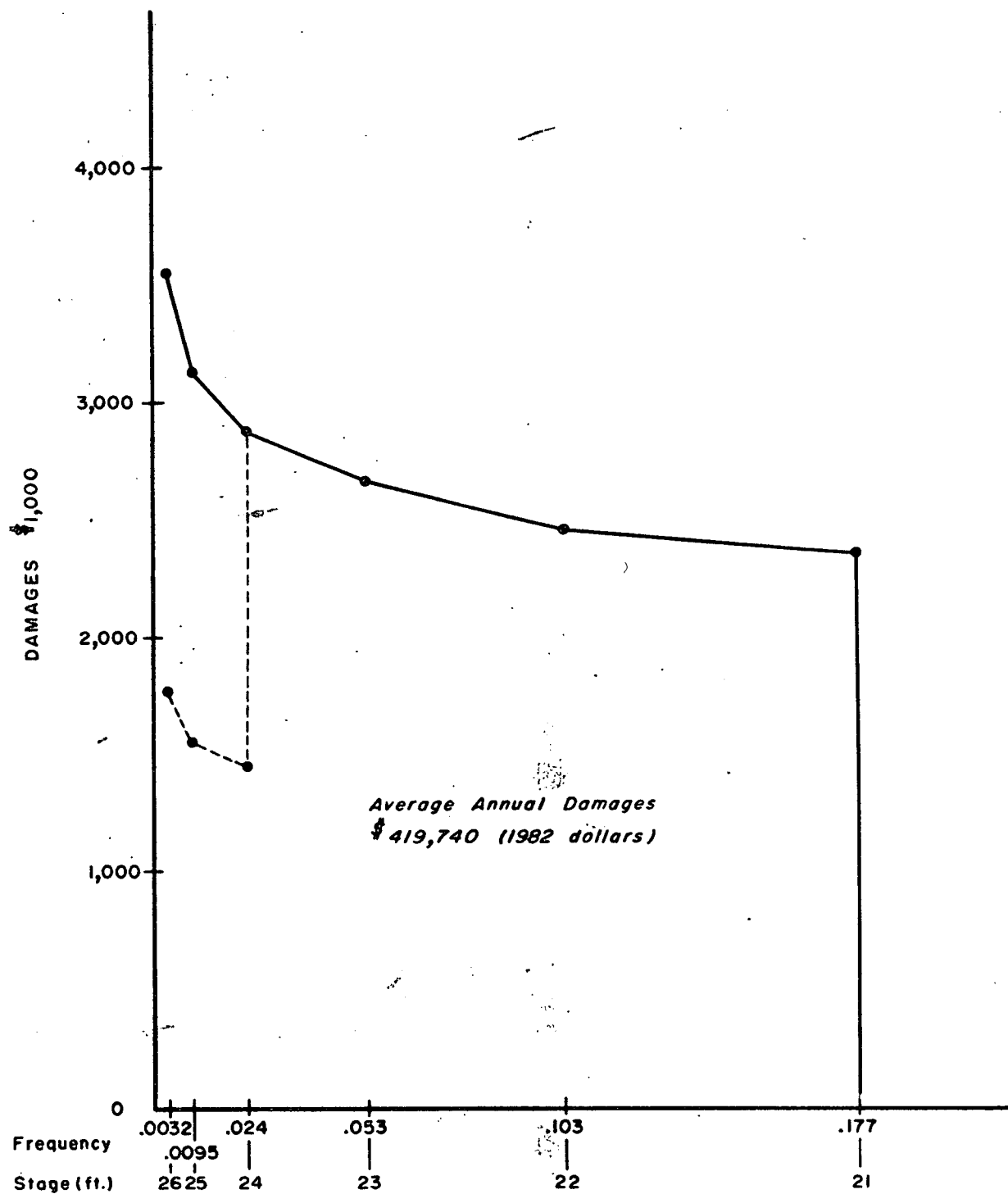
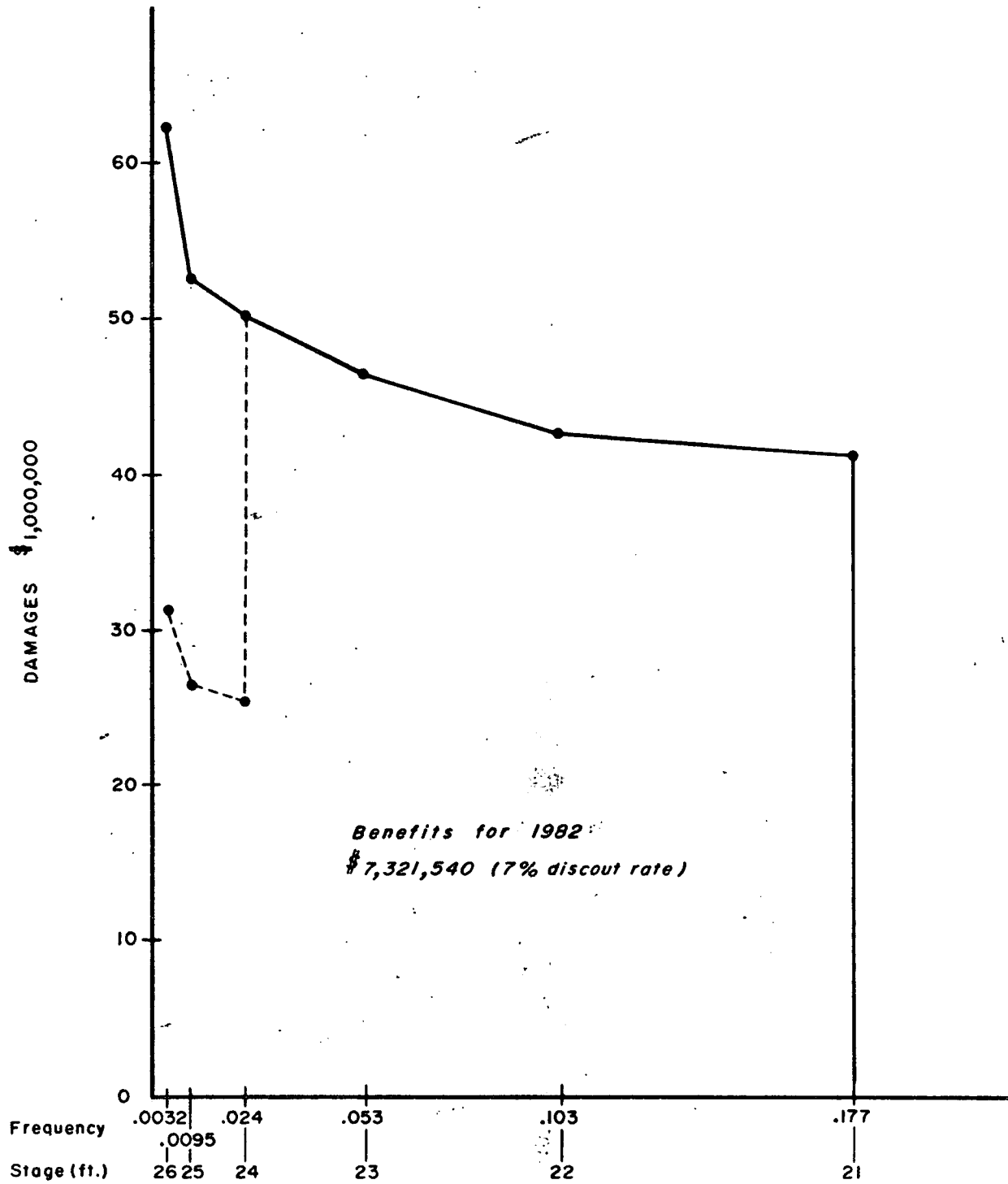


FIG. 2

DYKING DISTRICT OF PITT MEADOWS No.2  
ESTIMATE OF BENEFITS



5.65

APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1974

AREA: PITT MEADOWS NO. 2

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	540	581	670	770	879	1089
(b) Loss of use of dwelling	34	35	39	40	41	41
(c) Extra Food Cost	13	13	14	14	14	14
(2) Commercial						
(3) Industrial						
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	364	364	364	364	364	364
(b) Dairy production	40	40	40	40	41	41
(c) Beef Cattle production	6	6	6	6	6	6
(d) Livestock evacuation	2	2	2	2	2	2
(e) Milking equipment	5	5	5	5	5	5
(f) Extra feed	141	141	141	141	141	141
(5) Miscellaneous						
(a) Roads	51	51	51	51	51	51
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	14	14	14	14	14	14
TOTAL PRIMARY DAMAGES	1210	1252	1346	1447	1508	1768
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing	-	-	9	9	9	9
TOTAL SECONDARY DAMAGES	-	-	9	9	9	9
TOTAL DAMAGES	1210	1252	1355	1456	1517	1778

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: PITT MEADOWS NO. 2

TYPE OF DAMAGE	<u>\$000's DAMAGES</u> <u>FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	1118	1203	1387	1594	1820	2254
(b) Loss of use of dwelling	72	72	83	85	87	87
(c) Extra Food Cost	27	27	29	29	29	29
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	641	641	641	641	641	641
(b) Dairy production	84	84	84	84	86	86
(c) Beef Cattle production	21	21	21	21	21	21
(d) Livestock evacuation	5	5	5	5	5	5
(e) Milking equipment	13	13	13	13	13	13
(f) Extra feed	269	269	269	269	269	269
(5) Miscellaneous						
(a) Roads	93	93	93	93	93	93
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	27	27	27	27	17	27
TOTAL PRIMARY DAMAGES	2370	2458	2652	2861	3091	3525
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing	--	-	22	22	22	22
TOTAL SECONDARY DAMAGES	-	-	22	22	22	22
TOTAL DAMAGES	2370	2458	2674	2883	3113	3547



APPENDIX 3

PRESENT VALUE OF FLOOD DAMAGES - SUMMARY 1974

AREA: PITT MEADOWS NO. 2

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	9879	10629	12257	14086	15166	19922
(b) Loss of use of dwelling	512	527	587	602	617	617
(c) Extra Food Cost	196	196	211	211	211	211
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	7439	7439	7439	7439	7439	7439
(b) Dairy production	696	696	696	696	713	713
(c) Beef Cattle production	112	112	112	112	112	112
(d) Livestock evacuation	33	33	33	33	33	33
(e) Milking equipment	70	70	70	70	70	70
(f) Extra feed	1967	1967	1967	1967	1967	1967
(5) Miscellaneous						
(a) Roads	711	711	711	711	711	711
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	195	195	195	195	195	195
<b>TOTAL PRIMARY DAMAGES</b>	<b>21810</b>	<b>22575</b>	<b>24278</b>	<b>26122</b>	<b>27234</b>	<b>31990</b>
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing	-	-	157	157	157	157
<b>TOTAL SECONDARY DAMAGES</b>	<b>-</b>	<b>-</b>	<b>157</b>	<b>157</b>	<b>157</b>	<b>157</b>
<b>TOTAL DAMAGES</b>	<b>21810</b>	<b>22575</b>	<b>24435</b>	<b>26279</b>	<b>27391</b>	<b>32165</b>
<b>LESS 1974 DAMAGES</b>	<b>1210</b>	<b>1252</b>	<b>1355</b>	<b>1456</b>	<b>1517</b>	<b>1778</b>
<b>TOTAL DAMAGES</b>	<b>20600</b>	<b>21323</b>	<b>23080</b>	<b>24823</b>	<b>25874</b>	<b>30387</b>

APPENDIX 4

PRESENT VALUE OF FLOOD DAMAGES - SUMMARY 1982

AREA: PITT MEADOWS NO. 2

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	20449.5	22002.0	25372.0	29158.0	31393.6	41238.5
(b) Loss of use of dwelling	1090.6	1122.5	1250.3	1282.3	1314.2	1314.2
(c) Extra Food Cost	401.8	401.8	432.6	432.6	432.6	432.6
(2) Commercial	-	-	-	-	-	-
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	13092.6	13092.6	13092.6	13092.6	13092.6	13092.6
(b) Dairy production	1461.6	1461.6	1461.6	1461.6	1497.3	1497.3
(c) Beef Cattle production	395.4	395.4	395.4	395.4	395.4	395.4
(d) Livestock evacuation	82.8	82.8	82.8	82.8	82.8	82.8
(e) Milking equipment	176.4	176.4	176.4	176.4	176.4	176.4
(f) Extra feed	3757.0	3757.0	3757.0	3757.0	3757.0	3757.0
(5) Miscellaneous						
(a) Roads	1294.0	1294.0	1294.0	1294.0	1294.0	1294.0
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	372.5	372.5	372.5	372.5	372.5	372.5
TOTAL PRIMARY DAMAGES	42574.2	44158.6	47687.2	51505.2	53808.4	63653.3
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages	-	-	-	-	-	-
(2) Forward Linkages	-	-	-	-	-	-
(d) Milk processing	-	-	375.2	375.2	375.2	375.2
TOTAL SECONDARY DAMAGES	-	-	375.2	375.2	375.2	375.2
TOTAL DAMAGES	42574.2	44158.6	48062.4	51880.4	54183.6	64071.6
LESS 1974 DAMAGES	1210	1252	1355	1456	1517	1778
TOTAL DAMAGES	41364.2	42906.6	46707.4	50424.4	52666.6	62293.6

Dyking District of Glen Valley  
Analysis of Benefits

A. Introduction

The Dyking District of Glen Valley is located on the south bank of the Fraser River some 50 Kms. east of Vancouver. Total area of the Dyking District is 950 hectares, 650 hectares of which are in agricultural production. An estimated 40 residences and about 150 people would be affected by a 200 year return flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the District of Glen Valley dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1971.

E. Future Damages

The Glen Valley area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in population

and associated activity are expected to be low. Real price changes over time are also expected to be low. It was felt therefore, that a 1% rate of growth would be used to reflect both expected real growth and real price changes over time.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for Glen Valley were estimated to be \$400,000.

2. Benefits

Benefits were calculated for the Dyking District of Glen Valley by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

Table 1  
Benefit - Glen Valley Dykes

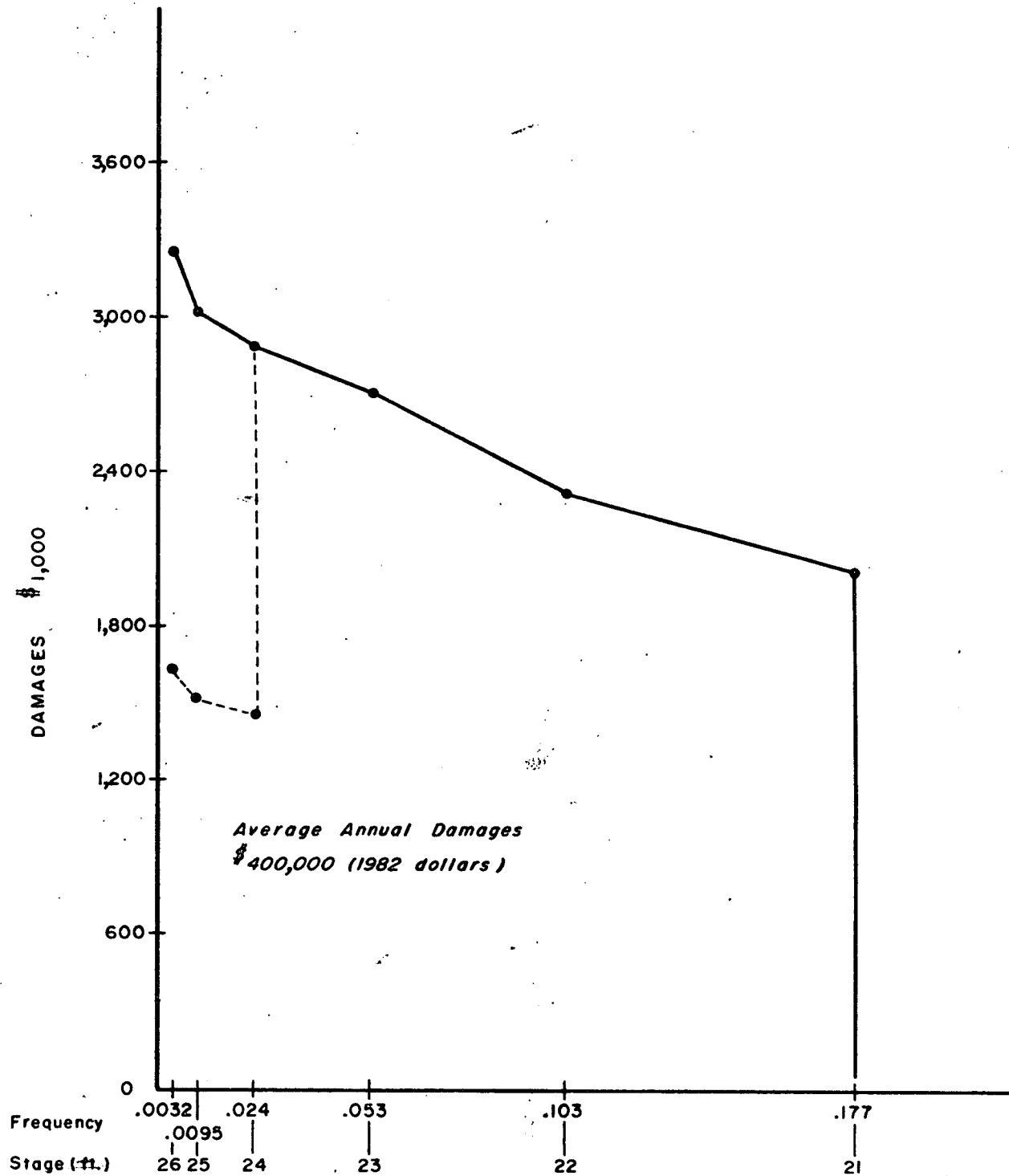
DISCOUNT RATE	BENEFITS (\$000)
7%	5,800
6%	6,550
8%	5,177
10%	4,258

G. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures. If these changes were taken into account, benefits would likely be higher.

FIG. 1

DYKING DISTRICT OF GLEN VALLEY  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: GLEN VALLEY

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	69	124	178	200	226	243
(b) Loss of use of dwelling	9	10	11	12	13	14
(c) Extra Food Cost	3	3	4	5	5	5
(2) Commercial	4	7	10	10	10	10
(3) Industrial						
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	293	307	322	335	343	359
(b) Dairy production	88	88	88	99	105	124
(c) Beef Cattle production	3	4	4	4	4	5
(d) Livestock evacuation	-	4	8	9	10	10
(e) Milking equipment	-	6	12	13	14	16
(f) Extra feed	87	92	97	100	103	108
(5) Miscellaneous						
(a) Roads	68	83	83	83	83	83
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	3	4	4	4	4	4
TOTAL PRIMARY DAMAGES	627	732	821	874	920	981
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages	2	2	2	2	3	3
(2) Forward Linkages	-	-	9	10	10	11
(d) Milk processing	-	-	35	40	42	50
TOTAL SECONDARY DAMAGES	2	2	46	52	55	64
TOTAL DAMAGES	629	734	867	926	975	1045

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: Glen Valley

TYPE OF DAMAGE	<u>\$000's DAMAGES</u> <u>FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	193.2	347.2	498.4	560.0	632.8	680.4
(b) Loss of use of dwelling	22.5	25.0	27.5	30.0	32.5	35.0
(c) Extra Food Cost	9.0	9.0	12.0	15.0	15.0	15.0
(2) Commercial	10.4	18.2	26.0	26.0	26.0	26.0
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	870.2	911.8	956.3	995.0	1018.7	1066.2
(b) Dairy production	299.2	299.2	299.2	336.6	357.0	421.6
(c) Beef Cattle production	16.5	22.0	22.0	22.0	22.0	27.5
(d) Livestock evacuation	-	11.6	23.2	26.1	29.0	29.0
(e) Milking equipment	-	18.0	36.0	39.0	42.0	48.0
(f) Extra feed	370.6	391.9	413.2	426.0	438.8	460.1
(5) Miscellaneous						
(a) Roads	210.8	257.3	257.3	257.3	257.3	257.3
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	8.1	10.8	10.8	10.8	10.8	10.8
TOTAL PRIMARY DAMAGES	2010.5	2322.0	2581.9	2743.8	2881.9	3076.9
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages	5.4	5.4	5.4	5.4	8.1	8.1
(2) Forward Linkages	-	-	20.7	23.0	23.0	25.3
(d) Milk processing	-	-	112.0	128.0	134.4	160.0
TOTAL SECONDARY DAMAGES	5.4	5.4	138.1	156.4	165.5	193.4
TOTAL DAMAGES	2015.9	2327.4	2720.0	2900.2	3047.4	3270.3



DYKING DISTRICT OF DERBY

Analysis of Benefits

A. Introduction

The Dyking District of Derby is located on the south bank of the Fraser River some 40 Kms. east of Vancouver. Derby has an area of about 365 hectares of which only 20% is in agricultural production. Only a handful of houses and a small population would be affected by a 200 year return flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Derby dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction) which has occurred in the area since 1971.

E. Future Damages

The Derby area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in population and associated activity are expected to be low. Real price changes over

time are also expected to be low. It was felt therefore, that no real growth and real price changes would occur in this area over the next 35 years.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for Derby were estimated to be \$13,935.

2. Benefits

Benefits were calculated for Derby by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1

Benefits - Derby Dykes

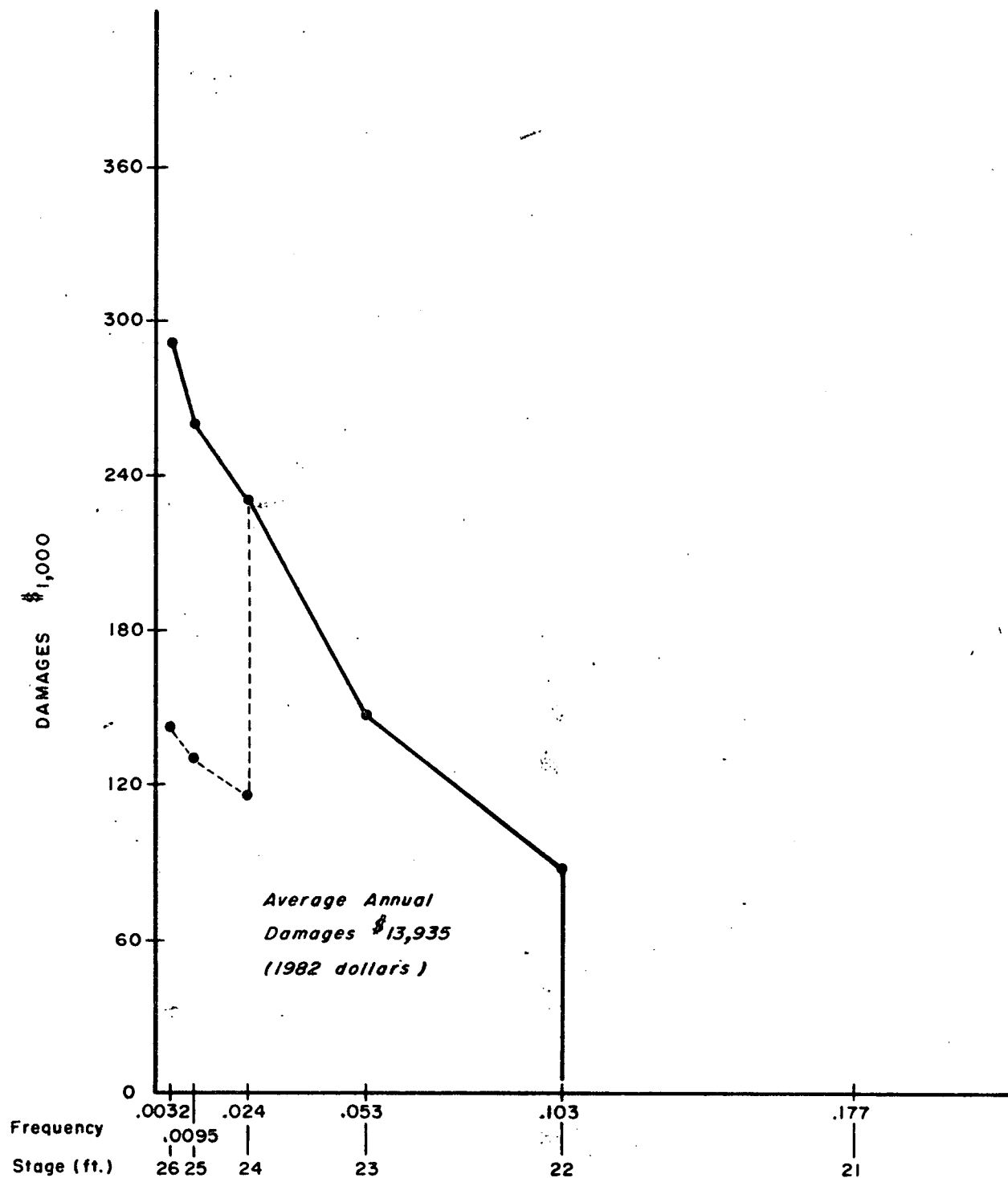
DISCOUNT RATE	BENEFITS (\$1,000)
7%	180
6%	202
8%	162
10%	134

G. Conclusion

This analysis provides an estimate of benefits which relies on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures.

FIG. 1

DYKING DISTRICT OF DERBY  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: DERBY

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	1	10	32	35	37
(b) Loss of use of dwelling	-	-	1	2	2	2
(c) Extra Food Cost	-	-	1	1	1	1
(2) Commercial						
(3) Industrial						
(4) Agricultural and Income Loss						
(a) Crop damage and income loss		23	28	29	31	32
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed						
(5) Miscellaneous						
(a) Roads	-	5	9	14	19	25
(b) Railways						
(c) Schools						
(d) Barns and outbuildings	-	-	1	2	2	2
TOTAL PRIMARY DAMAGES	-	29	50	79	89	98
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES						
TOTAL DAMAGES	-	29	50	79	89	98

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: DERBY

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	2.8	28.0	89.6	98.0	103.6
(b) Loss of use of dwelling	-	-	2.5	5.0	5.0	5.0
(c) Extra Food Cost	-	-	3.0	3.0	3.0	3.0
(2) Commercial						
(3) Industrial						
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	68	83	86	92	95
(b) Dairy production	-	-	-	-	-	-
(c) Beef Cattle production	-	-	-	-	-	-
(d) Livestock evacuation	-	-	-	-	-	-
(e) Milking equipment	-	-	-	-	-	-
(f) Extra feed	-	-	-	-	-	-
(5) Miscellaneous						
(a) Roads	-	15.5	27.9	43.4	58.9	77.5
(b) Railways	-	-	-	-	-	-
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	2.7	2.7	2.7	2.7
TOTAL PRIMARY DAMAGES	-	86.3	147.1	229.7	259.6	286.8
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES						
TOTAL DAMAGES	-	86.3	147.1	229.7	259.6	286.8

DYKING DISTRICT OF ALBION AND MAPLE RIDGE RD. 13  
ANALYSIS OF BENEFITS

A. Introduction

The Dyking Districts of Albion and Maple Ridge Rd. 13 are located on the north bank of the Fraser River some 45 kms. east of Vancouver. The total area of these dyking districts is 175 hectares. An estimated 40 houses, about 150 people, several industries and a number of commercial establishments would be affected by a 200 year return flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Albion and Maple Ridge Rd. 13 dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Control Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction, industrial development etc.) which has occurred in the area since 1971.

E. Future Damages

The Albion area has light industry and commercial establishments. Some new development has occurred in the area in recent years. There is

still some room for further expansion. The Maple Ridge Rd.13 area is primarily rural residential. No change has occurred in this area in recent years. Based on the observed land use change over the past 10 years, 1% rate of growth is used to reflect expected growth in this area in the future.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for Albion and Maple Ridge Rd. 13 were estimated to be \$72,820.

2. Benefits

Benefits were calculated for Albion and Maple Ridge Rd. 13 by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.



Table 1

Benefits - Albion and Maple Ridge Rd. 13 Dykes

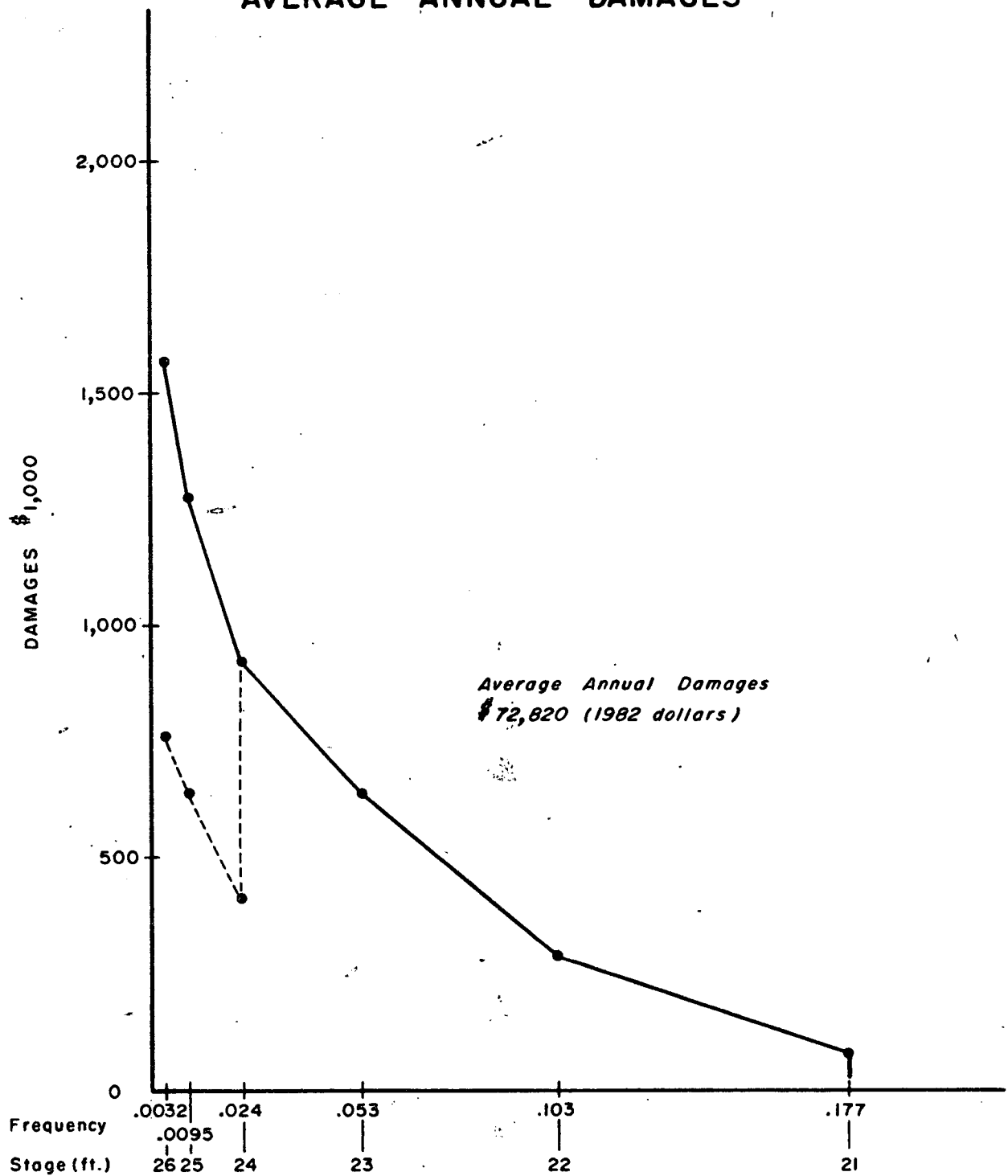
DISCOUNT RATE	BENEFITS (\$000)
7%	1,056
6%	1,192
8%	943
10%	770

G. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been some new industrial and commercial activity in the area. If these changes were taken into account, benefits would likely be higher.

FIG. 1

DYKING DISTRICT OF  
 ALBION AND MAPLE RIDGE ROAD "13  
 AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: ALBION AND MAPLE RIDGE RD. 13

TYPE OF DAMAGE	<u>\$000's DAMAGES</u> <u>FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	50	114	176	208
(b) Loss of use of dwelling	-	-	6	9	12	14
(c) Extra Food Cost	-	-	2	3	4	4
(2) Commercial	-	-	20	32	44	56
(3) Industrial	-	6	39	42	45	63
a) Industrial Income	-	1	8	23	66	93
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	42	44	45	46	47
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	12	13	14	14	14
(5) Miscellaneous						
(a) Roads	30	33	36	36	36	36
(b) Railways	-	-	-	-	5	10
(c) Schools						
(d) Barns and outbuildings						
(e) Gas Distribution Systems	-	-	1	1	1	1
TOTAL PRIMARY DAMAGES	30	94	219	319	449	546
(6) Secondary Income Loss						
(a) From severance of rail-way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES	-	-	-	-	-	-
TOTAL DAMAGES	30	94	219	319	449	546

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: ALBION AND MAPLE RIDGE RD. 13

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	140.0	319.2	492.8	582.4
(b) Loss of use of dwelling	-	-	15.0	22.5	30.0	35.0
(c) Extra Food Cost	-	-	6.0	9.0	12.0	12.0
(2) Commercial	-	-	51.0	81.6	112.2	142.8
(3) Industrial	-	16.2	105.3	113.4	121.5	170.1
a) Industrial Income (Vancouver)	-	3.0	24.0	69.0	198.0	279.0
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	124.7	130.7	133.7	136.6	139.6
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	51.1	55.4	59.6	59.6	59.6
(5) Miscellaneous						
(a) Roads	93.0	102.3	111.6	111.6	111.6	111.6
(b) Railways	-	-	-	-	15.5	31.0
(c) Schools						
(d) Barns and outbuildings						
(e) Gas Distribution Systems	-	-	3.7	3.7	3.7	3.7
TOTAL PRIMARY DAMAGES	93.0	297.3	642.7	923.3	1293.5	1566.8
(6) Secondary Income Loss						
(a) From severance of rail- way transport						
(b) From severance of road transport						
(c) Effects of agriculture crop damage						
(1) Backward Linkages						
(2) Forward Linkages						
(d) Milk processing						
TOTAL SECONDARY DAMAGES						
TOTAL DAMAGES	93.0	297.3	642.7	923.3	1293.5	1566.8

MISSION DYKING DISTRICT  
ANALYSIS OF BENEFITS

A. Introduction

The Mission Dyking District is located on the north bank of the Fraser River some 60 kms. east of Vancouver. The entire 120 hectares which would be protected by the rehabilitated dykes are zoned for industrial use. A sizeable portion of the area is currently being used by industrial and commercial establishments. There are 26 houses in the area and a permanent population of approximately 100. A major highway crossing between the north and south shore of the Fraser River would be unusable in the event of a major flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Mission Dyking District dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.
4. Confidence level of existing dyke is 22 feet.

D. Analysis of Damages

1. General

Flood damage data were originally prepared in 1971 for use in the Fraser River Flood Control Program.<sup>1/</sup> A reconnaissance of the Mission area floodplain in early 1982 showed that significant changes in land use had occurred since the original study was prepared. Merely updating the 1971 damages to 1982 using price

<sup>1/</sup> Princic, R. "Mission and Silverdale Dyking Proposal Benefit Study", Planning Division, Water Planning and Management Branch, Environment Canada, December 6, 1971.

indexes would not give a true picture of the potential damages in 1982. Therefore, field surveys were conducted to update the base data.

2. Residential Damages

Since a stage damage curve for this area was prepared in 1971 it was necessary only to update this to 1982 dollars (Appendix 2). Estimates of the number of houses likely to suffer damages at each flood stage were obtained from a field survey. The number of houses affected at each flood stage and the associated dollar damage is provided in Appendix 3.

3. Loss of Use of Dwellings

Loss of use of dwellings was established by taking the number of houses inundated at each flood stage, multiplying this by the total number of days during which they could not be occupied times the rental value of the homes. The monthly rental value of houses was taken to be 1% of the market value of an average home in the area. An estimate of the total loss of use per flood stage is provided in Appendix 3.

4. Extra Food Cost

Extra food cost was estimated by multiplying the number of houses inundated at each flood stage by the estimated extra cost of food per household times the length of evacuation. Extra food cost per person was estimated to be \$.38 in 1971. This was updated to \$1.14 in 1982. An estimate of the extra food cost for each flood stage is provided in Appendix 3.

5. Commercial Damages

The basic steps involved in estimating commercial damages in this study were: (1) identify and assign individual commercial establishments to their appropriate categories; (2) determine

the elevation of each establishment; (3) determine the height of the main floor above ground level for each establishment; (4) estimate the floor area of each establishment; 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 Appendix 1.

6. Industrial Damages

The basic steps involved in estimating the majority of the industrial damages in this study were: (1) identify and assign individual industrial establishments to their appropriate categories; (2) determine the height of the industry above ground level; (3) estimate the area of active use (in acres) of each industrial establishment; (4) obtain the dollar damage estimate for each industry by applying updated unit damage costs (originally generated in 1971) to the area of activity (step (3)). Damages for those industries for which there were no unit damage costs were estimated by on-site inspection and discussion with management. Damages for several of the establishments which were felt to have changed very little since 1971 were merely updated to 1982 dollars using Statistics Canada price indices.

7. Damage to Roads

Road damages were estimated using two sets of values; a value of \$3,840 per kilometre was used to estimate damages for floods of less than 7 days and \$17,330 per kilometre for floods longer than 7 days.

8. Damage to Railways

Damage to railway tracks were obtained by updating the 1971 damage estimates using Statistics Canada price indices.

9. Primary Income Losses

Primary income losses result when floodplain firms are forced to shut down due to flooding. Because of the nature of most of the industries on the Mission floodplain it was assumed that any production losses by these industries would be made up by increases by other lower mainland firms. Losses to the B.C. economy therefore, would be small. For those industries which suffer production losses which cannot be made up by other B.C. industries income losses were calculated in the following manner: (1) each firm's daily gross value of production was established either by contacting the firm directly or through secondary sources; (2) each firm's value added portion of its gross income was established by consulting the publication "The Input-Output structure of the Canadian Economy 1961"; and, (3) primary income loss was calculated by multiplying the firm's daily income (value added) by the total number of days out of production.

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

10. Damage to Outbuildings

It is assumed that outbuildings would have to be repaired and painted at a cost of \$110 per outbuilding.

E. Future Damages

The entire floodplain at Mission is zoned for industrial-commercial use. Considerable expansion has occurred in the area in recent years. Based on discussion with district planning personnel it appears



that growth in this area will continue at a relatively rapid rate over the next few years. It was felt therefore, that a 1% rate of growth would be used to reflect the increase in damages in the future.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 1. Figure 1 shows the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated only 50% of damages. Average annual damages for the Mission Dyking District were estimated to be \$461,630.

2. Benefits

Benefits were calculated for the Mission Dyking District by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1

Benefits - Mission Dykes

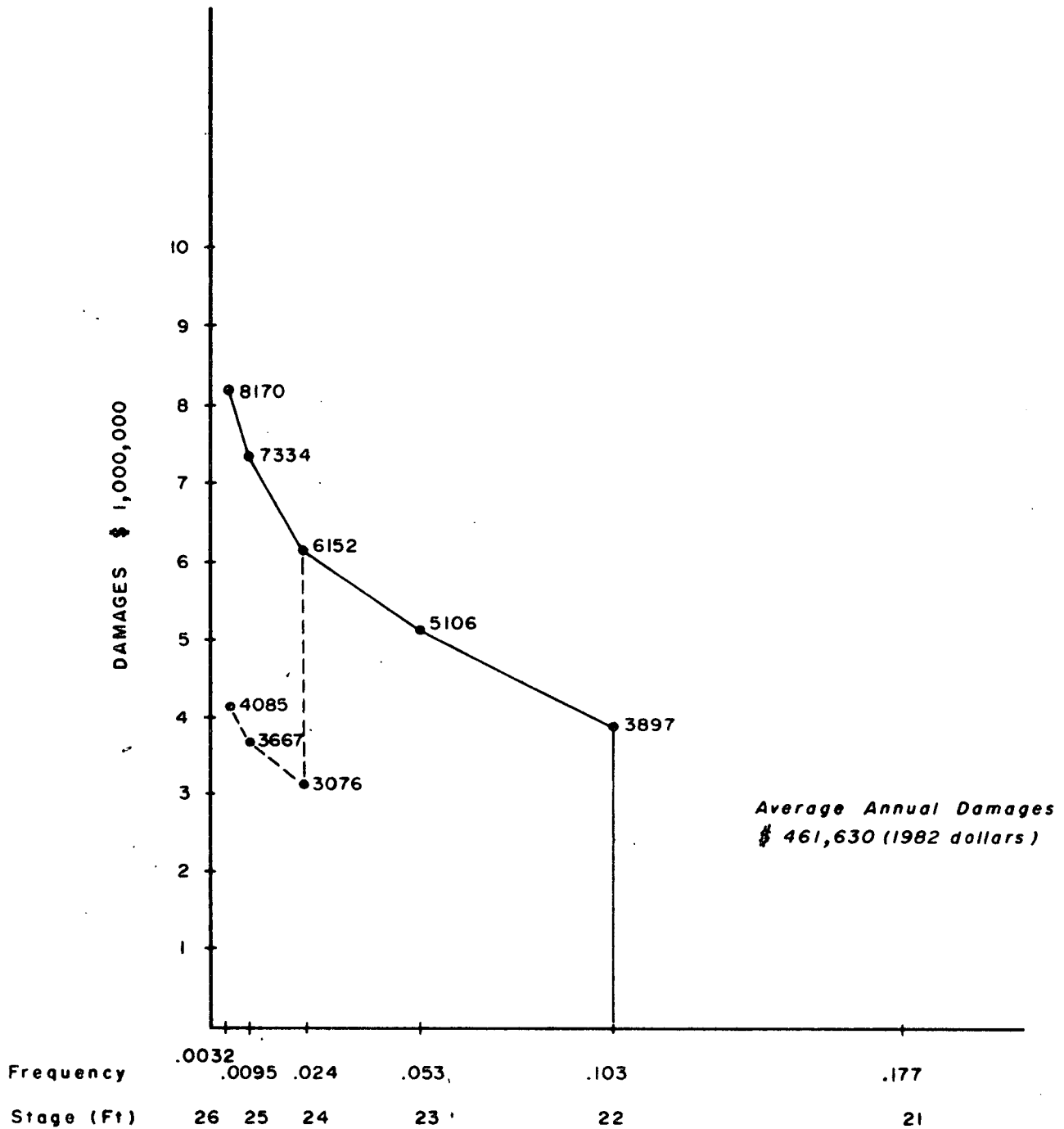
<u>DISCOUNT RATE</u>	<u>BENEFITS (\$000)</u>
7%	6,693
6%	7,559
8%	5,977
10%	4,878

G. General Comments

Benefits prepared in this analysis have increased significantly from earlier Mission dyking studies. One of the main reasons for this is that earlier updates of Mission have made use of 1971 base data. For this analysis a new field survey was taken and all important damage categories i.e. commercial, industrial, etc. were updated to current (1982) conditions. The survey identified several new industries and commercial establishments which are largely responsible for the large increase in benefits. In fact, more than 75% of all flood benefits at Mission are attributable to one industry which has located on the floodplain since 1971.

FIG . 1

DYKING DISTRICT OF MISSION  
AVERAGE ANNUAL DAMAGES



APPENDICES

APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1982

• AREA: MISSION CITY

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	21	64	157	266	319
(b) Loss of use of dwelling		2	5	13	15	18
(c) Extra Food Cost		1	3	7	8	10
(2) Commercial	-	23	381	1,060	1,827	2,504
(3) Industrial	-	2,401	2,471	2,521	2,622	2,657
(4) Primary Income		1,449	2,115	2,233	2,389	2,468
(5) Agricultural and Income Loss						
(a) Crop damage and income loss						
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed						
(6) Miscellaneous						
(a) Roads	-	-	50	62	65	70
(b) Railways	-	-	17	98	141	223
(c) Outbuildings	-	-	-	1	1	1
 TOTAL DAMAGES		3,897	5,106	6,152	7,334	8,170

APPENDIX 2

Residential Stage Damage Curve - Mission

FLOOD DEPTH ft. Above Ground	<u>MISSION</u>	
	1971	1982*
1	\$ 1,300	\$ 3,640
2	3,600	10,080
3	4,300	12,040
4	4,800	13,440
5	5,500	15,400
6	5,700	15,960
7	6,000	16,800
8	6,100	17,080
9	6,500	18,200
10	6,500	18,200
10+	9,000	25,200

\* Price index for 1982 is 280 (1971 = 100)•

Source

British Columbia Assessment Authority, Appraisal Systems Division, Composite Cost Indices.  
Residences, Frame Structure .

# APPENDIX 3

## MISSION CITY

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

Flood Stage (ft)	Level of Flooding above Ground Level (M)	Length of Evacuation period (DAYS)	Damage per House \$	No. of Houses	Loss of use per House * Extra Food Cost	Total Loss of Use \$	Damage to Houses \$	Extra food Costs \$
22	0	1	-	21	8/5	168	-	105
	1(.3)	50	3,640	3	417/228	1251	10,920	684
	2(.6)	52	10,080	1	433/237	433	10,080	237
				25		1852	21,000	1026
23	0	1	-	15	8/5	120	-	75
	1(.3)	61	3,640	6	508/278	3,048	21,840	1668
	2(.6)	65	10,080	3	542/296	1,626	30,240	888
	3(.9)	84	12,040	1	700/383	700	12,040	383
				25		5,494	64,120	3,014
24	0	1	-	2	8/5	16	-	10
	1(.3)	61	3,640	13	508/278	6,604	47,320	3,614
	2(.6)	65	10,080	6	542/296	3,252	60,480	1,776
	3(.9)	85	12,040	3	708/388	2,124	36,120	1,164
	4(1.2)	87	13,440	1	725/397	725	13,440	397
				25		12,721	157,360	6,961
25	0	1	-	0	-/-	-	-	-
	1	61	3,640	2	508/278	1,016	7,280	556
	2	66	10,080	13	550/301	7,150	131,040	3,913
	3	86	12,040	6	717/392	4,302	72,240	2,352
	4	89	13,440	3	742/406	2,226	40,320	1,218
	5	91	15,400	1	758/415	758	15,400	415
				25		15,452	266,280	8,454
26	0	1	-	0	-/-	-	-	-
	1	61	3,640	0	-/-	-	-	-
	2	66	10,080	2	550/278	1,100	20,160	556
	3	86	12,040	13	717/392	9,321	156,520	5,096
	4	90	13,440	6	750/410	4,500	80,640	2,460
	5	92	15,400	3	767/420	2,301	46,200	1,260
	6	93	18,960	1	775/424	775	15,960	424
				25		17,997	319,480	9,796

\* Monthly rental value \$250

\*\* Extra food cost is \$4.56 per household per day.

UPPER SUMAS RIVER DYKES (DISTRICT OF ABBOTSFORD)

ANALYSIS OF BENEFITS

---

A. Introduction

The Dyking District of Sumas is located about 80 kms east of Vancouver. The total area which would be protected by the rehabilitated dykes is 4,050 hectares of rural and agricultural land. The area also has about 215 houses and a population of some 850 people.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Upper Sumas River dykes to withstand a 1935 level flood.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Flood Frequencies, Elevations and Durations

Original report prepared in 1971 had flood elevations, areas flooded, durations and return periods as shown in Appendix 1, Table A. A new dam currently being constructed on the Sumas River will reduce flood elevations, areas flooded and durations as shown in Appendix 1, Table B. An additional important change since the completion of the original study in 1971 is that a frequency curve has been developed for the Sumas River, making it possible to calculate benefits more accurately.

E. Analysis of Damages

Flood damages for Sumas River for 1982 were estimated in the following manner. Flood damage data originally prepared in 1971 (Appendix 2)



for use in the Fraser River Flood Control Program were updated to 1982 dollars (Appendix 3). A stage damage curve for the 1971 hydrologic conditions on the Sumas River (old dam and pump) was developed by plotting the updated (1982) damages versus their peak elevations (Appendix 4). Damages which could be used to estimate benefits for 1982 hydrologic conditions were obtained from the stage damage curve. Damages for the various elevations are shown in Table 1.

TABLE 1  
Damages at Various Flood Elevations 1982

Flood Frequency (Years)	Peak River Elevation at Dam(ft)	<u>Existing Conditions</u>		<u>Improved Conditions</u>	
		Peak Flood Elevation ft	Damages (\$1,000)	Peak Flood Elevation ft	Damages (\$1,000)
50	87.7	79.7	9,000	73.3	995
35	86.3	76.9	5,800	72.4	200
10	85.8	71.5	200		

This approach to estimating damages is useful and provides a reliable measure of damages in 1982 dollars for conditions which existed in the Sumas River floodplain in 1971. However, it does not take into account any real growth (e.g. residential construction, agricultural land use) which has occurred in the area since 1971.

F. Future Damages

The Sumas River area is primarily rural and agricultural. Since most of the area is zoned for agricultural use, real growth in population and associated activity are expected to be low. Real price changes over time are also expected to be low. It was felt, therefore, that

a 1% rate of growth would be used to reflect both expected real growth and real price changes over time.

G. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Table 1. Figures 1 & 2 show the damage-frequency relationship used to generate average annual damages. Average annual damages for Sumas River dykes were estimated to be \$277,840 for existing conditions and \$5,139 for improved conditions.

2. Benefits

Benefits were calculated for the Sumas River dykes by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 2.

TABLE 2  
Benefits - Sumas River Dykes

Discount Rate	Gross Benefits Existing Conditions (\$000)	Residual Damages After Improvement (\$000)	Project Benefits (\$000)
7%	4,028	75	3,953
6%	4,549	84	4,465
8%	3,597	67	3,530
10%	2,936	54	2,882

FIG. 1  
UPPER SUMAS RIVER DYKES  
AVERAGE ANNUAL DAMAGES  
Existing Conditions

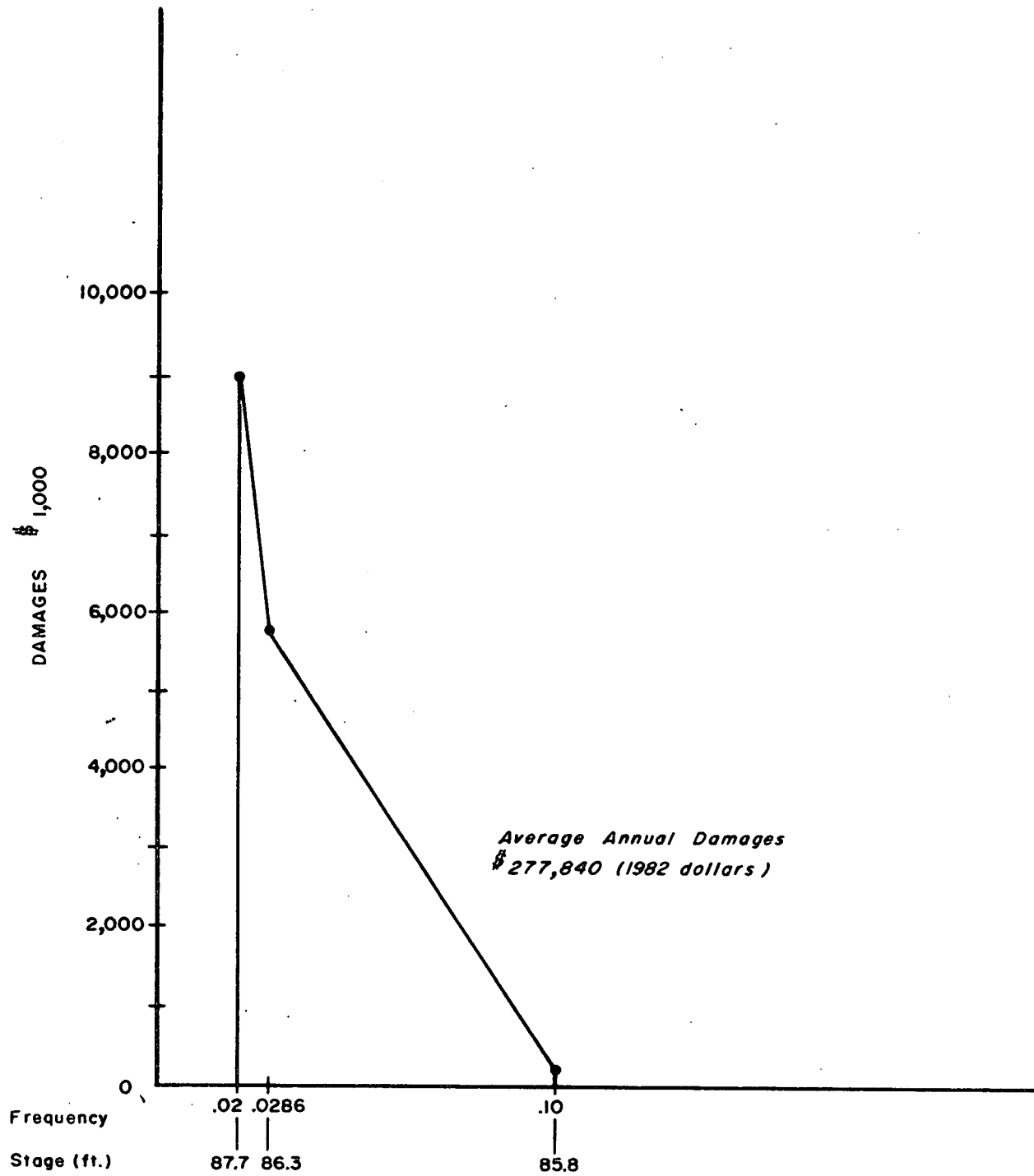
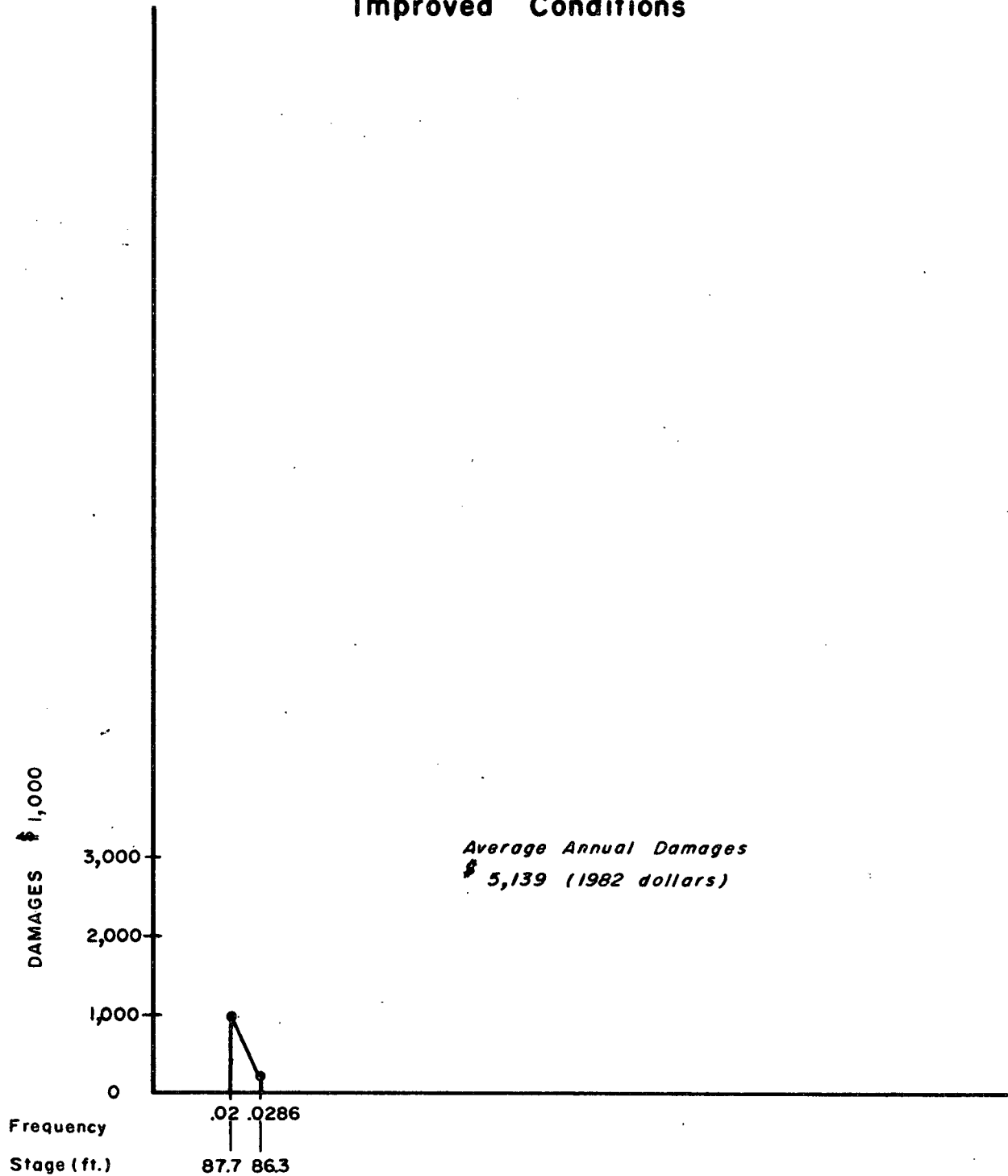


FIG . 2

UPPER SUMAS RIVER DYKES  
AVERAGE ANNUAL DAMAGES

Improved Conditions



H. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and other structures. If these changes were taken into account, benefits would likely be higher.

## APPENDICES

# APPENDIX I

## TABLE A

### Flood Elevations, Areas and Durations

Flood	Existing Conditions			Improved Conditions		
	Peak Elevation	Area Flooded	Duration of Flooding Above 70.0'	Peak Elevation	Area Flooded	Duration of Flooding Above 70.0'
	Sumas Datum	Acres	Days	Sumas Datum	Acres	Days
1935	80.7	10,000	47	74.0	4,200	11
1951	77.6	8,200	28	73.1	3,000	7
1954	72.7	2,500	11	No	Flooding	
1955	72.0	1,800	5	No	Flooding	

## TABLE B

### Flood Frequencies, Elevations Areas and Durations

Flood Frequency years	Existing Conditions				Improved Conditions		
	Peak River Elev. @ Dam	Peak Flood Elevation	Area Flooded	Duration of Flooding above 70.0'	Peak Flood Elev.	Area Flooded	Duration of flooding Above 70.0'
	ft	ft	Acres	Days	ft.	Acres	Days
50	87.7	79.7	9,600	26	73.3	3,200	7
35	86.3	76.9	7,700	15	72.4	2,200	3
10	85.8	71.5	800	3	No	Flooding	

APPENDIX 2A

FLOOD DAMAGES - SUMMARY

1971 - PRESENT

AREA: SUMAS RIVER DYKES

TYPE OF DAMAGE	<u>\$000's DAMAGES</u>			
	1955	1954	1951	1935
(1) Residential and Associated				
(a) Residential and content	30.9	87.4	888.5	1,556.8
(b) Loss of use of dwelling	3.1	8.7	52.0	90.5
(c) Extra Food Cost	.9	2.4	15.1	26.2
(2) Commercial				
(3) Industrial				
(4) Agricultural Damage and Income Loss				
(a) Crop damage and income loss	-	28.7	608.3	849.2
(b) Dairy production	24.6	56.5	216.0	353.2
(c) Beef Cattle production				
(d) Hog production	.2	.3	.8	1.0
(e) Turkey production				
(f) Broiler production	-	-	4.7	15.0
(g) Egg production	-	-	4.8	23.5
(h) Livestock evacuation				
(i) Milking equipment	7.2	14.4	43.8	51.6
(j) Extra feed	10.8	21.6	64.2	77.4
(5) Miscellaneous				
(a) Roads	12.0	90.0	279.0	315.0
(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	4.6	9.4	43.6	58.0
(f) Evacuating people				
TOTAL PRIMARY DAMAGES	94.3	319.4	2,220.9	3,417.4
(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	94.3	319.4	2,220.9	3,417.4



APPENDIX 2B

FLOOD DAMAGES - SUMMARY

1971 - IMPROVED

AREA: SUMAS RIVER DYKES

TYPE OF DAMAGE	<u>\$000's DAMAGES</u>			
	1955	1954	1951	1935
(1) Residential and Associated				
(a) Residential and content			101.0	190.2
(b) Loss of use of dwelling			9.6	13.7
(c) Extra Food Cost			2.9	4.0
(2) Commercial				
(3) Industrial				
(4) Agricultural Damage and Income Loss				
(a) Crop damage and income loss				48.2
(b) Dairy production			60.2	77.3
(c) Beef Cattle production				
(d) Hog production			.3	.4
(e) Turkey production			-	-
(f) Broiler production			-	-
(g) Egg production			-	-
(h) Livestock evacuation			-	-
(i) Milking equipment			17.1	20.2
(j) Extra feed			25.6	30.3
(5) Miscellaneous				
(a) Roads			24.0	153.0
(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			11.6	14.8
(f) Evacuating people				
TOTAL PRIMARY DAMAGES			252.3	552.1
(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			252.3	552.1

APPENDIX 3A

FLOOD DAMAGES - SUMMARY

1982 - PRESENT

AREA: SUMAS RIVER DYKES

TYPE OF DAMAGE	<u>\$000's DAMAGES</u>			
	1955	1954	1951	1935
(1) Residential and Associated				
(a) Residential and content	86.5	244.7	2,487.8	4,359.0
(b) Loss of use of dwelling	7.7	21.6	129.0	224.4
(c) Extra Food Cost	2.7	7.2	45.5	78.9
(2) Commercial				
(3) Industrial				
(4) Agricultural Damage and Income Loss				
(a) Crop damage and income loss	-	85.2	1,804.3	2,518.7
(b) Dairy production	83.9	192.7	736.6	1,204.4
(c) Beef Cattle production				
(d) Hog production	.5	.6	2.0	2.5
(e) Turkey production				
(f) Broiler production	-	-	12.1	38.7
(g) Egg production	-	-	12.7	61.3
(h) Livestock evacuation				
(i) Milking equipment	21.6	43.3	131.6	155.0
(j) Extra feed	46.0	92.0	273.4	329.6
(5) Miscellaneous				
(a) Roads	37.2	279.0	864.9	976.5
(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	12.4	25.4	117.8	156.7
(f) Evacuating people				
TOTAL PRIMARY DAMAGES	298.5	991.6	6,617.6	10,105.8
(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	298.5	991.6	6,617.6	10,105.8

APPENDIX 3B

FLOOD DAMAGES - SUMMARY

1982 - IMPROVED

AREA: SUMAS RIVER DYKES

TYPE OF DAMAGE	<u>\$000's DAMAGES</u>			
	1955	1954	1951	1935
(1) Residential and Associated				
(a) Residential and content			282.8	532.6
(b) Loss of use of dwelling			23.8	34.0
(c) Extra Food Cost			8.7	12.1
(2) Commercial				
(3) Industrial				
(4) Agricultural Damage and Income Loss				
(a) Crop damage and income loss			-	143.0
(b) Dairy production			205.3	263.6
(c) Beef Cattle production				
(d) Hog production			.7	1.0
(e) Turkey production				
(f) Broiler production				
(g) Egg production				
(h) Livestock evacuation				
(i) Milking equipment			51.4	60.7
(j) Extra feed			109.0	129.0
(5) Miscellaneous				
(a) Roads			74.4	474.3
(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			31.3	40.0
(f) Evacuating people				
TOTAL PRIMARY DAMAGES			787.5	1,690.1
(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			787.5	1,690.1

APPENDIX 4  
SUMAS RIVER DYKES  
Stage Damage Curves

EXISTING  
CONDITIONS

LEGEND

- - 1972 Elevations
- - 1982 Elevations

IMPROVED  
CONDITIONS

DAMAGES  
\$1,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

0

68

70

72

74

76

78

80

82

FLOOD ELEVATIONS IN FEET

PORT COQUITLAM (COQUITLAM RIVER)

ANALYSIS OF BENEFITS

A. INTRODUCTION

The Port Coquitlam flood plain is located south of the Lougheed Highway and CPR mainline tracks between the Coquitlam R. and the Pitt R. Land use in the central and western portion of the flood plain, on both sides of the Coquitlam R., is zoned residential and commercial with occasional parcels of industrial land. The eastern portion is zoned industrial and contains several commercial-industrial strata lot warehouse complexes together with a number of major industrial enterprises.

Much of the commercial and residential development in the flood plain is old and undergoing piece meal redevelopment. The industrial development, east of Kingsway and Tyner Roads, is comparatively recent. Industrial land developers are advised by the City to fill to a height of at least 10m above datum or 0.3m above the crown of the road and most appear to have done this.

For purposes of this study three potential flood stages were considered:

200 year flood; duration 1-4 days; discharge 20670 cfs.  
50 year flood; duration 1-3.5 days; discharge 17070 cfs  
20 year flood; duration 1-3 days; discharge 14500 cfs

B. OBJECTIVE

The objective of this analysis is to estimate the present and future economic benefits of flood damage protection for Port Coquitlam.



### C. BASIC ASSUMPTIONS

1. Expected economic life of the engineering works: 35 years
2. Future benefits discounted at 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year: 1982
4. Future growth of damage values: 1.5% per year.

### D. ANALYSIS OF DAMAGES

#### 1. General

Flood damage estimates for some of the area were prepared in 1971 as part of a study for the Fraser River Flood Control Program. However, considerable expansion has occurred since that time and it was considered desirable to undertake a new field study to re-estimate potential damages. Moreover, the present study considers a flood from the Coquitlam R. rather than the Fraser R. (via the Pitt R.) resulting in a different flood profile. Nevertheless, basic stage damage data for industrial damages in the 1971 study has been updated and used as an indicator of current 1982 industrial damages.

#### 2. Residential Damages

For this study a 1971 stage damage curve for the Port Coquitlam area was updated to 1982 dollars; see Appendix I. Estimates of the number of houses likely to suffer damage at each flood stage were obtained from a field survey, Appendix IIIA - IIIB. Total estimated damage to residential buildings and contents at each flood stage is summarized in Appendix II.

#### 3. Loss of Use of Dwellings

Loss of use of dwellings was established by taking the number of houses inundated at each flood stage, multiplying this by the total number of days during which they could not be occupied times the rental value of the homes. The monthly rental value was taken to be 1% of the market value of an average home in the area. An estimate of the total residential loss-of-use value per flood stage is provided in Appendix III.

#### 4. Extra Food Cost

Extra food cost was estimated by multiplying the number of houses inundated at each flood stage by the estimated extra cost of food per household times the length of evacuation. Extra food cost per person was estimated to be \$1.14 in 1982 dollars. Total extra food costs for each flood stage are shown in Appendix III.

#### 5. Commercial Damages

Commercial damages were estimated for the total number of establishments in each of 20 categories as defined in Appendix IV. There were 157 active commercial establishments in total. The main floor area above ground level and the depth of water in each establishment, for each flood stage, was estimated in the field. The dollar damage for each establishment was then estimated by multiplying its floor area by the appropriate unit damage estimate extracted from the stage damage table reproduced in Appendix V.

Total estimated commercial damages for each flood stage are summarized in Appendix II.

#### 6. Industrial Damages

Time did not allow for field interviews with each of the 44 identified industrial establishments in the flood plain. Consequently industrial damages were estimated by treating the 1971 survey data as a sample and updating to 1982 values with a cost index of 2.9:1.0.

Industrial damage estimates for each flood stage are summarized in Appendix II.

#### 7. Damage to Roads

Road damages were estimated using a value of \$3,840/km applied to the length of road flooded in each flood stage. Road damage estimates are summarized in Appendix II, for each flood stage.

#### 8. Damage Railways

It was assumed, on advice, that the CPR mainline tracks to the north of the flood plain would be unaffected by flood waters.



## 9. Primary Income Losses

Since the expected duration of the maximum 200 year flood is four days it was assumed that loss of primary income due to firms being shut down by flooding would be negligible.

## E. FUTURE DAMAGES

Port Coquitlam Engineering Department personnel estimate that industrial and commercial development will grow at about 2.5 percent per year. With the Mary Hills by-pass along the eastern boundary of the area, connecting the Lougheed Highway to Highway 401, and with easy access to CPR railhead, the area is extremely attractive to industry and business. Residential growth is expected to grow at about 1 percent per year with increasing emphasis on multiple-family units, apartments and townhouses.

For purposes of estimation it was assumed that potential flood damages for all categories of use would increase at an average rate of 1.5% per year in real terms.

## F. ANALYSIS OF BENEFITS

### 1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix II. Figure 1 shows the damage-frequency relationship used to generate average annual damages. Average annual damages for the Port Coquitlam Dyking District were estimated to be \$478,460.

### 2. Benefits

Benefits were calculated by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7 percent was used. Sensitivity analysis was also conducted using 6, 8 and 10 percent discount rates. Estimates of benefits are provided in Table 1.

FIG. 1

PORT COQUITLAM (COQUITLAM RIVER)  
AVERAGE ANNUAL DAMAGES

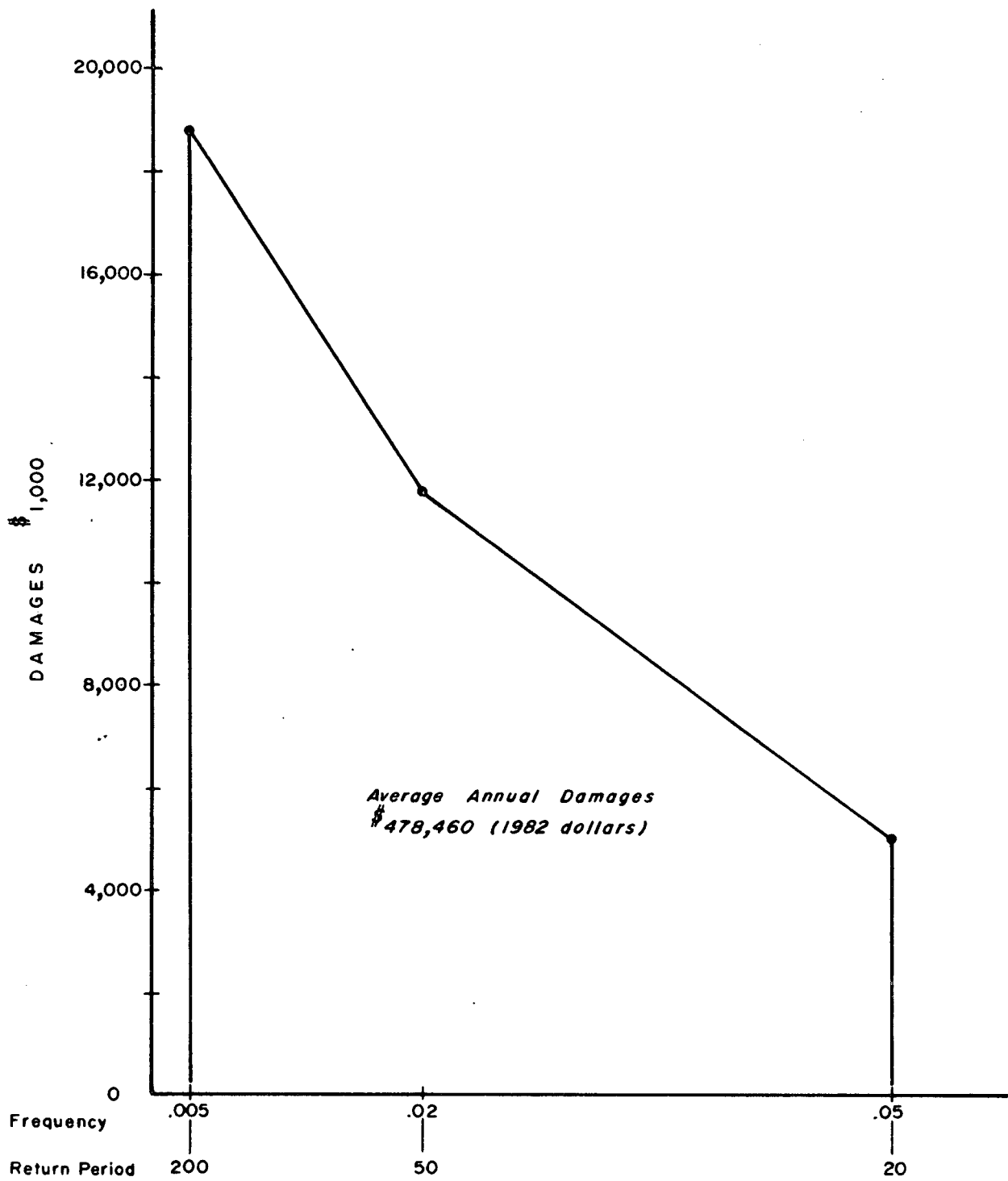


Table 1

Flood Benefits - Port Coquitlam 1982

Discount Rate	Benefits
(%)	(\$000's)
7	7,363
6	8,354
8	6,549
10	5,305

G. Conclusions

This analysis provides a reliable estimate of dyke benefits of flood protection from the Coquitlam River. A field survey was used to obtain an up-to-date assessment of the majority of the more important damage categories. However, because of time it was not possible to conduct a thorough field investigation of the industrial establishments in the floodplain. Consequently, a short-cut approach, relying on 1971 data was used to assess these damages. This method is believed to provide a reasonable approximation of the industrial damages.

APPENDIX

## APPENDIX I

### RESIDENTIAL STAGE DAMAGE CURVE

#### PORT COQUITLAM, 1982

<u>Flood Depth</u> (m)	<u>Damage</u> (\$000's)
0.3	4 200
0.6	8 960
0.9	10 920
1.2	13 160
1.5	15 120
1.8	17 080
2.1	22 120
2.4	23 240
2.7	24 920
3.0	26 040
3.3	40 040

## APPENDIX II

### FLOOD DAMAGES - SUMMARY

PORT COQUITLAM, 1982

<u>Type of Damage</u>	<u>Value of Damage by Flood Stage</u>		
	<u>200 yr.</u> (\$000's)	<u>50 yr.</u> (\$000's)	<u>20 yr.</u> (\$000's)
(1) Residential			
Buildings & Contents	7 919 700	5 274 400	2 293 400
Loss of Use	529 100	389 600	202 500
Extra Food Cost	178 700	131 600	67 900
(2) Commercial	7 644 730	4 522 920	1 606 540
(3) Industrial	2 379 440	1 344 070	712 030
(4) Agricultural	--	--	--
(5) Miscellaneous:			
Road	75 800	65 800	60 060
	<hr/>	<hr/>	<hr/>
(7) TOTAL DAMAGES	18 727 470	11 728 390	4 942 430
	<hr/>	<hr/>	<hr/>

## AREA - COQUITLAM RIVER

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

Flood Stage (M)	Level of Flooding above Ground Level(M)	Length of Evac- uation period (DAYS)	Damage per House \$	No. of Houses	Loss of use per House * Extra ** Food Cost	Total Loss of Use \$	Damage to Houses \$	Extra food Costs \$			
20 yr	0	1	0	248	13/4.5	3,224	0	1,116			
	.3	48	4,200	91	660/216	60,060	382,200	19,656			
	.6	48	8,960	86	640/216	55,040	770,560	18,576			
	.9	63	10,920	46	840/284	38,640	502,320	13,064			
	1.2	63	13,160	25	840/284	21,000	329,000	7,100			
	1.5	63	15,120	3	840/284	2,520	45,360	852			
				499		180,484	2,029,440	60,364			
50 yr	0	1	0	254	13/4.5	3,302	0	1,143			
	.3	46	4,200	100	613/207	61,300	420,000	20,700			
	.6	47	8,960	110	627/212	68,970	985,600	23,320			
	.9	64	10,920	86	853/288	73,358	939,120	24,768			
	1.2	64	13,160	77	853/288	65,681	1,013,320	22,176			
	1.5	64	15,120	55	853/288	46,915	831,600	15,840			
	1.8	64	17,080	15	853/288	12,795	256,200	4,320			
				2.1	64	22,120	1	853/288	853	22,120	288
				698		333,174	4,467,960	112,555			
200 yr	0	1	0	172	13/4.5	2,236	0	774			
	.3	46	4,200	109	613/207	66,817	457,800	22,563			
	.6	47	8,960	105	627/212	65,835	940,800	22,260			
	.9	64	10,920	115	853/288	98,095	1,255,800	33,120			
	1.2	64	13,160	107	853/288	91,271	1,408,120	30,816			
	1.5	64	15,120	58	853/288	49,474	876,960	16,704			
	1.8	64	17,080	60	853/288	51,180	1,024,800	17,280			
	2.1	64	22,120	24	853/288	20,472	530,880	6,912			
					2.4	64	23,240	7	853/288	5,971	162,680
				757		451,351	6,657,840	152,445			

\* Monthly rental value - \$400.

\*\* Extra food cost is \$4.50 per household per day

## AREA - COQUITLAM RIVER

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

Flood Stage (M)	Level of Flooding above Ground Level (M)	Length of Evacuation period (DAYS)	Damage per House \$	No. of Houses	Loss of use per House * Extra Food Cost	Total Loss of Use \$	Damage to Houses \$	Extra food Costs \$
20 yr	0	1	0	282	13/4.5	3666	0	1269
	.3	48	4200	-	640/216	-	-	-
	.6	48	8,960	8	640/216	5120	71,680	1728
	.9	63	10,920	8	840/284	6720	87,360	2272
	1.2	63	13,160	8	840/284	6720	105,280	2272
				306		22,226	264,320	7541
50 yr	0	1	0	228	13/4.5	2964	0	1026
	.3	46	4,200	-	613/207	-	-	-
	.6	47	8,960	58	627/212	36,366	519,680	12,296
	.9	64	10,920	-	853/288	-	-	-
	1.2	64	13,160	8	853/288	6824	105,280	2304
				12	853/288	10,236	181,440	3456
				306		56,390	806,400	19,082
200 yr	0	1	0	224	13/4.5	2912	0	1008
	.3	46	4,200	4	613/207	2452	16,800	828
	.6	47	8,960	4	627/212	2508	35,840	848
	.9	64	10,920	4	853/288	3412	43,680	1152
	1.2	64	13,160	54	853/288	46,062	710,640	15,552
	1.5	64	15,120	8	853/288	6,824	120,960	2,304
	1.8	64	17,080	4	853/288	3,412	68,320	1152
				12	853/288	10,236	265,440	3456
				314		77,818	1,261,680	26,300

\* Monthly rental value - \$400

\*\* Extra food cost is \$4.50 per household per day



## APPENDIX IV

### Commercial Categories for Which Average Stage-Damage Relationships Were Determined\*

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

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

# APPENDIX V

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

Cumulative Damage (\$) Various Levels of Flooding (\$1982)

Category of Establishment:	meters							
	.3	.6	.9	1.2	1.5	1.8	2.1	2.4
1. Petroleum Services	75.7	102.0	122.3	145.6	148.6	148.6	148.6	148.6
2. Financial Services	63.3	88.1	145.9	159.7	162.6	162.6	162.6	162.6
3. Grocery Retail	66.4	162.2	217.1	246.1	266.3	283.8	292.4	292.4
4. Hardware	42.7	69.8	117.1	144.1	171.0	195.7	222.9	231.9
5. General	56.1	114.6	150.4	178.3	206.5	234.4	254.8	257.4
6. Retail Stores	130.4	266.0	339.0	480.5	505.9	550.3	584.2	602.4
7. Furniture & Furnishings	248.9	315.0	412.1	451.6	475.9	498.0	511.1	513.4
8. Small Retail Trade	101.8	169.6	247.6	375.6	451.2	521.7	550.3	560.7
9. Retail Apparel	211.1	484.2	555.4	718.3	762.0	798.6	830.6	858.3
10. Mechanical Retail	51.5	76.2	115.4	161.9	196.3	220.9	247.8	247.8
11. Building Supplies	111.9	122.1	134.6	144.7	157.5	170.2	183.0	185.6
12. Contractor Services	50.9	68.9	89.3	114.7	145.2	160.6	168.2	176.0
13. Personal Services	91.0	182.0	267.7	295.4	311.8	314.6	314.6	314.6
14. Recreation Services	32.4	44.9	84.7	85.6	92.1	92.1	94.7	94.7
15. Hotel-Motel Services	57.7	70.4	88.1	108.2	113.2	115.7	115.7	115.7
16. Trans.&Communc. Services	99.6	161.0	222.5	281.0	336.7	389.5	389.5	389.5
17. Professional Services	71.7	104.7	134.9	162.6	167.9	173.6	176.4	176.4
18. Institutional Services	42.3	133.6	154.3	183.0	183.0	183.0	183.0	183.0
19. Food Services	43.2	94.0	177.9	244.1	267.0	267.0	292.5	292.5
20. Drug Stores	30.6	91.7	162.3	235.0	333.7	350.3	364.7	366.7

DYKING DISTRICT OF EAST LANGLEY  
ANALYSIS OF BENEFITS

A. Introduction

The Dyking District of East Langley is located on the south bank of the Fraser River some 50 Km. east of Vancouver. This area has a small amount of industrial land and a few residences which would be flooded by a high level flood.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the District the District of East Langley dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate used is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data were originally prepared in 1971 (see Appendix 1) for use in the Fraser River Flood Program. These damages were updated to 1982 dollars (Appendix 2) using various price indices.

E. Future Damages

Very little if any change in activity has occurred in this area between 1971 and 1982. No significant land use changes are expected in this area over the next 35 years.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2. Figure 1 shows the damage-frequency relationship used to generate average annual damages. Average annual damages for East Langley were estimated to be \$8,500.

## 2. Benefits

Benefits were calculated for the Dyking District of East Langley by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1  
Benefits - East Langley Dykes

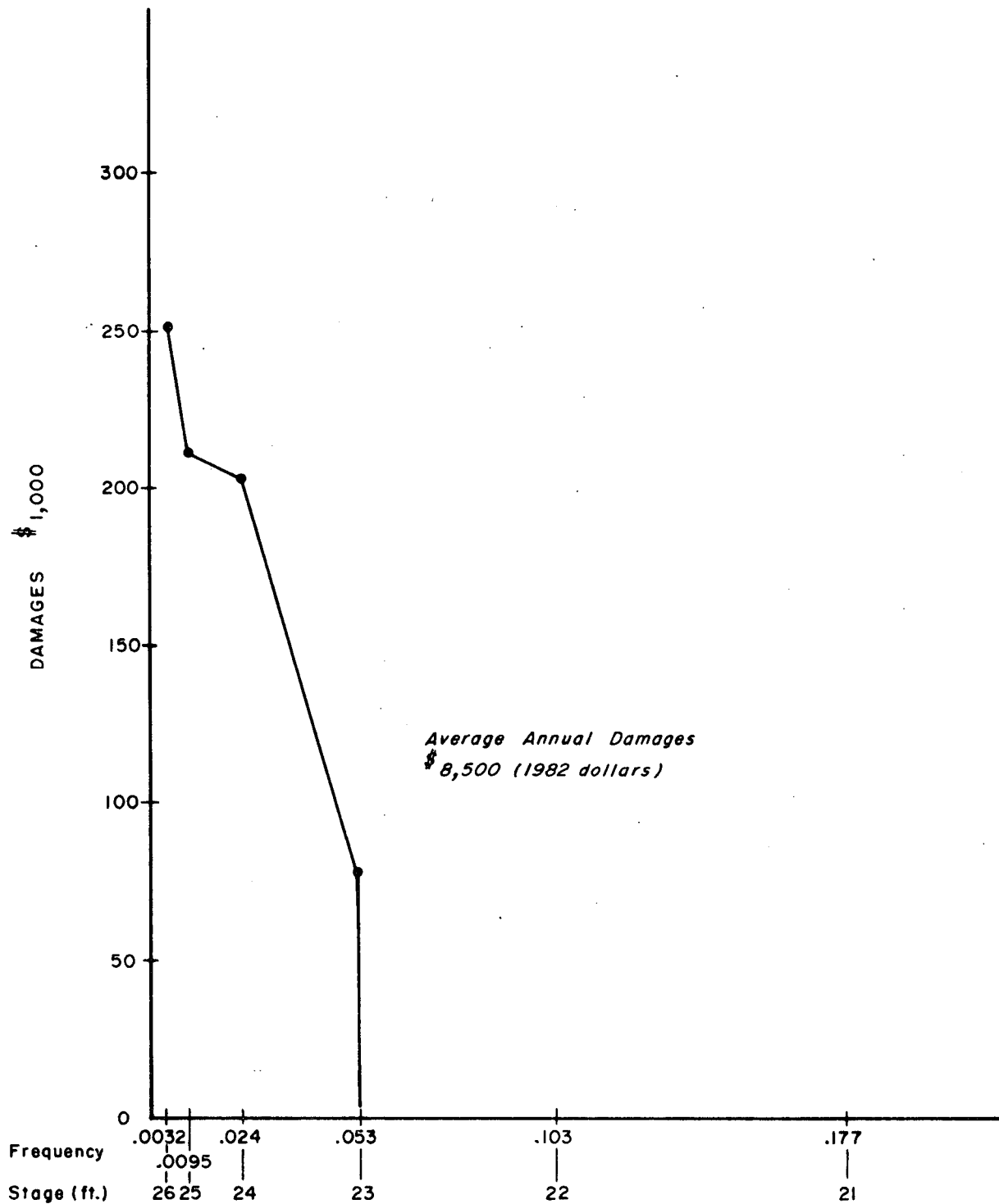
<u>Discount Rate</u>	<u>Benefits</u>
7%	\$110,000
6%	\$123,160
8%	\$ 99,000
10%	\$ 81,930

## G. Conclusion

- This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been only minor changes in land use and numbers of new residences and other structures.

FIG . I

DYKING DISTRICT OF EAST LANGLEY  
AVERAGE ANNUAL DAMAGES



APPENDIX 1  
FLOOD DAMAGES - SUMMARY 1971

AREA: DYKING DISTRICT OF EAST LANGLEY

TYPE OF DAMAGE	<u>\$000's DAMAGES FEET AT MISSION</u>			
	23	24	25	26
(1) Residential and Associated				
(a) Residential and content	25	28	30	32
(b) Loss of use of dwelling	-	2	2	2
(c) Extra Food Cost	-	1	1	1
(2) Commercial	-	-	-	-
(3) Industrial	3	4	5	11
(a) Income	-	34	34	40
(4) Agricultural and Income Loss				
(a) Crop damage and income loss				
(b) Dairy production				
(c) Beef Cattle production				
(d) Livestock evacuation				
(e) Milking equipment				
(f) Extra feed				
(5) Miscellaneous				
(a) Roads				
(b) Railways				
(c) Schools				
(d) Barns and outbuildings	-	1	1	1
TOTAL DAMAGES	28	70	73	87

APPENDIX 2  
FLOOD DAMAGES - SUMMARY 1982

AREA: DYKING DISTRICT OF EAST LANGLEY

TYPE OF DAMAGE

\$000's DAMAGES  
FEET AT MISSION

	23	24	25	26
(1) Residential and Associated				
(a) Residential and content	70.0	78.4	84.0	89.6
(b) Loss of use of dwelling	-	5.0	5.0	5.0
(c) Extra Food Cost	-	3.0	3.0	3.0
(2) Commercial	-	-	-	-
(3) Industrial	8.0	10.7	13.4	29.5
(a) Income	-	102.7	102.7	120.8
(4) Agricultural and Income Loss				
(a) Crop damage and income loss				
(b) Dairy production				
(c) Beef Cattle production				
(d) Livestock evacuation				
(e) Milking equipment				
(f) Extra feed				
(5) Miscellaneous				
(a) Roads				
(b) Railways				
(c) Schools				
(d) Barns and outbuildings	-	2.7	2.7	2.7
TOTAL DAMAGES	78.0	202.5	210.8	250.6

DYKING DISTRICTS OF ALBION AND MAPLE RIDGE RD.13

ANALYSIS OF BENEFITS

A. Introduction

The Dyking Districts of Albion and Maple Ridge Rd.13 are located on the north bank of the Fraser River some 45 kms. east of Vancouver. Albion has an area of about 80 hectares and is primarily industrial-commercial. Maple Ridge Rd.13 has an area of 95 hectares and is mainly rural-residential. The majority of the 40 houses and 150 people which would be affected by a 200 year return flood are located in the Maple Ridge Rd.13 dyking area.

B. Purpose

The purpose of this analysis is to estimate the economic benefits of reconstructing the Albion and Maple Ridge Rd.13 dykes to Fraser River Flood Control Program standards.

C. Basic Assumptions

1. The expected economic life of the engineering works is 35 years.
2. The discount rate is 7%. Sensitivity analysis is provided using 6%, 8% and 10% discount rates.
3. Base year of study is 1982.

D. Analysis of Damages

Flood damage data for the combined area of Albion and Maple Ridge Rd.13 were originally prepared in 1971 (Appendix 1A) for use in the Fraser River Flood Control Program. These damages have been separated into the two dyking districts of Albion (Appendix 1B) and Maple Ridge Rd.13 (Appendix 1C) and then updated to 1982 dollars (Appendices 2A-C) using various price indices. This approach is expedient, and takes into account price changes over time, however, it does not take into account any real growth (e.g. new residential construction, industrial development etc.) which has occurred in the area since 1971.

E. Future Damages

The Albion area has light industry and commercial establishments. Some new development has occurred in the area in recent years. There is



still some room for further expansion. The Maple Ridge Rd.13 area is primarily rural residential. No change has occurred in this area in recent years. Based on the observed land use change over the past 10 years, 1% rate of growth is used to reflect expected growth in this area in the future.

F. Analysis of Benefits

1. Average Annual Damages

Average annual damages were calculated for the damages summarized in Appendix 2A-C. Figures 1-3 show the damage-frequency relationship used to generate average annual damages. In accordance with the procedure established under the Fraser River Flood Control Program, the area between the 24 and 26 foot stage (Mission Gauge) was allocated 50% of damages. Average annual damages for the combined area of Albion and Maple Ridge Rd.13 were estimated to be \$72,820, for Albion \$32,709 and Maple Ridge Rd.13 \$33,975.

2. Benefits

Benefits were calculated for Albion and Maple Ridge Rd.13 by multiplying the average annual damage times the appropriate present worth factor. For the purpose of this analysis a discount rate of 7% was used. Sensitivity analysis was also conducted using 6%, 8% and 10% discount rates. Estimates of benefits are provided in Table 1.

TABLE 1  
Benefits - Albion and Maple Ridge Rd. 13 Dykes

DISCOUNT RATE	Albion (\$,000)	BENEFITS Maple Ridge Rd. 13 (\$,000)	Combined Maple Ridge Rd.13 (\$,000)
7%	474	493	1,056
6%	536	556	1,192
8%	424	440	943
10%	346	359	770

G. Conclusion

This analysis provides an estimate of benefits based on data generated in 1971. Although these data were updated to 1982 dollars using price indices, no attempt was made to account for changes in land use or for increases in numbers of new residences and other structures constructed since 1971. A recent survey of the area showed that there have been some new industrial and commercial activity in the area. If these change were taken into account, benefits would likely be higher.

FIG. 1

DYKING DISTRICT OF  
ALBION AND MAPLE RIDGE ROAD "13  
AVERAGE ANNUAL DAMAGES

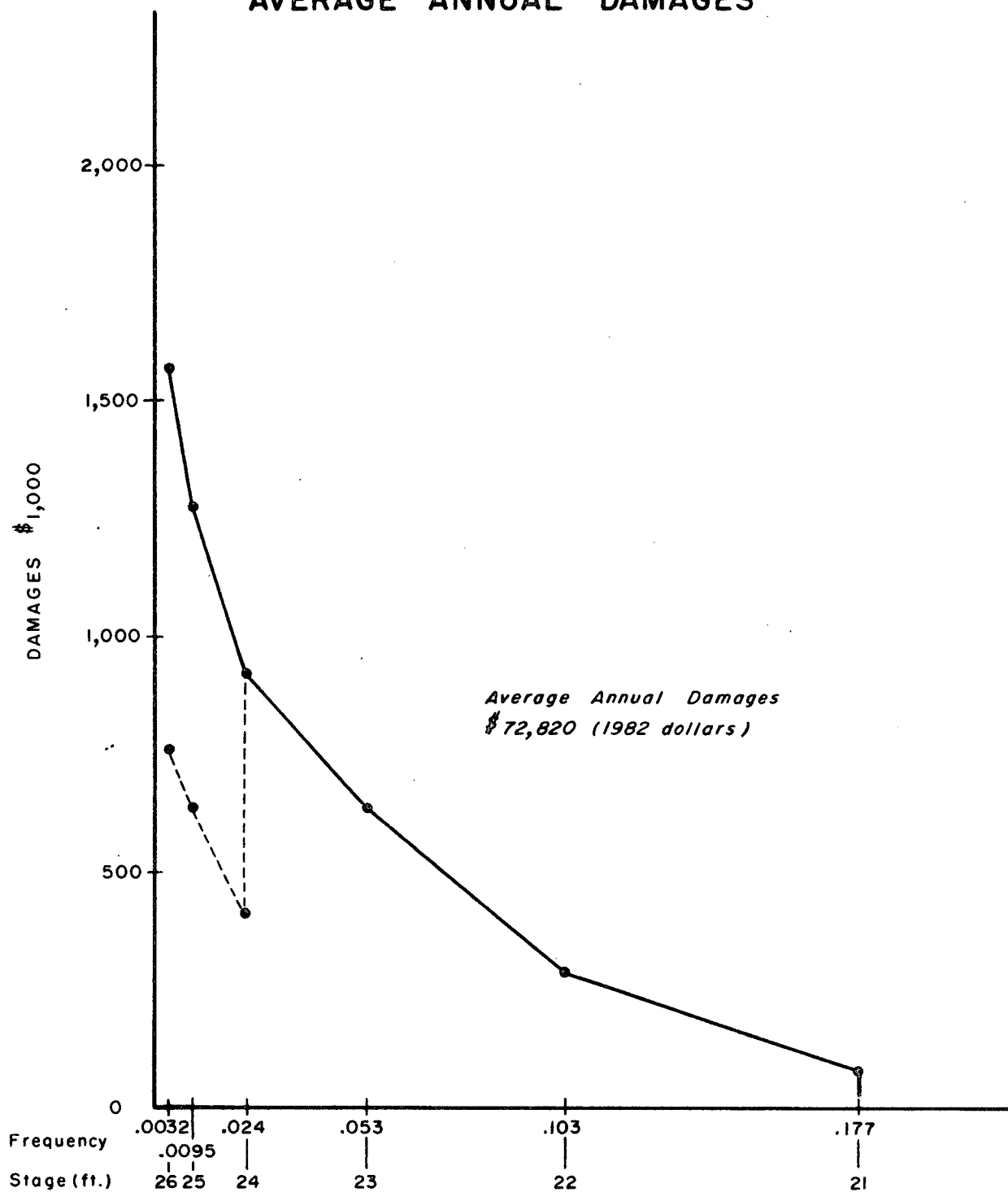


FIG. 2

DYKING DISTRICT OF ALBION  
AVERAGE ANNUAL DAMAGES

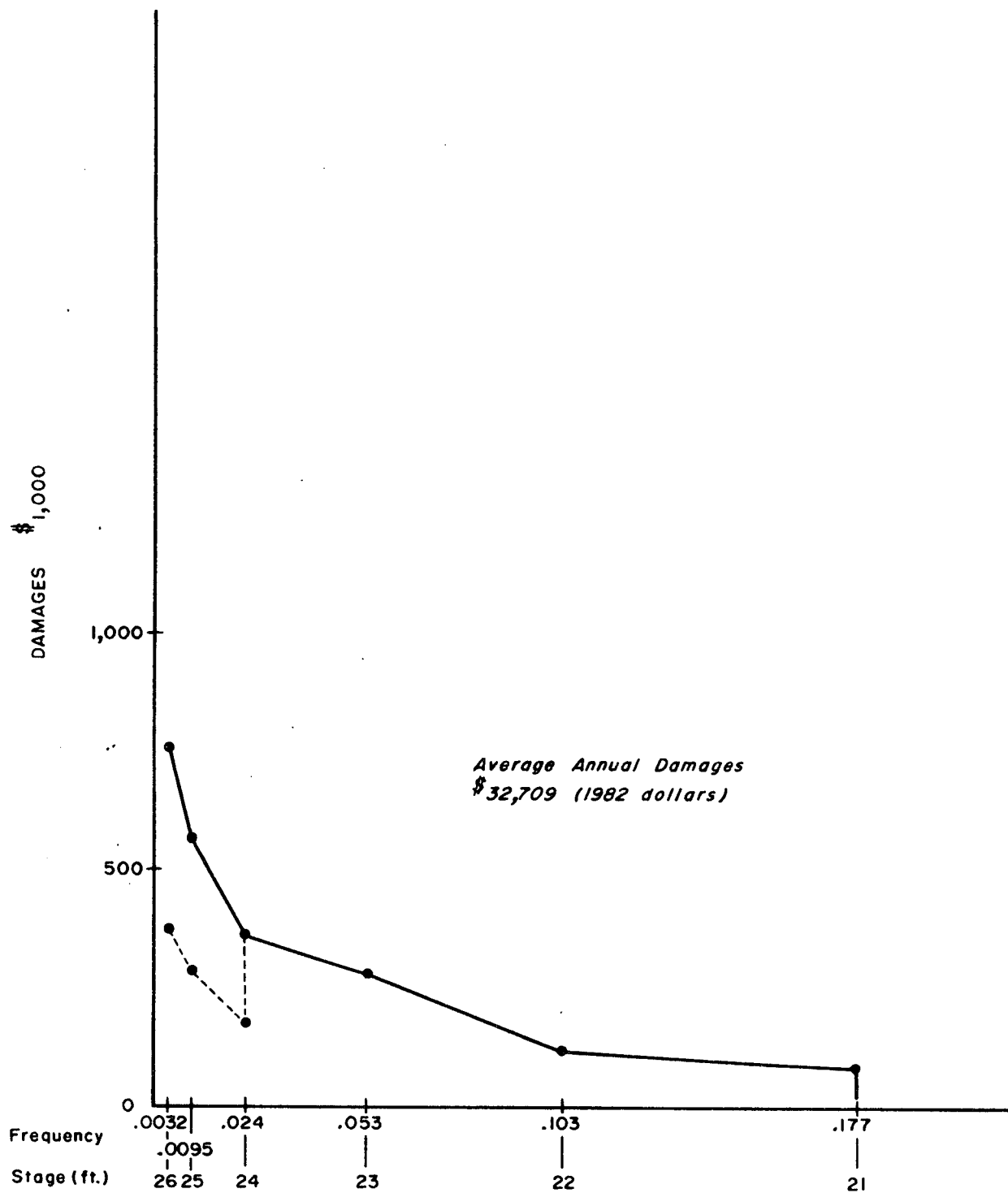
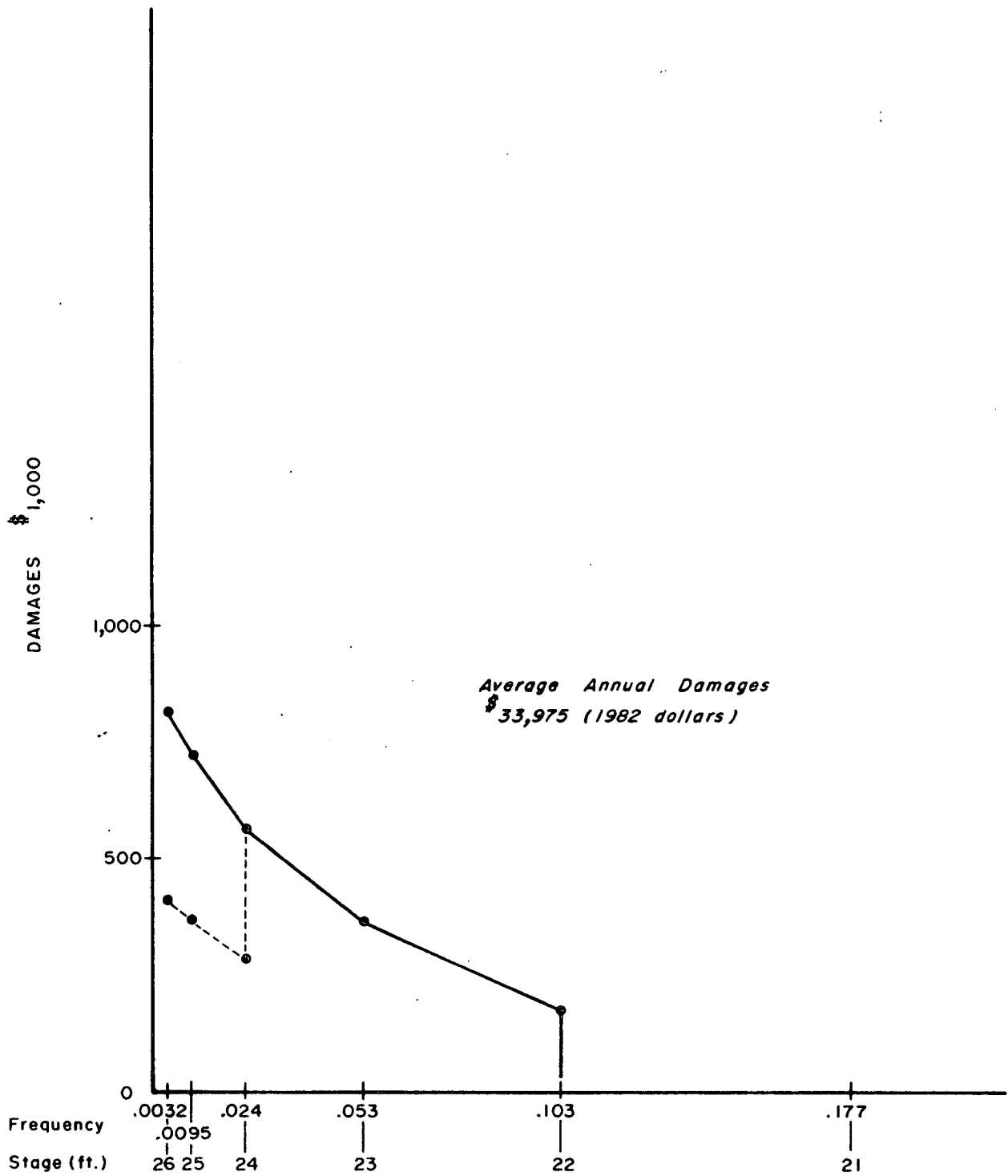


FIG . 3

DYKING DISTRICT OF MAPLE RIDGE ROAD #13  
AVERAGE ANNUAL DAMAGES



APPENDIX 1A  
FLOOD DAMAGES - SUMMARY 1971

AREA: ALBION AND MAPLE RIDGE RD. 13

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	50	114	176	208
(b) Loss of use of dwelling	-	-	6	9	12	14
(c) Extra Food Cost	-	-	2	3	4	4
(2) Commercial	-	-	20	32	44	56
(3) Industrial	-	6	39	42	45	63
a) Industrial Income	-	1	8	23	66	93
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	42	44	45	46	47
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	12	13	14	14	14
(5) Miscellaneous						
(a) Roads	30	33	36	36	36	36
(b) Railways	-	-	-	-	5	10
(c) Schools						
(d) Barns and outbuildings						
(e) Gas Distribution Systems	-	-	1	1	1	1
TOTAL DAMAGES	30	94	219	319	449	546

TABLE 1B  
FLOOD DAMAGES - SUMMARY 1971

AREA: ALBION

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	-	-	10.4	16.8
(b) Loss of use of dwelling	-	-	-	-	1.0	1.2
(c) Extra Food Cost	-	-	-	-	.3	.4
(2) Commercial	-	-	15.8	25.2	34.6	42.8
(3) Industrial	-	6.0	39.0	42.0	45.0	63.0
(a) Industrial income	-	1.0	8.0	23.0	66.0	93.0
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	-	-	-	-	-
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed						
(5) Miscellaneous						
(a) Roads	30.0	33.0	36.0	36.0	36.0	36.0
(b) Railways	-	-	-	-	5.0	10.0
(c) Schools	-	-	-	-	-	-
(d) Barns and outbuildings	-	-	-	-	-	-
(e) Gas distribution system	-	-	-	-	-	-
TOTAL DAMAGES	30.0	40.0	98.8	126.2	198.3	263.2

TABLE 1C  
FLOOD DAMAGES - SUMMARY 1971

AREA: MAPLE RIDGE ROAD 13

TYPE OF DAMAGE	<u>\$000's DAMAGES</u> <u>FEET AT MISSION</u>					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	50.0	114.0	165.6	191.2
(b) Loss of use of dwelling	-	-	6.0	9.0	11.0	12.8
(c) Extra Food Cost	-	-	2.0	3.0	3.7	3.8
(2) Commercial	-	-	4.2	6.8	9.4	13.2
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	42.0	44.0	45.0	46.0	47.0
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	12.0	13.0	14.0	14.0	14.0
(5) Miscellaneous						
(a) Roads						
(b) Railways						
(c) Schools						
(d) Barns and outbuildings						
TOTAL DAMAGES	-	54.0	119.2	191.8	249.7	282.0



APPENDIX 2A  
FLOOD DAMAGES - SUMMARY 1982

AREA: ALBION AND MAPLE RIDGE RD. 13

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	140.0	319.2	492.8	582.4
(b) Loss of use of dwelling	-	-	15.0	22.5	30.0	35.0
(c) Extra Food Cost	-	-	6.0	9.0	12.0	12.0
(2) Commercial	-	-	51.0	81.6	112.2	142.8
(3) Industrial	-	16.2	105.3	113.4	121.5	170.1
a) Industrial Income (Vancouver)	-	3.0	24.0	69.0	198.0	279.0
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	124.7	130.7	133.7	136.6	139.6
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	51.1	55.4	59.6	59.6	59.6
(5) Miscellaneous						
(a) Roads	93.0	102.3	111.6	111.6	111.6	111.6
(b) Railways	-	-	-	-	15.5	31.0
(c) Schools						
(d) Barns and outbuildings						
(e) Gas Distribution Systems	-	-	3.7	3.7	3.7	3.7
TOTAL DAMAGES	93.0	297.3	642.7	923.3	1293.5	1566.8

TABLE 2B  
FLOOD DAMAGES - SUMMARY 1982

AREA: ALBION

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	-	-	29.1	47.0
(b) Loss of use of dwelling	-	-	-	-	2.5	3.0
(c) Extra Food Cost	-	-	-	-	.9	1.2
(2) Commercial	-	-	40.3	64.3	88.2	109.1
(3) Industrial	-	16.2	105.3	113.4	121.5	170.1
(a) Industrial Income	-	3.0	24.0	69.0	198.0	279.0
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	-	-	-	-	-
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed						
(5) Miscellaneous						
(a) Roads	93.0	102.3	111.6	111.6	111.6	111.6
(b) Railways	-	-	-	-	15.5	31.0
(c) Schools						
(d) Barns and outbuildings						
TOTAL DAMAGES	93.0	121.5	281.2	358.3	567.3	752.0

TABLE 2C  
FLOOD DAMAGES - SUMMARY 1982

AREA: MAPLE RIDGE ROAD 13

TYPE OF DAMAGE	\$000's DAMAGES FEET AT MISSION					
	21	22	23	24	25	26
(1) Residential and Associated						
(a) Residential and content	-	-	140.0	319.2	463.7	535.4
(b) Loss of use of dwelling	-	-	15.0	22.5	27.5	32.0
(c) Extra Food Cost	-	-	6.0	9.0	11.1	11.1
(2) Commercial	-	-	10.7	17.3	24.0	33.7
(3) Industrial	-	-	-	-	-	-
(4) Agricultural and Income Loss						
(a) Crop damage and income loss	-	124.7	130.7	133.7	136.6	139.6
(b) Dairy production						
(c) Beef Cattle production						
(d) Livestock evacuation						
(e) Milking equipment						
(f) Extra feed	-	51.1	55.4	59.6	59.6	59.6
(5) Miscellaneous						
(a) Roads	-	-	-	-	-	-
(b) Railways						
(c) Schools						
(d) Barns and outbuildings						
(e) Gas distribution system	-	-	3.7	3.7	3.7	3.7
TOTAL DAMAGES	-	175.8	361.5	565.0	726.2	815.1