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REPORT OF THE  
CANADA - MANITOBA  
PEMBILIER DAM REVIEW COMMITTEE

FEBRUARY 1974

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CANADA - MANITOBA  
PEMBILIER DAM REVIEW COMMITTEE

FEBRUARY 1974

PEMBILIER DAM REVIEW COMMITTEE

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The Under Secretary of State  
Department of External Affairs  
Ottawa, Ontario, Canada

Attention: U.S.A. Division

Dear Sir:

Following the meeting of officials of the Governments of Canada and the United States on February 9, 1973, in Washington, D.C., the Pembilier Dam Review Committee was formed in Canada for the following purposes:

- a) to study and discuss with Regional officials of the U.S. Corps of Engineers, the 1972 Corps report entitled "Review Survey of Flood Control and Related Purposes, Pembina River, North Dakota", and
- b) to assess the flood control benefits that would accrue to Canada as a result of the construction of the Pembilier Dam.

The Pembilier Dam Review Committee has completed its assignment and presents its findings herewith. During the course of its studies, continuous liaison was maintained with the U.S. Corps of Engineers.

In addition to determining the flood control benefits which would accrue to Canada through the development of the Pembilier Dam project, an evaluation was carried out to apportion project costs. The Review Committee estimates that, in terms of 1971 prices, annual flood control benefits in the amount of \$147,200 would accrue to Canada. This represents 10.17% of total project benefits and has a present worth of \$1,961,300. On the basis of benefits received (10.17%), the prorated present worth of project costs is estimated to be \$1,938,600 (1971 prices) resulting in a benefit-cost ratio of 1.011. Certain intangibles such as the benefits of resolving the International Boundary dispute have not been quantified in the report but should be considered in any overall decision regarding Canadian participation in the project.

## SUMMARY

In 1972 the United States asked Canada to consider sharing the cost of the proposed Pembilier Dam on the Pembina River in North Dakota in proportion to Canada's share of the benefits accruing from the project as suggested in a 1972 report by the U.S. Corps of Engineers entitled "Review Summary of Flood Control and Related Purposes, Pembina River, North Dakota". Flood control benefits in Canada were estimated at \$249,500 annually and the suggested cost allocation to Canada \$237,400 annually, both values estimated over the 100 year life of the project. Canada and the Province of Manitoba agreed to consider the request and early in 1973 appointed a Pembilier Dam Review Committee, comprised of officials representing the two governments, to review the 1972 Corps of Engineers Report.

The Review Committee was active from March to December 1973, and throughout the review period maintained liaison with the St. Paul District, Corps of Engineers. The review was concentrated mainly on the estimate of benefits accruing to Canada and the proposals for cost allocation.

The Review Committee questioned the data, assumptions and procedures used by the Corps of Engineers to estimate Canadian benefits and concluded that the estimate was unrealistic. The Review Committee prepared a revised estimate of Canadian benefits based on current data and revised assumptions and procedures. The Review Committee estimates that

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## CHAPTER 1

### INTRODUCTION

The Pembina River rises in south-western Manitoba and flows in a south easterly direction into the United States to its confluence with the Red River near Pembina, North Dakota, as shown in Figure 1. There is a long history of flood damage associated with the spring snowmelt in the Pembina River Basin. Damaging floods have occurred mainly on the broad, flat plain east of Walhalla, North Dakota, where overbank flows from the Pembina River escape south into the Tongue River Basin in North Dakota and north into the Plum and Aux Marais River Basins in Canada. In recent years major floods have occurred in 1966, 1969, 1970 and 1971. Although the Pembina flood peaks do not usually coincide with flood peaks on the Red River, they do contribute to the magnitude and duration of floods on the Red. Thus there are two areas in Manitoba affected by floods on the Pembina River: the Gretna-Altona area, affected by overland flows from the Pembina, and the Red River area, affected by overbank flows from the Red River. The limits of the area flooded by the 1950 floods on the Pembina and the Red Rivers are indicated in Figure 1.

In a 1972 report entitled "Review Survey of Flood Control and Related Purposes, Pembina River, North Dakota", the United States Corps of Engineers proposed the construction of the Pembillier Dam on the Pembina River southwest of Walhalla, North Dakota. This dam would provide for flood storage on the Pembina

The Committee met on several occasions to review and revise the estimates of Canadian benefits and to discuss the revised estimate and the cost allocation proposals with the Corps of Engineers. At the request of the Committee the Corps provided revised cost allocation proposals based on the revised estimate of Canadian benefits. This report summarizes the work of the Review Committee.

## CHAPTER 2

### CANADIAN BENEFITS

#### 2.1 Review of U.S. Corps of Engineers Estimates

The basic source of data used by the U.S. Corps of Engineers to estimate Canadian benefits for their 1972 report was a 1964 report to the International Joint Commission by the International Pembina River Engineering Board entitled "Joint Investigation for Development of the Water Resources of the Pembina River Basin, Manitoba and North Dakota". The Canadian flood damage data in the 1964 report was, in turn, based on the 1958 report of the Manitoba Royal Commission on Flood Cost Benefit. Damage estimates in the 1964 report reflected the impact of protective measures taken between 1958 and 1964, but damages were expressed in terms of 1957 prices. Manitoba provided the Corps with discharge-flooded area relationships for the Gretna-Altona reach of the Pembina River and the Emerson-St. Norbert reach of the Red River that reflected the impact of protective measures taken up to the time of the most recent Corps study. Based on this information the Corps estimated frequency-damage relationships for each reach both with and without the proposed Pembilier Dam. The discharge-damage curves and frequency damage curves for each reach are shown in Plates C-15 to C-18 in Appendix C of the 1972 Corps report. The estimated average annual flood damages, in 1957 prices, as derived from these curves, were \$35,800 for the Gretna-Altona reach and \$493,800 for the Red River Reach.



For purposes of estimating benefits and costs, the Corps assumed that the Pembilier Dam would be constructed by 1980 and that the life of the project would be 100 years (ie: 1980-2080). It was also assumed that there would be real growth in both Canada and the United States during the 100 year life of the project which would result in an increase in the potential flood damage, and thus in the benefits from the project.

The final estimates of benefits and costs used by the Corps were for the period 1980-2080, expressed in 1971 prices. Working with the basic estimate of 1964 damage modified by protective measures taken up to 1971, a number of adjustments were necessary to produce the final estimates of benefits. These were as follows:

1. 1971 Average Annual Damage Estimate (1957 Prices)

The basic estimate of damages was adjusted to account for real growth during the period 1957 to 1971. Growth of 14% was assumed for all categories of damages for the 14-year period. Thus the basic damage estimates were increased by a factor of 1.14.

2. 1971 Average Annual Damage Estimate (1971 Prices)

The basic estimate as adjusted in Step 1 was further adjusted to reflect 1971 prices. Three indices drawn from Statistics Canada data were weighted equally to reflect price changes from 1957. These were as follows:

Farm Products:	1971 =	265.4	= 1.242
	1957 =	<u>213.6</u>	
Residential Building Materials	1971 =	144.3	= 1.596
	1957 =	<u>90.4</u>	
Non-Residential Building Materials	1971 =	133.4	= 1.472
	1957 =	<u>90.6</u>	
		<u>4.310</u>	= 1.437
		3	

the 1980 average annual damage estimate (Step 3) and the annual equivalent of the 1980-2080 average annual damages (Step 6).

The dollar values and factors used by the Corps in preparing the estimate in the 1971 report are presented in Table 1.

After reviewing the U.S. Corps Report and the procedures that were followed to estimate the economic benefits to Canada, the Committee concluded that the estimates of Canadian benefits were likely to be unrealistic. The main reasons for reaching this conclusion were related to the over estimate of the impact of the proposed Pembilier Dam on flood frequency due to including the affects of the Kindred and Twin Valley Dams, and to the procedures employed to estimate the Canadian benefits as outlined in Table 1 and the preceding discussion. The procedures questioned were as follows:

- 1) conversion from 1957 to 1971 prices to estimate cost of damages.
  - a) price indices for only three sectors of the economy were used, each was given equal weight to derive one index that was applied to the total damage estimate to determine the 1971 cost.
- 2) Growth
  - a) a common rate of growth was assumed for all categories of flood damage.
  - b) the assumption that flood damage in all categories would increase by 22% due to growth in the period 1971 to 1980.

- c) the assumption that flood damages in all categories would increase by 105%, due to growth during the period from 1980 to 2030.
- d) the use of the United States discount rate of 5 3/8% to calculate the equivalent average annual damages during the period 1980 to 2080.

## 2.2 Review Committee Estimate of Canadian Benefits

### 2.2.1 General

Since the U.S. Corps of Engineers' estimate of Canadian benefits was considered unrealistic the Review Committee undertook to provide its own estimate. The Committee followed the U.S. Corps' approach to estimating damages but revised the procedures to provide a more accurate reflection of conditions in Canada. Damages were disaggregated by category as in the 1958 Royal Commission Report to adjust to 1972 prices and levels of development. The Committee used what it felt were more appropriate price indices for each category, more realistic assumptions about growth and a discount rate of 7.5%, which is a reasonable reflection of Canadian Federal and Provincial borrowing rates at this time.

The Committee questioned the rationale for including projected future damages in the estimate of benefits. However, in the absence of other measures to regulate growth in relation to potential flood damage, growth is likely to take place and no alternatives for adjustment to the flood hazard are being considered in this study. Thus the Committee decided that to be consistent with the United States approach increased

### 2.2.3 Estimates of Potential Flood Damage

#### 2.2.3.1 Approach and Assumptions

The Committee prepared estimates of the potential flood damage from selected floods in both the Red River area and the Gretna-Altona area. The approach used to estimate the potential damage was consistent with the approach used by the U.S. Corps of Engineers. In order to use this approach and to provide an estimate of damages without conducting a detailed study it was necessary to make a number of assumptions. The basic assumptions used by the Review Committee were as follows:

- (1) that the method of estimating flood damages used by the Manitoba Royal Commission on Flood Cost-Benefit 1958, is applicable to this review.
- (2) that due to similar socio-economic characteristics in the Red River area and the Gretna-Altona area, flood damage data is transferable from one area to the other on a per capita or a per acre basis.
- (3) that except for damage to farm crops, the existing levees and farm pads in the Red River flood area will prevent 80% of all agricultural damages from floods of a magnitude up to and inclusive of the 1950 flood.

Using the estimates of flood damages reported by the Royal Commission on Flood Cost Benefit, 1958, as a base, the Review Committee prepared damage estimates reflecting 1972 prices and levels of development for three historical floods in the Red River area (1852, 1947 & 1950) and two historical floods

3. For category D in the Gretna-Altona area a consulting firm was employed to provide an estimate of damages. These estimates were developed on the basis of detailed studies of the 1969 and 1970 floods in the Aux Marais River Basin and on the basis of the Royal Commission Report.
4. For category D in the Red River area damages were estimated by transferring unit values, on a per acre basis, from the Gretna-Altona estimates.

More detail on the derivation of specific estimates is provided in the footnotes to Tables 2 and 4. A study on agricultural damages in the Gretna-Altona area was prepared for the Review Committee by Stow Associates, Carman, Manitoba.

#### 2.2.3.2 Red River Area

Estimates of potential flood damages from selected floods in the Red River area are detailed in Table 2. These estimates reflect 1972 prices and levels of development assuming the channel conditions and flood control works in existence in 1958.

Since 1958, ring dykes have been constructed to protect urban centres in the Red River area. These ring dykes provide protection from floods up to and including a flood of the magnitude of the 1950 flood. Many farm properties have been provided protection in the form of pads and levees. The farm pads and levees provide no protection against damage to farm crops; however, it was estimated that they will prevent 80% of all other agricultural damages from all floods

TABLE 2  
ESTIMATED FLOOD DAMAGES  
RED RIVER AREA (EMERSON TO ST. NORBERT) - 1958 & 1972  
1958 CONDITIONS<sup>1</sup>

DAMAGE CATEGORY	1957 PRICES & LEVEL OF DEVELOPMENT <sup>2</sup>			ADJUSTMENT <sup>7</sup> FACTOR	1972 PRICES & LEVEL OF DEVELOPMENT <sup>3</sup>		
	1948 FLOOD <sup>4</sup> (\$)	1950 FLOOD <sup>5</sup> (\$)	1952 FLOOD <sup>6</sup> (\$)		1948 FLOOD <sup>4</sup> (\$)	1950 FLOOD <sup>5</sup> (\$)	1952 FLOOD <sup>6</sup> (\$)
<b>Non-Agricultural</b>							
<b>A. Urban</b>							
1. Non-Farm Income	217,000	724,000	1,472,000	1.86	404,000	1,347,000	2,738,000
2. Rental Value of Homes	41,000	232,000	404,000	1.70	70,000	394,000	687,000
3. Evacuation Costs - People	10,000	27,000	44,000	1.50	15,000	41,000	66,000
4. Extra Living Costs	28,000	151,000	256,000	1.55	43,000	234,000	397,000
5. Extra Work - Clean-up	34,000	156,000	236,000	1.65	56,000	257,000	389,000
6. Residential Property	486,000	2,022,000	3,177,000	1.70	826,000	3,437,000	5,401,000
7. Personal Property	129,800	537,500	845,000	30% of (A.6)	248,000	1,031,000	1,620,000
8. Business, Stocks and Fixtures	91,000	452,000	710,000	167% of (A.9)	153,000	767,000	1,204,000
9. Business, Real Prop- erty	54,000	270,000	424,000	1.70	92,000	459,000	721,000
10. Schools & Churches	56,000	261,000	443,000	12% of (A.6+A.7)	129,000	536,000	843,000
Sub-Total	1,146,500	4,832,500	8,011,000		2,036,000	8,503,000	14,066,000
<b>B. Utilities &amp; Railroads</b>							
1. Manitoba Telephone	31,000	51,000	216,000	1.24	38,000	63,000	268,000
2. Manitoba Power	-----	62,000	89,000	1.24	-----	77,000	110,000
3. CPR	6,000	100,000	625,000	1.42	9,000	142,000	888,000
4. CNR	4,000	634,000	1,281,000	1.42	6,000	900,000	1,819,000
Sub-Total	41,000	847,000	2,211,000		53,000	1,182,000	3,085,000
<b>C. Government</b>							
1. Roads & Bridges	250,000	1,203,000	2,400,000	1.42	355,000	1,708,000	3,408,000
2. Flood Fighting Costs	28,000	130,000	214,000	2.50	70,000	325,000	535,000
Sub-Total	278,000	1,333,000	2,614,000		425,000	2,033,000	3,943,000
<b>Agricultural</b>							
<b>D. Loss of Income and Extra Costs</b>							
1. Farm Crops	275,000	1,852,000	3,525,000	1.58	435,000	2,926,000	5,570,000
2. Livestock	24,000	235,000	493,000	2.92	70,000	680,000	1,440,000
3. Extra Feed for Liva- stock	11,000	95,000	184,000	2.00	22,000	190,000	368,000
4. Cost of Moving Livestock	2,000	6,000	14,000	4.06	8,000	24,000	57,000
Sub-Total	312,000	2,186,000	4,216,000		535,000	3,820,000	7,435,000
<b>E. Agricultural Property</b>							
1. Farm Buildings	219,000	1,184,000	2,355,000	1.76	385,000	2,084,000	4,145,000
2. Personal Property	58,800	314,500	626,000	30% of (E.1)	116,000	625,000	1,243,000
3. Grain, Livestock, Machinery	127,000	581,000	934,000	1.29	164,000	749,000	1,205,000
Sub-Total	404,800	2,079,500	3,915,000		665,000	3,458,000	6,593,000
<b>TOTAL</b>	<b>2,182,000</b>	<b>11,278,000</b>	<b>20,967,000</b>		<b>3,714,000</b>	<b>18,996,000</b>	<b>38,122,000</b>

The footnotes to this Table are on Page 17.

TABLE 3  
ESTIMATED FLOOD DAMAGES  
RED RIVER AREA (EMERSON - ST. NORBERT)  
1972 PRICES & LEVELS OF DEVELOPMENT  
1972 CONDITIONS<sup>1</sup>

DAMAGE CATEGORY	ESTIMATED DAMAGES		
	1948 FLOOD <sup>2</sup> (\$)	1950 FLOOD <sup>3</sup> (\$)	1852 FLOOD <sup>4</sup> (\$)
<u>NON-AGRICULTURAL</u> <sup>5</sup>			
A. Urban	145,000	4,806,000	14,066,000
B. Utilities & Railroads	6,000	793,000	3,085,000
C. Government	117,000	1,410,000	3,943,000
<u>AGRICULTURAL</u>			
D. Loss of Income & Extra Costs <sup>6</sup>	455,000	3,105,000	7,435,000
E. Agricultural Property <sup>7</sup>	133,000	692,000	6,593,000
TOTAL	856,000	10,806,000	35,062,000

Notes for Table 3

1. Channel conditions & flood control measures in existence in 1972.
2. Peak flow of 52,000 cfs on Red River at Emerson. 67,400 acres flooded.
3. Peak flow at 94,000 cfs on Red River at Emerson. 316,000 acres flooded.
4. Peak flow of 137,000 cfs on Red River at Emerson. 523,000 acres flooded.
5. Non-Agricultural damages were derived by subtracting the benefits estimated to accrue from community ring dykes in the 1967 Manitoba Water Resources Branch Report "Benefit-Cost Study, Proposed Dyking System for Towns & Villages in the Red River Valley" from the damage estimates in Table 2 of this report.
6. 1948 & 1950 Floods: Damages = 100% of Item D.1, Table 2 plus 20% of Items D.2, D.3 and D.4, Table 2.  
1852 Flood: Damage = 100% of Category D, Table 2.
7. 1948 & 1950 Floods: Damages = 20% of Category E, Table 2.  
1852 Flood: Damages = 100% Category E, Table 2.

TABLE 4  
ESTIMATED FLOOD DAMAGES  
GREYNA-ALTONA AREA - 1972 PRICES AND LEVEL OF DEVELOPMENT  
1950 CONDITIONS<sup>1</sup>

DAMAGE CATEGORY	1948 FLOOD <sup>2</sup>			1950 FLOOD <sup>3</sup>		
	Unit Value <sup>4</sup> (\$/Capita or \$/Acre)	Population or <sup>5</sup> acres affected	Damages <sup>6</sup> (\$)	Unit Value <sup>7</sup> (\$/Capita or \$/Acre)	Population or <sup>8</sup> acres affected	Damages <sup>6</sup> (\$)
<b>NON-AGRICULTURAL</b>						
A. Urban						
1. Non-Farm Income	138.45	522	72,000	337.17	734	247,000
2. Rental Value of Homes	23.89	522	13,000	98.62	1,159	114,000
3. Evacuation Costs - People	5.14	522	3,000	10.26	1,159	12,000
4. Extra Living Costs	14.74	522	8,000	58.57	1,159	68,000
5. Extra Work - Clean-up	19.19	522	10,000	64.33	1,159	75,000
6. Residential Property	283.07	522	148,000	860.32	1,159	997,000
7. Personal Property	84.98	522	44,000	258.07	1,159	299,000
8. Business, Stocks & Fixtures	52.43	522	27,000	192.00	734	141,000
9. Business, Real Property	31.53	522	16,000	114.89	734	84,000
10. Schools & Churches	44.20	522	23,000	134.17	1,159	156,000
Sub-Total			364,000			2,193,000
B. Utilities & Railroads						
1. Manitoba Telephone	0.56	11,150	6,000	.20	36,400	7,000
2. Manitoba Power		11,150	-	.24	36,400	9,000
3. CPR	0.13	11,150	1,000	.45	36,400	16,000
4. CNR	0.09	11,150	1,000	2.84	36,400	103,000
Sub-Total			8,000			135,000
C. Government						
1. Roads & Bridges	5.27	11,150	59,000	5.40	36,400	197,000
2. Flood Fighting Costs	1.04	11,150	12,000	1.05	36,400	37,000
Sub-Total			71,000			234,000
<b>AGRICULTURAL</b>						
D. Loss of Income & Extra Costs						
1. Farm Crops	7.76	11,150	87,000	7.76	36,400	282,000
2. Livestock	2.19	11,150	24,000	2.19	36,400	80,000
3. Extra Food for Livestock	0.76	11,150	8,000	0.76	36,400	28,000
4. Cost of Moving Livestock	0.07	11,150	1,000	0.07	36,400	3,000
Sub-Total			120,000			393,000
E. Agricultural Property						
1. Farm Buildings	8.26	11,150	92,000	8.26	36,400	301,000
2. Personal Property	30% of (E.1)	11,150	28,000	30% of (E.1)	36,400	90,000
3. Grain, Live-stock and Machinery	2.98	11,150	32,000	2.88	36,400	105,000
Sub-Total			152,000			496,000
<b>TOTAL</b>			<b>715,000</b>			<b>3,451,000</b>

The notes for this Table are on Page 21.



7. See Footnote 4. Population of the Red River area affected by 1950 flood - 3995 persons. Acreage flooded in the Red River area by 1950 flood = 316,500 acres.
8. For Category A the figure given is the population that would be affected in the Gretna-Altona area by a flood of the magnitude of the 1950 flood.

For Categories B, C, D & E the figure is the acreage in the Gretna-Altona area that would be inundated by a flood of the magnitude of the 1950 flood.

the area under the curve. The average annual benefit is equal to the difference between the average annual damage with and without the Pembilier Dam, ie: the area between the two curves in each figure.

The average annual damages for both areas and the average annual benefit with the Pembilier Dam is summarized by damage category in Table 6.

#### 2.2.5 Increase in Benefits Resulting from Growth

To be consistent with the U.S. Corps of Engineers' approach to estimating benefits, an estimate of the increase in the average annual benefit associated with increases in the damage potential resulting from economic growth in the two areas was prepared. To prepare these estimates it was necessary to make a number of assumptions as follows:

- (1) that the project would be in operation by 1980,
- (2) that the increase in future benefits would be in the same proportion to future damages as was estimated for past floods,
- (3) that future construction of roads, bridges, railroads and other utilities would be limited and would be designed to avoid flood damage.
- (4) that growth in the various damage categories over the period 1972 to 1980 would be as follows:

Categories A (Urban) & E (Agricultural Property) = 3%  
Categories B (Utilities & Railroads) & C (Government) = 0%  
(see assumption 3)  
Category D (Loss of Income & Extra Costs) - 27%

- (5) that growth over the period 1980 to 2080 would be as follows:

Categories A (Urban) & E (Agricultural Property) = 15%  
Categories B (Utilities & Railroads) & C (Government) = 0%  
(see assumption 3)

Category D (Loss of Income & Extra Costs) = 60%

- it was further assumed that all growth during this period would occur between 1980 and 2030 and would be in the form of a uniform increasing series over this 50 year period.

- (6) that the appropriate interest rate to be used in estimating Canadian benefits is 7.5% per annum.

The estimates of growth used by the Review Committee varied significantly from those used by the U.S. Corps of Engineers.

Using the 1972 estimate of average annual benefits given in Table 6 and the various assumptions outlined above, the Review Committee estimated the average annual benefit to Canada of the proposed Pembilier Dam at the completion of construction in 1980. The calculation and estimates are outlined in Table 7 using 1972 prices with a final adjustment to 1971 prices. While it had been agreed with the U.S. Corps of Engineers that all estimates of benefits and costs would be provided in 1972 prices the Corps ultimately advised that it would be unable to provide cost estimates in 1972 prices. Since the Review Committee had completed its work, it was decided to make a simple downward adjustment of 5% to provide an estimate in 1971 prices.

TABLE 7  
 AVERAGE ANNUAL BENEFIT TO CANADA  
 OF PROPOSED PENDILIER DAM  
 AT COMPLETION OF CONSTRUCTION IN 1980

DAMAGE CATEGORY	AVERAGE ANNUAL BENEFIT 1972 (\$)	ADJUSTMENT FACTOR 1972 - 1980	AVERAGE ANNUAL <sup>3</sup> BENEFIT 1980 (\$)	ADJUSTMENT <sup>4</sup> FACTOR 1980 - 2080	AVERAGE ANNUAL <sup>5</sup> BENEFIT 2080 (\$)	INCREASE IN AVERAGE ANNUAL BENEFIT 1980 to 2080 (\$)	DEVELOPMENT PERIOD FACTOR	ANNUAL EQUIVALENT <sup>8</sup> VALUE OF 2080 AVERAGE ANNUAL BENEFIT 1980-2080 (\$)	FINAL AVERAGE <sup>9</sup> ANNUAL BENEFIT (1972 Prices) (\$)	FINAL AVERAGE <sup>10</sup> ANNUAL BENEFIT (1971 Prices) (\$)
<b>RED RIVER AREA</b>										
A. Urban	11,000	1.03	11,300	1.15	13,000	1,700	.278	500	11,800	11,200
B. Utilities & Railroads	2,200	1.00	2,200	1.00	2,200	0	.278	0	2,200	2,100
C. Government	2,500	1.00	2,500	1.00	2,500	0	.278	0	2,500	2,400
D. Loss of Income & Extra Cost	4,300	1.27	5,400	1.60	8,200	3,100	.278	900	6,000	5,700
E. Agricultural Property	5,200	1.03	5,400	1.15	6,200	800	.278	200	5,600	5,300
Sub-Total	24,900		26,500		32,100	5,600		1,600	28,100	26,700
<b>GREYNA-ALTONA AREA</b>										
A. Urban	31,800	1.00 <sup>11</sup>	31,800	1.00 <sup>11</sup>	31,800	0	.278	0	31,800	30,200
B. Utilities & Railroads	8,000	1.00	8,000	1.00	8,000	0	.278	0	8,000	7,600
C. Government	14,800	1.00	14,800	1.00	14,800	0	.278	0	14,800	14,100
D. Loss of Income & Extra Cost	25,500	1.27	32,400	1.60	51,800	19,400	.278	5,400	37,800	35,900
E. Agricultural Property	32,000	1.03	33,000	1.15	38,000	5,000	.278	1,400	34,400	32,700
Sub-Total	112,100		120,000		144,400	24,400		6,800	126,800	120,500
<b>TOTAL</b>	<b>137,000</b>		<b>146,500</b>		<b>176,500</b>	<b>30,000</b>		<b>8,400</b>	<b>159,900</b>	<b>147,200</b>

The notes for Table 7 are on Page 29.

The proposed Pembilier Dam would provide an equitable and comprehensive means for alleviating the chronic flood problem in the basin, which could lead to a more harmonious relationship between residents in the two countries.

The Review Committee is aware of a study underway by a Committee of Canadian and United States officials to solve problems associated with localized flooding of agricultural lands in the Gretna-Neché area along the International Boundary. In a memorandum of understanding dated June 22, 1973, the latter committee noted that while the development of works is required to drain surface water from agricultural lands, the total problem can only be resolved by effectively controlling the Pembina River.

### 2.3.3 Backwater Effects in Canada

A first estimate of the backwater effect in Canada of the Pembilier Dam was provided to the Review Committee by the Corps of Engineers. The limited analysis that has been done to date indicates that at the design flood level, a flood with approximately a 2% probability of occurrence in any year, the reservoir created by the Pembilier Dam would flood an area of about 3200 acres, all within the United States. In the event of a flood with a 1% probability of occurrence in any year an area of 3550 acres would be flooded, but the backwater effect in Canada would be confined to the channel of the Pembina River. At the spillway design flood level, a flood with about a .01%

CHAPTER 3  
COST SHARING

3.1 Cost Allocation

In the 1972 report the U.S. Corps of Engineers suggested that Canada be allocated a part of the cost of the Pembilier Dam proportionate to its share of the total benefit from the project. The suggest cost allocation to Canada was \$237,400 annually over the 100 year life of the project. The question of cost sharing was discussed when the Review Committee met with representatives of the U.S. Corps of Engineers. It was agreed that the Corps would provide the Review Committee with a new cost allocation proposal based on the same cost sharing rationale used in their 1972 report, but using the revised estimate of Canadian benefits and incorporating the Canadian interest rate. The Corps subsequently presented a number of cost allocation proposals, each of which differed in the magnitude of benefits attributed to the United States depending upon whether national or both national and regional benefits were included. Using the Corps definition of national and regional benefits, the Review Committee's estimate of Canadian benefits must be considered an aggregate of national and regional benefits. Thus only the cost allocation proposal that included United States national and regional benefits was considered by the Review Committee.

represents an annual cost to Canada of \$148,400.

The Review Committee prepared a revised cost allocation based on the assumption that each country should share the present worth of the cost of the project in the same proportion as its share of the present worth of the benefits. For this allocation all costs were estimated using the United States federal interest rate of 5½%. Since all expenditures for the project will be made in the first instance by the United States, with subsequent reimbursement for a portion of these expenditures by Canada, it seems reasonable to the Committee to use the United States interest rate for estimating costs.

The revised allocation proposed by the Review Committee, based on 1971 prices, is outlined in Tables A to D, Appendix III. As indicated in Table D the present worth of the costs of the project is \$19,062,000, the present worth of the annual benefits is \$19,284,600 and the benefit to cost ratio is 1.011:1. The annual benefit to Canada is estimated at \$147,200, the present worth of which is \$1,961,300; 10.17% of the total benefit. Canada's share of the present worth of the costs allocated in proportion to Canada's share of the present worth of the benefits is \$1,938,600; an annual cost of \$145,600. The ratio of benefits to costs for Canada in this allocation is 1.011:1.

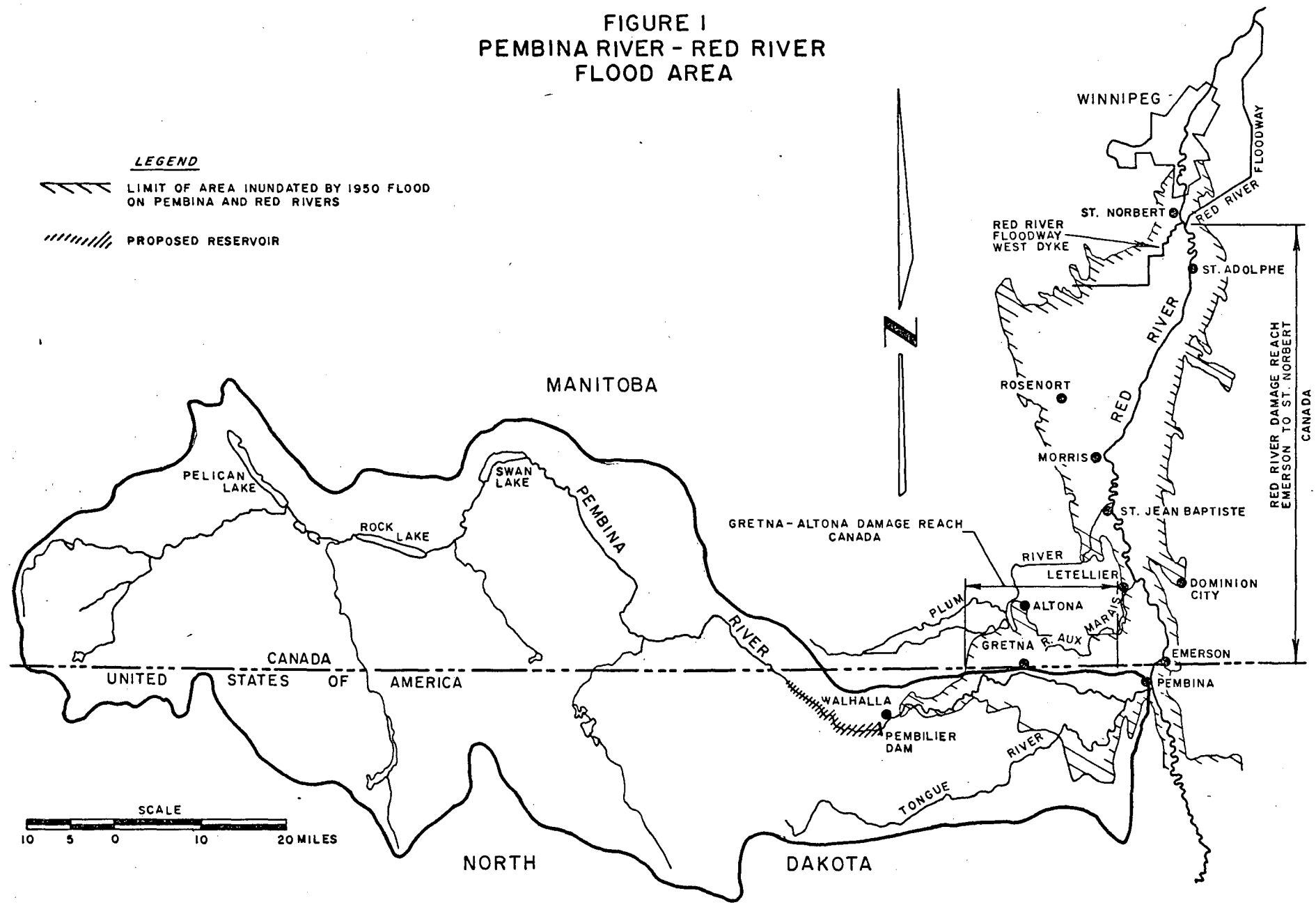
The cost allocation worked out by the Review Committee would appear to be a reasonable economic basis for negotiating cost sharing if a decision is made to proceed with the project.

APPENDIX I


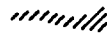
FIGURES 1 TO 27



FIGURE I  
PEMBINA RIVER - RED RIVER  
FLOOD AREA



**LEGEND**

-  LIMIT OF AREA INUNDATED BY 1950 FLOOD ON PEMBINA AND RED RIVERS
-  PROPOSED RESERVOIR

SCALE  
10 5 0 10 20 MILES

RED RIVER DAMAGE REACH  
EMERSON TO ST. NORBERT  
CANADA

GREтна - ALTONA DAMAGE REACH  
CANADA

WINNIPEG

ST. NORBERT

ST. ADOLPHE

RED RIVER  
FLOODWAY  
WEST DYKE

ROSENORT

MORRIS

ST. JEAN BAPTISTE

RIVER  
LETELLIER

DOMINION  
CITY

PLUM

ALTONA

GREтна R. AUX

EMERSON

PEMBINA

WALHALLA

PEMBILIER  
DAM

RIVER

TONGUE

NORTH

DAKOTA

MANITOBA

PELICAN  
LAKE

SWAN  
LAKE

ROCK  
LAKE

PEMBINA  
RIVER

RIVER

RED  
RIVER

RED  
RIVER

RED  
RIVER

RED  
RIVER

RED  
RIVER

RED  
RIVER

RED  
RIVER

FLOODWAY

RED RIVER

RED RIVER

RED RIVER

RED RIVER

RED RIVER

RED RIVER

RED RIVER

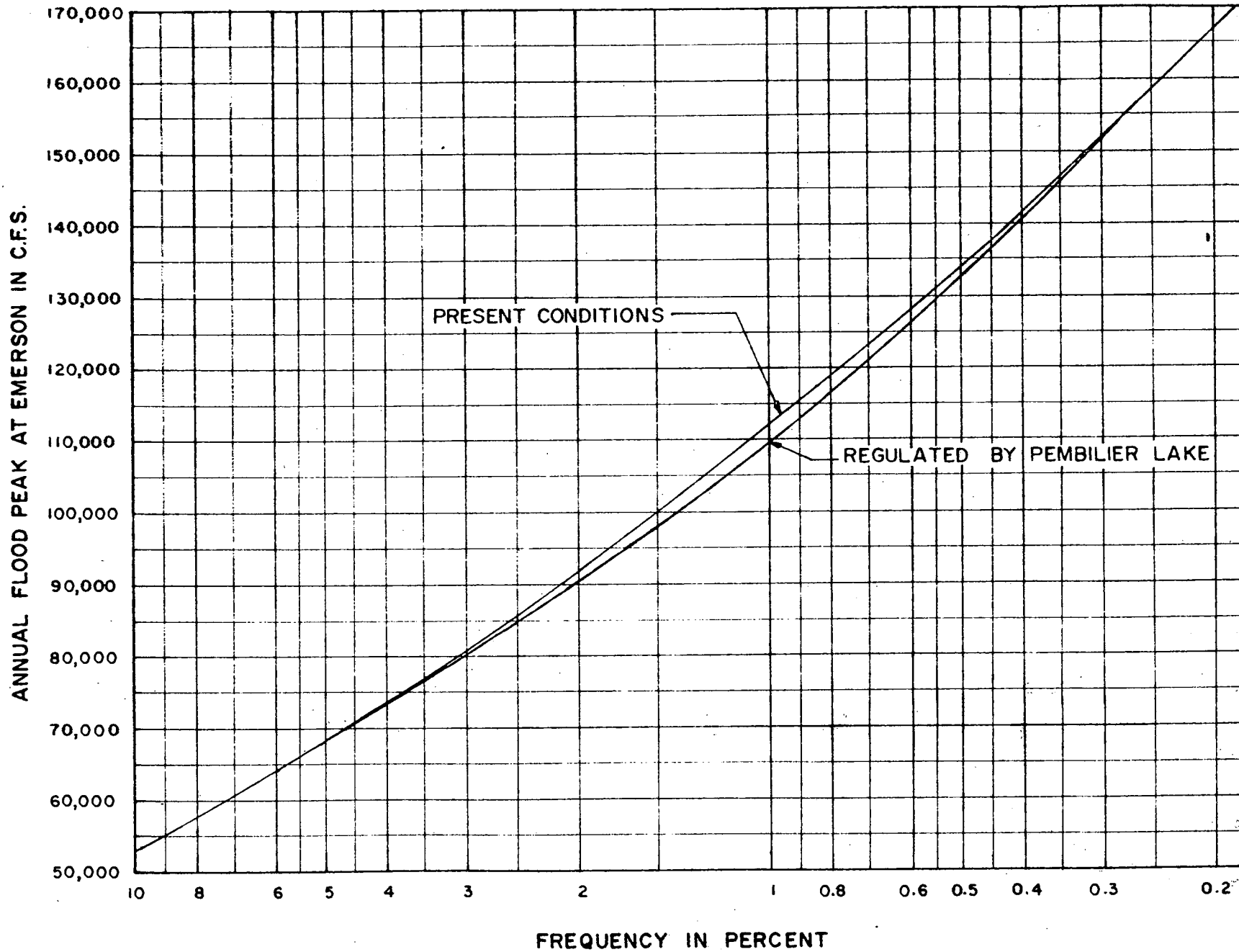


FIG. 2

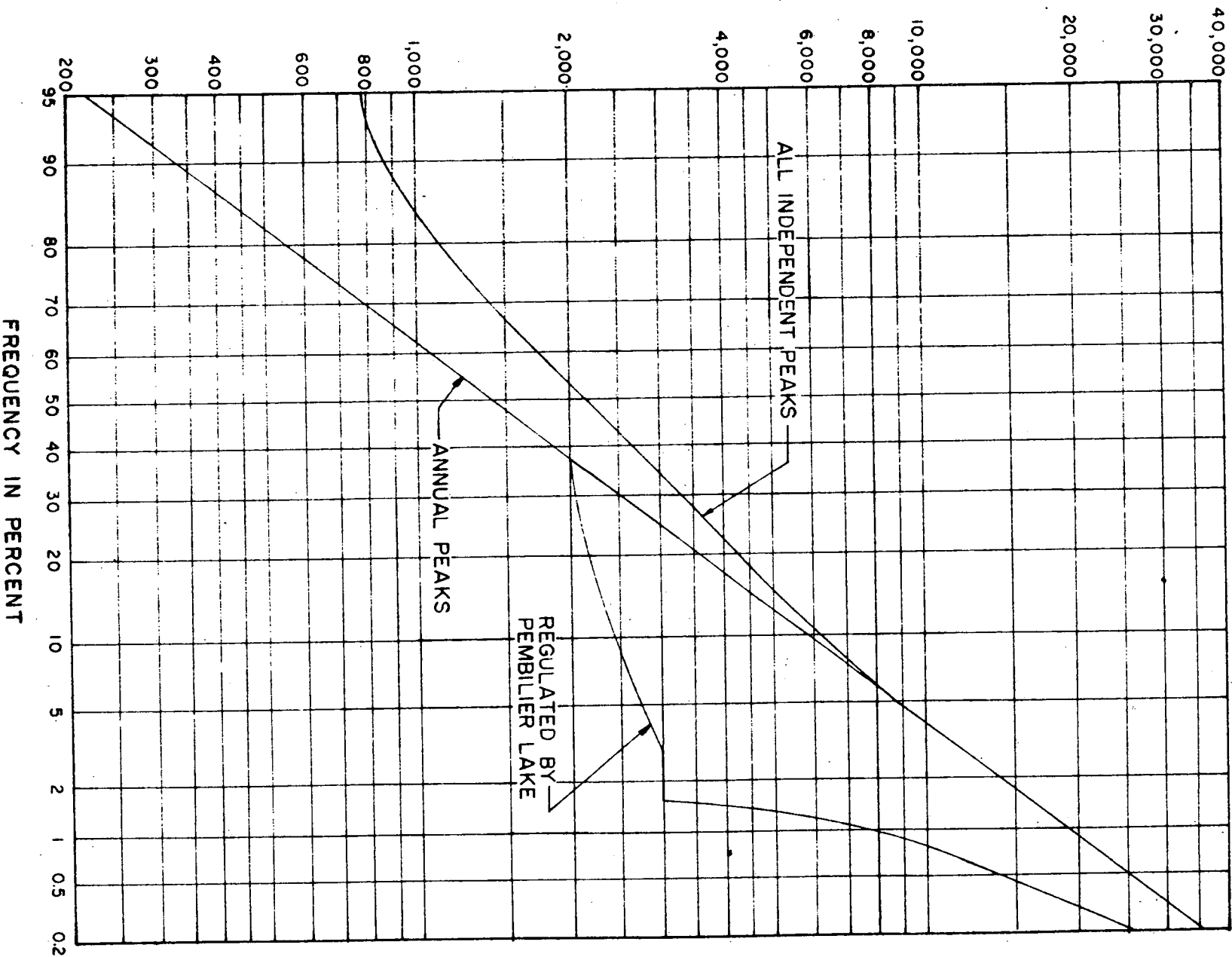
PEMBILIER DAM REVIEW

DISCHARGE - FREQUENCY CURVE

RED RIVER AT EMERSON

SCALE AS SHOWN DATE JUNE/73 SHEET OF FILE NO.

MAX. MEAN DAILY DISCHARGE - PEMBINA RIVER AT WALHALLA

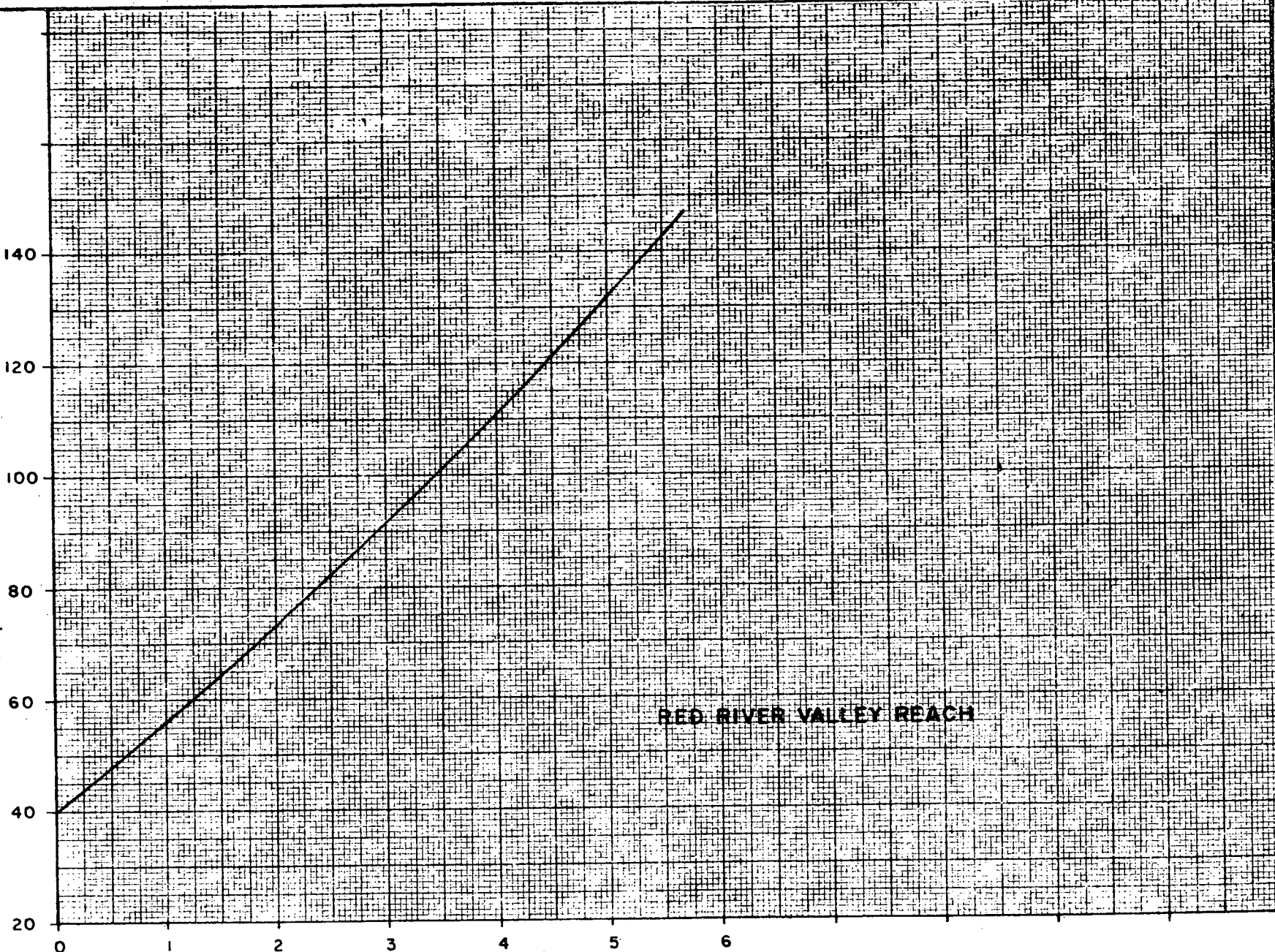


PEMBILIER DAM REVIEW  
 DISCHARGE - FREQUENCY CURVES  
 PEMBINA RIVER  
 AT WALHALLA, NORTH DAKOTA

SCALE AS SHOWN    DATE JUNE/73    SHEET OF    FILE NO.

FIG. 3

ANNUAL FLOOD PEAK AT EMERSON  
(x 1,000 C.F.S.)



RED RIVER VALLEY REACH

FLOODED AREA (x 100,000 ACRES)

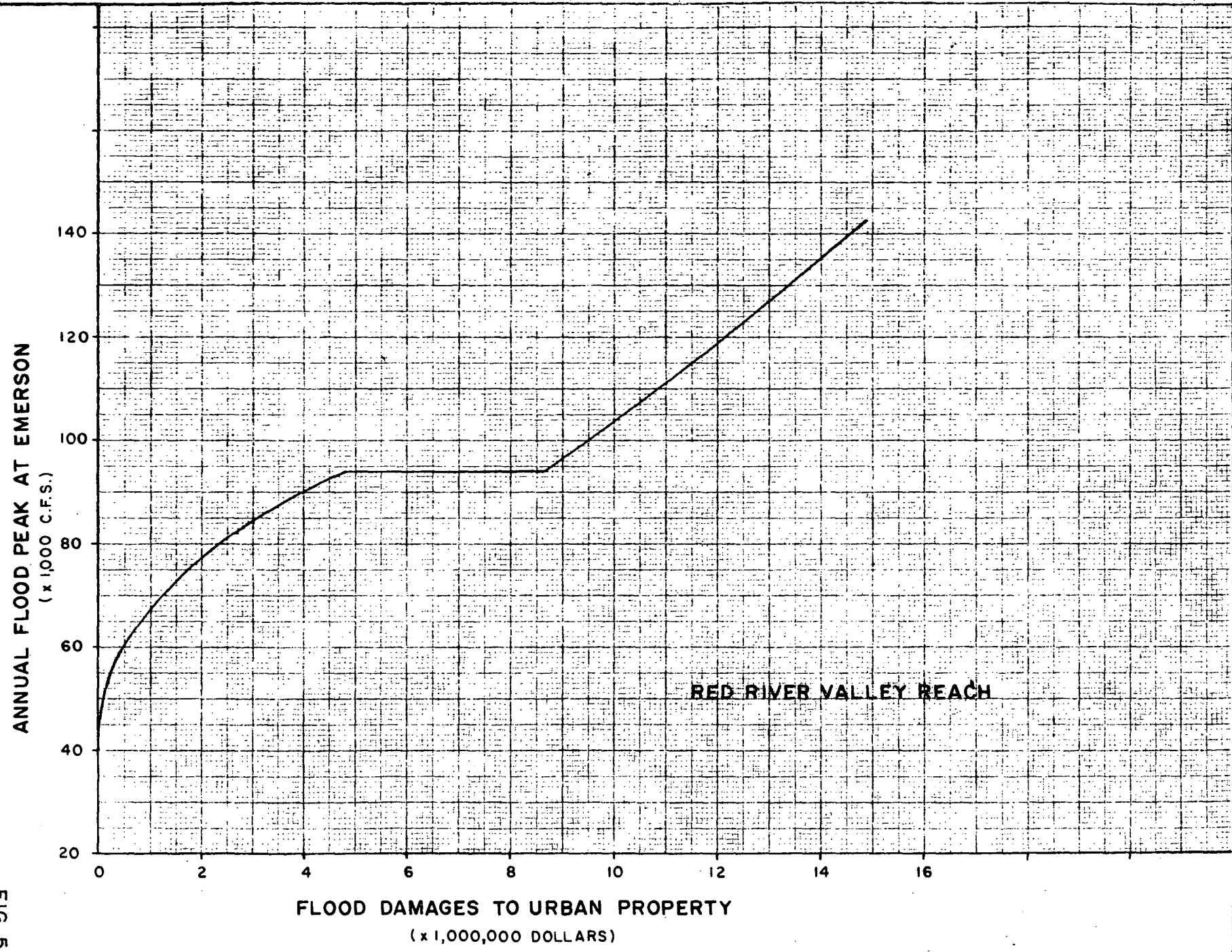
FIG. 4

PEMBLIER DAM REVIEW			
DISCHARGE - FLOODED AREA CURVE			
RED RIVER VALLEY REACH			
SCALE AS SHOWN	DATE JUNE / 73	SHEET OF	FILE NO.

SCALE AS SHOWN  
 DATE JUNE/73  
 SHEET OF  
 FILE NO.

PEMBILIER DAM REVIEW  
 DISCHARGE - DAMAGE  
 URBAN FLOOD DAMAGE  
 RED RIVER VALLEY REACH

FIG. 5



SCALE  
AS SHOWN

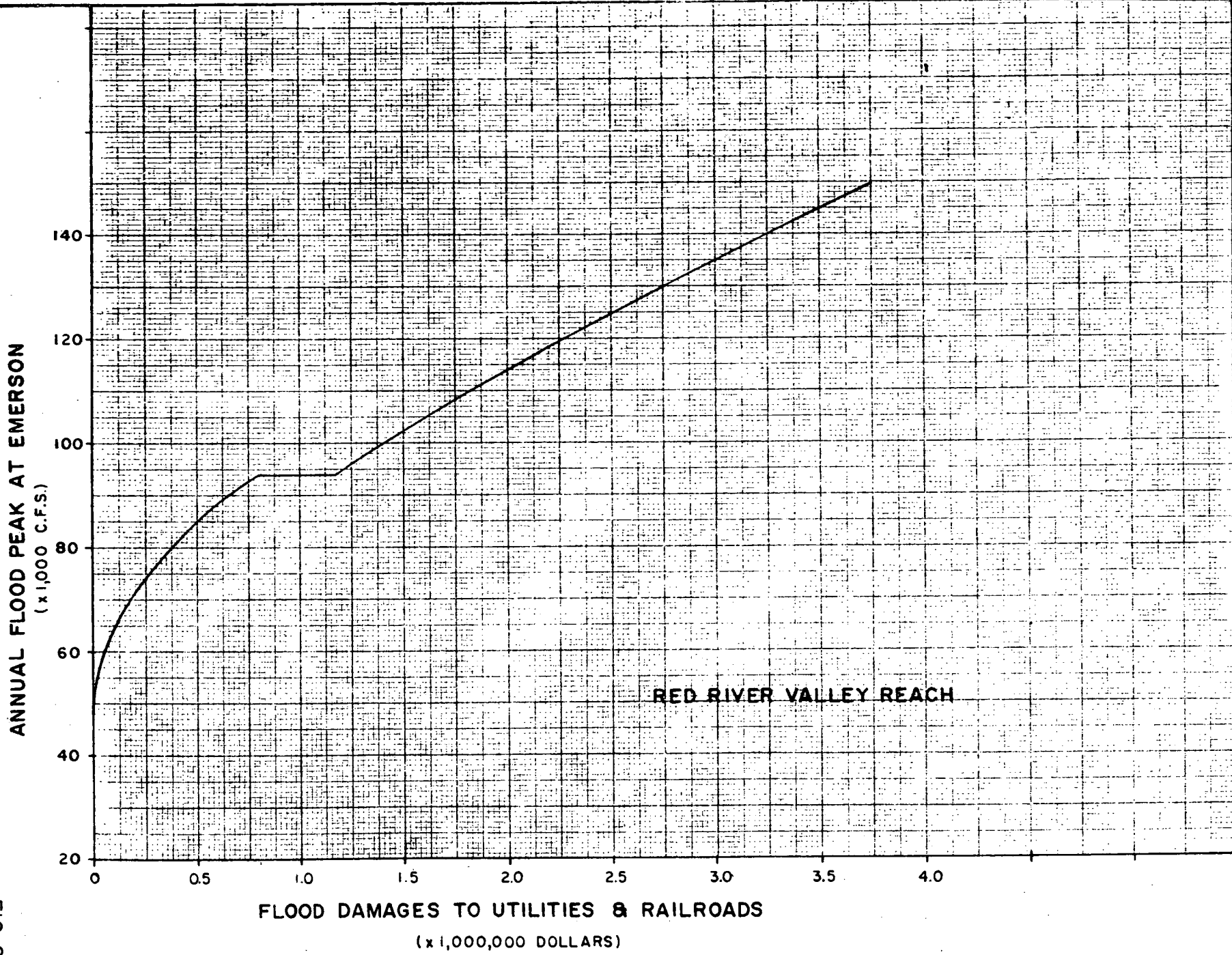
DATE  
JUNE/73

SHEET  
OF

FILE NO.

PEMBLIER DAM REVIEW  
DISCHARGE - DAMAGE  
UTILITIES & RAILROADS DAMAGE  
RED RIVER VALLEY REACH

FIG. 6



SCALE AS SHOWN

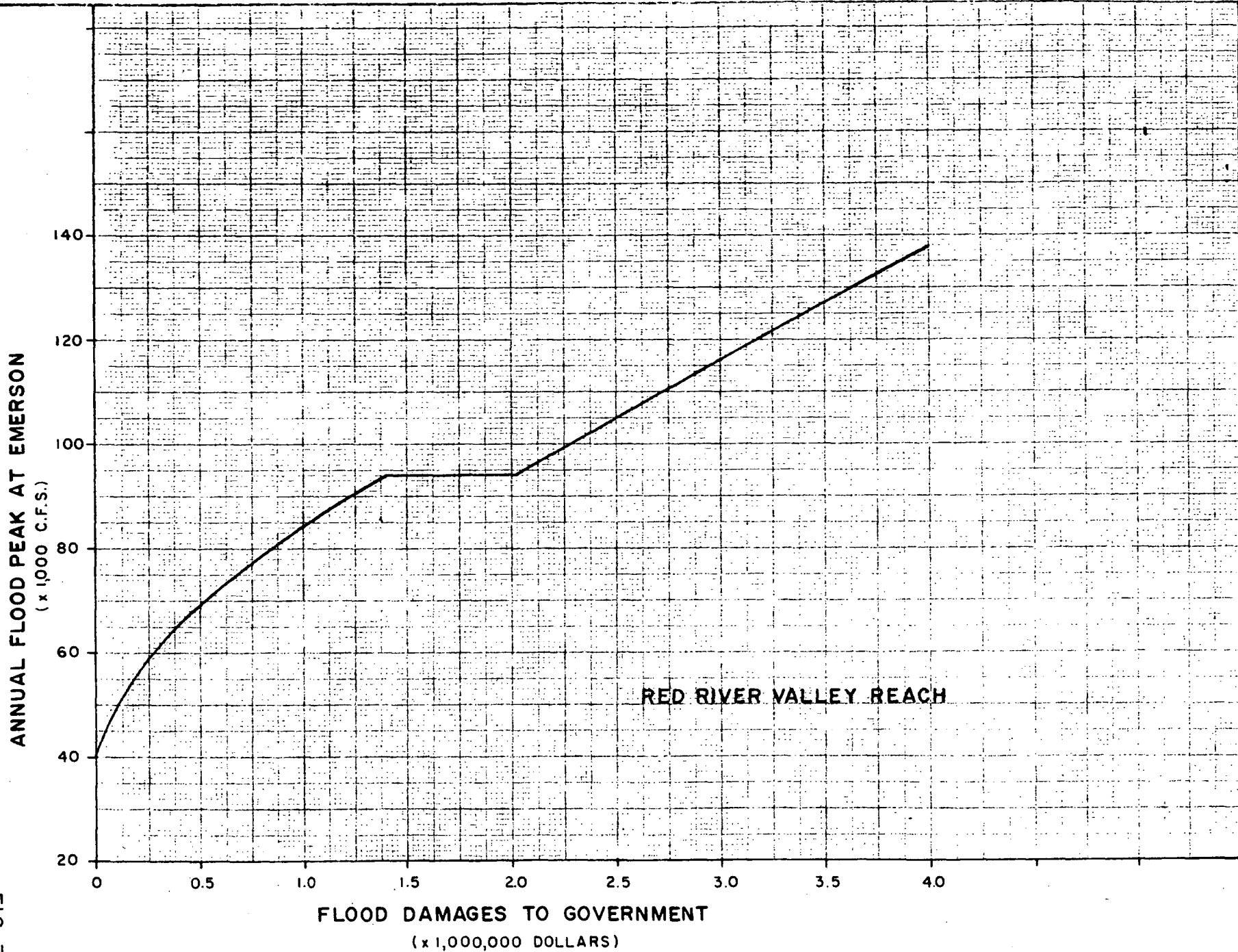
DATE JUNE / 73

SHEET OF

FILE NO.

PEMBILIER DAM REVIEW  
DISCHARGE - DAMAGE  
GOVERNMENT DAMAGE  
RED RIVER VALLEY REACH

FIG. 7



SCALE AS SHOWN  
 DATE JUNE/73 SHEET OF FILE NO.  
 PEBILIER DAM REVIEW  
 DISCHARGE - DAMAGE  
 AGR. LOSS OF INCOME & EXTRA COSTS  
 RED RIVER VALLEY REACH

ANNUAL FLOOD PEAK AT EMERSON (x 1,000 C.F.S.)

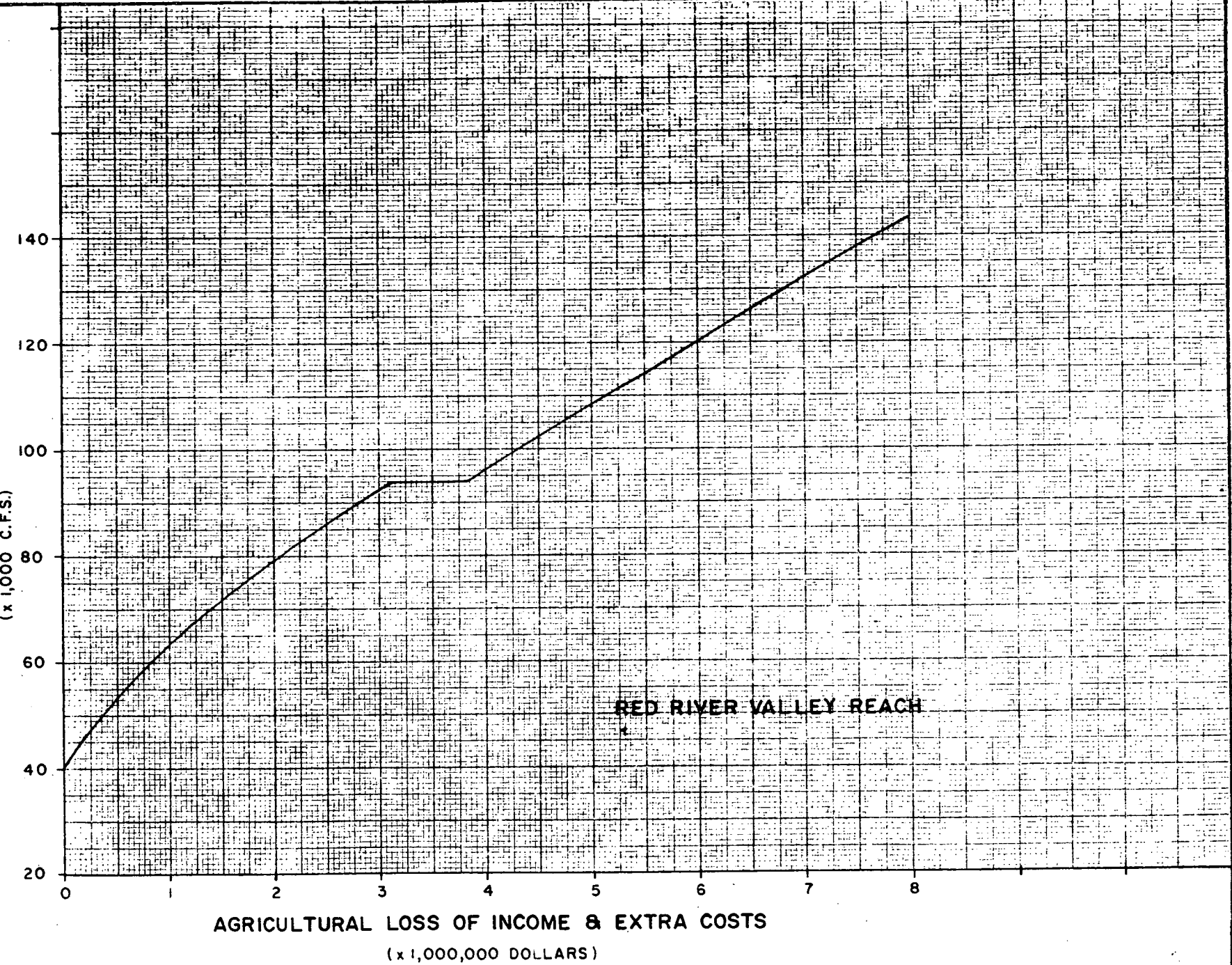


FIG. 8

AGRICULTURAL LOSS OF INCOME & EXTRA COSTS  
 (x 1,000,000 DOLLARS)

RED RIVER VALLEY REACH



SCALE AS SHOWN  
 DATE JUNE/73  
 SHEET 01  
 FILE NO.

**PEMBILIER DAM REVIEW**  
**DISCHARGE - DAMAGE**  
**DAMAGES TO AGRICULTURAL PROPERTY**  
**RED RIVER VALLEY REACH**

ANNUAL FLOOD PEAK AT EMERSON

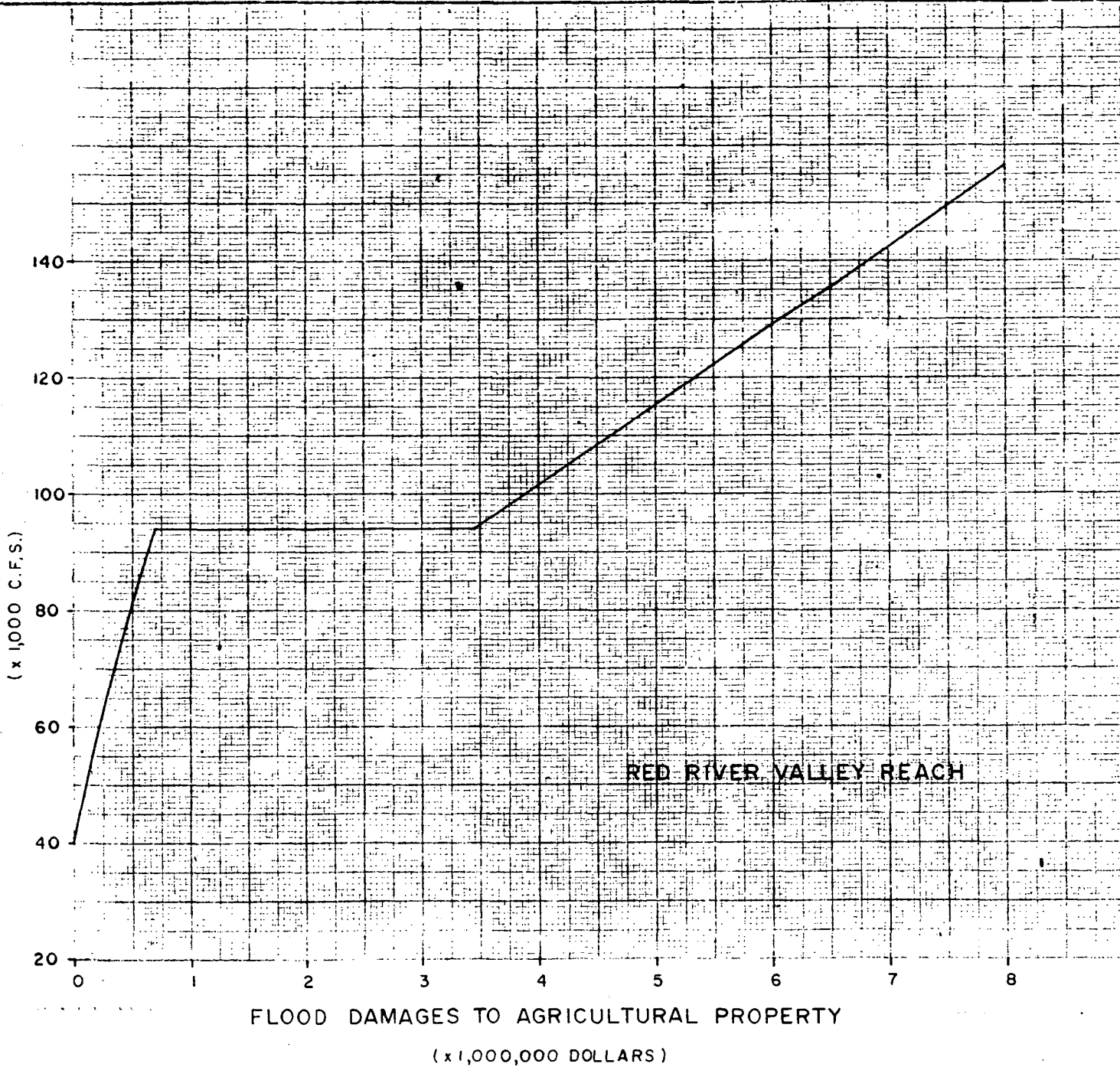


FIG. 9

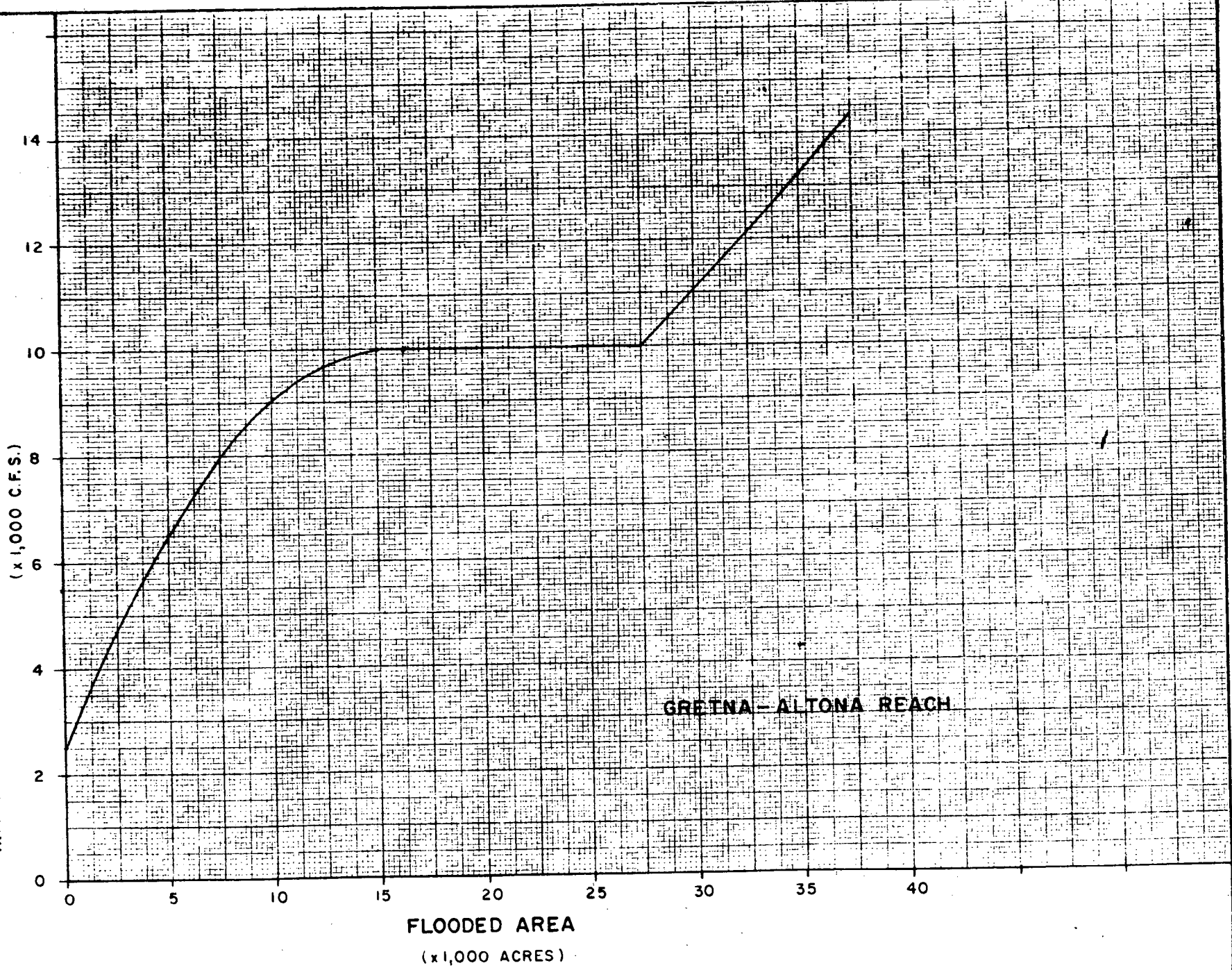
PEMBILIER DAM REVIEW

DISCHARGE - FLOODED AREA CURVE

GRETNA - ALTONA REACH

SCALE AS SHOWN    DATE JUNE /73    SHEET OF    FILE NO

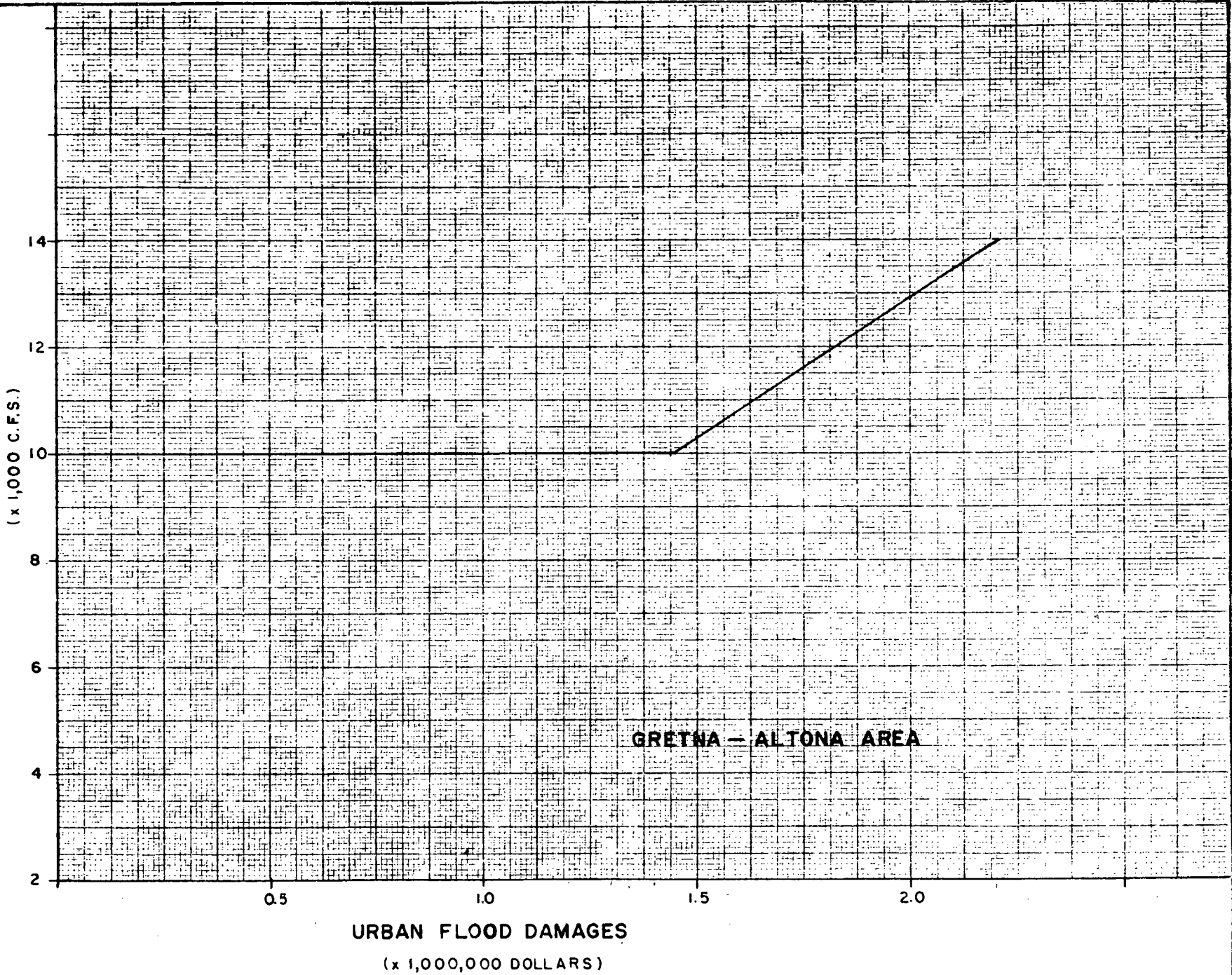
FIG. 10    MAX. MEAN DAILY DISCHARGE - PEMBINA RIVER AT WALHALLA



PEMBILIER DAM REVIEW			
DISCHARGE - DAMAGE			
URBAN FLOOD DAMAGE			
GRETNA - ALTONA REACH			
SCALE AS SHOWN	DATE JUNE/73	SHEET OF	FILE NO.

**MAX. MEAN DAILY DISCHARGES - PEMBINA RIVER AT WALHALLA**

**FIG. 11**



**GRETNA - ALTONA AREA**

SCALE  
AS SHOWN

DATE JUNE/73

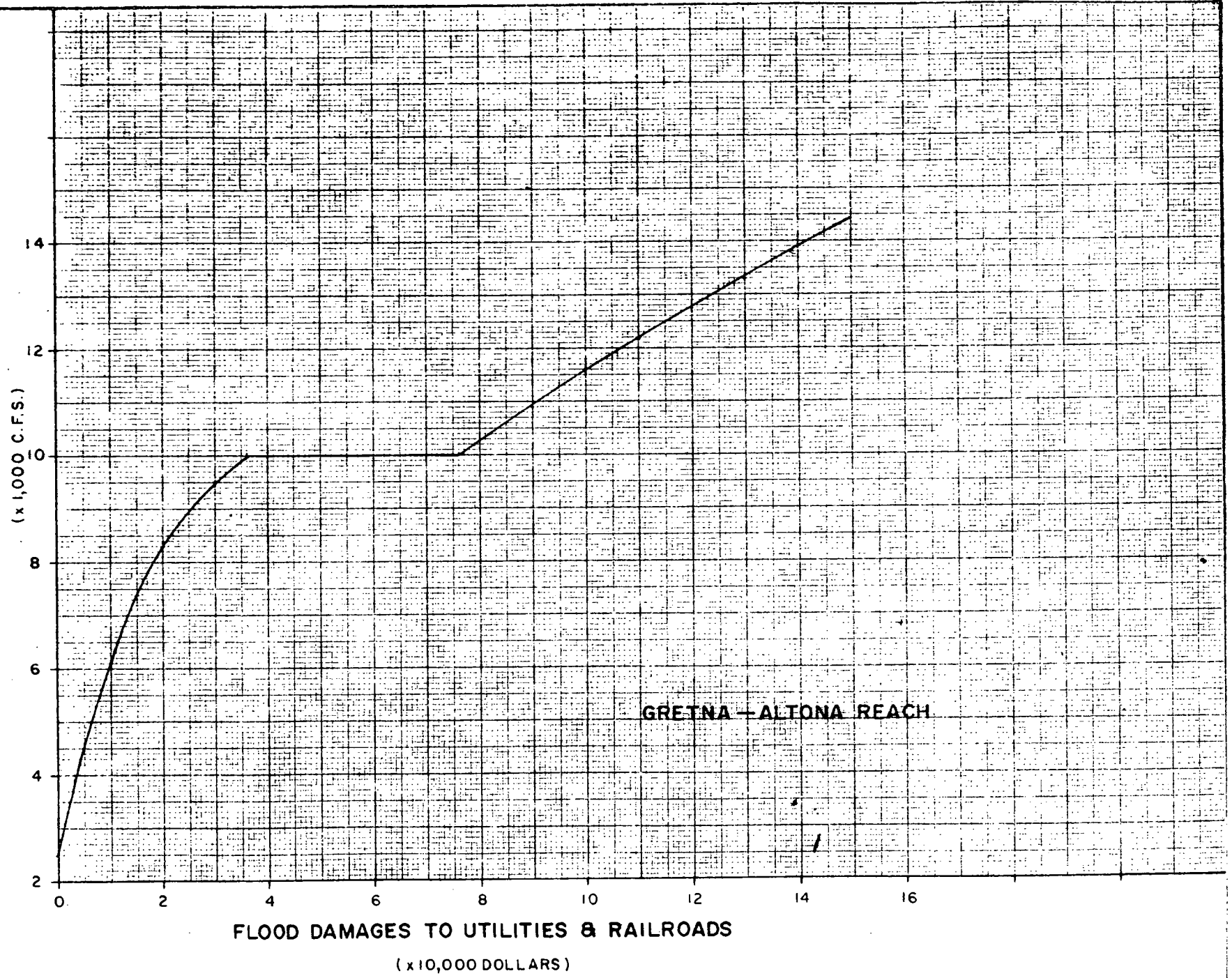
SHEET  
OF

FILE NO.

PEMBLIER DAM REVIEW  
DISCHARGE - DAMAGE  
UTILITIES & RAILROADS DAMAGE  
GRETNA - ALTONA REACH

FIG 12

MAX. MEAN DAILY DISCHARGES - PEMBINA RIVER AT WALHALLA



SCALE AS SHOWN  
 DATE JUNE /73  
 SHEET OF  
 FILE NO.

PEMBIILER DAM REVIEW  
 DISCHARGE - DAMAGE  
 GOVERNMENT DAMAGE  
 GRETNA - ALTONA REACH

MAX. MEAN DAILY DISCHARGES - PEMBINA RIVER AT WALHALLA

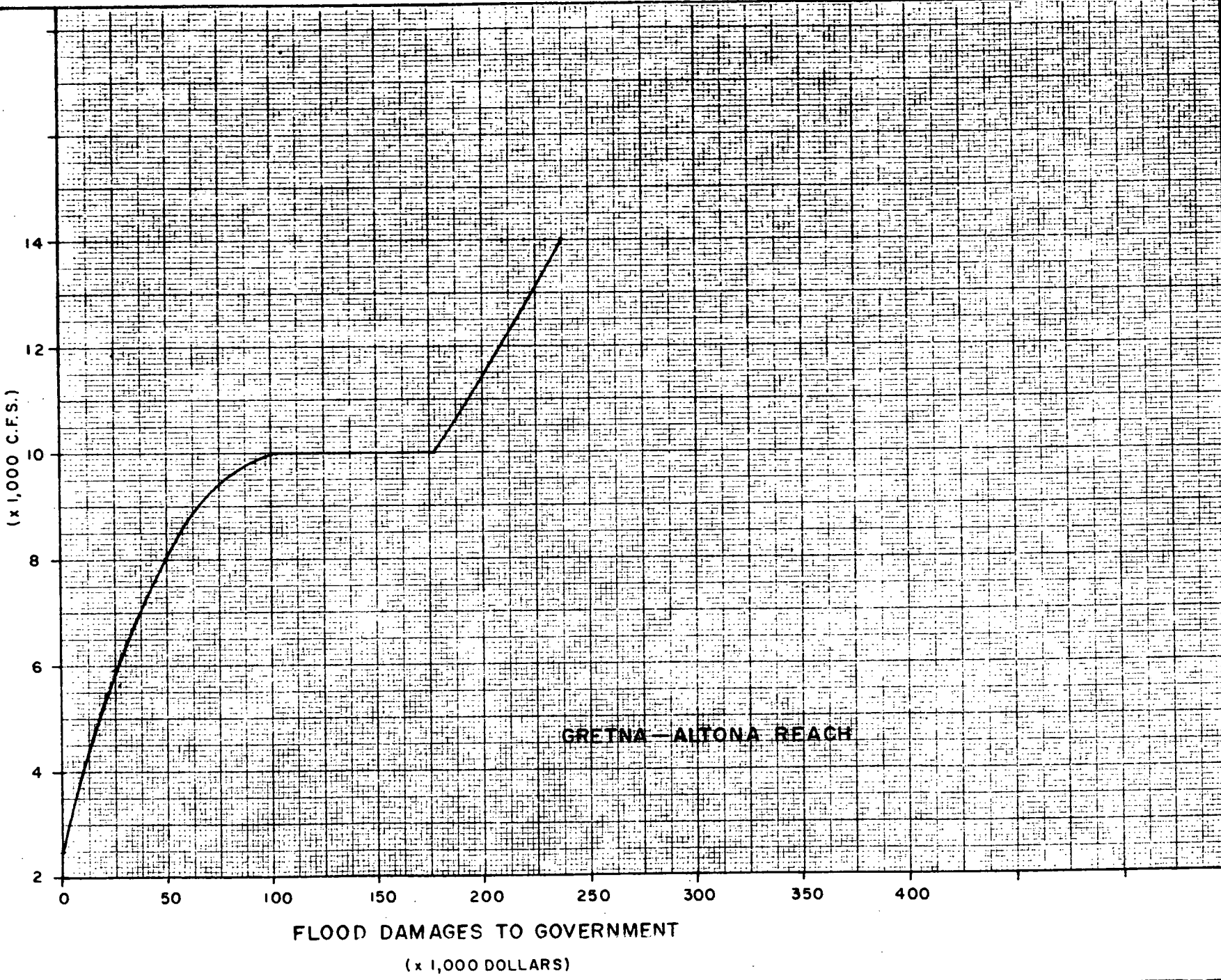


FIG. 13

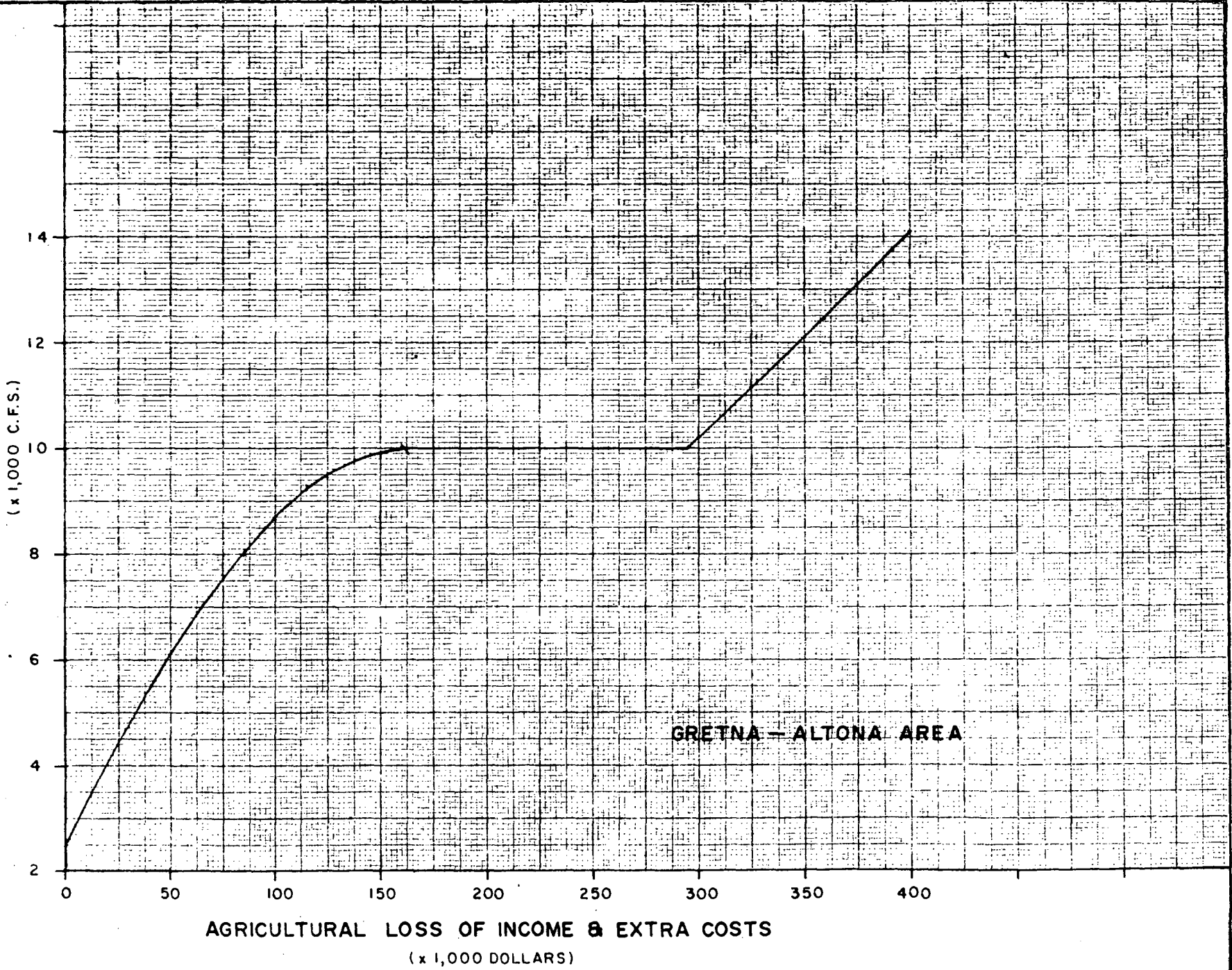
FLOOD DAMAGES TO GOVERNMENT  
(x 1,000 DOLLARS)

SCALE AS SHOWN  
 DATE JUNE/73  
 SHEET OF  
 FILE NO.

DISCHARGE - DAMAGE  
 AGR. LOSS OF INCOME & EXTRA COSTS  
 GREYNA - ALTONA REACH

PEMBILIER DAM REVIEW

MAX. MEAN DAILY DISCHARGES - PEMBINA RIVER AT WALHALLA



GREYNA - ALTONA AREA

FIG. 14

SCALE AS SHOWN

DATE JUNE /73

SHEET OF

FILE NO.

PEMBLIER DAM REVIEW  
DISCHARGE - DAMAGE  
DAMAGES TO AGRICULTURAL PROPERTY  
GRETNA - ALTONA REACH

FIG. 15

MAX. MEAN DAILY DISCHARGES - PEMBINA RIVER AT WALHALLA

(x 1,000 C.F.S.)

14

12

10

8

6

4

2

0

50

100

150

200

250

300

350

400

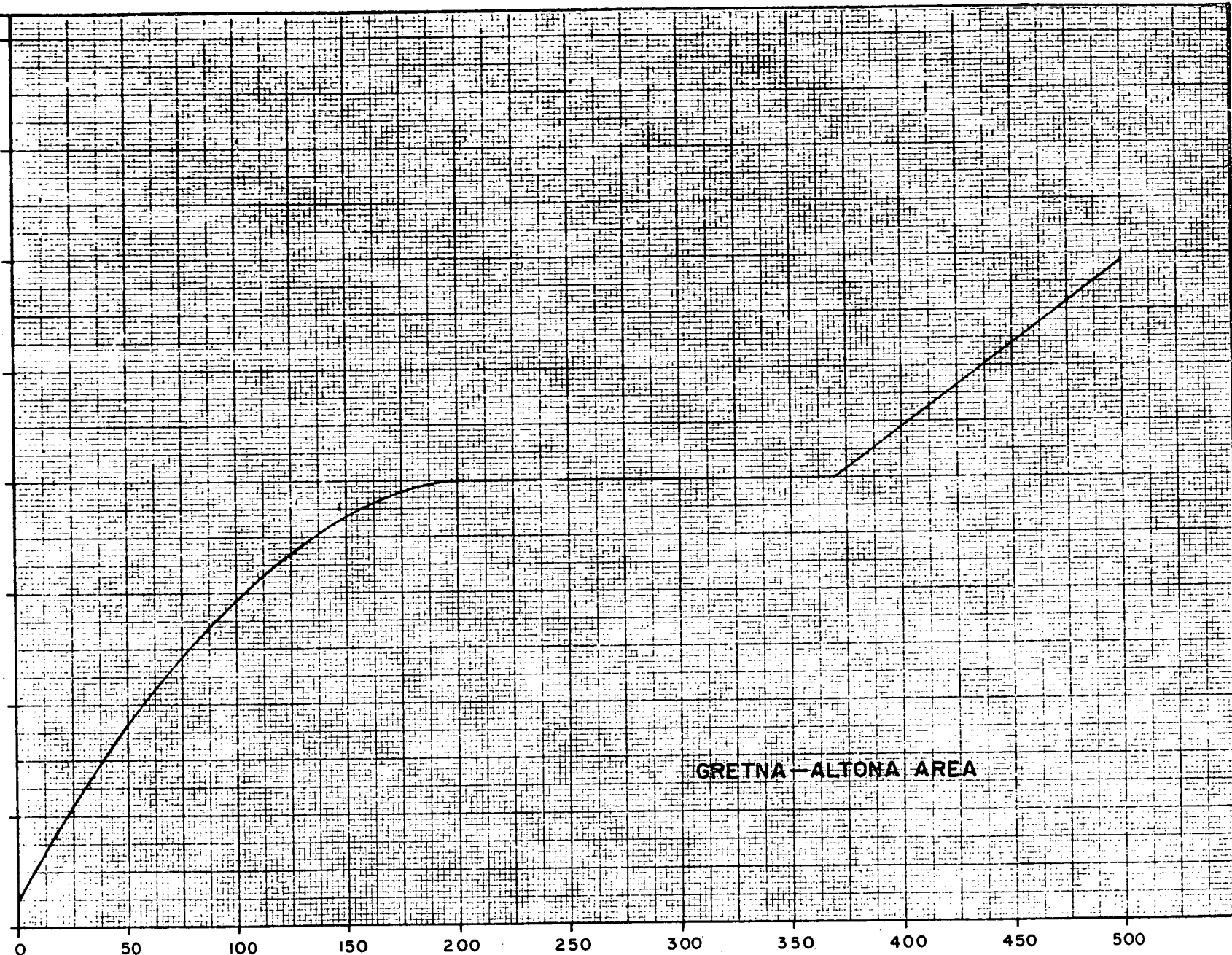
450

500

FLOOD DAMAGES TO AGRICULTURAL PROPERTY

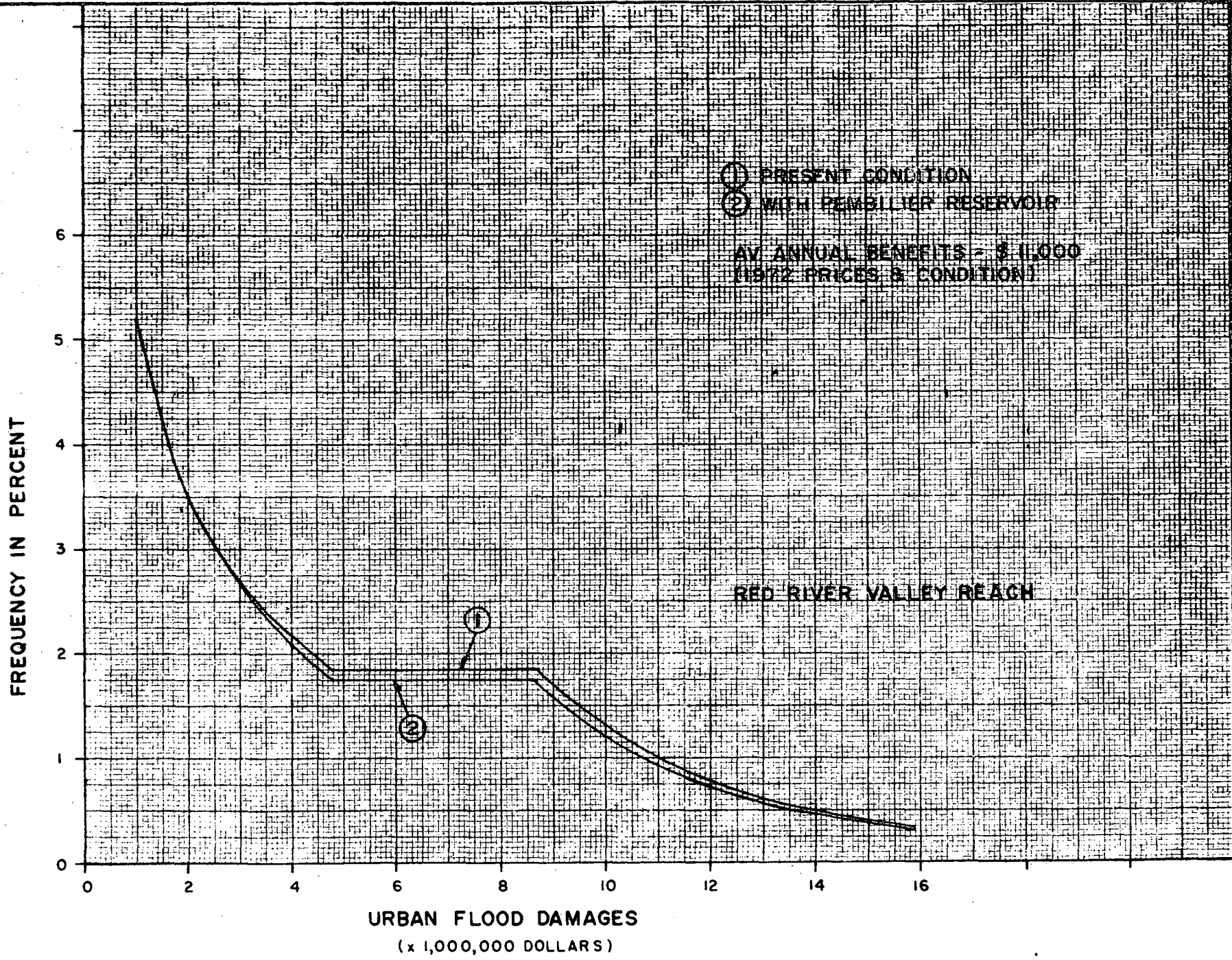
(x 1,000 DOLLARS)

GRETNA - ALTONA AREA



SCALE AS SHOWN  
 DATE JUNE/73 SHEET OF FILE NO.  
 PEMBLIER DAM REVIEW  
 FREQUENCY-DAMAGE CURVE  
 URBAN FLOOD DAMAGE  
 RED RIVER VALLEY REACH

FIG. 16

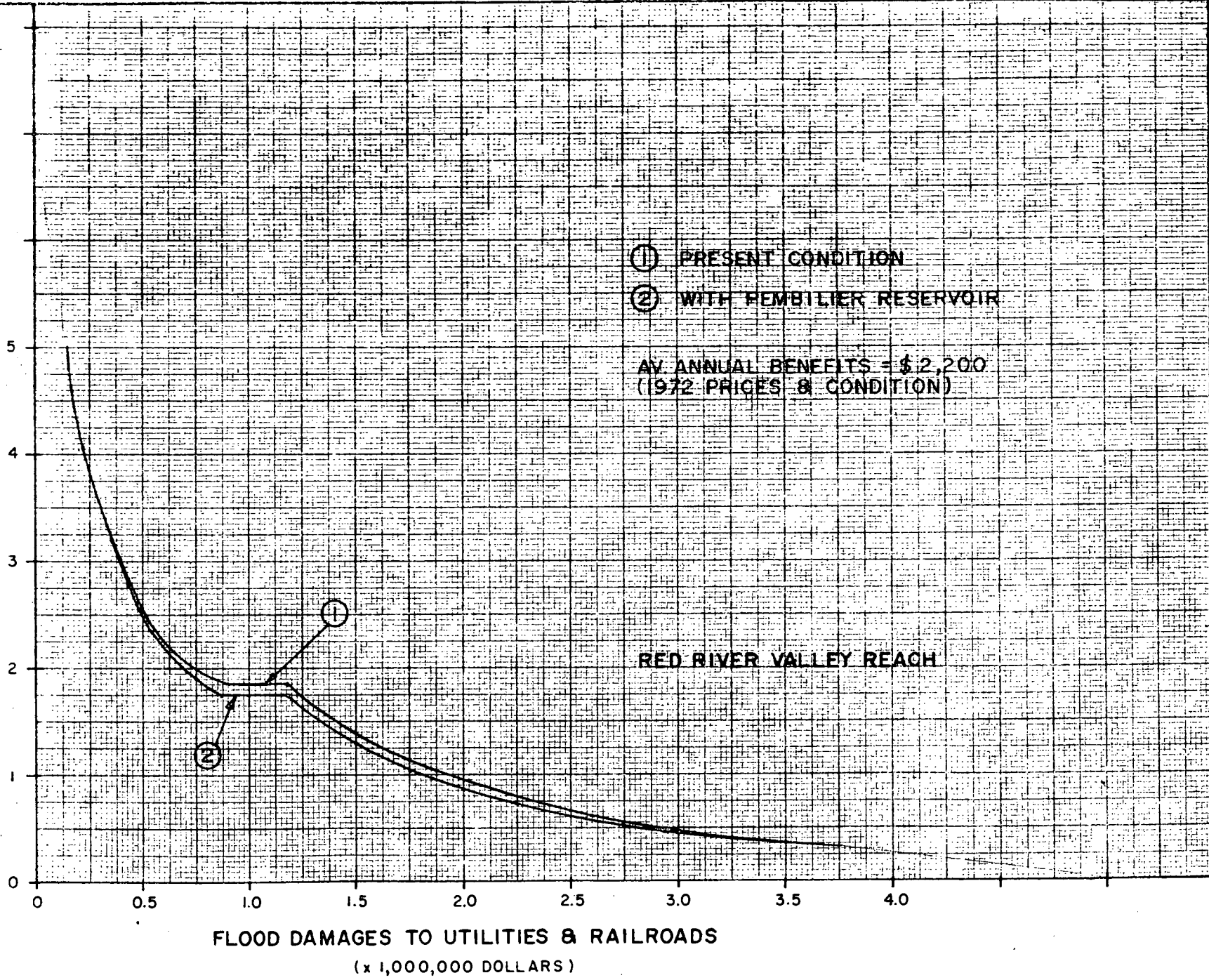




SCALE AS SHOWN  
 DATE JUNE / 73  
 SHEET OF  
 FILE NO.

**PEMBILIER DAM REVIEW**  
**FREQUENCY - DAMAGE CURVE**  
**UTILITIES & RAILROADS DAMAGE**  
**RED RIVER VALLEY REACH**

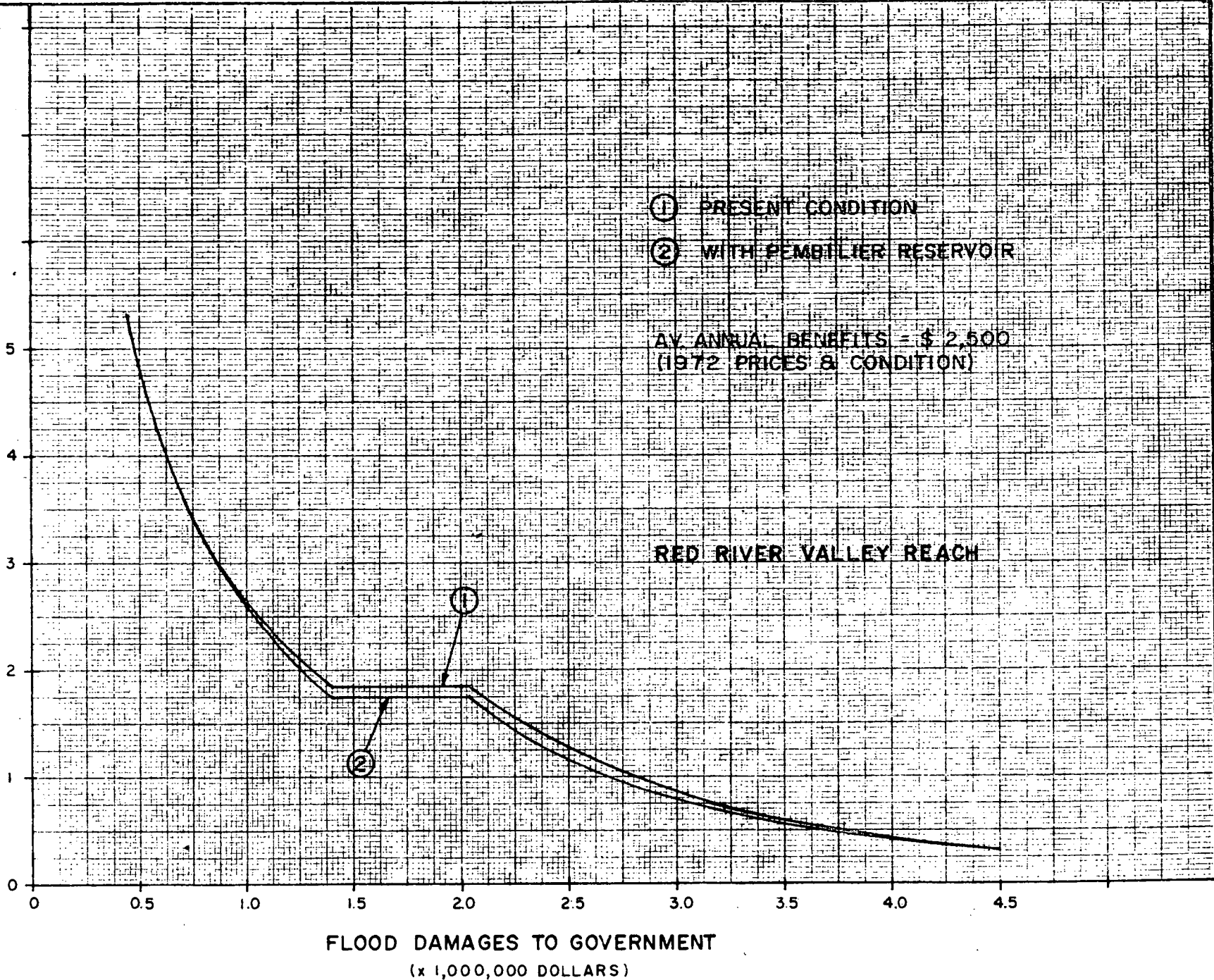
FREQUENCY IN PERCENT



FLOOD DAMAGES TO UTILITIES & RAILROADS  
 (x 1,000,000 DOLLARS)

FIG. 17

FREQUENCY IN PERCENT



FLOOD DAMAGES TO GOVERNMENT  
(x 1,000,000 DOLLARS)

FIG. 13

PEMBLIER DAM REVIEW

FREQUENCY-DAMAGE CURVE

GOVERNMENT DAMAGE

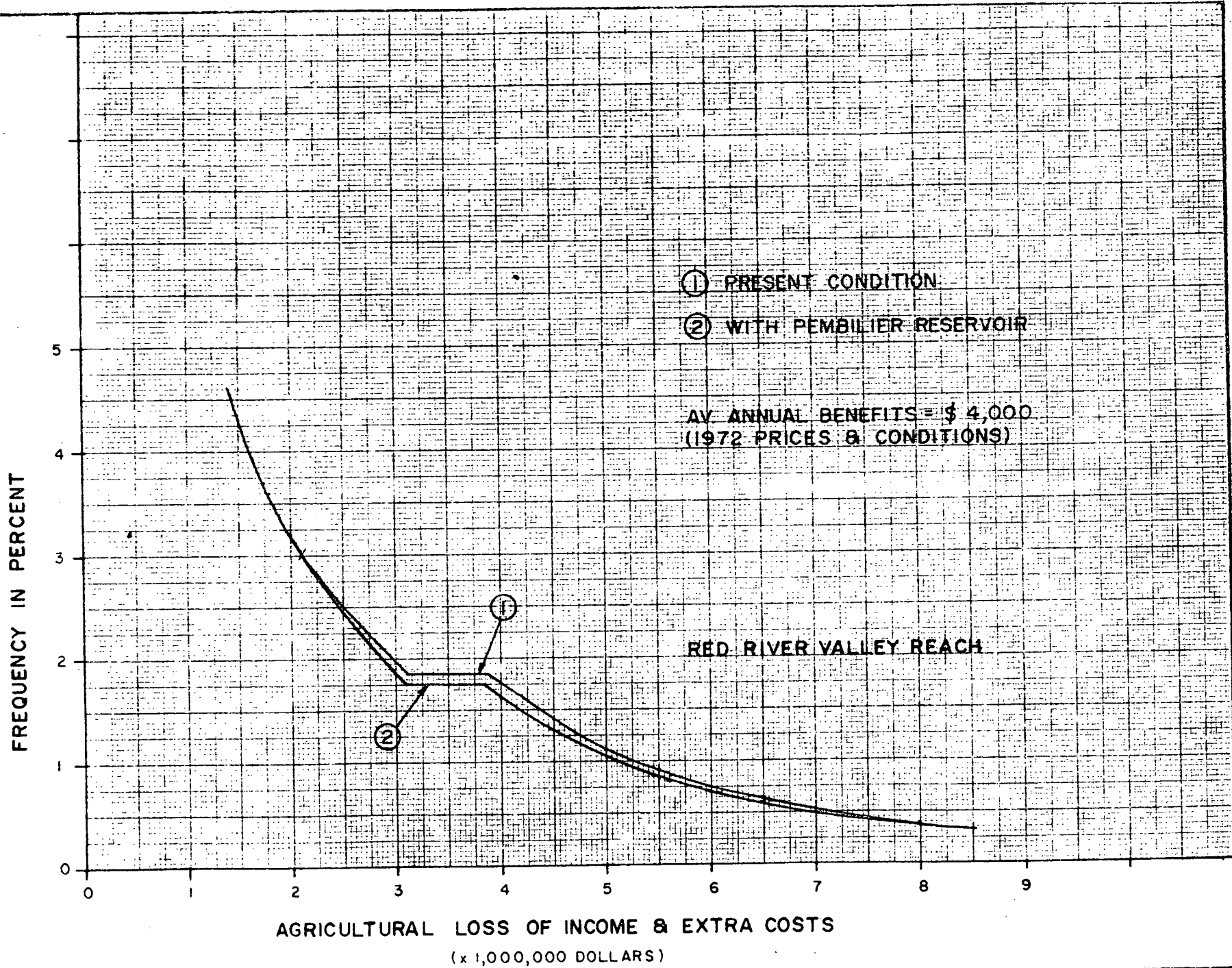
RED RIVER VALLEY REACH

SCALE AS SHOWN DATE JUNE/73 SHEET OF FILE NO.

SCALE AS SHOWN  
 DATE JUNE/73  
 SHEET OF  
 FILE NO.

PEMBILIER DAM REVIEW  
 FREQUENCY-DAMAGE CURVE  
 AGR. LOSS OF INCOME & EXTRA COSTS  
 RED RIVER VALLEY REACH

FIG. 19



FREQUENCY IN PERCENT

5

4

3

2

1

0

① PRESENT CONDITION

② WITH PEMBILIER RESERVOIR

AV. ANNUAL BENEFITS = \$ 5,200  
(1972 PRICES & CONDITIONS)

RED RIVER VALLEY REACH

FLOOD DAMAGES TO AGRICULTURAL PROPERTY

(x 1,000,000 DOLLARS)

FIG 20

PEMBILIER DAM REVIEW

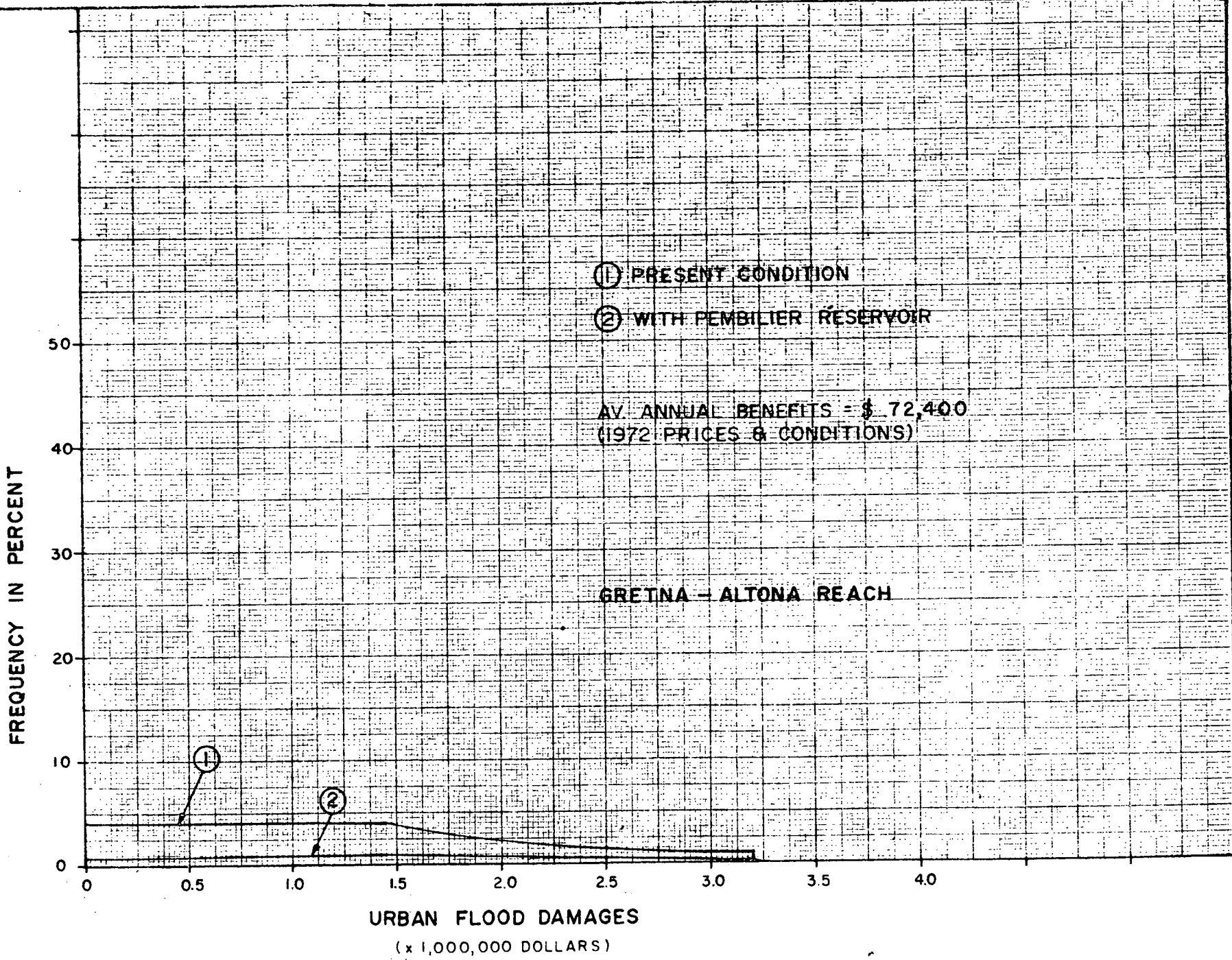
FREQUENCY-DAMAGE CURVE  
DAMAGES TO AGRICULTURAL PROPERTY  
RED RIVER VALLEY REACH

SCALE  
AS SHOWN

DATE  
JUNE/73

SHEET  
OF

FILE NO.



PEMBLIER DAM REVIEW

FREQUENCY - DAMAGE CURVE

URBAN FLOOD DAMAGE

GRETNA - ALTONA REACH

SCALE AS SHOWN

DATE JUNE / 73

SHEET OF

FILE NO.

FIG. 21

PEMBILIER DAM REVIEW  
 FREQUENCY - DAMAGE CURVE  
 UTILITIES & RAILROADS DAMAGE  
 GREYNA - ALTONA REACH

SCALE AS SHOWN  
 DATE JUNE / 73  
 SHEET OF FILE NO.

FREQUENCY IN PERCENT

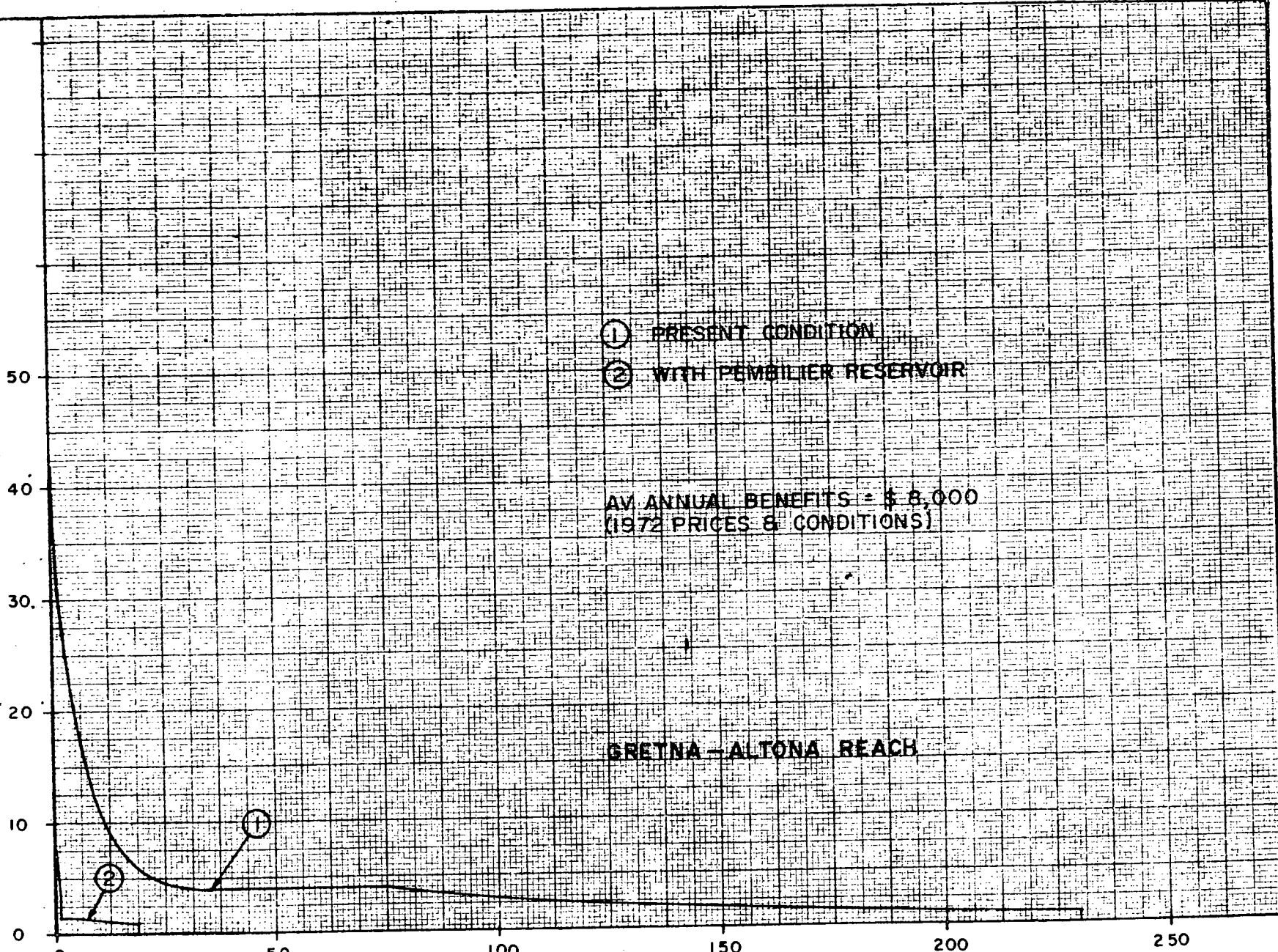
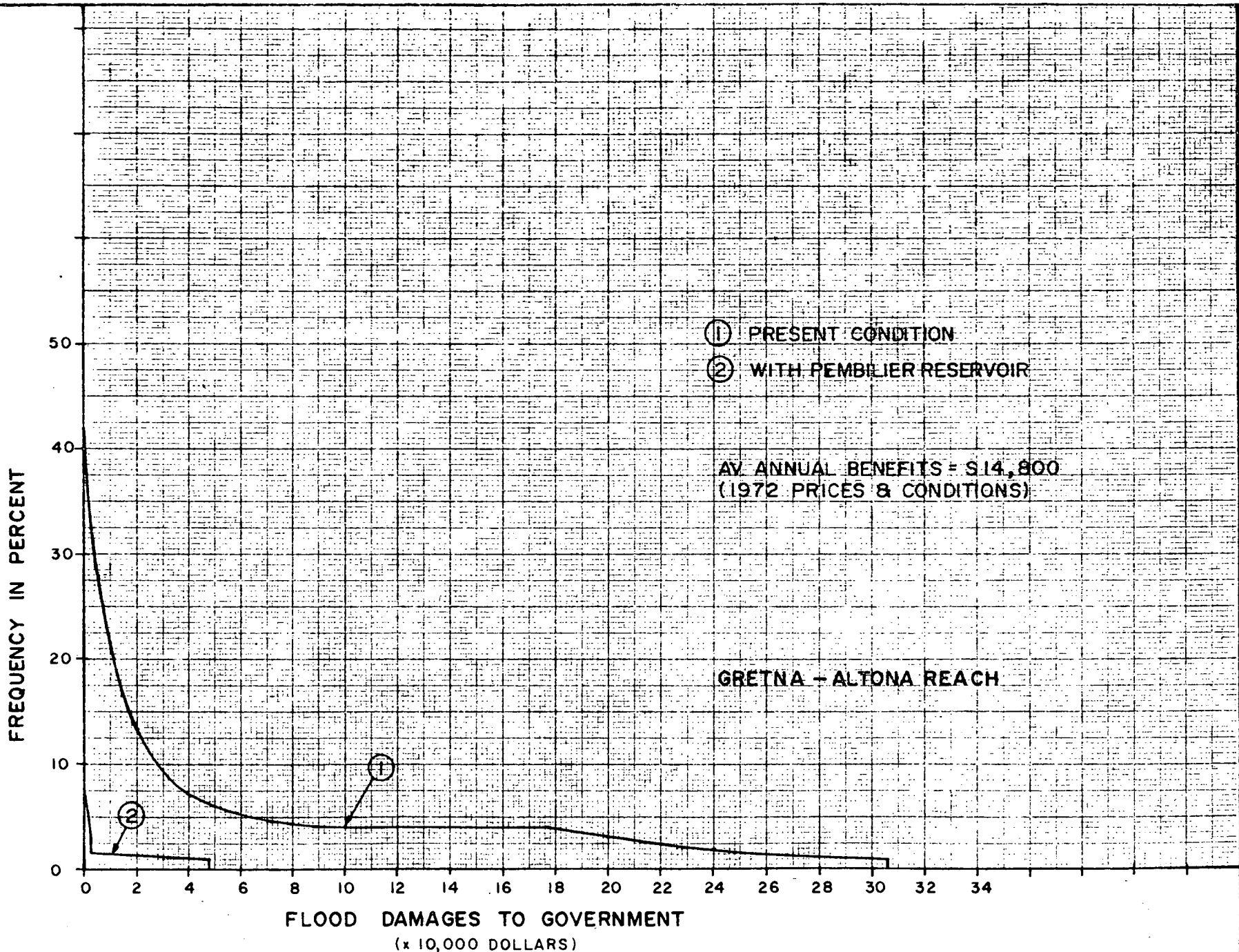


FIG. 22

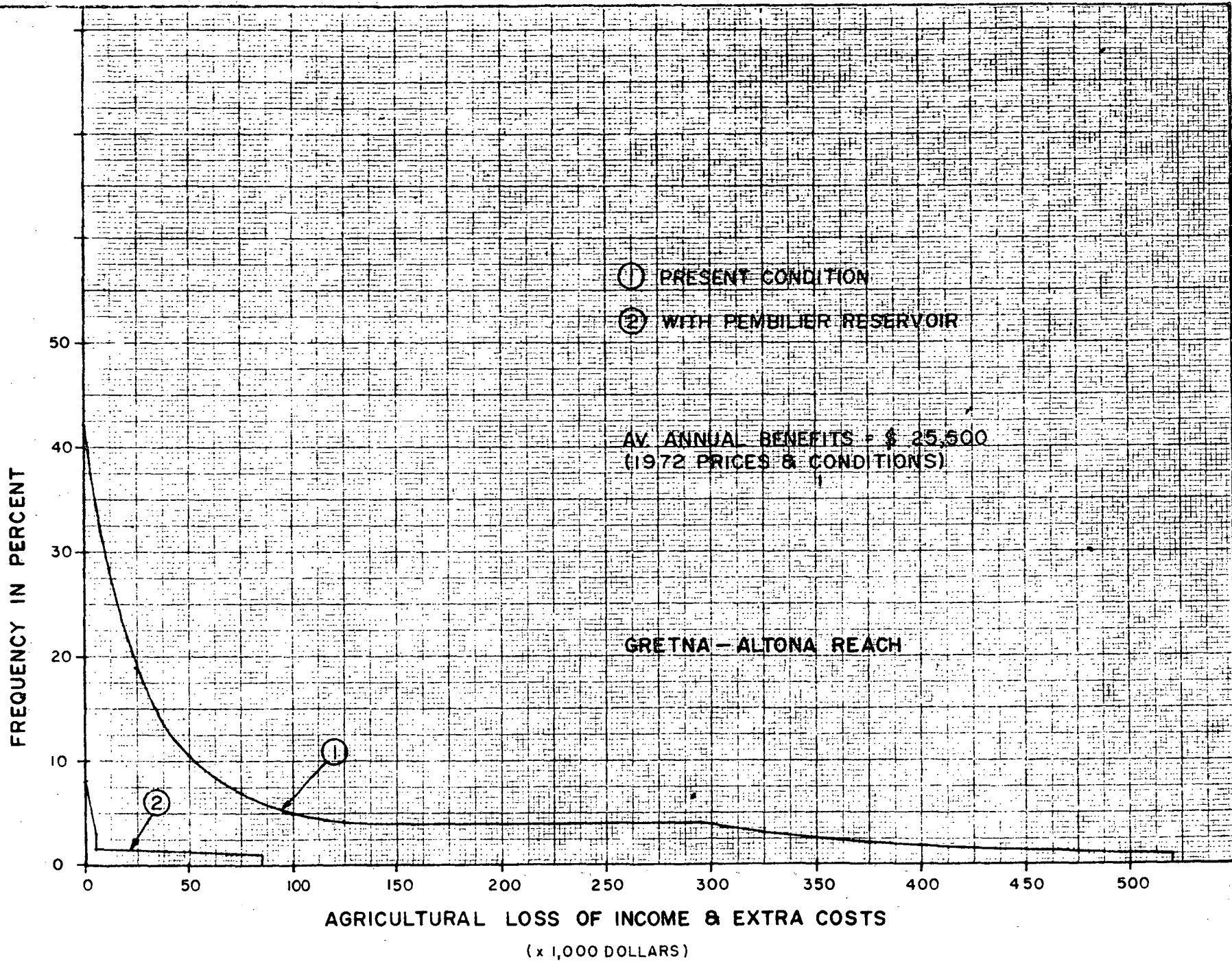
FLOOD DAMAGES TO UTILITIES & RAILROADS  
 (x 1,000 DOLLARS)



PEMBLIER DAM REVIEW  
 FREQUENCY - DAMAGE CURVE  
 GOVERNMENT DAMAGE  
 GREYNA - ALTONA REACH

SCALE AS SHOWN  
 DATE JUNE / 73  
 SHEET OF  
 FILE NO.

FIG. 23



PEMBLIER DAM REVIEW

FREQUENCY-DAMAGE CURVE

AGR. LOSS OF INCOME & EXTRA COSTS

GRETNA - ALTONA REACH

SCALE AS SHOWN

DATE JUNE/73

SHEET 01

FILE NO.

FIG 24



PEMBILLIER DAM REVIEW  
 FREQUENCY-DAMAGE CURVE  
 DAMAGES TO AGRICULTURAL PROPERTY  
 GREYNA - ALTONA REACH

SCALE AS SHOWN  
 DATE, JUNE, 73  
 SHEET OF  
 FILE NO.

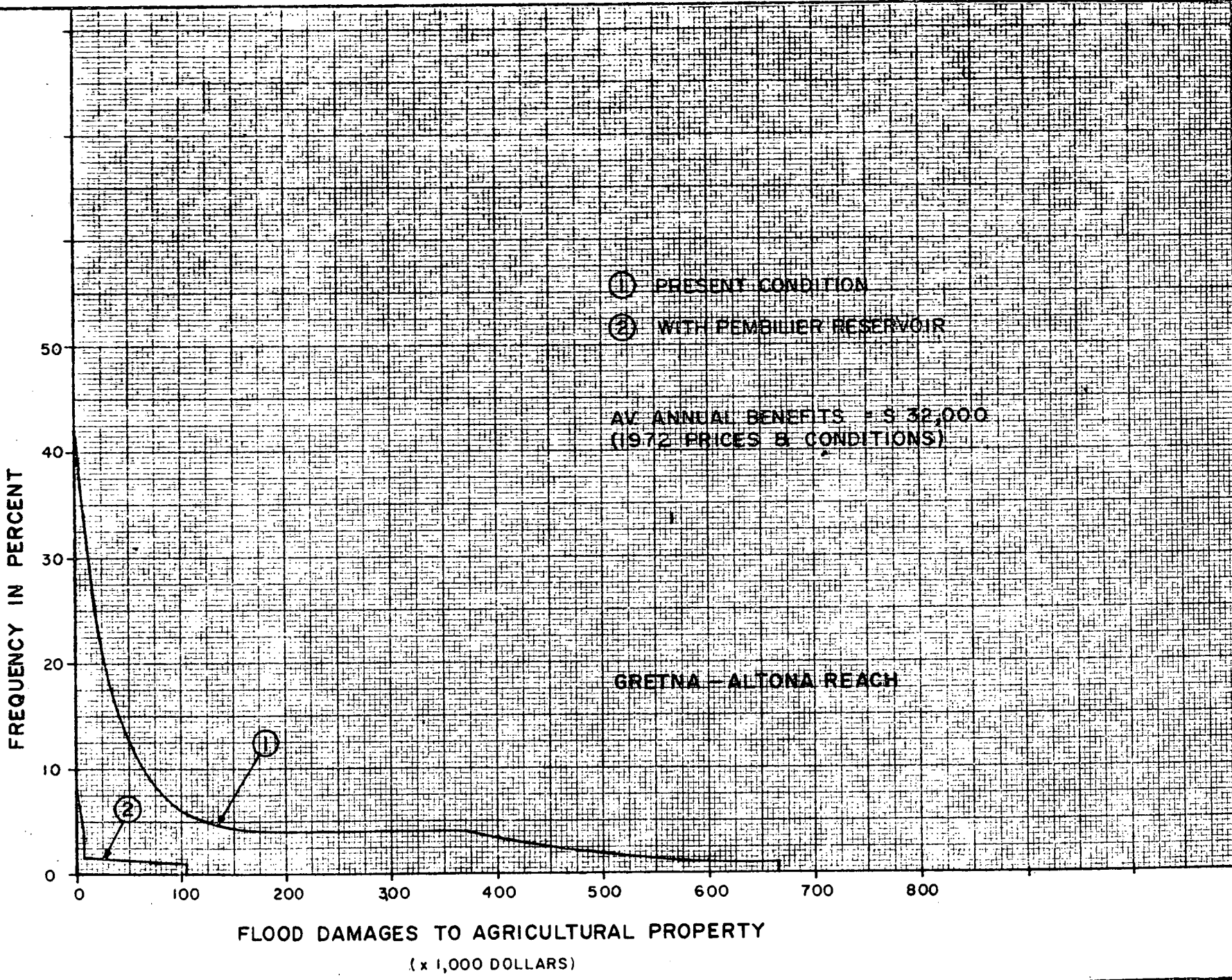


FIG. 25

FIGURE 26  
GROWTH OF AVERAGE ANNUAL BENEFITS  
PEMBILIER DAM 1980-2080  
ADJUSTMENTS FOR UNIFORM BUILDUP PERIOD 1980-2030  
U.S. CORPS. OF ENGINEERS ESTIMATE  
(DEVELOPMENT PERIOD FACTOR = 0.3612)

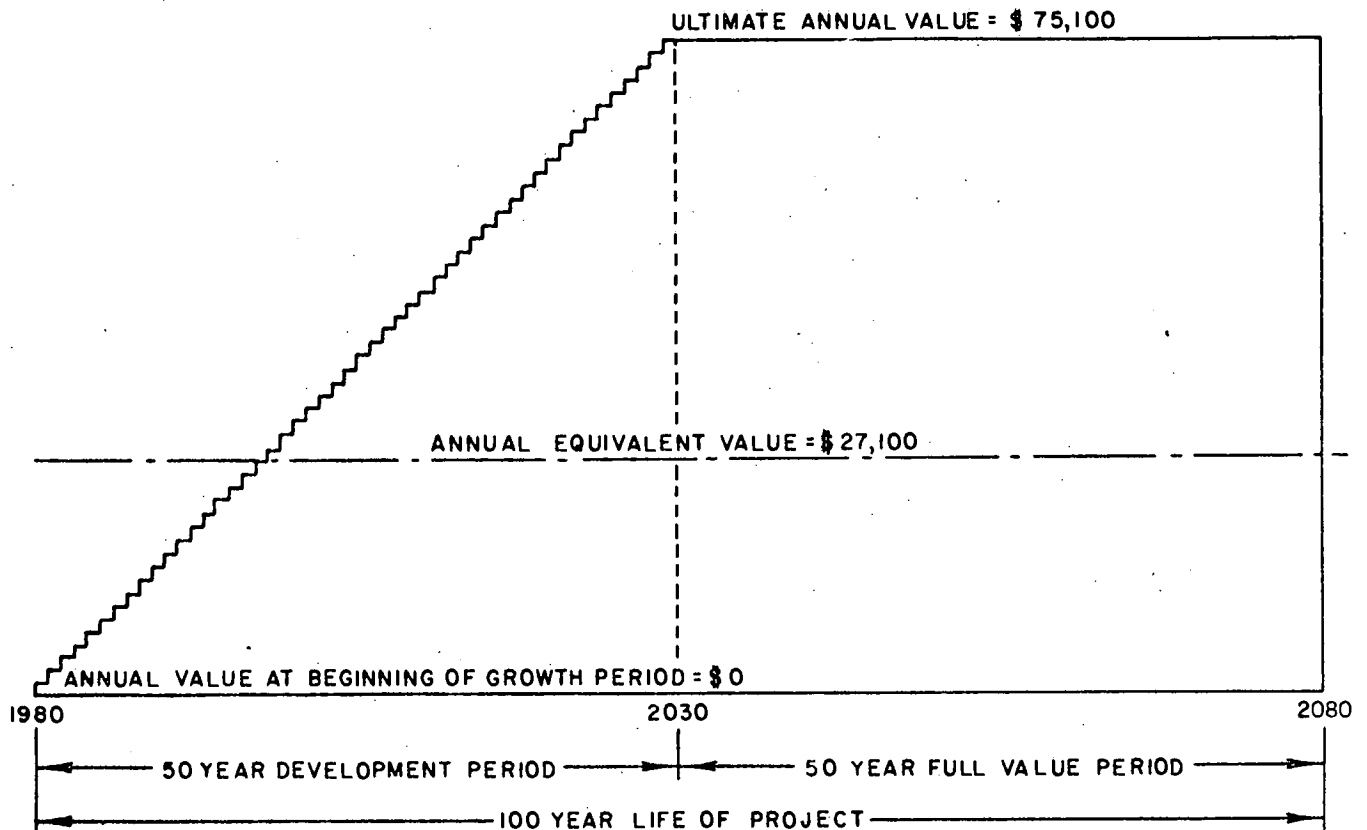
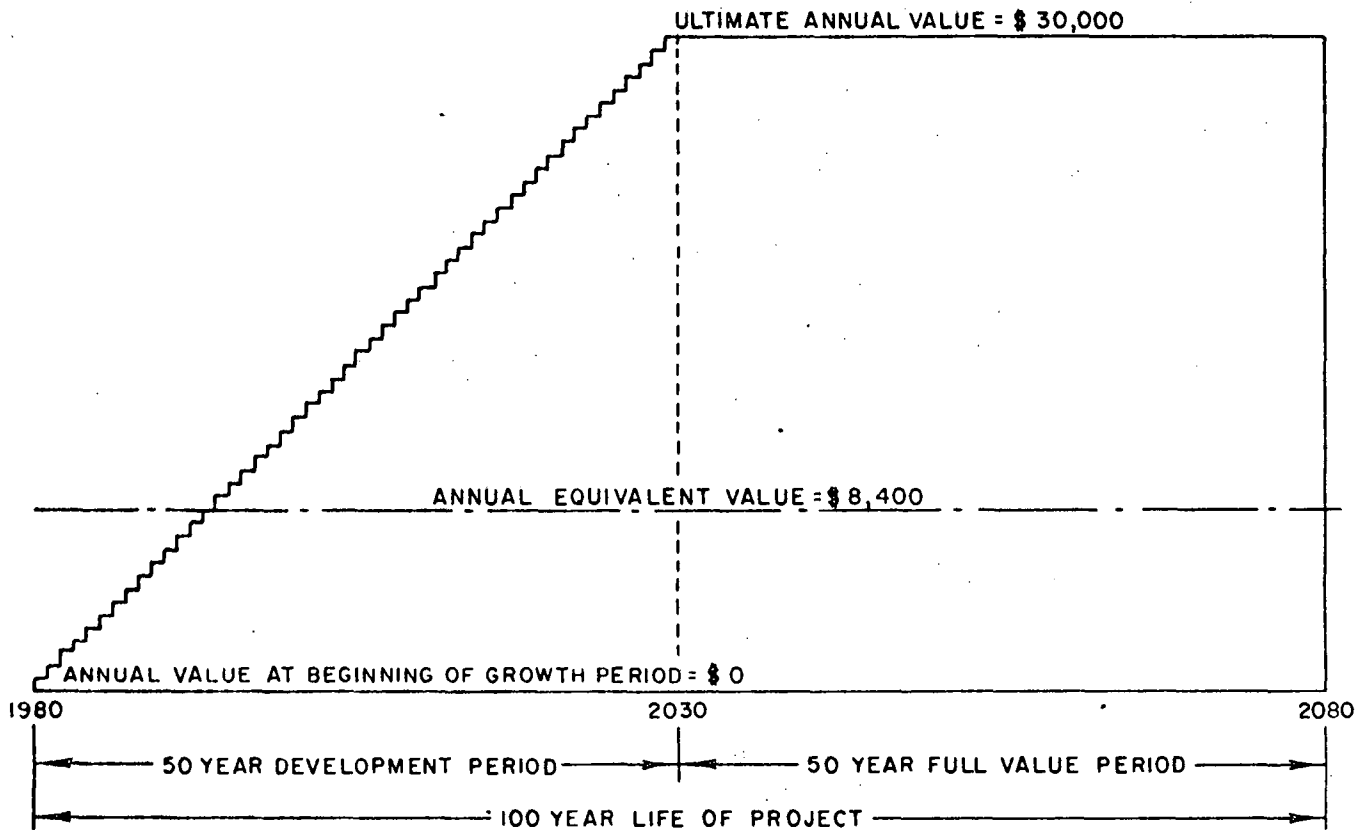


FIGURE 27  
GROWTH OF AVERAGE ANNUAL BENEFITS  
PEMBILIER DAM 1980 - 2080  
ADJUSTMENTS FOR UNIFORM BUILDUP PERIOD 1980 - 2030  
REVIEW COMMITTEE ESTIMATE  
(DEVELOPMENT PERIOD FACTOR = 0.278)



APPENDIX II

U.S. CORPS OF ENGINEERS  
COST ALLOCATION  
TABLES A TO D

ALLOCATION # 2 - NATIONAL BENEFITS PLUS REGIONAL BENEFITS

Table A - Multiple-purpose project costs - specific and joint-use costs

Item	Specific costs			Joint-use costs	Total
	Flood control	Water supply	Recreation		
<u>Direct first costs</u>					
Lands and damages (1)				\$710,000	\$710,000
Highway relocations				1,354,000	1,354,000
Reservoir				178,000	178,000
Embankment				4,807,000	4,807,000
Spillway				4,778,000	4,778,000
Outlet works				3,902,000	3,902,000
Channels	\$110,000			-	110,000
Fish and wildlife mitigation				726,000	726,000
Recreation facilities			\$1,186,000		1,186,000
Total direct first costs	110,000		1,186,000	16,455,000	17,751,000
<u>Indirect first costs</u>					
Engineering and design	5,000		115,000	941,000	1,061,000
Supervision and administration	5,000		115,000	868,000	988,000
Total indirect first costs	10,000		230,000	1,809,000	2,049,000
Total first costs	120,000		1,416,000	18,264,000	19,800,000
<u>Project investment</u>					
Interest during construction (land) (2)				122,000	122,000
Interest during construction (3)	10,000		34,000 (4)	1,534,000	1,578,000
Total project investment	130,000		1,450,000	19,920,000	21,500,000
<u>Annual costs</u>					
Interest and amortization	7,200		83,800	1,150,000	1,241,000
Operation, maintenance, and replacements	2,000		11,700	61,000	74,700
Total annual costs	9,200		95,500	1,211,000	1,315,700
Annual benefits					1,324,400 (5)
Net benefits					8,700
Benefit-cost ratio					1.01

(1) Exclusive of lands for fish and wildlife mitigation, recreation development, and natural preservation area.  
 (2) Purchase of lands assumed to commence 3 years prior to start of construction.  
 (3) Construction period of dam assumed to be 3 years.  
 (4) Assumes one third of recreation facilities will be constructed concurrent with dam construction.  
 (5) Includes Canadian flood control benefits attributable to the project of \$147,200 and U.S. regional benefits of \$138,700.

ALLOCATION # 2 - NATIONAL BENEFITS PLUS REGIONAL BENEFITS

Table B - Cost allocation studies - summary of first costs, investments, and annual charges for project purposes - Pemblier Dam and Lake

Item	Two-purpose project costs											
	Multiple-purpose project cost	Single-purpose project costs			Flood control and water supply			Water supply and recreation			Separable costs	
		Flood control	Water supply	Recreation	Flood control and water supply	Flood control and recreation	Water supply and recreation	Flood control	Water supply	Recreation	Joint costs	
<b>Direct first costs</b>												
Lands and damages (1)	\$710,000	\$680,000	-	\$235,000	\$710,000	\$710,000	\$235,000					
Highway relocations	1,354,000	1,354,000	-	450,000	1,354,000	1,354,000	450,000					
Reservoir	178,000	0	-	178,000	178,000	178,000	196,000					
Embankment	4,807,000	4,660,000	\$685,000 (2)	1,200,000	4,807,000	4,807,000	1,200,000					
Spillway	4,778,000	4,826,000	-	2,380,000	4,778,000	4,778,000	2,380,000					
Outlet works	3,902,000	3,866,000	-	1,170,000	3,902,000	3,902,000	1,370,000					
Channels	110,000	110,000	-	-	110,000	110,000	-					
Fish and wildlife mitigation	726,000	459,000	-	630,000	726,000	726,000	630,000					
Recreation facilities (1)	1,186,000	0	-	1,186,000	-	1,186,000	1,186,000					
<b>Total direct costs</b>	<b>17,751,000</b>	<b>15,955,000</b>	<b>685,000</b>	<b>7,429,000</b>	<b>16,565,000</b>	<b>17,751,000</b>	<b>7,647,000</b>	<b>\$10,104,000</b>	<b>0</b>	<b>\$1,186,000</b>	<b>\$6,461,000</b>	
<b>Indirect costs</b>												
Engineering and design	1,061,000	920,000	69,000	443,000	946,000	1,061,000	456,000					
Supervision and administration	988,000	845,000	68,000	413,000	873,000	988,000	425,000					
<b>Total indirect first costs</b>	<b>2,049,000</b>	<b>1,765,000</b>	<b>137,000</b>	<b>856,000</b>	<b>1,819,000</b>	<b>2,049,000</b>	<b>881,000</b>	<b>1,168,000</b>	<b>0</b>	<b>230,000</b>	<b>651,000</b>	
<b>Total first costs</b>	<b>19,800,000</b>	<b>17,720,000</b>	<b>822,000</b>	<b>8,285,000</b>	<b>18,384,000</b>	<b>19,800,000</b>	<b>8,528,000</b>	<b>11,272,000</b>	<b>0</b>	<b>1,416,000</b>	<b>7,112,000</b>	
<b>Project investment</b>												
Interest during construction (5) (lands)	122,000	117,000	-	26,000	123,000	122,000	26,000	96,000	0	0	26,000	
Interest during construction (5)	1,578,000	1,470,000	49,300 (3)	399,000	1,532,000	1,572,000	413,000	1,155,000	0	46,000	367,000	
Present worth of deferred construction	0	0	170,500	0	-	-	-	0	0	0	0	
<b>Total project investment</b>	<b>21,500,000</b>	<b>19,307,000</b>	<b>1,041,800</b>	<b>8,710,000</b>	<b>20,039,000</b>	<b>21,494,000</b>	<b>8,967,000</b>	<b>12,533,000</b>	<b>0</b>	<b>1,462,000</b>	<b>7,505,000</b>	
<b>Annual costs (1980-2080)</b>												
Interest and amortization (5)	1,241,000	1,114,000	63,000 (3)	481,300	1,157,300	1,240,000	495,500	745,500	0	83,700	411,800	
Operation, maintenance, and replacements	74,700	28,000	54,000 (4)	49,700	63,000	74,700	49,700	25,000	0	11,700	38,000	
<b>Total annual costs</b>	<b>1,315,700</b>	<b>1,142,000</b>	<b>117,000</b>	<b>531,000</b>	<b>1,220,300</b>	<b>1,314,900</b>	<b>545,200</b>	<b>770,500</b>	<b>0</b>	<b>95,400</b>	<b>449,800</b>	
Annual benefits (6)	1,324,400	1,104,500	120,200	99,700	1,224,700	1,204,200	219,900	1,110,900	\$120,200	99,700	0	
Net benefits	8,700	-37,500	3,200	-431,300	4,400	-110,700	-325,300					
Benefit-cost ratio	1.01	0.97	1.03	0.19	1.00	0.92	0.40					

(1) Exclusive of lands for fish and wildlife mitigation, recreation development, and natural preservation areas.

(2) Total cost of channel dam and water supply network from Red River of the North to Neche.

(3) Using non-Federal interest rate of 6 percent.

(4) Includes energy and extra treatment costs.

(5) Interest rate is weighted composite of Canadian interest rate of 7 1/2 percent, U.S. Federal interest rate of 5 1/2 percent, and U.S. non-Federal interest rate of 6 percent.

(6) Flood control, water supply, and recreation benefits include \$133,200, \$3,200, and \$2,300 regional benefits, respectively.

ALLOCATION # 2 - NATIONAL BENEFITS PLUS REGIONAL BENEFITS

Table C - Allocation of costs to project purposes - 100-year project life, separable costs-remaining benefits - Pembilier Dam and Lake

Item	Flood control	Water supply	Recreation	Total
1. Benefits (1)	\$1,104,500	\$120,200	\$99,700	\$1,324,400
2. Alternative single-purpose project annual costs	1,142,000	117,000	531,000	1,790,000
3. Separable annual costs	770,500	0	95,400	865,900
4. Separable operation, maintenance, and replacement costs in (3)	25,000	0	11,700	36,700
5. Annual benefits limited by alternative costs	1,104,500	117,000	99,700	1,321,200
6. Remaining annual benefits (5 - 3)	334,000	117,000	4,300	455,300
7. Percentage of total for (6)	73.4	25.7	0.9	100.0
8. Allocated residual annual charges (\$1,315,700 - \$865,900) X (7)	330,200	115,600	4,000	449,800
9. Allocated residual operation, maintenance, and replacement costs (\$74,700 - \$36,700) X (7)	27,900	9,800	300	38,000
10. Total annual costs (3 + 8)	1,100,700	115,600	99,400	1,315,700
11. Total operation, maintenance, and replacement costs (4 + 9)	52,900	9,800	12,000	74,700
12. Net annual costs (10 - 11)	1,047,800	105,800	87,400	1,241,000
13. Project investment	18,153,000	1,833,000	1,514,000	21,500,000
14. Interest during construction (lands)	115,100	6,700	200	122,000
15. Interest during construction	1,434,400	94,300	49,300	1,578,000
16. Project first cost (13 - (14 + 15))	16,603,500	1,732,000	1,464,500	19,800,000

(1) Flood control benefits include damages prevented in Canada and the United States of \$971,300, U.S. regional benefits of \$133,200. U.S. regional employment gains which are a part of the regional benefits total \$32,400 and are distributed as follows: \$26,900 to flood control, \$3,200 to water supply, and \$2,300 to recreation.

ALLOCATION #2 - NATIONAL BENEFITS PLUS REGIONAL BENEFITS

Table D - An apportionment of costs allocated to flood control between countries, Pembilier Dam and Lake

ITEM	TOTAL	UNITED STATES	CANADA
1. Flood control benefits	\$1,104,500	\$957,300	\$147,200
2. Benefit-Cost Ratio	1.00	1.00	1.00
3. Total annual charges	1,100,700	954,000	146,700
4. Percent of total	100.00	86.67	13.33
5. Annual O & M Charges	52,900	45,800	7,100
6. Annual Investment Charges	1,047,800	908,100	139,700
7. Annual First Cost Charges	958,400	830,600	127,800
8. Interest Rate	-	0.0550	0.0750
9. Interest and amortization factor	-	0.055261	0.075054
10. a. Approximate project First Cost	16,733,300	15,030,500	1,702,800
b. Approximate project Investment Cost	18,294,200	16,432,900	1,861,300
11. a. First cost adjustment (1)	-129,800	-116,600	-13,200
b. Investment Cost adjustment (1)	-141,200	-126,800	-14,400
12. a. Project first cost	16,603,500	14,913,900	1,689,600
b. Project Investment cost	18,153,000	16,306,100	1,846,900
13. Present worth of annual O&M charges (2)	957,300	828,800	128,500

(1) The difference between the capitalized total first (or investment) cost and the actual total first (or investment) cost distributed to each country in the same ratio that the approximate first (or investment) costs for countries bear to each other.

(2) Brought back to present worth using United States interest rate of 5½ percent.



APPENDIX III  
PEMBILIER DAM REVIEW COMMITTEE  
COST ALLOCATION  
TABLES A TO D

Table A - Multiple-purpose project costs - specific and joint-use costs

ITEM	Specific Costs			JOINT-USE COSTS	TOTAL
	FLOOD CONTROL	WATER SUPPLY	RECREATION		
<u>Direct first Costs</u>					
Lands and damages (1)				\$710,000	710,000
Highway relocations				1,354,000	1,354,000
Reservoir				178,000	178,000
Embankment				4,807,000	4,807,000
Spillway				4,778,000	4,778,000
Outlet Works				3,902,000	3,902,000
Channels	\$110,000			-	110,000
Fish & Wildlife Mitigation				726,000	726,000
Recreation facilities			\$1,186,000		1,186,000
Total Direct First Costs	110,000		1,186,000	16,455,000	17,751,000
<u>Indirect first Costs</u>					
Engineering & Design	5,000		115,000	941,000	1,061,000
Supervision and Administration	5,000		115,000	868,000	988,000
Total Indirect First Costs	10,000		230,000	1,809,000	2,049,000
Total First Costs	120,000		1,416,000	18,264,000	19,800,000
<u>Project Investment</u>					
Interest during construction (land) (2)				117,000	117,000
Interest during construction (3)	10,000		39,000	1,448,000	1,497,000
Total Project Investment	130,000		1,455,000	19,829,000	21,414,000
<u>Annual Costs</u>					
Interest and Amortization	7,200		80,400	1,095,000	1,183,400
Operation, Maintenance, and Replacements	2,000		11,700	61,000	74,700
Total annual costs	9,200		92,100	1,156,800	1,258,100
Annual benefits					1,324,400 (5)
Net Benefits					66,300
Benefit-Cost Ratio					1.05

(1) Exclusive of lands for fish and wildlife mitigation, recreation development, and natural preservation area.

(2) Purchase of lands assumed to commence 3 years prior to start of construction

(3) Construction period of dam assumed to be 3 years.

(4) Assumes one third of recreation facilities will be constructed concurrent with dam construction.

(5) Includes Canadian flood control benefits attributable to the project of \$147,200 and U.S. regional benefits of \$138,700.

TABLE B - COST ALLOCATION STUDIES  
SUMMARY OF FIRST COSTS, INVESTMENTS, AND ANNUAL CHARGES FOR PROJECT PURPOSES  
PEMBILTER DAM AND LAKE

ITEM	MULTIPLE-PURPOSE PROJECT COST	SINGLE-PURPOSE PROJECT COSTS			TWO-PURPOSE PROJECT COSTS			SEPARABLE COSTS OF MULTI-PURPOSE PROJECT			
		FLOOD CONTROL	WATER SUPPLY	RECREATION	FLOOD CONTROL AND WATER SUPPLY	FLOOD CONTROL AND RECREATION	WATER SUPPLY AND RECREATION	FLOOD CONTROL	WATER SUPPLY	RECREATION	JOINT COSTS
<b>Direct first costs</b>											
Lands and damages <sup>(1)</sup>	\$710,000	\$680,000	-	\$235,000	\$710,000	\$710,000	\$235,000				
Highway Relocations	1,354,000	1,354,000	-	450,000	1,354,000	1,354,000	450,000				
Reservoir	178,000	0	-	178,000	178,000	178,000	196,000				
Embankment	4,807,000	4,660,000	\$685,000 <sup>(2)</sup>	1,200,000	4,807,000	4,807,000	1,200,000				
Spillway	4,778,000	4,826,000	-	2,380,000	4,778,000	4,778,000	2,380,000				
Outlet Works	3,902,000	3,866,000	-	1,170,000	3,902,000	3,902,000	1,370,000				
Channels	110,000	110,000	-	-	110,000	110,000	-				
Fish & Wildlife Mitigation	726,000	459,000	-	630,000	726,000	726,000	630,000				
Recreation Facilities <sup>(1)</sup>	1,186,000	0	-	1,186,000	-	1,186,000	1,186,000				
<b>Total Direct Costs</b>	<b>17,751,000</b>	<b>15,955,000</b>	<b>685,000</b>	<b>7,429,000</b>	<b>16,565,000</b>	<b>17,751,000</b>	<b>7,647,000</b>	<b>\$10,104,000</b>	<b>0</b>	<b>\$1,186,000</b>	<b>\$6,461,000</b>
<b>Indirect Costs</b>											
Engineering and design	1,061,000	920,000	69,000	443,000	946,000	1,061,000	456,000				
Supervision and Administration	988,000	845,000	68,000	413,000	873,000	988,000	425,000				
<b>Total Indirect first costs</b>	<b>2,049,000</b>	<b>1,765,000</b>	<b>137,000</b>	<b>856,000</b>	<b>1,819,000</b>	<b>2,049,000</b>	<b>881,000</b>	<b>1,168,000</b>	<b>0</b>	<b>230,000</b>	<b>651,000</b>
<b>Total First Costs</b>	<b>19,800,000</b>	<b>17,720,000</b>	<b>822,000</b>	<b>8,285,000</b>	<b>18,384,000</b>	<b>19,800,000</b>	<b>8,528,000</b>	<b>11,272,000</b>	<b>0</b>	<b>1,416,000</b>	<b>7,112,000</b>
<b>Project Investment</b>											
Interest during Construction <sup>(5)</sup> (Lands)	117,000	112,000	-	26,000	117,000	117,000	26,000	91,000	0	0	26,000
Interest during Construction <sup>(5)</sup> Present worth of deferred construction	1,497,000	1,406,000	49,300 <sup>(3)</sup>	443,000	1,458,000	1,497,000	456,000	1,041,000	0	39,000	417,000
	0	0	170,500	0	-	-	-	0	0	0	0
<b>Total project investment</b>	<b>21,414,000</b>	<b>19,238,000</b>	<b>1,041,800</b>	<b>8,754,000</b>	<b>19,959,000</b>	<b>21,414,000</b>	<b>9,010,000</b>	<b>12,404,000</b>	<b>0</b>	<b>1,455,000</b>	<b>7,555,000</b>
<b>Annual Costs (1980-2080)</b>											
Interest and amortization <sup>(5)</sup> Operation, Maintenance, and Replacements	1,183,400	1,063,100	63,000 <sup>(3)</sup>	483,700	1,102,900	1,183,400	497,900	685,000	0	80,500	417,400
	74,700	28,000	54,000 <sup>(4)</sup>	49,700	63,000	74,700	49,700	25,000	0	11,700	38,000
<b>Total annual costs</b>	<b>1,258,100</b>	<b>1,091,100</b>	<b>117,000</b>	<b>533,400</b>	<b>1,165,900</b>	<b>1,258,100</b>	<b>547,600</b>	<b>710,500</b>	<b>0</b>	<b>92,200</b>	<b>455,400</b>
<b>Annual benefits<sup>(6)</sup></b>	<b>1,324,400</b>	<b>1,104,500</b>	<b>120,200</b>	<b>99,700</b>	<b>1,224,700</b>	<b>1,204,200</b>	<b>219,900</b>	<b>1,104,500</b>	<b>120,000</b>	<b>99,700</b>	<b>0</b>
<b>Net Benefits</b>	<b>66,300</b>	<b>13,400</b>	<b>3,200</b>	<b>-433,700</b>	<b>58,800</b>	<b>-53,900</b>	<b>-327,700</b>				
<b>Benefit-cost ratio</b>	<b>1.05</b>	<b>1.01</b>	<b>1.03</b>	<b>0.19</b>	<b>1.05</b>	<b>0.96</b>	<b>0.40</b>				

- (1) Exclusive of lands for fish and wildlife mitigation, recreation development, and natural preservation areas.  
(2) Total cost of channel dam and water supply network from Red River of the North to Neche.  
(3) Using non-Federal interest rate of 6 percent.  
(4) Includes energy and extra treatment costs.  
(5) Interest rate is U.S. Federal interest rate of 5½ percent.  
(6) Flood control, water supply, and recreation benefits include \$133,200, \$3,200, and \$2,300 regional benefits, respectively.

Table C - Allocation of costs to project purposes - 100-year project life, separable costs - remaining benefits - Pembilier Dam and Lake

ITEM	FLOOD CONTROL	WATER SUPPLY	RECREATION	TOTAL
1. Benefits (1)	\$1,104,500	\$120,200	\$99,700	\$1,324,400
2. Alternative single-purpose project annual costs	1,091,100	117,000	533,400	1,741,500
3. Separable annual costs	710,500	0	92,200	802,700
4. Separable operation, maintenance, and replacement costs in (3)	25,000	0	11,700	36,700
5. Annual benefits limited by alternative costs	1,091,100	117,000	99,700	1,307,800
6. Remaining annual benefits (5 - 3)	380,600	117,000	7,500	505,100
7. Percentage of total for (6)	75.3	23.2	1.5	100.0
8. Allocated residual annual charges (1,258,100 - \$802,700) x (7)	342,900	105,700	6,800	455,400
9. Allocated residual operation, maintenance, and replacements costs (\$74,700 - \$36,700)(7)	28,600	8,800	600	38,000
10. Total annual costs (3 + 8)	1,053,400	105,700	99,000	1,258,100
11. Total operation, maintenance, and replacement costs (4 + 9)	53,600	8,800	12,300	74,700
12. Net annual costs (10 - 11)	999,800	96,900	86,700	1,183,400
13. Project Investment (2)	18,092,000	1,753,000	1,569,000	21,414,000
14. Interest during construction (lands) (3)	110,600	6,000	400	117,000
15. Interest during construction (3)	1,355,000	96,700	45,300	1,497,000
16. Project First Cost (13 - (14 + 15))	16,626,400	1,650,300	1,523,300	19,800,000

(1) Flood control benefits include damages prevented in Canada and the United States of \$971,300, U.S. regional benefits of \$133,200. U.S. regional employment gains which are a part of the regional benefits total \$32,400 and are distributed as follows: \$26,900 to flood control, \$3,200 to water supply, and \$2,300 to recreation.

(2) Derived from Net Annual Costs and U.S. Federal interest rate of 5½ percent.

(3) Interest during construction = interest on separable cost + (interest on Joint Cost) (adjusted percentage of total).

TABLE D

## APPORTIONMENT OF COSTS ALLOCATED TO FLOOD CONTROL BETWEEN COUNTRIES

	TOTAL	USA	CANADA
1. Annual Flood Control Benefits	\$1,104,500	\$957,300	\$147,200
2. Present Worth of Annual Benefits	19,284,600	17,323,300 <sup>1</sup>	1,961,300 <sup>2</sup>
3. Percentage of Present Worth of Benefits	100.0	89.83	10.17
4. Present Worth of Flood Control Costs	19,062,000	17,123,400	1,938,600 <sup>3</sup>
5. Annual Costs	-	946,300 <sup>1</sup>	145,600 <sup>2</sup>
6. Benefit to Cost Ratio	1.011	1.011	1.011

## Notes:

1.  $i = 5\frac{1}{2}\%$  for 100 years
2.  $i = 7\frac{1}{2}\%$  for 100 years
3. Allocated in proportion to share of present value of benefits.

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