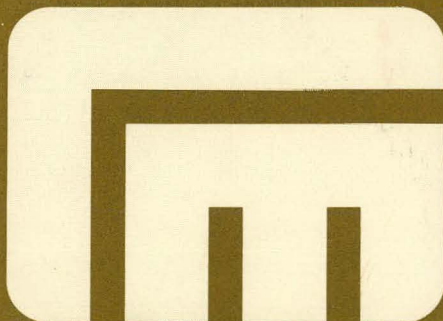


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FEASIBILITY DETERMINATION OF
LOW HEAD HYDROELECTRIC
POWER DEVELOPMENT AT
EXISTING SITES:
MOUSAM RIVER PROJECT

Submitted to:

U.S. Department of Energy
Idaho Operations Office
Advanced Technology Branch
550 Second Street
Idaho Falls, ID 83401

Submitted from:

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350 Second Avenue
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Under Cooperative Agreement No. EW-78-F-07-1777

June 1979

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1. EXECUTIVE SUMMARY

1.1 Introduction

The objective of this study was to determine the technical and economic feasibility of low head hydroelectric power development at existing sites along the Mousam River in southeastern Maine. The study was conducted on behalf of the Kennebunk Light and Power District (KL&PD) which is the municipally-owned electric utility supplying the town.

This study included the following areas of investigation:

- Determination of available energy
- Development of restoration concepts
- Environmental studies
- Historical and archeological studies
- Assessment of civil construction requirements
- Geotechnical and geologic assessment of existing dams
- Assessment of turbine alternatives
- Assessment of generator and utility interface alternatives
- Economic analysis
- Restoration concept evaluation and selection
- Miscellaneous field studies.

1.2 Study Contributors

The major contributors to this study were:

<u>Name</u>	<u>Function</u>
Foster-Miller Associates, Inc. Waltham, MA	Principal investigator; study coordinator
Metcalf and Eddy, Inc. Boston, MA	Geotechnical and geologic assessment, civil construction requirements, civil construction design and economics
J.E. Edinger Associates, Inc. Wayne, PA	Environmental Study
M. Harper, P.E. Peterborough, NH	Hydropower consultant; energy determination, turbine; generator; and interface assessment, economic assessment, concept development
Kennebunk Light and Power District	Program guidance and emphasis. Title verification.

1.3 Site Description

The river under study is the Mousam River which rises on the Maine-New Hampshire border in the southeastern foothills of the White Mountains. From its source, the Mousam flows approximately 50 mi to join the North Atlantic Ocean at Kennebunk, Maine. The river is tidal for about the last 3.6 mi of its course. The hydroelectric potential of the river, principally within the Kennebunk town boundaries, was investigated, although a part of the upstream area involved is within the boundary of the town of Sanford. Along the approximately 7.5 mi length of river under examination, there is a total of seven dam sites, most of which were originally built in the last years of the 19th century (see Figure 1, for more detail see USGS map in Appendix A, Figure A-1).

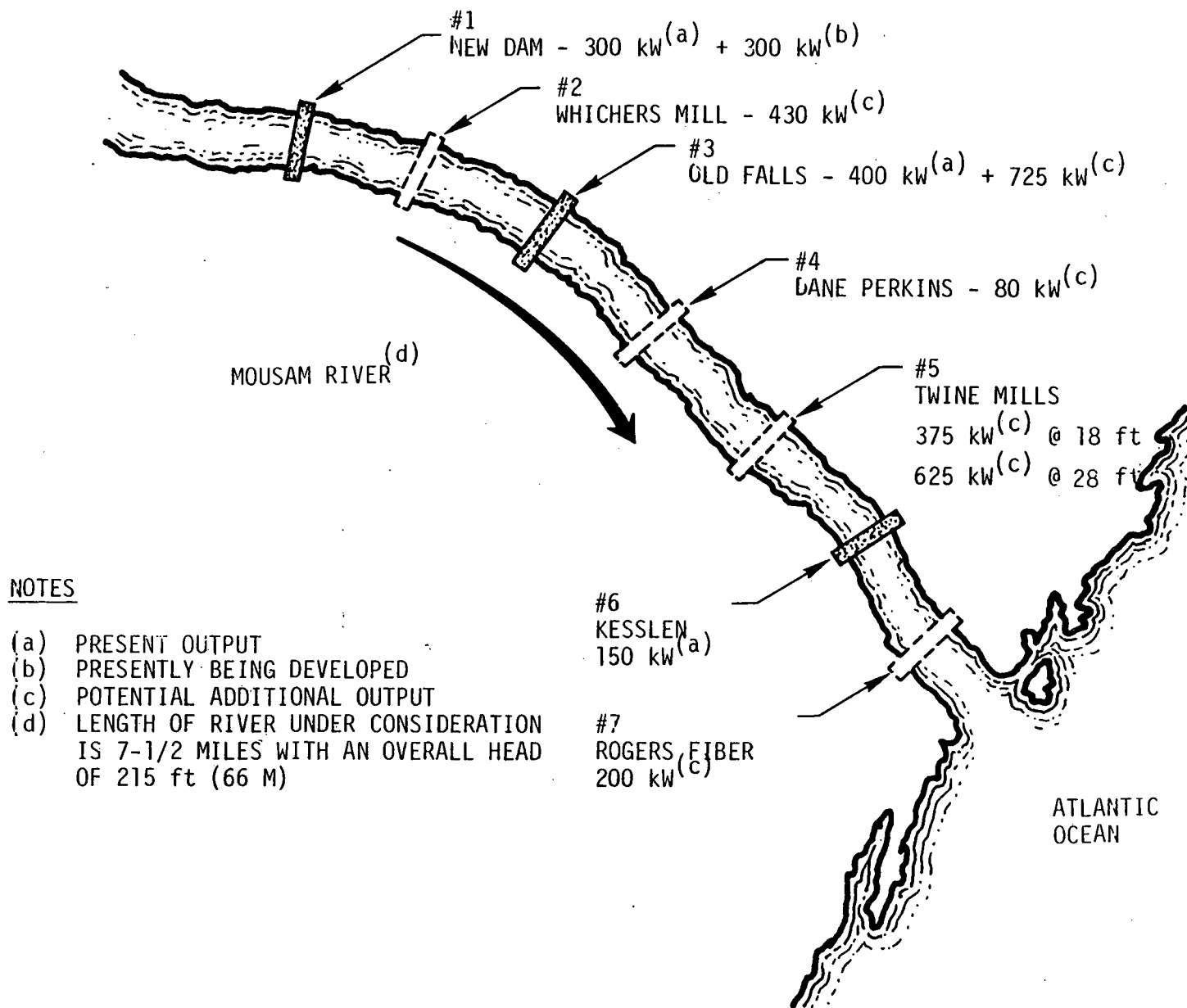


Figure 1. Schematic Map of Mousam River Sites

Over these seven dams, the river falls a total of some 215 ft. Dams No. 1 and No. 3 presently have operating hydroelectric plants which are owned by a private company. As of May 1979, the entire production from these two plants is being purchased by KL&PD, which also, in 1977, recommissioned an old hydroelectric unit in the town of Kennebunk itself (Dam No. 6, Figure 1). As a result of the 1977 activities, hydroelectric power now provides 800 kW, or approximately 9 percent of the total peak demand of KL&PD.

The present KL&PD system has a peak load of about 10 mW, and growth appears to have stabilized at approximately 5 percent per annum. Apart from the output of the existing 150 kW hydro unit at Kesslen Mill, all energy is purchased from Central Maine Power Company (CMPC) or from the 700 kW (total) hydro plants at New Dam and Old Falls.

Pertinent information for the seven sites included in the study are listed, starting from the upstream end of the river, in Table 1.

1.4 Conclusions and Recommendations

1.4.1 Environmental Study

The results of the enviromental study are summarized as follows:

- No known prehistoric sites exist in the region.
- No endangered plant species were observed within the study area.
- No rare, threatened, or endangered bird or fish species are known to inhabit the Mousam River area.

Table 1. Site Information

No.	Name	Net Head		Present kW Operable
		Meters	Feet	
1.	New Dam	10.97	36	300
2.	Whichers Mill (Note 1)	7.31	24	0
3.	Old Falls	19.20	63	400
4.	Dane Perkins (Note 1)	2.43	8	0
5.	Twine Mill (Note 1)	5.48	18	0
	Twine Mill (Note 1)	8.53	28	0 (Note 2)
6.	Kesslen Mill	3.96	13	150
7.	Rogers Mill (Note 1)	6.09	22	0 (Note 3)
Note 1: Dam breached. Note 2: The present dam structure at Twine Mill, if rebuilt to its original height, would restore the operating head to 5.48M (18 ft). However, if this dam was raised so as to flood back over the abandoned Dane Perkins site, the head would be raised to 8.53M (28 ft). Note 3: The listed head at Rogers Mill of 6.09M (22 ft) is to tail water level at Mean High Spring Tide. The normal tidal range at this site does not exceed 1.2M (4 ft), so that the maximum design head will range from 6.09M (22 ft) to 7.29M (26 ft). The listed head also assumes that Rogers Mill dam would be rebuilt so as not to raise tailwater level at Kesslen Mill.				

- The effect of the proposed restoration of dams on the lower Mousam River can be summarized as including effects on soil and vegetation, water quality, and cultural resources.
- The restoration of dams along the river will enhance recreational opportunities.
- The effect of restoration on water quality is expected to be minimal.

1.4.2 Civil Construction Study Results

- Preliminary design and structural analysis of the dams was performed. This indicated that either wood deck and frame or concrete construction could be utilized.
- The cost of reconstructing either wood deck and frame or concrete dams at Rogers Mill and Twine Mill was determined. The construction costs of these dams range from \$154,000 to \$208,000 each including engineering work but excluding the cost of the environmental impact statement and maintenance and permit application and inspection costs during construction.
- Investigation of permit requirements needed for dam design and construction at the local, state, and federal levels showed that there is no standard procedure for obtaining such permits and that the agencies involved are themselves unsure of their authorization in such matters.

1.4.3 Hydropower Study and General Economics

The results of the hydropower evaluation are as follows:

- Of the seven sites evaluated, only four can be considered economically feasible for refurbishment at this time. These sites are, in order of preference:
 - Kesslen Mill
 - New Dam
 - Twine Mill
 - Old Falls
- The maximum *average* annual theoretical energy available from the seven sites covered by this study is 18,045,700 kWh.
- The "go-no go" point for deciding whether or not an installation should be restored presently is the purchased cost of power from CMPC of \$0.0301/kWh.
- In general, the use of used and/or rebuilt equipment is more economically attractive than new equipment.
- For this project the cost of equipment at each site was of the same order as the cost of the dam reconstruction. This was a surprising result. It was first thought that dam reconstruction cost might be as much as a factor of five greater than the power generating equipment cost.
- Go-no go decisions concerning reconstruction are difficult to make because of the uncertainty in the cost of imported crude oil. As these prices rise, more of

the sites along the Mousam will become more economically attractive.

- Table 2 is a complete economic summary of the seven sites. Details of the recommendations are included in latter sections of this report (Section 9). Footnotes indicate all assumptions.

Table 2. Economic and Hydropower Summary for the Mousam River

		New Dam	Whichers Mill	Old Falls	Dane Perkins	Twine Mill	Kesslen Mill	Rogers Mill
1.	Head; ft	36	24	63	8	18	13	22
2.	Present kW	300	0	400	0	0	130	0
3.	Present kWh/yr	1,896,000	0	2,692,500	0	0	778,100	0
4.	(A) Maximum kWh/yr	3,528,600	2,360,800	6,194,200	785,300	1,742,400	1,274,000	2,160,400
5.	Recommended kW	600	430	1125	80	375	130	200
6.	Increase kW	300	430	725	80	375	0	200
7.	Possible kWh/yr	3,052,000	2,122,900	5,541,000	479,100	1,685,100	778,100	1,231,500
8.	Increase kWh/yr	1,156,000	2,122,900	2,848,500	479,100	1,685,100	0	1,231,500
9.	(B) Value of Increase	\$ 34,800	\$ 63,900	\$ 85,700	\$ 14,420	\$ 50,700		\$ 37,000
10.	(C) Initial Capital Cost; May 1979	\$217,464	\$1,053,741	\$684,473	\$195,192	\$434,147	\$33,700	\$783,386
11.	(D) Annual Operating Cost of May, 1979 Increase Capacity	\$ 22,799	\$ 110,471	\$ 71,758	\$ 20,463	\$434,147	\$ 3,533	\$ 82,128
12.	(E) Cost of Energy; May 1979; \$/kWh	\$0.0197	\$0.0520	\$0.0252	\$0.0427	\$0.0212	\$0.0045	\$0.0667
	Best Value	2	6	3	5	4	1	7
	Proposed Program	79/80	Future	79/80	Future	79/80	79	Future
Notes: (A) Based on 39 year average flows (B) At projected 1980 CMP purchase sort of \$0.0301/kWh (C) In 1979 dollars (D) Based on 30 yr amortisation @ 7 percent interest (per yr) (E) Cost of the increased energy in \$/kWh (divide #11 by #8) (F) Cost of necessary safety improvements - no energy increase								

2. INTRODUCTION

2.1 Site Description

The river under study is the Mousam River which rises on the Maine-New Hampshire border in the southeastern foothills of the White Mountains. From its source, the Mousam flows approximately 50 mi to join the North Atlantic Ocean at Kennebunk, Maine. The river is tidal for about the last 3.6 mi of its course. The hydroelectric potential of the river, principally within the Kennebunk town boundaries was investigated, although a part of the upstream area involved is within the boundary of the town of Sanford. Along the approximately 7.5 mi length of river under examination, there is a total of seven dam sites, most of which were originally built in the last years of the 19th century (see Figure 2, for more detail see USGS map in Appendix A, Figure A-1). Over these seven dams, the river falls a total of some 215 ft. Dams No. 1 and No. 3 presently have operating hydroelectric plants which are owned by a private company. As of May, 1979, the entire production from these two plants is being purchased by KL&PD, which also, in 1977, recommissioned an old hydroelectric unit in the town of Kennebunk itself (Dam No. 6, Figure 2). As a result of the 1977 activities, hydroelectric power now provides 800 kW, or approximately 9 percent of the total peak demand of KL&PD.

The present KL&PD system has a peak load of about 10 mW and growth appears to have stabilized at approximately 5 percent per annum. Apart from the output of the existing 150 kW hydro unit at Kesslen Mill, all energy is purchased from CMPC or from the 700 kW (total) hydro plant at New Dam and Old Falls.

KL&PD presently owns all of the sites along the river except Nos. 1, 2 and 3; which are privately owned. This study addresses all seven sites because, being a run-of-the-river system, all

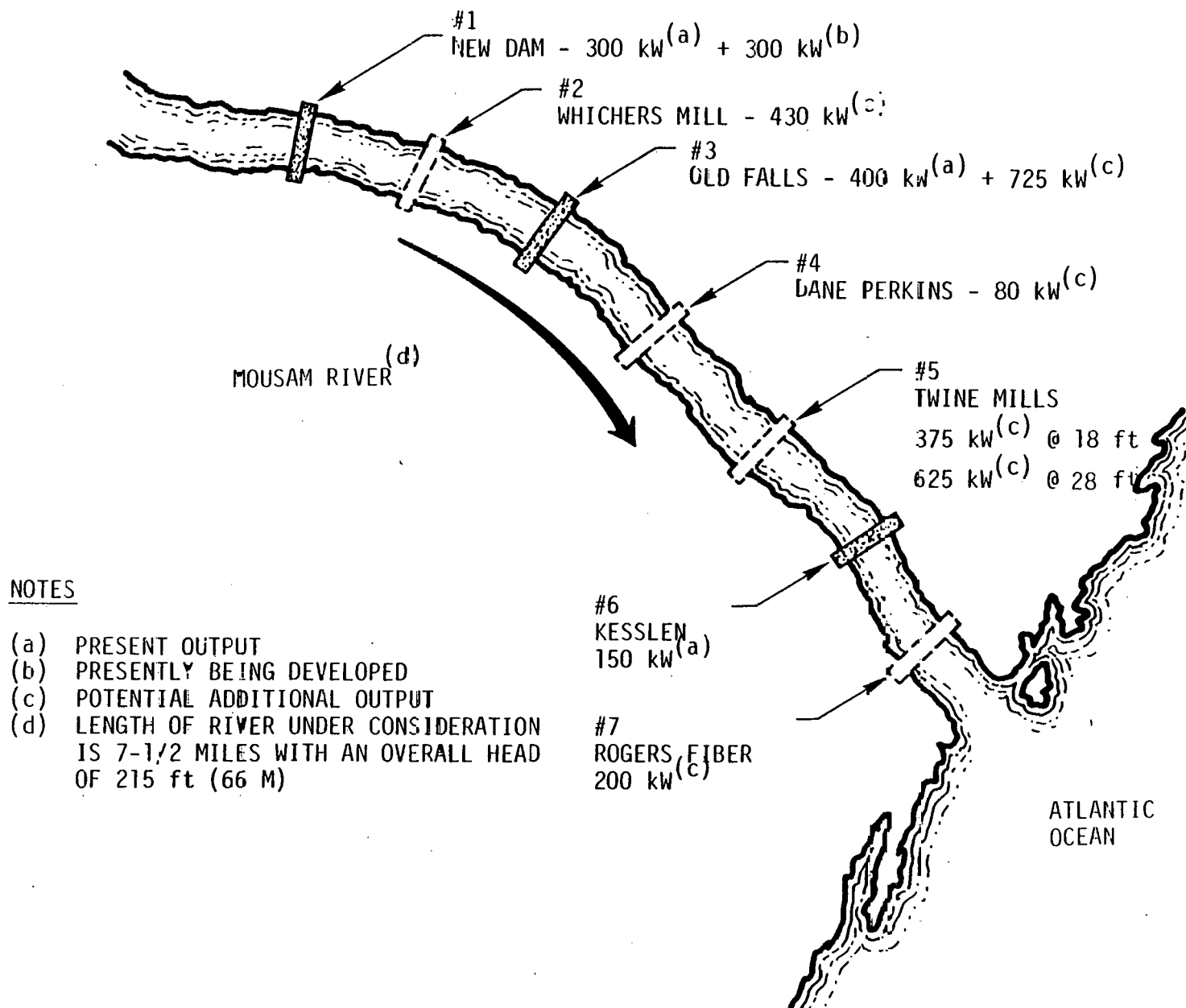


Figure 2. Schematic Map of Mousam River Sites

sites are interdependent. A *detailed* assessment of environmental impact and civil construction requirements was *not* performed at sites 1, 2 and 3 at the request of the owner. KL&PD is presently negotiating to purchase these sites. If these negotiations prove successful, additional studies may be required. The seven sites are briefly described as follows.

2.1.1 New Dam

The concrete gravity dam here controls the outfall of Estes Lake and water is fed through the intake to a short penstock, with surge column, which feeds directly to two turbine casings.

Each of the two francis turbines drives a 300 kW generator. However, one unit is out of service at this time and requires a major overhaul to restore it to service.

2.1.2 Whichers Mill

This is a completely abandoned old sawmill site and the wood crib spillway section of the dam is completely breached, leaving only the masonry wing walls in place. These are, however, in such poor condition that complete rebuilding of the structure will be necessary. By use of an approximately 300 ft penstock, water could be conducted under the highway (immediately downstream of the dam) to a new powerhouse site at the upper end of Old Falls Pond, so that a head of about 24 ft could be developed, about three times the head at the old mill site.

2.1.3 Old Falls

At 63 ft, this plant has the highest head on the river and at present comprises one spiral-cased francis turbine directly coupled to a 400 kW generator. This plant originally

supplied energy for a traction system and the penstock is sized for the old installation of 1200 kW.

2.1.4 Dane Perkins

This is an old sawmill site, and the wood crib spillway section of the dam has failed although the masonry and concrete wings remain in good condition. The useful head is only 8 ft.

2.1.5. Twine Mill

The wood crib dam is breached but the wing walls require only repair of spalled areas to restore them to service. The head is 18 ft and brief consideration was given to raising the dam to give a 28 ft head by flooding back the Dane Perkins site. However, this approach proved economically unattractive.

The existing powerhouse still contains the old Rodney Hunt twin-wheel turbine and casing. These are in sufficiently good condition that restoration is considered possible, although the governor, generator, and switchgear have all gone for scrap in the 18 years since the unit was last operated.

2.1.6 Kesslen Mill

This plant comprises a vertical shaft unit rated at 150 kW at 13 ft and had been out of service for some 17 years until it was successfully restarted through the initiative of KL&PD's General Manager in 1977. New switchgear and certain minor overhaul items are required.

2.1.7 Rogers Mill

This site, like Whichers, is completely abandoned and the wood crib dam is non-existent. Rebuilding would entail the re-excavation of almost 1500 ft of headrace, the construction of a new powerhouse and the cleanout of the tailrace channel to tidewater.

2.2 Scope of Study

2.2.1 Goals

The major goal of this study was to determine the feasibility of the refurbishment/redevelopment of seven sites along the Mousam River in southeastern Maine. The areas assessed are:

- Economic
- Technical
- Environmental
- Civil construction.

The seven sites were all previously used to generate hydroelectric and hydromechanical power. No new sites were considered.

2.2.2 Team Members

In order to accomplish these goals, a team of experts was brought together, each having expertise in a particular area or areas.

The team members and their functions were:

- | | |
|--|--|
| <ul style="list-style-type: none">● Foster-Miller Associates
Waltham, MA | <ul style="list-style-type: none">Principal investigatorMechanical engineeringEngineering economicsProgram management |
|--|--|

- M. Harper, P.E.
Peterborough, NH Co-principal investigator
Hydropower consultant
- Metcalf and Eddy, Inc.
Boston, MA Civil construction
engineering
Geotechnical and
Geologic assessment
- J.E. Edinger Associates
Wayne, PA Environmental consultant
- Kennebunk Light and
Power District
Kennebunk, ME Site owner and operator
Study recipient

2.2.3 Study Tasks

In order to make the assessments mentioned in Section 2.2, tasks were assigned to each team member. These tasks included:

<u>Task Title</u>	<u>Report Chapter</u>
● Determination of Available Energy	3
● Generation of Redevelopment Concepts	4
● Environmental Assessment	5
● Civil Construction Requirements	6
● Turbine Alternatives	7
● Generator and Utility Alternatives	8
● Redevelopment Concept Evaluation, Selection, and Recommendations	9
● System Economics	9

<u>Task Title</u>	<u>Report Chapter</u>
● Field Studies	3,4,5,6,7,8
● Equipment Inspection	3,4,5,6,7,8

In the following chapters, the results of each task are presented.

3. DETERMINATION OF AVAILABLE ENERGY

3.1 Introduction

The objective of this section is to determine the available energy of the Mousam River from the outfall of Estes Lake. This information is computed from averaged flow data records for the past 39 years. The theoretical maximum power and energy outputs for various sites are given as a function of calendar month. Flow duration and average monthly flow charts are presented. The total annual average available energy from the Mousam River is 18,045,700 kWh.

3.2 Technical Discussion

The section of the Mousam River covered by this study extends from the outfall of Estes Lake at elevation +65.5M (215 ft) to tidewater at a point approximately one-half mi downstream of the Main Street bridge in the town of Kennebunk - a total distance of approximately 7-1/2 mi. This length includes a total of seven existing hydraulic power sites, some of which are in operation while others have been abandoned and become virtually derelict over the past several years. These sites from the upstream end are listed in Table 3.

Figure 3 shows the average monthly flows of the Mousam River, based on 1974 data corrected for the average discharge of the previous 39 years, while Figure 4 shows the flow duration, again based on 1974 data corrected for the average discharge of the previous 39 years.

Taking the monthly flows, the theoretical maximum power and energy outputs for the various sites may be tabulated as shown in Tables 4 through 12, but it should be noted that this flow

Table 3. Details of Dam Sites Along the Mousam River

No.	Name	Net Head		Present kW Operable
		Meters	Feet	
1.	New Dam	10.97	36	300
2.	Whichers Mill (Note 1)	7.31	24	0
3.	Old Falls	19.20	63	400
4.	Dane Perkins (Note 1)	2.43	8	0
5.	Twine Mill (Note 1)	5.48	18	0
	Twine Mill (Note 1)	8.53	28	0 (Note 2)
6.	Kesslen Mill	3.96	13	150
7.	Rogers Mill (Note 1)	6.09	22	0 (Note 3)
Note 1: Dam breached. Note 2: The present dam structure at Twine Mill, if rebuilt to its original height, would restore the operating head to 5.48M (18 ft). However, if this dam was raised so as to flood back over the abandoned Dane Perkins site, the head would be raised to 8.53M (28 ft). Note 3: The listed head at Rogers Mill of 6.09M (22 ft) is to tail water level at Mean High Spring Tide. The normal tidal range at this site does not exceed 1.2M (4 ft), so that the maximum design head will range from 5.09M (22 ft) to 7.29M (26 ft). The listed head also assumes that Rogers Mill dam would be rebuilt so as not to raise tailwater level at Kesslen Mill.				

data is based on a period when KL&PD had no control over the river. Unified control of all sites may be expected to produce some improvement in rate of flow variation.

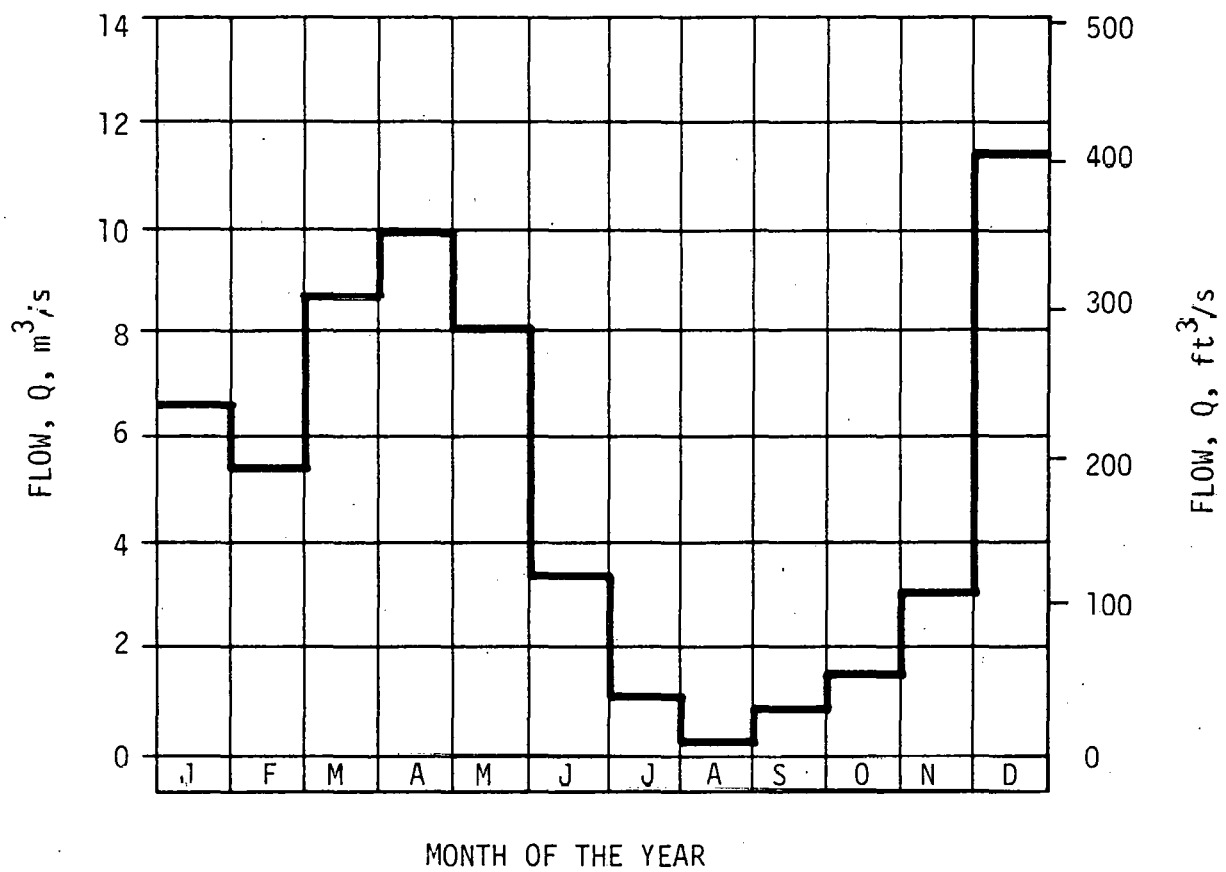


Figure 3. Average Monthly Flows for the Mousam River, Kennebunk, Maine. Thirty-Nine Year Average

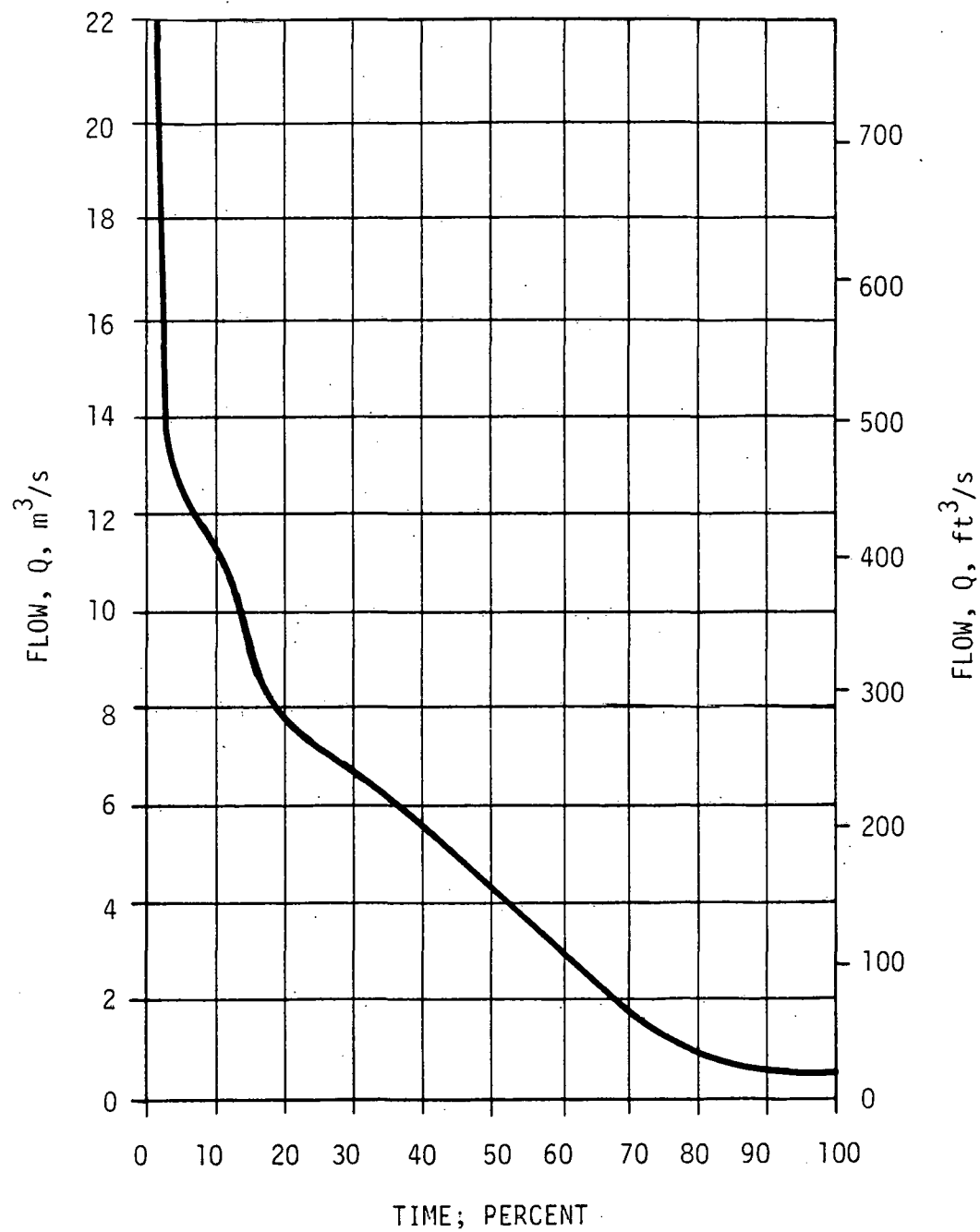


Figure 4. Flow Duration Curve for the Mousam River
Kennebunk, Maine. Thirty-Nine Year
Average Flows

Table 4. Maximum Available Energy at Each Site Along the Mousam River

1. New Dam	3,528,600
2. Whichers Mill	2,350,800
3. Old Falls	6,194,200
4. Dane Perkins	735,300
5. Twine Mill (28 ft)	2,752,200
5a. Twine Mill (18 ft)	1,742,400
6. Kessien Mill	1,274,000
7. Rogers Mill	<u>2,160,400</u>
Totals: Assumes Twine Mill raised to 23 ft or	18,270,200
Assumes Twine Mill raised to 13 ft.	18,045,700

Table 5. Available Energy at New Dam for Each Month

New Dam H = 10.97 (36 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	520	744	386,800
February	5.13	203	456	672	306,400
March	8.55	308	690	744	513,300
April	9.94	358	805	720	579,600
May	8.00	288	648	744	482,100
June	3.41	123	275	720	198,000
July	1.00	36	80	744	59,500
August	0.38	14	31	744	23,000
September	0.80	29	65	720	46,800
October	1.38	50	112	744	83,300
November	3.00	108	240	720	172,800
December	11.27	406	910	744	677,000
Total					3,528,600

Table 6. Available Energy at Whichers Mill for Each Month

Whichers Mill H = 7.31M (24 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	348	744	258,900
February	5.63	203	304	672	204,200
March	8.55	308	462	744	343,700
April	9.94	358	537	720	386,600
May	8.00	288	632	744	321,400
June	3.41	123	185	720	133,200
July	1.00	36	54	744	40,100
August	0.38	14	21	744	15,600
September	0.80	29	43	720	30,900
October	1.38	50	75	744	55,800
November	3.00	108	162	720	116,600
December	11.27	406	610	744	<u>453,800</u>
Total					2,360,800

Table 7. Available Energy at Old Falls for Each Month

Old Falls H = 19.20M (63 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	913	744	679,200
February	5.63	203	800	672	537,600
March	8.55	308	1,212	744	901,700
April	9.94	358	1,410	720	1,015,200
May	8.00	288	1,134	744	843,600
June	3.41	123	484	720	348,400
July	1.00	36	141	744	104,900
August	0.23	14	55	744	40,800
September	0.80	29	114	720	82,000
October	1.38	50	196	744	145,800
November	3.00	108	425	720	306,000
December	11.27	406	1,598	744	<u>1,188,900</u>
Total					6,194,200

Table 8. Available Energy at Dane Perkins for Each Month

Dane Perkins H = 2.43M (8 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	116	744	86,300
February	5.63	203	101	672	67,800
March	8.55	308	154	744	114,500
April	9.94	358	179	720	128,800
May	8.00	288	144	744	107,100
June	3.41	123	61	720	43,900
July	1.00	36	18	744	13,300
August	0.28	14	7	744	5,200
September	0.80	29	14	720	10,000
October	1.38	50	25	744	18,600
November	3.00	108	54	720	38,800
December	11.27	406	203	744	<u>151,000</u>
Total					785,300

Table 9. Available Energy at Twine Mill for Each Month with H = 18 ft

Twine Mill H = 5.48M (18 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	258	744	191,900
February	5.63	203	261	672	151,100
March	8.55	308	342	744	254,700
April	9.94	358	390	720	280,800
May	8.00	288	320	744	238,000
June	3.41	123	138	720	99,300
July	1.00	36	40	744	29,700
August	0.38	14	15	744	11,100
September	0.80	29	32	720	23,000
October	1.38	50	56	744	41,600
November	3.00	108	120	720	86,400
December	11.27	406	450	744	334,800
Total					1,742,400

Table 10. Available Energy at Twine Mill for Each Month with H = 28 ft

Twine Mill H = 8.53M (28 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	406	744	302,000
February	5.63	203	355	672	238,500
March	8.55	308	539	744	401,000
April	9.94	358	626	720	450,700
May	8.00	288	504	744	374,900
June	3.41	123	215	720	154,800
July	1.00	36	63	744	46,800
August	0.38	14	24	744	17,800
September	0.80	29	50	720	36,000
October	1.38	50	87	744	64,700
November	3.00	108	190	720	136,800
December	11.27	406	710	744	<u>528,200</u>
Total					2,752,200

Table 11. Available Energy at Kesslen Mill for Each Month

Kesslen Mill H = 3.96M (13 ft)					
Month	Flow, Q		kW	Hrs	kWh
	m ³ /s	ft ³ /s			
January	6.44	272	188	744	139,800
February	5.63	203	164	672	110,200
March	8.55	308	250	744	186,000
April	9.94	358	290	720	208,800
May	8.00	288	234	744	174,000
June	3.41	123	100	720	72,000
July	1.00	36	29	744	21,500
August	0.38	14	11	744	8,200
September	0.80	29	23	720	16,500
October	1.38	50	40	744	29,700
November	3.00	108	87	720	62,600
December	11.27	406	329	744	<u>244,700</u>
Total					1,274,000

Table 12. Available Energy at Rogers Mill for Each Month

Rogers Mill H = 6.09M (22 ft)					
	Flow, Q				
Month	m ³ /s	ft ³ /s	kW	Hrs	kWh
January	6.44	232	319	744	237,300
February	5.63	203	279	672	187,400
March	8.55	308	423	744	314,700
April	9.94	358	492	720	354,200
May	8.00	288	396	744	294,600
June	3.41	123	169	720	121,600
July	1.00	36	49	744	36,400
August	0.78	14	19	744	141,100
September	0.80	29	39	720	28,000
October	1.38	50	68	744	50,500
November	3.00	108	148	720	106,500
December	11.27	406	558	744	<u>415,100</u>
Total					2,160,400

4. DEVELOPMENT CONCEPTS

4.1 Introduction

In this section, development concepts are generated for each of the seven potential sites. The development concepts are summarized in Tables 13 and 14. Detailed monthly output data for existing and proposed developments are presented in Tables 15 through 28. These development concepts are used as a framework for conducting subsequent assessments of:

- Environmental impact
- Civil construction requirements
- Turbine alternatives
- Generating alternatives and utility interface requirements.

4.2 Technical Discussion

The maximum average annual theoretical energy available from the seven sites on the section of the Mousam River covered by this study is shown in Section 3 to be 18,045,700 kWh. Study of the flow duration curve, Figure 4 indicates that a flow of $4.00 \text{ m}^3/\text{s}$ ($144 \text{ ft}^3/\text{s}$) is available for 52 percent of annual time. Further, an additional $4.00 \text{ m}^3/\text{s}$ ($144 \text{ ft}^3/\text{s}$) is available for 18 percent of the time. It is, therefore, proposed that development at each of the three undeveloped sites, should, if possible, be approached from the concept of two-unit installations. Each site would contain one "base-load" unit of fixed-gate, fixed-blade design to run at full load for the 52 percent of time for which base flow of $4.00 \text{ m}^3/\text{s}$ ($144 \text{ ft}^3/\text{s}$) is available. In addition,

Table 13. Energy Production Available From Mousam River Sites

Energy Production (kWh)				
Site	Present	Proposed	Increase	\$ Value of Increase*
New Dam	1,896,000	3,052,000	1,156,200	34,800
Whichers Mill	0	2,122,900	2,122,900	63,900
Old Falls	2,692,500	5,541,000	2,848,500	85,700
Dane Perkins	0	479,100	479,100	14,420
Twine Mill 18 (Table 21)	0	1,685,100*	1,685,100	50,700
Twine Mill (Table 22)	0	1,650,500	1,650,000	49,700
Twine Mill 28 (Table 23)	0	2,752,200	2,752,000	82,800
Twine Mill 28 (Table 24)	0	2,466,500	2,466,500	74,200
Kesslen Mill	778,200*	1,252,300	474,200	14,200
Rogers Mill (Table 27)	0	1,231,500*	1,231,500	37,000
Rogers Mill (Table 28)	0	1,964,800	1,964,800	59,100
Totals	5,366,600 (29.37%)	15,889,900* (83.38%)	9,523,300 (177.45%)	\$286,500*
*Current CMP Cost = \$0.0301/kWh				

Table 14. Power Output Alternatives for the Mousam River Sites

Power Outputs (kW)			
Site	Present kW	Proposed kW	Increase
New Dam	300	600	300
Whichers Mill	0	430	430
Old Falls	400	1,125	725
Dane Perkins	0	80(5)	80 (6) (7)
Twine Mill 18 ft (1)	0	375	375 (7)
Twine Mill 18 ft (2)	0	320	320
Twine Mill 28 ft (3)	0	625	675
Twine Mill 28 ft (4)	0	500	500
Kesslen Mill	150	320	170 (6)
Rogers Mill	0	400	400
Totals	830	3,160 (7)	2,310 (7) (278%)

NOTES:

- (1) Existing turbine at 18 ft
- (2) New turbine at 18 ft
- (3) Existing turbine at 28 ft
- (4) New turbine at 28 ft
- (5) Dane Perkins can only be developed if Twine Mill remains at 18 ft
- (6) Available ex-Dalton unit can only be used at one site
- (7) Total output is based on Twine Mill with existing turbine and Dalton unit at Dane Perkins.

there would be a second unit which would be equipped with flow control equipment (variable gates, variable blades, or both) to enable that machine to operate at full load for 18 percent of the time, then at partial load in parallel with the base unit for a further (approximately) 25 percent of time, and finally, alone at partial load for about 20 percent of time.

At the sites where generation equipment is present, it is proposed that new development be treated individually in order to adhere as closely as possible to the proposed 4 plus 4 m³/s (144 + 144 ft³/s) flow pattern, which is considered to be attainable with unified control of all sites.

Tables 13 and 14 are a consolidation of the data for the various sites as tabulated in Tables 15 through 26; the consolidated tables also show the annual value of the increased energy outputs which would be available for the various development alternatives available at each site. These alternatives are as follows:

1. New Dam - Table 15 shows the energy available from the existing 300 kW unit. Some 54 percent of the available water is used but the remainder is spilled. Table 16 shows that if the existing unused 300 kW unit was restored to service, it would generate useful energy for 6 months of the year, amounting to 1,156,200 kWh worth of \$34,800 and increasing flow utilization to 86.5 percent with only 13.5 percent spillage.
2. Whichers Mill - Table 17 shows that development of this site with two 215 kW packaged units would produce 2,122,900 kWh/yr, worth \$63,900 and would use about 90 percent of the flow, with 10 percent spillage.

3. Old Falls - Table 18 shows the available output from the present 400 kW unit, which uses only 43 percent of the flow and spills 57 percent. Table 19 shows that the installation of new unit(s) totalling 725 kW would produce an increase of 2,848,000 kWh, worth \$85,700/yr and using 89 percent of the flow, with 11 percent spilled.
4. Dane Perkins - If Twine Mills is not raised, it would be possible to install at Dane Perkins the used Kaplan unit out of Dalton, MA and Table 20 shows that 479,000 kWh would be produced, worth \$14,400. It should be noted that, although the head here is only 8 ft, versus 13 ft at Kesslen, the utilization of the Dalton unit is slightly better at this site.
5. Twine Mill
 - a. Eighteen ft head. Table 21 shows that, if the existing Hunt turbine was restored to service, it should produce about 375 (generated) kW, giving 1,685,000 kWh and using 97 percent of the flow; the value of the energy is \$50,700. Should it not prove possible to restore this turbine, installation of two 160 kW packages would give 1,650,500 kWh worth \$49,700 and would use 95 percent of the flow (Table 22).
 - b. Twenty-eight ft head. If the height of the dam is increased to flood back over Dane Perkins site, the existing turbine would give 625 kW, 2,752,000 kWh worth \$82,800/yr; (see Table 23). Use of two 250 kW packages at this head (Table 24) would give 2,466,500 kWh worth \$74,200. Raising the height of this dam to 28 ft is not justified.

6. Kesslen Mill - Table 25 shows that the existing unit will produce 778,100 kWh/yr, worth \$23,400, while from Table 26 it can be seen that installation of the S. Morgan Smith Kaplan unit out of Dalton, MA, would increase output by 474,200 kWh, worth \$14,200/yr.
7. Rogers Mill - This site is at present abandoned, and the old canal is only large enough to pass water for one 200 kW unit. Table 27 shows an output of 1,231,500 kWh worth \$37,000 and use of 57 percent of the flow. If the canal is enlarged to permit the use of two 200 kW units, then output rises to 1,964,800 kWh, worth \$59,100.

Table 28 shows that it would be possible to increase the power output of the river from 830 kW to 3,140 kW, an increase of 2,310 kW, or 278 percent.

Table 15. Present New Dam Development (One 300 kW Turbine)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	
January	744	6.44	232	3.70	133	300	223,200	-	-	-	-	2.74	99	165,100	223,200
February	672	5.63	203	3.70	133	300	201,600	-	-	-	-	1.93	70	105,500	201,600
March	744	8.55	308	3.70	133	300	223,200	-	-	-	-	4.85	175	293,500	223,200
April	720	9.94	358	3.70	133	300	216,000	-	-	-	-	6.24	225	36,500	216,000
May	744	8.00	288	3.70	133	300	223,200	-	-	-	-	4.30	155	26,000	223,200
June	720	3.41	123	3.41	123	275	198,000	-	-	-	-	0	0	0	198,000
July	744	1.00	36	1.00	36	80	59,500	-	-	-	-	0	0	0	59,500
August	744	0.38	14	0.38	14	31	23,000	-	-	-	-	0	0	0	23,000
September	720	0.80	29	0.80	29	65	46,800	-	-	-	-	0	0	0	46,800
October	744	1.38	50	1.38	50	112	83,300	-	-	-	-	0	0	0	83,300
November	720	3.00	108	3.00	108	243	175,000	-	-	-	-	0	0	0	175,000
December	744	11.27	406	3.70	133	300	223,200	-	-	-	-	7.57	273	467,200	223,200
Totals														1,656,300 (46.27%)	1,896,000 (53.73%)

Table 16. Proposed New Dam Development (Two 300 kW Turbines)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	kWh
January	744	6.44	232	3.70	133	300	223,200	2.74	99	222	165,100	0	0	0	388,300
February	672	5.63	203	3.70	133	300	201,600	1.93	70	157	105,500	0	0	0	307,100
March	744	8.55	308	3.70	133	300	223,200	3.70	133	300	223,200	1.15	42	70,300	446,400
April	720	9.94	358	3.70	133	300	216,000	3.70	133	300	216,000	2.54	92	149,000	432,000
May	744	8.00	288	3.70	133	300	223,200	3.70	133	300	223,200	0.65	22	36,800	446,400
June	720	3.41	123	3.41	123	275	198,000	0	0	0	0	0	0	0	198,000
July	744	1.50	36	1.00	36	80	59,500	0	0	0	0	0	0	0	59,500
August	744	0.58	14	.87	14	31	23,000	0	0	0	0	0	0	0	23,000
September	720	0.50	29	.80	29	65	46,800	0	0	0	0	0	0	0	46,800
October	744	1.38	50	1.38	50	112	83,300	0	0	0	0	0	0	0	83,300
November	720	3.00	108	3.00	108	243	175,000	0	0	0	0	0	0	0	175,000
December	744	11.27	406	3.70	133	300	223,200	3.70	133	300	223,200	3.87	140	234,000	446,400
Totals														490,100 (13.51%)	3,052,200 (86.49%)

Table 17. Proposed Whichers Mill Development

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	
January	744	6.44	232	4.00	144	215	160,000	2.44	88	132	98,200	0	0	0	258,200
February	672	5.63	203	4.00	144	215	144,500	1.63	59	88	59,100	0	0	0	203,600
March	744	8.55	308	4.00	144	215	160,000	4.0	144	215	160,000	0.55	20	22,300	320,000
April	720	9.94	358	4.00	144	215	154,800	4.0	144	215	154,800	1.94	70	75,600	309,600
May	744	8.00	288	4.00	144	215	160,000	4.0	144	215	160,000	0	0	0	320,000
June	720	3.41	123	3.41	123	184	132,500	4.0	0	0	0	0	0	0	132,500
July	744	1.00	36	1.00	36	54	40,000	0	0	0	0	0	0	0	40,000
August	744	0.38	14	0.38	14	21	15,600	0	0	0	0	0	0	0	15,600
September	720	0.80	29	0.80	29	43	31,000	0	0	0	0	0	0	0	31,000
October	744	1.38	50	1.38	50	75	55,800	0	0	0	0	0	0	0	55,800
November	720	3.00	108	3.00	108	162	116,600	0	0	0	0	0	0	0	116,600
December	744	11.27	406	4.00	144	215	160,000	4.0	144	215	160,000	3.27	118	131,700	320,000
Totals														229,600 (10.07%)	2,122,900 (£9.93%)

Table 18. Present Old Falls Development (One 400 kW Turbine)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
		Flow, Q		Flow, Q				Flow, Q				Flow, Q			
Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	kWh
January	744	6.44	212	2.82	101	400	197,600	-	-	-	-	3.62	131	383,700	297,600
February	672	5.63	203	2.82	101	400	168,800	-	-	-	-	2.81	102	169,800	268,800
March	744	8.55	308	2.82	101	400	197,600	-	-	-	-	5.73	207	606,400	297,600
April	720	9.94	358	2.82	101	400	188,000	-	-	-	-	7.12	257	728,500	188,000
May	744	8.00	288	2.82	101	400	197,600	-	-	-	-	5.13	187	547,800	197,600
June	720	3.41	123	2.82	101	400	188,000	-	-	-	-	0.59	22	62,300	288,000
July	744	1.00	36	1.00	36	140	104,100	-	-	-	-	0	0	0	104,100
August	744	0.38	14	.38	14	55	41,000	-	-	-	-	0	0	0	41,000
September	720	0.80	29	.80	29	110	79,200	-	-	-	-	0	0	0	79,200
October	744	1.38	50	1.38	50	195	145,000	-	-	-	-	0	0	0	145,000
November	720	3.00	108	1.81	101	400	188,000	-	-	-	-	0.18	7	19,800	288,000
December	144	11.27	406	1.81	101	400	197,600	-	-	-	-	8.45	305	893,400	297,600
Totals														3,511,700 (56.54%)	2,692,500 (43.46%)

Table 19. Proposed Old Falls Development (One 400 kW and One 725 kW Turbine)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		North	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s
January	744	6.44	232	125	45	175	130,200	5.19	187	725	539,400	0	0	0	669,600
February	672	5.63	203	0.44	16	63	42,300	5.19	187	725	487,200	0	0	0	529,500
March	744	8.55	308	2.82	101	400	197,600	5.19	187	725	539,400	0.54	19	57,000	837,000
April	720	9.94	358	2.82	101	400	288,000	5.19	187	725	522,000	1.93	69	197,000	810,000
May	744	8.00	288	2.82	101	400	197,600	5.19	187	725	539,400	0	0	0	837,000
June	720	3.41	123	0	0	0	0	3.41	123	480	345,600	0	0	0	345,600
July	744	1.00	36	0	0	0	0	1.00	36	140	104,100	0	0	0	104,100
August	744	0.38	14	0	0	0	0	.38	14	55	41,000	0	0	0	41,000
September	720	0.80	29	0	0	0	0	.80	29	110	79,200	0	0	0	79,200
October	744	1.38	50	0	0	0	0	1.38	50	195	145,000	0	0	0	145,000
November	720	3.00	108	0	0	0	0	3.00	108	425	306,000	0	0	0	306,000
December	744	11.27	406	2.82	101	400	197,600	5.19	187	725	539,400	3.26	117	344,000	837,000
Totals														598,000 (10.55%)	5,541,000 (89.45%)

Table 20. Proposed Dane Perkins Development

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s
January	744	6.44	232	4.44	160	80	59,500	-	-	-	-	1.00	72	26,700	59,500
February	672	5.63	203	4.44	160	80	53,700	-	-	-	-	1.19	43	14,100	53,700
March	744	6.55	308	4.44	160	80	59,500	-	-	-	-	4.11	148	55,000	59,500
April	720	9.94	358	4.44	160	80	57,600	-	-	-	-	6.50	198	69,100	57,600
May	744	6.00	288	4.44	160	80	59,500	-	-	-	-	3.56	128	47,600	59,500
June	720	3.41	123	3.41	123	61	43,900	-	-	-	-	0	0	0	43,900
July	744	1.00	36	1.00	36	16	13,300	-	-	-	-	0	0	0	13,300
August	744	0.38	14	0.38	14	7	5,200	-	-	-	-	0	0	0	5,200
September	720	0.80	29	0.80	29	14	10,000	-	-	-	-	0	0	0	10,000
October	744	1.38	50	1.38	50	25	18,600	-	-	-	-	0	0	0	18,600
November	720	3.00	108	3.00	108	54	38,800	-	-	-	-	0	0	0	38,800
December	744	11.27	406	4.44	160	80	59,500	-	-	-	-	6.83	246	91,500	49,500
Totals														304,000 (39.00%)	479,000 (61.00%)

Table 21. Restoration of Twine Mill Using Turbine on Site

		Flow, Q		Unit 1				Unit 2				Spill			Generate
Month	Hrs			Flow, Q				Flow, Q				Flow, Q			
		m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	kWh
January	744	6.44	232	6.44	232	260	193,400	-	-	-	-	0	0	0	193,400
February	672	5.63	203	5.63	203	228	153,200	-	-	-	-	0	0	0	153,200
March	744	8.55	308	8.55	208	345	156,600	-	-	-	-	0	0	0	256,600
April	720	9.94	358	9.38	338	375	270,000	-	-	-	-	0.56	20	16,200	270,000
May	744	8.00	288	8.00	288	325	241,800	-	-	-	-	0	0	0	241,800
June	720	3.41	123	3.41	123	138	99,300	-	-	-	-	0	0	0	99,300
July	744	1.00	36	1.00	36	40	19,700	-	-	-	-	0	0	0	29,700
August	744	0.38	14	0.38	14	15	11,100	-	-	-	-	0	0	0	11,100
September	720	0.80	29	0.80	29	32	23,000	-	-	-	-	0	0	0	23,000
October	744	1.38	50	1.38	50	56	41,600	-	-	-	-	0	0	0	41,600
November	720	3.00	108	3.00	108	120	86,400	-	-	-	-	0	0	0	86,400
December	744	11.27	406	9.38	338	375	17,900	-	-	-	-	1.89	68	56,900	279,000
Totals														73,100 (3.29%)	1,605,100 (96.71%)

Table 22. Restoration of Twine Mill Using New Turbines (Two 160 kW Units)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
		Flow, Q		Flow, Q				Flow, Q				Flow, Q			
Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	kWh
January	744	6.44	232	4.00	144	160	11,500	2.44	88	98	72,900	0	0	0	191,900
February	672	5.63	203	4.00	144	160	107,500	1.63	59	65	43,600	0	0	0	151,000
March	744	8.55	308	4.00	144	160	119,000	4.00	144	160	119,000	0.55	20	16,700	238,000
April	720	9.34	358	4.00	144	160	115,200	4.00	144	160	115,200	1.34	70	56,700	302,400
May	744	8.00	288	4.00	144	160	119,000	4.00	144	160	119,000	0	0	0	238,000
June	720	3.41	123	3.41	123	138	99,300	0	0	0	0	0	0	0	99,300
July	744	1.00	36	1.00	36	40	29,700	0	0	0	0	0	0	0	29,700
August	744	0.38	14	0.38	14	15	11,100	0	0	0	0	0	0	0	11,100
September	720	0.60	29	0.60	29	32	23,000	0	0	0	0	0	0	0	23,000
October	744	1.38	50	1.38	50	56	0	0	0	0	0	0	0	0	41,600
November	720	3.00	108	3.00	108	120	86,400	0	0	0	0	0	0	0	86,400
December	744	11.27	406	4.00	144	160	119,000	4.00	144	160	119,000	3.27	117	98,500	238,000
Totals														171,900 (5.3%)	1,650,500 (94.7%)

Table 23. Rebuilding of Twine Mill at Increased Height of 28 Feet (One 625 kW Turbine)

		Flow, Q		Unit 1				Unit 2				Spill			Generate	
				Flow, Q				Flow, Q				Flow, Q				
		Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh
January	744	6.44	232	6.44	232	406	302,000	-	-	-	-	0	0	0		302,000
February	672	5.63	203	5.63	203	355	238,500	-	-	-	-	0	0	0		238,500
March	744	8.55	308	8.55	308	539	401,000	-	-	-	-	0	0	0		401,000
April	720	9.94	358	9.94	358	626	450,700	-	-	-	-	0	0	0		450,700
May	744	8.00	288	8.00	288	504	374,900	-	-	-	-	0	0	0		374,900
June	720	3.41	123	3.41	123	215	154,800	-	-	-	-	0	0	0		154,800
July	744	1.00	36	1.00	36	63	46,800	-	-	-	-	0	0	0		46,800
August	744	0.38	14	0.38	14	24	17,800	-	-	-	-	0	0	0		17,800
September	720	0.80	29	0.30	29	50	36,000	-	-	-	-	0	0	0		36,000
October	744	1.38	50	1.38	50	87	64,700	-	-	-	-	0	0	0		64,700
November	720	3.00	108	3.30	108	190	136,600	-	-	-	-	0	0	0		136,600
December	744	11.27	406	11.27	406	710	528,600	-	-	-	-	0	0	0		528,600
Totals														0		2,752,000 (100%)

Table 24. Rebuilding of Twine Mill at Increased Height of 28 Feet (Two 250 kW Units)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s
January	744	6.44	232	4.00	144	250	186,000	2.44	88	150	116,000	0	0	0	297,600
February	672	5.63	203	4.00	144	250	168,000	1.63	59	103	67,200	0	0	0	235,200
March	744	8.55	308	4.00	144	250	186,000	4.00	144	250	186,000	0.55	20	26,000	372,000
April	720	9.94	358	4.00	144	250	180,000	4.00	144	250	180,000	1.94	70	88,200	360,000
May	744	8.00	288	4.00	144	250	186,000	4.00	144	250	186,000	0	0	0	372,000
June	720	3.41	123	3.41	123	215	154,800	0	0	0	0	0	0	0	154,800
July	744	1.00	36	1.00	36	63	44,600	0	0	0	0	0	0	0	44,600
August	744	0.38	14	0.38	14	21	17,800	0	0	0	0	0	0	0	17,800
September	720	0.90	29	0.80	29	50	36,000	0	0	0	0	0	0	0	36,000
October	744	1.38	50	1.38	50	87	67,700	0	0	0	0	0	0	0	67,700
November	720	3.00	108	3.00	108	190	136,800	0	0	0	0	0	0	0	136,800
December	744	11.27	406	4.00	144	250	186,000	4.00	144	250	186,000	3.27	117	152,300	372,000
Totals														266,500 (10.39%)	2,466,500 (89.61%)

Table 25. Present Kessler Development (One 150 kW Unit)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s
January	744	6.44	232	4.40	160	130	96,700	-	-	-	-	2.04	72	43,500	96,700
February	672	5.63	203	4.40	160	130	87,300	-	-	-	-	1.23	43	23,500	87,300
March	744	8.55	308	4.40	160	130	96,700	-	-	-	-	4.15	148	89,400	96,700
April	720	9.94	358	4.40	160	130	93,600	-	-	-	-	5.54	198	115,800	93,600
May	744	8.00	288	4.40	160	130	96,700	-	-	-	-	3.60	128	77,300	96,700
June	720	3.41	123	3.41	123	100	72,000	-	-	-	-	0	0	0	7,200
July	744	1.00	36	1.00	36	29	21,500	-	-	-	-	0	0	0	21,500
August	744	0.38	14	0.38	14	11	8,100	-	-	-	-	0	0	0	8,100
September	720	0.80	29	0.80	29	23	16,500	-	-	-	-	0	0	0	16,500
October	744	1.38	50	1.38	50	40	29,700	-	-	-	-	0	0	0	29,700
November	720	3.00	108	3.00	108	87	62,600	-	-	-	-	0	0	0	62,600
December	744	11.27	406	4.40	160	130	96,700	-	-	-	-	6.87	246	148,700	96,700
Totals														498,200 (39.00%)	778,100 (61.00%)

Table 26. Proposed Kessler Development (One 150 kW and One 170 kW Unit)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	kWh
January	744	6.44	232	0.64	22	18	13,300	5.80	210	170	126,500	0	0	0	139,800
February	672	5.63	203	0	0	0	0	5.63	203	165	110,800	0	0	0	110,800
March	744	8.55	308	2.75	98	80	59,500	5.80	210	170	126,500	0	0	0	186,000
April	720	9.54	358	4.14	148	120	86,400	5.80	210	170	122,400	0	0	0	208,800
May	744	8.00	288	2.20	78	63	46,800	5.80	210	170	126,500	0	0	0	173,300
June	720	3.41	123	0	0	0	0	3.41	123	100	72,000	0	0	0	72,000
July	744	1.00	36	0	0	0	0	1.00	36	29	21,500	0	0	0	21,500
August	744	0.38	14	0	0	0	0	0.38	14	11	81,000	0	0	0	8,100
September	720	0.80	29	0	0	0	0	0.80	29	23	16,500	0	0	0	16,500
October	744	1.38	50	0	0	0	0	1.38	50	40	29,700	0	0	0	29,700
November	720	3.00	108	0	0	0	0	3.00	108	87	62,600	0	0	0	62,600
December	744	11.27	406	4.40	160	130	96,700	5.80	210	170	126,500	1.07	66	39,900	223,200
Totals														39,300 (1.70%)	1,252,300 (98.30%)

Table 27. Proposed Restoration of Rogers Mill (One 200 kW Unit)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kWh	
January	744	6.44	232	4.00	144	200	148,800	-	-	-	-	1.44	88	89,200	148,800
February	672	5.63	203	4.00	144	200	134,400	-	-	-	-	1.63	59	53,700	134,400
March	744	8.55	308	4.00	144	200	148,800	-	-	-	-	4.55	164	169,200	148,800
April	720	9.94	358	4.00	144	200	144,000	-	-	-	-	5.94	214	21,300	144,000
May	744	8.00	288	4.00	144	200	148,800	-	-	-	-	4.00	144	148,800	148,800
June	720	3.41	123	3.41	123	170	122,400	-	-	-	-	0	0	0	122,400
July	744	1.00	36	1.00	36	49	36,400	-	-	-	-	0	0	0	36,400
August	744	0.38	14	0.38	14	19	141,000	-	-	-	-	0	0	0	14,100
September	720	0.80	29	0.80	29	39	28,000	-	-	-	-	0	0	0	28,800
October	744	1.38	50	1.38	50	68	50,500	-	-	-	-	0	0	0	50,500
November	720	3.00	108	3.00	108	148	106,500	-	-	-	-	0	0	0	106,500
December	744	11.27	406	4.00	144	200	148,800	-	-	-	-	7.27	161	268,400	148,800
Totals														942,600 (43.00%)	1,231,500 (57.00%)

Table 28. Proposed Restoration of Rogers Mill (Two 200 kW Units)

		Flow, Q		Unit 1				Unit 2				Spill			Generate
				Flow, Q				Flow, Q				Flow, Q			
		Month	Hrs	m ³ /s	ft ³ /s	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s	kW	kWh	m ³ /s	ft ³ /s
January	744	5.44	232	4.00	144	200	148,800	2.44	88	120	89,200	0	0	0	238,000
February	672	5.63	203	4.00	144	200	134,400	1.63	59	80	53,700	0	0	0	188,100
March	744	3.55	308	4.00	144	200	148,800	4.00	144	200	148,800	0.55	20	20,400	297,600
April	720	9.94	358	4.00	144	200	144,000	4.00	144	200	144,000	1.94	70	69,300	288,000
May	744	8.00	288	4.00	144	200	148,800	4.00	144	200	148,800	0	0	0	297,650
June	720	1.41	123	3.41	123	170	122,400	0	0	0	0	0	0	0	122,400
July	744	1.00	36	1.00	36	49	36,400	0	0	0	0	0	0	0	36,400
August	744	0.38	14	0.38	14	19	14,100	0	0	0	0	0	0	0	14,100
September	720	0.80	29	0.80	29	39	28,000	0	0	0	0	0	0	0	28,000
October	744	1.38	50	1.38	50	68	50,500	0	0	0	0	0	0	0	50,500
November	720	3.00	108	3.00	108	148	106,500	0	0	0	0	0	0	0	106,500
December	744	11.27	406	4.00	144	200	148,800	4.00	144	200	148,800	3.27	117	119,600	297,600
Totals														209,300 (9.06%)	1,964,800 (90.94%)

5. ENVIRONMENTAL ASSESSMENT OF HYDROELECTRIC REDEVELOPMENT

5.1 Introduction

The objective of this section is to summarize the environmental impact of hydroelectric redevelopment along the Mousam River. Field studies were conducted by J. Edinger Associates, and others, M. Harper, P.E., M&E and FMA. The complete environmental impact study is presented in Appendix B.

The section begins with the presentation of basic data and text describing the existing natural and social settings for the restoration. There are descriptions of geology and soils, climatology, vegetation and land use, and hydrology and water quality. A discussion of recreational, historical, and archeological resources, and population and water use comprise the second subsection. The projected impact of the hydroelectric redevelopment plan on these natural and social environments is described in the final subsection.

In general, the conclusions of the study are as follows:

- No known prehistoric sites exist in the region.
- No endangered plant species were observed within the study area.
- No rare, threatened or endangered bird or fish species are known to inhabit the Mousam River area.
- The restoration of dams on the lower Mousam River will effect soil and vegetation, water quality, and cultural resources.

- The restoration of dams along the river will enhance recreational opportunities.
- The effect of restoration on water quality is expected to be minimal.

5.2 Technical Discussion

Much of the available information on the Mousam River is basin-wide in scope. Reports available from state and local governments provide data on a county-wide or municipality basis. For these reasons, a field investigation was conducted by the authors during late September 1978. These investigations included both primary data collection in the vicinity of the sites and interviews with county and municipal authorities. This report, therefore, combines site-specific information with basin-wide descriptive material.

The geology and soils of the Mousam basin are dominated by features associated with the Wisconsin glaciation. The topography of the lower Mousam basin, which lies in the physiographic region known as the Seaboard Lowland, is relatively flat. The Mousam valley is generally V-shaped with small flood plains, and the drainage basin as a whole is only moderately integrated with prominent marshes and natural ponds in the upper reaches. These are characteristic of a river in an advanced youthful stage and result from a drainage pattern which is post-glacial in origin.

Bedrock geology in the Mousam basin is essentially metamorphic with igneous intrusions. Bedrock is believed to be derived from metamorphism of material deposited as a result of repeated marine transgressions, erosion and vulcanism. These bedrock materials are found in both synclinal and anticlinal features in the vicinity of the lower Mousam River.

Soils are primarily sandy loams, with internal drainage properties related to particle size and irregular distribution of glacial drift.

The climate of the Mousam basin is dominated by the frequent movement through the region of three types of air masses: cold; dry polar air; warm and humid air with its source in the Gulf of Mexico; and cool moist air from the North Atlantic. These synoptic characteristics result in two important features of the local climate: changeable weather, with twice-weekly alterations on the average, between clear, cloudy, and stormy conditions; and, even distribution of rainfall throughout the year. Average annual precipitation is 40.80 in. and the mean annual temperature is 45°F.

Greater than half the Mousam basin, 51 percent, is forest land. Approximately one-third, 32 percent of the basin, is urban or built up, 9 percent is agricultural land, and the remaining 8 percent is water, wetland, barren land and range land.

The Rogers Mill Dam site is dominated by mixed hardwoods at higher elevations on the north facing slope, while the shallow soils and exposed bedrock at lower elevations support relatively undifferentiated intergrading communities of herbaceous species, alders, and gray birch. The south facing slope supports predominately weedy species, alder, and hardwood saplings.

The more gentle north facing slope at the Twine Mill site includes mixed hardwoods and a ladders down to the water's edge. The south facing slope is zoned into an herbaceous riverine community, an alder zone, and a mixed hardwood-softwood zone.

Extensive forest fires occur at irregular intervals, but with increasing frequency in recent times in southeastern Maine. The most recent large fire occurred in October 1947 and burned approximately 130,000 acres. Large fires were reported as early as 1761 and major fires in the 20th century occurred in 1908, 1941, 1947, 1953, and 1957.

The Mousam River drains an area of 125 mi², dropping a total of 522 ft over its length of 50 mi. The final 3.6 mi between Kennebunk and the Atlantic Ocean, are considered to be under the influence of the tide. Mean annual flow for the Mousam is 179 cfs, unadjusted for changes in storage of three large impoundments upstream of the study area. The record low flow was 0.4 cfs, which occurred during the Northeastern U.S. drought of 1964. Three small impoundments, Old Falls Dam, New Dam, and Kesslen Mill Dam, currently generate hydropower in the study area.

Water quality in the Mousam River Drainage Basin is generally considered to be satisfactory. Eutrophication in Estes Lake, upstream of the study area, is thought to be caused primarily by nutrient discharge from the Sanford, Maine waste treatment plant, which uses lagoons to effect secondary-level treatment. This discharge causes high nutrient levels and occasional low dissolved oxygen levels in the Mousam River immediately downstream of Sanford. Dissolved oxygen recovers to satisfactory levels near Kennebunk, a distance of 14 miles. Current plans call for upgrading the Sanford waste treatment plant to remove nutrients.

The Mousam River in the study area is classified as B-2, meaning waters are suitable for water contact recreation, water supply (with treatment), and fish and wildlife habitat. Water quality standards, primarily limits on fecal coliform, dissolved oxygen, and offensive or toxic discharge, are enforced by the Maine Department of Environmental Protection.

There are 38 sites in York County on the natural and state registers of historic places. Only the Kennebunk Historic District is close to either the Twine Mill or Rogers Mill Dam sites. There are no known prehistoric sites of significance in York County. The State Historic Preservation Officer notes that there has been no thorough investigation for such sites in southeastern Maine; the Mousam River drainage basis is therefore

considered to be a "sensitive" area. However, since both sites have been in prior operation, it is doubtful that prehistoric cultural sites remain intact.

Although there are two plant species present in York County being considered for threatened status by the U.S. Fish and Wildlife Service (Yellow Rein Orchis and Ram's Head Lady's Slipper), neither was observed at either the Twine Mill or Rogers Dam site. A number of endangered and threatened plant species found in Maine may occur in the Mousam basin, although none were observed at either dam site. No rare, threatened, or endangered fish or bird species are known to inhabit the Mousam River area under study in this investigation. There are nine areas in proximity to the sites which were inventoried for the Maine critical areas list but none was placed on the list and none would be affected by construction. The anadromous fishery on the Mousam is limited by the number of dams that prevent fresh water spawning by such species as Atlantic Salmon. Because of the large number of dams on the lower Mousam, installation of fishways to permit fish runs was considered impractical by the State of Maine in 1955.

In summary, the restoration of dams on the lower Mousam River will effect soils and vegetation, water quality, and cultural resources. Because the plan centers upon the restoration of recently breached dams, there has been some impact on the environment already. It should be noted that small dams such as those considered here, have been in existence on the Mousam continuously since 1670.

Two large dams, Rogers Mill and Twine Mill are being proposed for reconstruction. The Rogers Mill Dam restoration will probably have a lesser impact. The area to be flooded is less than half that for the Twine Mill Dam, and the site is occupied by predominantly weedy vegetation in shallow soil pockets which have been considerably altered.

The effects on vegetation and soils at the proposed Twine Mill Dam site restoration will be more extensive. The pool is to be larger and therefore more habitat will be altered from woodland to impoundment. In addition, the raising of the dam beyond the former 18 ft will change the composition of previously slightly altered woodland community to riverine habitat, that is, the current zonation will reappear, over time, at higher elevations. Because there are undisturbed soils below the Twine Mill site, erosive properties of the water immediately downstream of the dam will increase, particularly as a result of elevation of the structure.

The impact of the dams and pools on water quality is expected to be small. Chronic changes in water quality are found at large impoundments where average residence times exceed 200 days. The impoundments being considered here will have residence times of 1 day or less; hence, thermal stratification and the associated retention of poorly oxygenated bottom waters which are responsible for deteriorative water quality impacts in a large impoundment are not likely to occur here.

Groundwater effects will be confined to localized rises in the water table in response to filling of the impoundments.

No known threatened or endangered species are found on either site and there are no known prehistoric cultural sites in the immediate area of the proposed impoundment restorations. Further, it is believed that the restoration of these two pools will enhance certain recreational opportunities for water sports such as canoeing and fishing.

6. CIVIL CONSTRUCTION REQUIREMENTS

6.1 Introduction

In this chapter, an in-depth assessment of the construction requirements at the two major KL&PD owned breached dams is made, Twine Mill and Rogers Mill. This assessment is used as a basis for the construction cost estimates for the KL&PD-owned Dane Perkins site and the privately-owned Whichers Mill site, which are given in Chapter 9.

The following subsections incorporate the results of a site reconnaissance, conceptual design, preliminary cost analysis, and safety assessment for the Twine Mill and Rogers Fiber sites. The final subsection addresses the permit procedures required for construction of the dams.

The site reconnaissance included a study of the site geology and a visual inspection of the remaining elements of the two structures. The intent of this study is to determine the feasibility of the project from a physical standpoint, to present cost data as a basis for an economical evaluation, and to conceptualize a design. Prior to undertaking any reconstruction of these dams, topographic surveys, test borings, final design and a detailed cost analysis will be required.

The only other site recommended for early expansion, which requires major civil works, is Old Falls; where the existing penstock, already of adequate hydraulic size, will require overhaul and modification to accommodate a new unit or units. Also, extension of the power house foundations and buildings will be necessary in order to house the new plant installation. All of the civil engineering work involved is of a routine nature.

It is considered that some review of the possible advantages to be gained from the use of Bascule type spillway gates instead of flashboards at certain sites should be undertaken as part of the detailed redevelopment design, but such a review is outside the scope of the present study.

6.2 Site Reconnaissance

An engineering and geologic reconnaissance of the Twine Mills and Rogers Fiber dam sites was conducted on December 28 and 29, 1978. Each remaining element of the breached dams was examined to determine if they were suitable for incorporation in a new dam and the extent of the repairs necessary to make them usable. A geological study was also carried out. Rock outcrops were located, the rock classified, and the strike, dip, and fracture planes measured. Soil exposures were also examined and the topographic features of the valleys were noted to indicate the surficial geology. The field observations were hampered somewhat by the snow cover, which measured about 10 in. in depth at the time, and obscured the ground except in an occasional small exposure along the river banks. It may have covered other rock outcrops as well. Nevertheless, the rock and surficial geologic conditions at the sites could be sufficiently well established for the purposes of this study.

6.2.1 Seismic Conditions

The seismic risk zone map presented in the *Uniform Building Code* shows Kennebunk in Zone 2, having a potential for moderate damage corresponding to intensity VII on the modified Mercalli scale. This is based on the occurrence of past earthquakes and does not predict the occurrence of such earthquakes in the future.

Seismic values to account for earthquake shock loads on the dam were assigned as 0.10 g in the horizontal and 0.05 g in the vertical direction for the preliminary analysis. These values were selected to be consistent with values used for Zone 2 areas. A further consideration is that the southern Maine area has not undergone any major tectonic activity in recent times.

A recent listing of past earthquake epicenters in Maine shows that two intensity V events have occurred about 20 mi from the dam sites. One was in Westbrook in 1814 and the other in Kittery in 1905. Also, an intensity IV earthquake occurred 8 mi from the dam sites in Biddeford in 1906. Presumably, the earlier dam structures withstood the 1905 and 1906 events.

Geophysicists at Weston Observatory, Weston, MA are currently compiling more historical data on earthquakes in New England and correlating this data with fault zones and regional geologic structures. A more detailed evaluation of seismic risk should be conducted using data from their office during final design of the proposed dams.

6.2.2 Twine Mills Dam

6.2.2.1 Site Geology

The geologic description of this site is based both on the observations and measurements made during the site reconnaissance and on published information from the Maine Geological Survey. A discussion of the bedrock geology is given in Geology of Southern York County, Maine by A.M. Hussey (Special Geologic Studies Series No. 4, 1962). The surficial geology is presented on a map entitled Surficial Geology of the Kennebunk 15-Minute Quadrangle, York County, Maine by Geoffrey Smith (unpublished report, 1977). Information was also obtained from Mr. Robert Doyle, State Geologist, who is familiar with the regional geologic

setting, and with Mr. Phil Davis, General Manager of the KL&PD, who supervised shallow auger borings at the site.

The valley at the dam site is fairly narrow with side slopes averaging 20 percent or 5 to 1 (horizontal to vertical). The slopes rise from about elevation (El) 60 (in ft, mean sea level) in the valley bottom to about El 120 on top of the hill-sides. The valley bottom at the dam is obscured by scattered boulders and the remaining concrete slab from the previous dam. Bedrock outcrops, however, occur just upstream (north shore) and downstream (south shore) from the site. The bedrock is dark greenish and reddish gray, metamorphosed sedimentary rock, shown as the Eliot formation on the geologic map (Hussey). The rock, which has been identified as chloritic quartzite; is hard, resistant, and unweathered. The bedding strikes about north-south and dips 7 degrees east. The rock is thick-bedded upstream of the dam and thin-bedded downstream of the dam. Three sets of joints occur in the rock; one is along the bedding planes, a second strikes north 20 degrees east and dips 75 degrees northwest, and a third strikes approximately east-west and dips about vertically. The joints are spaced at 2 to 18 in. intervals and average 5 to 10 in. At the surface, the joints are slightly open, unfilled, and slightly stained. There are no major faults mapped in the project area. Photographs 1 and 2 of Appendix C show the rock outcrops that were mapped.

The hillside forming the abutments are shown on the geologic map (Smith) to be stratified sand (glacial outwash). This was confirmed by both the field observations and by the results of the shallow auger borings taken by Phil Davis at the site. A low, flat terrace about 5 ft high occurs upstream of the dam along the south bank of the river. The terrace is probably comprised of finer sands recently deposited by the river (alluvium). No clay or glacial till deposits are mapped within the area. Photographs 2 and 11, Appendix C show the topography at the dam site.

6.2.2.2 Foundation Conditions

The rock outcrops that were mapped on both sides of the river at the dam sites indicate with reasonable certainty that the original dam was founded on bedrock. Water, and the remaining concrete of the dam foundation obscured any direct observation of the rock and its presence must be verified by test borings in the final design. The rock appears to be competent and should be suitable for supporting the proposed new structure. The extent to which the proposed structure can be extended beyond the limits of the old foundation and remain on rock is indeterminant at this time. Any base extension beyond the base of the old dam, or any realignment of the dam axis, will require sufficient borings to determine the contours of the rock surface.

Similar rock is anticipated for support of the existing dam abutments, wing-walls and generator building, but this could not be ascertained by direct observation during the site reconnaissance due to the snow and earth cover. In any case, these features apparently performed adequately in the past and there is no present indication that they were either unstable or permitted excessive leakage despite the permeable nature of the sand soil that overlies the rock. This and the conditions of the concrete remaining from the old dam base will require additional study in the final design phase.

The amount of water loss through underseepage could not be evaluated at this time due to lack of information. An estimate of seepage losses will require data derived from in-situ water pressure "packer" tests conducted in drill holes that penetrate through the potential seepage zone. The amount of seepage will determine the need for pressure grouting to seal water passages in the rock. For present estimates, the assumption has been made that grouting will not be required. This is based on the past

performance of the original dam. Nevertheless, the need for grouting cannot be entirely discounted in rock with this type of jointing.

Prior to the final design, a boring and in-situ testing program must be implemented to determine the following:

1. The structure and permeability of the rock that will support the dam.
2. A measurement of the seepage potential in the rock beneath the dam by means of water pressure tests in drill holes.
3. The surface contours of the rock surface immediately upstream and downstream from the dam. The downstream borings are especially important in designing the type of discharge device that will be required to dissipate the overflow water energy and protect the toe of the dam.
4. The nature of the soil around and below the abutments and wing walls, especially in the area of the right (south) wing wall extension.

6.2.2.3 Condition of Existing Facilities

The Twine Mill Dam was breached in 1960 leaving intact only the abutments and wing walls on both sides of the river, the powerhouse located on the north bank, and the concrete base that supported the framework which formed the dam. At the time of the field reconnaissance, a thick sheet of water was discharging over this base and the channel above was partially frozen.

The north abutment incorporates the gate approach wall that controlled flow into the generator mechanism. The Twine Mill dam site is shown in Photographs 4 and 8 in Appendix C. Other photographs, as noted below, apply to specified elements of the dam.

In general, the exposed concrete has suffered extensively from weathering as evidenced by widespread scaling of the surface, spall along construction joints and severe erosion. The erosion is concentrated at the crest elevation of the original dam and results from ice action, water flow, and weathering along the water line. The remaining concrete appears to be relatively sound, although no tests have been made upon it. The visible coarse aggregate is nearly several inches in size. No consistent reinforcing pattern was exposed but steel in the form of small angle bars and smooth round reinforcing pattern was exposed but steel in the form of small angle bars and smooth round reinforcing bars was visible in some locations. The type and extent of the damage to this concrete indicates that the concrete which is not very resistant to weathering had cold construction joints that are a point of weakness. Each segment of the remaining dam structure is discussed below.

North (Left) Wing Wall

Scaling has occurred over nearly the entire upstream face of this wall below the dam crest elevation. Aggregate is exposed and there is some loose scale, joint spall, exudations and efflorescence. The junction with the north abutment at the dam crest elevation shows deep erosion and the exposure of some reinforcing steel. The downstream face of this wall is buried and not visible. The north wingwall, abutment, and gate entrance are shown in Photograph 5, Appendix C.

North (Left) Abutment Wall

A band of erosion estimated at 6 in. in depth and about 18 in. wide, located at the dam crest elevation, extends the full length of the exposed side of this wall. There is some additional erosion of the wall at the base which possibly developed after breaching. Spall also occurs in depths from 6 to 12 in. at several locations, apparently along the construction joints. Severe scale is evident over the entire surface, and there is some efflorescence and exudations. The north side of this wall is buried and no observation could be made. Photographs 5 and 8 show this wall and photograph 6 gives a closeup view of the concrete. These photographs are included in Appendix C.

Gate Wall and Gate

The wooden gate that controlled the flow of water into the turbine is located on this wall. The gate has decayed and must be replaced. The concrete in this wall has scaled and two construction joints across the wall have spalled to a depth of about 2 in. There is severe scaling at the top of this wall on the south side, (Photograph 7, Appendix C).

Gate Approach Wall

This wall has suffered more damage than any other element of the remaining structure. At the crest elevation of the upstream end of the dam, the full width of the wall has been eroded completely for a distance of about 2 ft. Similar erosion, although not as extensive, appears on the downstream end. These are connected on both sides by a band of erosion that has cut extensively into the concrete to an estimated depth of 6 in. (the stream side is inaccessible to direct measurement). These conditions are shown in Photographs 7 and 8. Other areas of joint spall up to 6 in. deep also occur. Severe scale covers the entire surface. On the

upstream toe of the wall there is an extension to the wall that is very severely eroded to a depth approaching 2 ft on each side. This may be post breach erosion as it is near to the present water level. It is shown in Photograph 9, Appendix C.

Upstream Side of South (Right) Wing Wall

There is severe scaling over the entire exposed surface of this wall. There is also a limited amount of joint spall and some concrete has been eroded away at the original dam crest evaluation. A large portion of this wall is buried (see Photograph 10).

Downstream Face of South (Right) Wing Wall

The northern portion of this wall was snow covered and no observation was possible. The remaining section north of the buttress that divides and supports this wall has severe scaling over the entire surface and one joint across the wall has spalled to a depth of about 10 in. The buttress itself is in excellent condition with no sign of any significant deterioration. That portion of the wall south of the buttress has medium scale across the entire surface (see Photograph 11). A water channel also appears to have been eroded in the soil around the end of this wall.

Downstream Powerhouse Wall

This wall has severe scaling. Otherwise the powerhouse and its foundation appear quite sound.

Dam Foundation

The foundation of the breached wooden portion of the dam between the abutments consists of concrete that was cast directly

upon bedrock. The high velocity flow of water across this base and the ice condition prevented any detailed observation of the base concrete. The uniformity of the flow, however, is indicative of no significant disintegration of this base (see Photographs 3 and 8).

6.2.3 Rogers Fiber Dam

6.2.3.1 Geology

The geologic descriptions in this report are based on site investigation and measurements made during the site reconnaissance and/or published information from the Maine Geological Survey. A discussion of the bedrock geology is given in Geology of Southern York County, Maine by A.M. Hussey (Special Geologic Studies Series No. 4, 1976). The surficial geology is presented on a map entitled Surficial Geology of the Kennebunk 15-Minute Quadrangle, York County, Maine by Geoffrey Smith (unpublished report, 1977). Information was also obtained from Mr. Robert Doyle, State Geologist, who is familiar with the regional geologic setting and from Mr. Phil Davis, General Manager of KL&PD.

The valley at this site is broader and flatter than at Twine Mill Dam. The stream bed is at about El 20. The sides of the valley are formed by terraces 15 to 25 ft high with slopes at about 20 percent, or 5 to 1. Some of this topography is shown in Photographs 12 and 15, Appendix C.

The river bed at the dam site is comprised of bedrock, which is a light pinkish gray quartzite, mapped as the Kittery formation (Hussey). Rock is also exposed in both banks of the river. The rock is hard, resistant, and unweathered. It breaks off as slabs, forming a stepped floor in the stream bed. The bedding strikes about north 67 degrees east, and dips at 12 degrees northwest. Joints occur along the bedding planes at about

8 in. spacing. Joints also occur along two other planes; one strikes north 77 degrees west, dips 55 degrees south and the other strikes north 13 degrees east and dips 60 degrees east. These joints are relatively widely spaced at 15 to 30 in. and are slightly open and unfilled. The rock is shown in Appendix C, Photograph 3. No major faults are mapped in this area.

The terraces are shown on the surficial map as consisting of stratified outwash sand. The slope on the north side of the river is near existing buildings and has been leveled by filling, therefore, some rock and other fill may overlay or be mixed with the local soil. The south abutment contains remnants of a building foundation at the surface. No clay or glacial till units are shown on the map in this area.

6.2.3.2 Foundation Conditions

The dam at this site will be founded on competent bedrock fully capable of supporting the dam. This rock covers the entire river bed for some distance upstream and downstream allowing some leeway in establishing the axis of the dam. The same rock probably underlies the north (left) abutment although this could not be determined during the reconnaissance study. Its existence under the proposed new south (right) abutment and wingwall is probable but also not known positively. Since the soil in the area is expected to be stratified and sandy, placing the wingwall on bedrock will be very desirable in eliminating seepage. Photographs 3 and 13 in Appendix C shows this rock base.

The rock contains a joint system that has a potential for underseepage. The volume of water that might be lost in the manner could not be analyzed at this time due to a lack of data. Any realistic estimate of seepage losses must be based on the results of in-situ water pressure tests performed in drill holes penetrating through the seepage zone. The data obtained

thereby would form a basis for a seepage loss calculation. This is a hydrostatic type of pressure test that directly measures the flow potential through the rock. From this the need and extent of pressure grouting requirement, if any, can be determined.

For purposes of estimating a cost at this time, it has been assumed that no grouting will be required based on the assumed past performance of the original dam. Nevertheless, the need for grouting cannot be entirely discounted until field tests prove otherwise.

Prior to the final design, a boring and testing program should be carried out to determine the following:

1. The structure and permeability of the rock beneath the dam. Hydrostatic "packer" pressure tests to determine the permeability of the rock will be required in order to estimate seepage losses.
2. The elevation of the rock surface in the south wing-wall area.
3. The nature of the soil in the wing wall area and its permeability if the walls are found on soil.
4. Whether or not the north wing wall is founded on rock.

6.2.3.3 Conditions of Existing Facilities

The Rogers Fiber Dam has been completely breached with only some remnants of framework and the concrete base remaining between the abutments. The north abutment and wing wall are integral with the gate house and are intact. The south (right) abutment and wing wall are in poor condition. Each element

of the dam that remains in place is discussed below. An overall view of the dam site is given in Photograph 12 and the north abutment is shown in Photograph 14. Other elements of the dam appear in Photographs 13, 15 and 16 (Appendix C).

South Abutment and Wing Wall

The south abutment and wing wall was constructed from large squared stone blocks. Joints between the blocks were not mortared. Sections of this stonework have collapsed and others have tilted (see Photograph 13, Appendix C).

Base of Dam

The base of this dam could be reasonably well examined after reducing the water flow through the Kesslen Dam. The base is a concrete slab cast directly onto bedrock. The concrete appears to be in good condition. Erosion and scaling have occurred on the face of the northern segment of this base where it is raised above the present river flow line (see Photographs 13 and 14, Appendix C).

North Abutment and Wing Wall

The continuation of the upstream face of the north abutment becomes the north wing wall (see Photograph 15, Appendix C). It has severe scaling below the level of the dam crest and almost none above that level. The corner of the wall beside the river has eroded to a height of about 3 ft and to a maximum depth of about 12 in. (see Photograph 16, Appendix C). This is probably due to freeze-thaw action and the flow of water over the dam crest at the abutment. The upstream face of the wall also forms support for the gate house and supports the metal gate and gate mechanism used to control the water flow into the canal leading to the generator. This gate is rusted and beyond repair. The

wall parallel to the river shows no scale or other form of deterioration, except at the base where the flow of water and freeze-thaw action have caused erosion into the wall to an estimated depth of 12 in. and to a height of about 2 ft. The foundation of the abutment where it is exposed along the river is founded on bedrock.

Sewer Easement

A sewer line crosses the river just upstream from the dam site. It has been placed in a trench cut into the rock and then encased in concrete. Reconstruction of the dam will have no detrimental effect on this sewer. However, the dam should not extend over the sewer.

6.3 Conceptual Design

6.3.1 Twine Mill Dam

Two types of dams were considered in the conceptual design. The first is a concrete gravity structure and the second a wood structure. A stability analysis was performed on both types of structures using the flow value, dimensions and elevations, including a +13 ft crest elevation above base, that were supplied by Mr. Mike Harper, Consulting Engineer, Energy Systems, Peterborough, NH. A layout of the dam is given in Appendix D-1.

The concrete gravity dam was taken as an ogee weir section that also functions as the spillway (see Appendix D-3). This will be incorporated into the breached portion of the original dam. A 3-ft deep concrete seepage cut off trench was included beneath the dam and a bucket deflector installed along the toe. The latter will deflect the spillway discharge and prevent erosion at the toe of the dam. The first section of the original dam on the south side will also act as a spillway, giving a total spillway width of about 90 ft. At the maximum recorded flow rate of

2830 cfs, the crest will be overtopped to a depth of about 4 ft requiring a base width of 20 ft for stability against overturning and sliding. The toe pressure developed is about 2300 psf (compression) which is well within the allowable capacity of both the rock and the concrete. During periods of normal flow, flashboards are suggested on the original portion of the dam to direct the flow over the ogee section. This will reduce erosion at the unprotected toe of the old dam by directing it over the ogee section and the deflector.

The stability analysis was performed for a condition of maximum water flow and earthquake. Other combinations of loadings should be examined in final design, including those of ice pressure with normal water and earthquake, and possibly those producing a silt deposit along the upstream face. Alternatives to the bucket deflector should also be examined including possibly heavy rip-rap stone protection.

Elements of the existing dam were retained to the maximum extent possible. Allowance has been made for removal and replacement of the wall leading to the gate as it has been severely damaged by erosion and weathering. The grate, gate, and gate mechanism must be replaced. The south wing wall must be extended an estimated 20 ft for a proper tie in to the valley wall and a transition wall is anticipated at the juncture of the new and proposed extension. Other existing concrete elements can be repaired and retained. Repair will consist of the removal of all loose material on the concrete by means of chipping followed by sand or water blasting. Spalled areas will need to be chipped out and dry packed with a 1 to 2.5 cement and sand mortar placed on top of a 1 to 1 cement and sand brush coat. It is extremely important that this work be done properly to insure that a good bond is developed. Scaled areas can be refaced with a pneumatically applied 1 to 4 cement-sand mortar placed in 3/4 in. thick layers. This will protect the concrete against additional deterioration and can most easily be accomplished during dam reconstruction.

One additional new element will be the construction of a buttress wall between the ogee section and the existing south portion of the dam. This will provide an effective connector and transition between the new and the old work. It will also add to the stability of the dam.

No provision has been made for a low level outlet gate. This is believed to be unnecessary because a combination of water flow control at upstream dams and the drawdown capacity of the penstock should adequately dewater the reservoir at periods of low flow. However, a need for a low level outlet should be addressed during final design. Also, no provision for a fishway has been included because the State of Maine is not expected to request one at this site.

The wood deck and frame section is an alternative to the ogee section described above. The typical section is given in Appendix D-4. All other elements of the dam would remain the same as described for the concrete gravity dam. Timbers would consist of nominal 12 x 12 southern yellow pine or equivalent. The wood should be treated against decay, termites and fungi. The Wolman chemical pressure treatment with 0.4 lb/ft^3 of chemicals will probably be the most desirable, as it exudes no chemicals that are harmful to fish or plant life nor will it leach out. A creosote treatment can also be used and will be equally effective and comparable in cost to the Wolman process, but some leaching does occur. A structural analysis sufficient for costing has been made, but a more thorough one will be required prior to finalizing the dam design. The wood dam facing is anticipated to be 4 in. tongue and groove plank. Bolts should be galvanized, or mortise and tenon joints should be used. A new base will probably need to be placed to form an even surface to support the frame of the dam. Expected life of the deck and frame members is 40 to 50 years.

6.3.2 Rogers Fiber Dam

Two types of dams were considered in the conceptual design. One is a concrete gravity structure and the second is a wood structure. A stability analysis was performed on both structures using the flow value, dimensions and elevations supplied by Mr. Mike Harper, Consulting Engineer, Energy Systems, Peterborough, NH. A layout of the dam is given in Appendix D-2.

The concrete gravity dam section was taken as an ogee weir wherein the dam itself performs the function of a spillway. The ogee section is shown in Appendix D-4. This will be inserted between the existing north (left) abutment and a rebuilt south (right) abutment. A 3 ft deep concrete seepage cut-off trench was included beneath the dam and a bucket deflector on the toe. The latter will deflect the water flow and prevent undercutting of the toe of the dam. At a maximum flow of 2830 cfs the crest will be overtopped to a depth of about 3.5 ft for the full 105 ft crest length. This requires a base width of about 18 ft for stability against overturning. The toe pressure will be about 2300 psf which is well below the compressive strength of either the rock base or proposed concrete.

The stability analysis was based on a maximum flow condition plus earthquake. Other combinations of loading should be examined in final design to assure that the most severe condition is determined. Ice pressure plus normal water flow pressure and earthquake should be investigated.

Elements of the existing dam were retained to the maximum extent possible. These include the north abutment and wing wall and the wall containing the gate that controls water flow into the turbine, although the gate itself must be replaced. The existing dam base may also be utilized but this will require further examination prior to final design. Repairs to the existing

concrete will be required of the nature described previously for the Twine Mill Dam. The eroded portion of the abutment must be replaced.

The south abutment and wing wall are constructed of unmortared stone block and are in a state of collapse. They should be entirely rebuilt both due to the present instability and the potential for leakage through the open joints. It is anticipated that the new wall would be constructed of concrete founded on bedrock and would be about 3 ft thick, 20 ft high and 50 ft long. A topographic survey will be required and the actual dimensions and location must be determined in final design. It also may be influenced by subsurface conditions. The new wall could follow the alignment of the existing wall (most probable) or be reoriented along the dam axis until tying into the bank. A 3 ft thick buttress type wall perpendicular to the dam axis could be included to form the dam section to wing wall interface and act as an abutment on the south side. It is anticipated that this would be about 20 ft high and 20 ft long.

A drawn down gate probably will not be required. The control on water flow that can be expected by the upstream dams plus the flow provision through the gate to the turbine should suffice to draw down the reservoir in times of low water and permit repair work. However, a cost analysis to include a gate has been made. It is visualized that this will require the addition of a second buttress wall, a gate wall, protective grate, and gate lifting mechanism.

The existing wood frame must be dismantled and removed. The stone block that formed the south abutment and wing wall also must be removed. These may be reusable as rip-rap at the toe of the dam thereby eliminating the need for the bucket deflector or other energy dissipator.

Comments on the wood deck and frame deck will be the same as given previously with regard to Twine Mill Dam.

6.4 Water Control During Construction

Water must be controlled during construction to provide dry working conditions and to protect the new construction. The cost of water control and the danger of damage due to construction can be minimized by scheduling the work for the low flow period. Cooperation from upstream dams at critical periods also could prove to be beneficial. One concept for dewatering that might be used is presented below. The contractor may devise simpler and less costly methods based on actual flow conditions at the time the work is being performed. If a draw down gate should be included, the amount of water diversion could be reduced by constructing it prior to the central dam construction. Sheet piles are doubtful for use of Twine Mills and impossible at Rogers Fiber due to the presence of bedrock.

6.4.1 Twine Mill Dam

The concept for dewatering at the Twine Mills site is based on the use of sand bags, some pumping, and sectionalized construction, as follows:

1. Place sand bags to divert water away from the north abutment, gate and gate approach wall, and reconstruct these features.
2. Redirect the water through the gate and away from the central part of the dam that is to be replaced. Excavation to allow water flow around the end of the south wing wall at a lower elevation would provide safety against flooding the work. Construct the new center portion of the dam.

3. Construct a sand bag barrier to prevent flow into the south wing wall and around the end of the wall. Overflow across the newly completed dam section will provide safety for flows that exceed the gate capacity.
4. Reconstruct the south wing wall.

6.4.2 Rogers Fiber Dam

A similar system of sand bags and pumping can be applied to the Rogers Fiber Dam with the north wing wall, gate, north abutment and probably the upstream slanted portion of the central dam section sand bagged off and reconstructed first. With water next diverted through the gate and around the south abutment, the remainder of the central portion of the dam and south abutment can be completed. Finally, with water diverted over the dam and through the gate, the south wing wall can be constructed.

6.5 Cost Estimates

The following is a tabulation of the estimated construction and engineering costs for both the concrete and wood dams at each of the two sites. The estimate does not include the appurtenant structures and facilities such as powerhouses, penstocks or forebays. The construction cost estimate is based on March 1979 prices and an escalator of about 10 to 15 percent per year should be used to account for time delays. The estimate does not make allowance for grouting on the assumption that the original dams were successful without it. Also, should grouting be necessary, present data is insufficient to make any logical estimate of the quantity required. Unit cost figures for grouting, however, are included. The accuracy of the construction cost estimate is about +25 percent due to lack of a topographic survey and subsurface information, and the fact that calculations sufficient only to conceptualize

the dam have been made. *Maintenance costs have not been evaluated to determine the long range cost effectiveness of concrete versus wood structures.* (See Tables 29 and 30).

The engineering estimate allows for design, construction inspection, survey and subsurface investigation (see Table 31).

6.6 Safety Assessment

The hazard potential for Twine Mills and Rigers Fiber Dam is based on the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams, dated November, 1976. In the event of failure of the reconstructed dams, loss of life is not expected to occur although appreciable economic loss may occur. Therefore, these dams are classified in the "significant" hazard category based on the Corps of Engineers guidelines. (See subsection 6.6.2 for permit considerations with regard to safety.)

6.7 Permit Procedure

The procedure that must be followed to obtain permits for reconstructing the Twine Mill and Rogers Fiber Dams has been investigated. The following summarizes the agencies involved and their licensing procedures. A detailed description of all aspects of this subject is beyond the scope of this report and for full details, reference is made to the reports on this subject that recently have been prepared by the Franklin Pierce Law Center, Concord, NH. Their report was prepared for the United States Department of Energy. The findings of this investigation suggest that the permit procedure can be rather lengthy, as it involves agencies at both the Federal and State levels. The importance of early initiation of a complete application procedure can be seen. The following agencies were contacted.

Table 29. Construction Cost (1979 Prices) - Twine Mill

Concrete Section

1.	Gravity ₃ section, including bucket deflector 470 yds ³ @ \$110 /yds ³	\$ 51,700
2.	Clean and prepare base 1200 ft ² @ \$1/ft ²	1,200
3.	Remove existing concrete (gate approach wall) 1024 ft ³ @ \$2/ft ³	2,050
4.	Replace gate approach wall 68 yds ³ @ \$110*/yd ³	14,950
5.	Replace gate to penstock and trashracks	8,000
6.	Construct south abutment wall 68 yds ³ @ \$110*/yds ³	14,950
7.	Construct south wing wall extension	
	Concrete - 16 yds ³ @ \$200*/yds ³	3,200
	Excavate rock - 50 yds ³ @ \$50/yds ³	1,500
	Excavate soil - 15 yds ³ @ \$6.50/yds ³	100
	Add abutment - 22 yds ³ @ \$200*/yds ³	4,400
	Key exiting walls & extend walls	500
8.	Resurface and repair of concrete	
	Gatehouse wall - 300 ft ²	
	North wing wall - 1700 ft ²	
	South dam section - 700 ft ²	
	South wing wall - $\frac{1200 \text{ ft}^2}{3980 \text{ ft}^2} @ \$3/\text{ft}^2$	11,940
9.	Water control - lump sum	15,000

Table 29. Construction Cost (1979 Prices) - Twine Mill
(Continued)

Concrete Section (Continued)

10. Miscellaneous site preparation and access	\$ 2,000
Subtotal	131,490
Contingency of 10 percent	<u>13,150</u>
Total Construction Cost of Concrete Dam	<u>\$145,000</u>

* Includes concrete, forms, keyways, waterstops, placing and curing and cut-off wall excavation and replacement.

Wood Section

Everything same except for item 1 above

= (131, 490 - 51,700) =	79,790
Cost of woodwork =	<u>17,350</u>
Place new base - 63 yds ³ @ \$80/yds ³	5,040
Place seal-at-base - 60 yds ³ @ \$80/yds ³	4,800
Place rip-rap - 100 tons @ \$20/tons	<u>2,000</u>
Subtotal	108,980
Contingency of 10 percent	<u>10,900</u>
Total Construction Cost for Wood Dam	<u>\$120,000</u>

Table 30. Construction Cost (1979 Prices) - Rogers Fiber Dam

Concrete Section

1.	Gravity section including bucket deflector 774 yds ³ @ \$110/yds ³	\$ 85,150
2.	Repair north abutment 9 yds ³ concrete @ \$250/yds ³	2,200
3.	Construct south abutment 67 yds ³ @ \$180/yds ³	12,000
4.	Construct south wing wall 120 yds ³ @ \$200/yds ³	24,000
5.	Excavation for south wing wall 50 yds ³ @ \$25/yds ³	1,300
6.	Remove granite blocks from south wing wall and place as rip-rap - 200 yds ³ @ \$5/yds ³	1,000
7.	Replace existing gate to penstock and trashrack	7,500
8.	Remove existing wood frame work	2,000
9.	Clean and repair existing concrete base	1,900
10.	Water control - lump sum	15,000
11.	Miscellaneous site preparation and access	<u>2,000</u>
	Subtotal	\$154,050
	Contingency of 10 percent	<u>15,405</u>
	Total Construction Cost of Concrete Dam	<u>\$169,500</u>

Wood Section

Everything same as for concrete except item 1 above

$$= (154,050 - 85,150) = 68,900$$

Cost of woodwork: 33,220

Table 30. Construction Cost (1979 Prices) - Rogers Fiber Dam
(Continued)

Wood Section (Continued)

Place new base 120 yds ³ @ \$80/yds ³	9,600
Place seal at base 115 yds ³ @ \$80/yds ³	9,200
Place rip-rap 158 tons @ \$20/ton	<u>3,160</u>
Subtotal	\$124,080
Contingency of 10 percent	<u>12,410</u>
Total Cost for Wood Dam	\$136,500

If a drawdown gate were added, the cost of either a wood or concrete dam at either site would add an estimated \$22,500 to the cost.

The cost of the wood dam is about 83 percent of the cost of the concrete dam at the Twine Mills site for a saving of about \$25,000. At Rogers Fiber Dam the wood will cost about 80.5 percent of the cost of the concrete or \$33,000 less. The maintenance for a wood structure will probably be somewhat more.

Table 31. Engineering Cost Estimate

Twine Mills Dam

Test borings	\$11,500	
Survey	1,200	
Engineering	<u>21,500</u>	
Design total		\$34,200

Rogers Fiber Dam

Test borings	13,000	
Survey	1,200	
Engineering	<u>24,000</u>	
Design total		\$38,200

Inspection and construction services estimated at about \$2,500 per week to cover both sites (not included above). Construction costs (1979 prices) including engineering costs (exclusive of maintenance costs, environmental impact statement, permit application costs and inspection during construction).

Twine Mills Dam

Concrete	145,000 and 34,000	179,000
Wood	120,000 and 34,000	154,000

Rogers Fiber Dam

Concrete	169,500 and 38,200	208,000
Wood	136,500 and 38,200	175,000

6.7.1 Federal

- a. Federal Energy Regulatory Commission, New York City Office, Mr. Martin Imwald, Tel. (212) 264-1160 and Washington D.C. Office, Mr. Edward Abrams, Application Branch, Tel. (202) 275-4981.
- b. U.S. Army Corps of Engineers, New England Division, Mr. Morgan Reese, Permits Division, Tel. (617) 894-2400.

Of the Federal agencies, the one with primary concern is the Federal Energy Regulatory Commission (FERC). Apparently, a declaration of intent must be filed with them and from this, they themselves determine whether or not they have jurisdiction. The FERC will have jurisdiction if the Mousam River has ever been, or may become, navigable (including having been used in log drives), will affect interstate commerce; will derive water from government dams; or will utilize any Federal land. The FERC also has the power to require fishways in any dam. The FERC will issue a preliminary permit to secure the site while studies are being completed. There is now a short application form for dams of less than 1.5 mW generating capacity. Dams qualifying for the short form will not require an environmental impact statement. Action time with FERC for minor dams is 1 to 2 years.

A permit also must be obtained from the United States Army Corps of Engineers. The Corps also is required to approve licenses being issued by FERC wherever navigable waters are involved. The Corps licensing powers for dam construction are limited to dams on navigable waters but the license for dredging operations pertains to all waters.

The United States Environmental Protection Agency (EPA) will require certification from the State of Maine Department

of the Environment that the Clean Water Act has been followed. The FERC will require this from EPA before issuing a license.

The United States Fish and Wildlife Service of the Department of the Interior must be consulted by both the FERC and the Corps of Engineers prior to either of these agencies issuing a permit. The Heritage Conservation and Recreation Service of the Department of the Interior also may be required to comment. However, the applicant apparently need not contact these agencies directly.

6.7.2 State

- a. Office of Energy Resources, 55 Capital Street,
 Augusta, ME, MR. Gerald Dawbin.
- b. Department of Environmental Protection, Ray Building
 Hospital Street, Augusta, ME, Mr. Normal Marcotte
 and Mr. Teco Brown, Tel. (207) 289-2111.
- c. Public Utilities Commission, 242 State Street,
 Augusta, ME, Mr. Normal Leonard and Ms. Ruth White
 (Acting Secretary), Tel. (207) 289-2446.
- d. Soil and Water Conservation Commission, State Office
 Building, Augusta, ME, Mr. Frank Ricker, Executive
 Director, Tel. (207)
- e. Department of Inland Fish and Wildlife, 284 State Street,
 Augusta, ME, Mr. Charles Ritzl, Tel. (207) 289-3206.
- f. Department of Marine Resources, State House,
 Augusta, ME, Mr. Vinol Look, Commissioner and
 Mr. Lewis Flagg, Tel. (207) 289-2291.

- g. Land Use Regulatory Commission, Ray Building,
Hospital Street, Augusta, ME, Mr. Tom Radsky,
Tel. (207) 289-2631.
- h. Department of Transportation, State House,
Augusta, ME, Mr. Larry Roberts, Design Division,
Tel. (207) 289-3171.

The Office of Energy Resources, in the person of Mr. Gerald Dawbin, has the best overall knowledge of the state licensing requirements and procedures. Mr. Dawbin recently has made a survey of the agencies involved and contact with him could be helpful to the applicant. The three principal agencies in Maine that must be satisfied are the Department of Environmental Protection, the Department of Inland Fish and Wildlife, and the Soil and Water Conservation Committee.

The Department of Environmental Protection administers both water quality and the Great Ponds Act. The Great Ponds Act requires a permit for all artificial impoundments in excess of 30 acres, and it appears that Twine Mill Dam will exceed that limit. It will not affect the Rogers Fiber Dam. However, the DEP also requires a Water Quality Certification for impoundments under 30 acres, which will apply at Rogers Fiber Dam.

The Maine Department of Inland Fish and Wildlife administers the Stream Alteration Act. This act appears to control impoundments of under 30 acres on any stream, and therefore, will pertain to the Rogers Fiber Dam. They also will have the final decision on the need to include fishways (not anticipated at this time) and they will coordinate with the Department of Maine Resources on this matter for sea run fish. Mr. Ritzi of the Fish and Wildlife Department indicated that permits will not be needed from both the DEP and the Fish and Wildlife on any one dam.

The Soil and Water Conservation Commission retains responsibility for dam safety. They refer to the Department of Transportation for assistance in engineering evaluation. Apparently, the above Departments coordinate their permits with the Soil and Water Commission but the latter could not be determined to have a direct licensing role. As of this writing, the State of Maine does not have a dam safety engineer. However, there is legislative provision for one and if the position should be activated, it probably would impact the licensing procedures from a safety standpoint.

The Land Use Regulatory Commission (LURC), Department of Energy, and the Public Utilities Commission (PUC) do not issue dam construction permits. The LURC's jurisdiction is limited to unorganized townships and the PUC is concerned only with financing procedures and rate regulation. The Department of Marine Resources will not have jurisdiction because the dams are above tidewater, however, the Department of Inland Fish and Wildlife must coordinate with them before issuing a permit. The DMR may require a fishway in Rogers Fiber Dam in the future to accommodate an alewife run.

7. TURBINE ALTERNATIVES

7.1 Introduction

This section deals with the selection of turbine designs, sizes, and manufacturers for each of the seven dam sites. Turbine manufacturers were contacted, and their technical and pricing literature requested. The inventory of used equipment in the eastern United States was investigated so as to try and locate suitable used equipment. Field studies of the existing equipment at all sites were conducted. Equipment was inspected for wear, corrosion, and general mechanical integrity.

The results of this study are as follows:

- There are at least eight turbine manufacturers who can supply machines in the sizes required for the Mousam sites. A list is provided.
- A recommendation has been made for each site as to the type and size turbine which would be suitable.
- In general, if a used machine is available, it should be chosen as it is more economically attractive than a new unit.
- Used machines are difficult to locate.
- Reaction type turbines are required at all sites.

7.2 Technical Discussion

The various sites under consideration in this study have reasonably high differences in head, ranging from a low of about

2.5 m (8 ft) to a high of almost 20 m (60 ft). It follows, therefore, that there are a number of reaction turbine types and configurations which may be applicable to these sites.

Figures 5 and 6 are selection charts covering various types of runners. All the heads are too low to permit serious consideration of impulse runners, so that the choice is limited to various forms of reaction runners, viz: Francis, Banki, Kaplan and Propeller. At this time, there are several manufacturers of new equipment which would be applicable to various sites, and the programs of these manufacturers are as follows:

- Allis Chalmers - This U.S. company, drawing on its long experience, now offers a range of semi-packaged axial flow units, incorporating a variable-pitch propeller runner, with fixed guide vanes. Throat diameters from 750 to 3,000 mm are covered in the standard range, giving outputs from 50 kW at 2 m head to 500 kW at 15 m. An alternative fixed-blade runner is available for fixed-flow applications.
- The James Leffel and Company - This, the oldest surviving U.S. turbine manufacturer, has a range of Francis and Propeller designs reflecting over a century of experience, but at this time does not appear to be offering a "standardized" design, so that all of its units are still custom-built. The existing unit at Kessler Mill is a Leffel machine, and Leffel are now the owners of the old Rodney Hunt turbine business, which built the existing turbine at Twine Mill.
- Gilbert Gilkes and Gordon Ltd. - This very old English company offers Francis and Propeller designs, but, like Leffel, has no standardized unit. Its

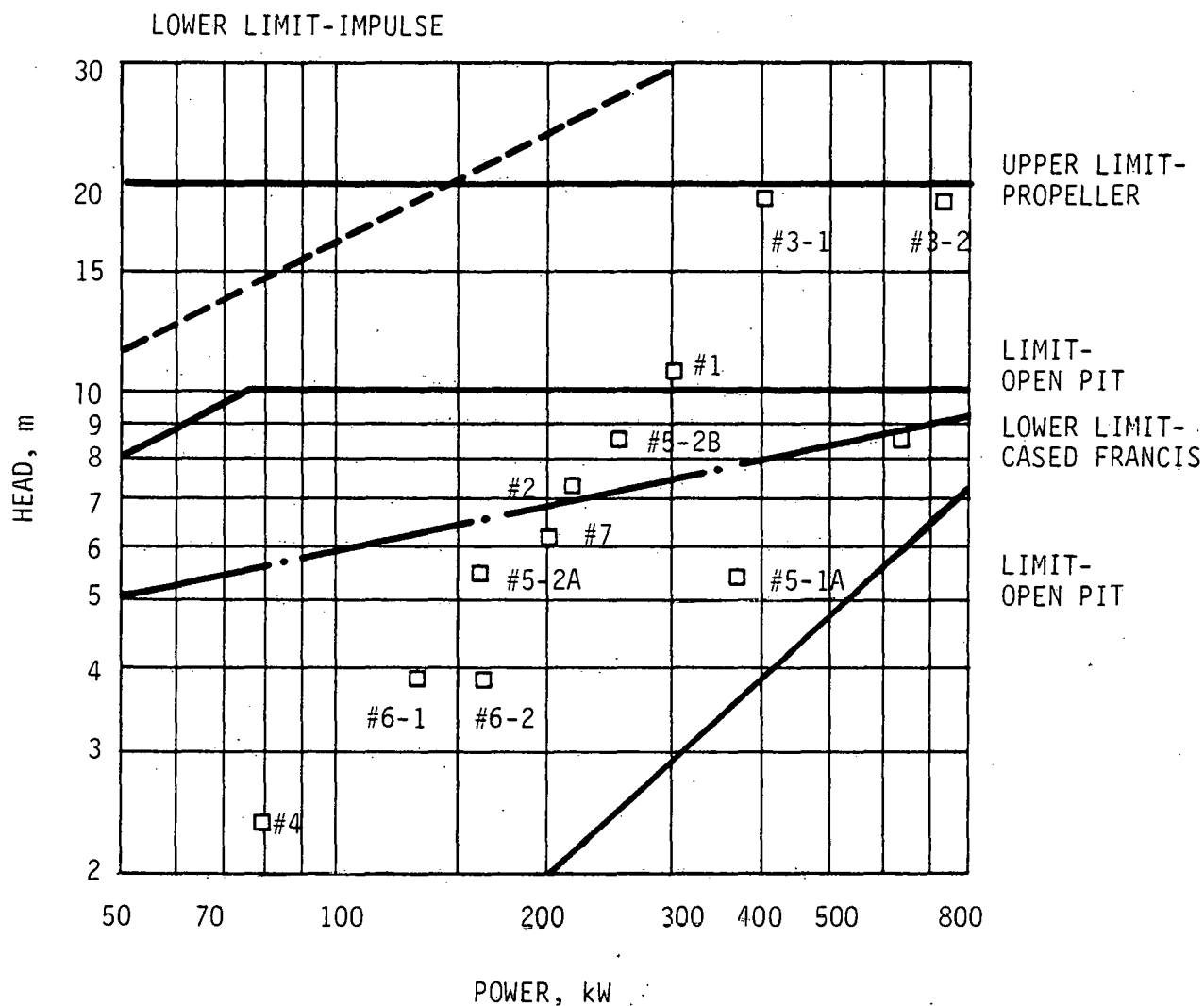


Figure 5. Water Turbine Selection Chart - 1

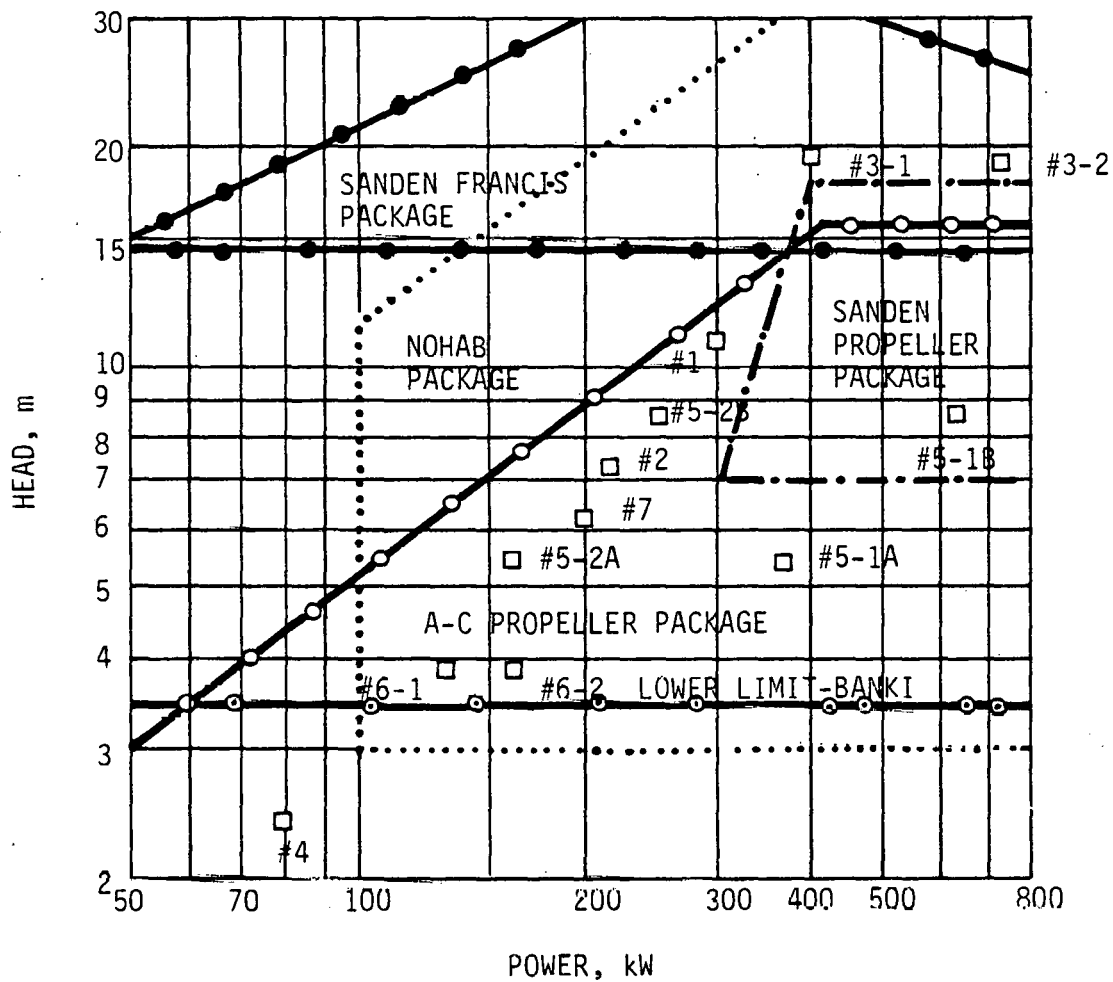


Figure 6. Water Turbine Selection Chart - 2
 Note: Numbers next to indicate site and unit number

experience is worldwide, with an excellent reputation for quality and efficiency.

- Bofors-Nohab Ab. - This experienced Swedish company now offers packaged designs covering almost exactly the same range as Allis-Chalmers and with both variable-pitch and fixed-blade runners. It appears that they are able to offer a wider range of flow configurations than Allis-Chalmers and therefore may be more competitive for certain sites covered by the study.
- Sørumsand Verkstad A/S (Sanden) - This company is the water-turbine subsidiary of the Norwegian Kvaerner Group, with worldwide operations. Sanden offers two types of packages: an axial flow unit similar to Allis-Chalmers and Nohab, again with both fixed- and variable-pitch blades; and a Francis unit covering somewhat lower unit powers than the tubular machine. Marketing and service in the U.S. is in the hands of Brown Boveri Corporation.
- Ossberger AG - This German company, represented in North America by a Montreal agent, manufactures a cross-flow turbine of the Banki type and must be considered as a possible source for the medium head sites in the study. The design has some first-cost advantages but care must be taken in selection of equipment for northern sites as there is some evidence that the design is not as tolerant of ice-ingestion problems as are the propeller and Francis runners.

- Straflo Group - This subsidiary of the Swiss Sulzer Group offers the straight-through flow design developed by Escher-Wyss of Zurich. In this design the turbine propeller runner carries the alternator rotor on its periphery; over 70 installations in Germany and Austria since 1930 have proved reliable, although the water seal assembly necessary to eliminate flooding of the rotor would appear to be a fairly high-maintenance item.

The Straflo is offered down to diameters of about 1200 mm, which would be an excellent size for most of the Mousam sites, but it does not appear that the generator is economical under about 2.0 mW.

- Fuji Electric - This Japanese company offers a range of packaged standard Bulb designs starting at 1250 mm, but again the problems of generator cost and shaft seal reliability probably render the unit uneconomic at sizes under about 800 kW at the heads and flows involved on the Mousam.

There are a number of other manufacturers in Japan, Scandinavia, Western Europe, Canada, and Russia, but none have the type of manufacturing program which may be expected to offer the low-cost equipment which will be necessary to justify development of most of the Mousam sites.

From time to time, used turbine equipment comes onto the market, but much of it is of old design and has seen long service and sometimes arduous conditions, so that the cost of restoration may, in some cases, approach that of new equipment. Great care must be taken in the application of old equipment to new sites; For example, most experienced hydraulic designers would be reluctant to see a unit applied to a new site where the head variation

from its original site is greater than about 5 percent, without an appropriate change in running speed. This may well require the scrapping of the original generator, with obvious cost problems, and in addition, great care must be taken that the old shaft is not subjected to excessive torque in its new application.

The following comments apply to the individual sites covered by the study:

- New Dam - There can be no justification at this site for any other course than the retention of the existing Francis 300 kW unit and the restoration to service of the existing inoperative second unit of the same size. It may well be that the provision of new internals (guide cases, gates, runners, shafts and bearings) would result in some increase in flowage (and, thus, power) in both units, and it is possible that careful design of the new components would allow the flow rate for each unit to closely approach the selected "target" rate of $4.0 \text{ m}^3/\text{s}$ ($144 \text{ ft}^3/\text{s}$) which would increase the output to about 325 kW per unit. It is considered that present generators would be capable of delivering this increased output with little or no modification. The fact that it has not been possible, during the conduct of this study, to closely inspect these units, means that cost data for restoration is based on best estimates of likely needs in an overhaul of this nature.
- Whichers Mill - This site is completely abandoned at present and restoration would require the supply of all generating equipment. Figure 6 shows that several options are open. Since the optimum powerhouse location requires the use of a fairly long penstock, it is not practical to consider open pit turbines, but the site head/unit power characteristic

falls within or close to the applications envelope for new, packaged equipment from Allis-Chalmers, Nohab, Sanden, and Banki, plus of course Leffel and Gilkes in "non-packaged" designs. There is at this time no known available used unit(s) of suitable characteristic for this site.

- Old Falls - This is the highest head site on the river and is very close to the practical upper limit of satisfactory experience with "small" propeller turbines, although Nohab claims good results in this area. It is, however, well inside the envelope for cased Francis units, including the Sanden package; conventional Francis machines from Gilkes or Leffel, as well as (possibly) a cross-flow Banki. The present unit is rated at 400 kW, and there is adequate water for an additional 725 kW. There would be certain operational advantages in the addition of two more 400 kW units. No known suitable used equipment exists.
- Dane Perkins - This is the lowest head site and the one best suited to open pit layout. The energy output is, of course, fairly small and new equipment will be too costly. It is, therefore, considered that the used Kaplan unit (out of Dalton, MA) presently on offer to KL&PD by Wind & Water Power Inc., would offer the best solution at this site, giving an output of 80 kW and being relatively easy to install.
- Twine Mill - Whether the head here remains at 5.4 m (18 ft) or is raised to 8.5 m (28 ft) the same remarks apply in regard to turbine applications. The existing Rodney Hunt twin-wheel unit appears to be in reasonably good condition for its age, and should be capable of

restoration, with the use of some new internals. It will, however, be necessary to define the problem which limited the output of this unit in past years to a reported 125 kW, whereas a unit of this size could be expected to deliver 375 kW at 18 ft. If the solution to this problem can be found, it would appear most practical to restore this turbine and fit to it a new generator, switchgear, gate actuator and so on. At 28 ft, the old turbine output should be about 625 kW. Should restoration not be possible, unit sizes for a two-machine package installation would be 160 kW at 18 ft and 250 kW at 28 ft. Both package outputs fall within the range of all manufacturers, while it is apparent that the James Leffel & Co., as the owners of the Rodney Hunt operation, would be the logical supplier of any restoration parts needed for the old turbine.

- Kesslen Mill - The existing 150 kW Leffel unit here is in good operating condition and no major changes to the turbine or its components are contemplated. This unit uses only about 61 percent of the available water, but any increase in plant capacity to improve this usage will be relatively expensive unless used equipment can be used. At present the only known suitable used machine is the Kaplan unit, mentioned earlier. If this machine is not used at Dane Perkins it could be installed at Kesslen, although, in spite of the 170 kW output, the annual energy production would be very slightly less.
- Rogers Mill - This is the downstream site of the study and, like Whichers Mill, a fairly long canal/penstock is involved so that an open-pit installation is unattractive. It falls within or close to, the

propeller package envelope of all the potential suppliers, and conventional propeller or Banki units would be applicable also. Again, no suitable used equipment is currently known to be available.

8. GENERATION ALTERNATIVES AND UTILITY INTERFACES

8.1 Introduction

This section deals with the selection of generating equipment and interface equipment for the Mousam sites.

Synchronous and asynchronous machines were investigated. The present equipment was evaluated to determine whether or not it should be replaced or refurbished. Interface requirements were studied and equipment for interfacing was suggested. Protection equipment was specified.

The major conclusions of this section are that asynchronous (or induction) generators are preferable for new installations and that the existing synchronous machines are repairable. In addition, the switch gear at Kesslen Dam is a hazard and should be replaced as soon as possible. The details of these conclusions and others are clarified in the following section.

8.2 Technical Discussion

The following general considerations apply to the application of A-C generators and control gear to the production of hydroelectric energy from the Mousam River within the area served by KL&PD.

1. The maximum power available from the sites under consideration is of the order to 3.0 mW, or slightly under 30 percent of the present system maximum demand.
2. The electrical arrangement of the KL&PD distribution system is such that it is impossible to run the plants isolated so as to supply even essential loads (hospital, fire station, ambulance and police stations, telephone exchange, gas pumps, traffic lights, etc.) in the event

of storm conditions causing prolonged outage of the bulk supply from CMPC.

3. The present hydro-generation at New Dam, Old Falls and Kesslen Mill incorporates synchronous generators, but these sites are electrically so far apart that, with the possible exception of the limited-output Kesslen site, it is not economically feasible to rearrange the distribution system to provide power for any essential services.
4. If the conditions outlined in 1 through 3 above are accepted, it follows that any hydroelectric generation can only contribute useful energy to KL&PD as long as the distribution system is intact and operating normally with bulk energy being received from CMPC. Thus, any new hydro-generation capacity need not incorporate synchronous generators, but may equally effectively use asynchronous (or induction) generators.
5. The induction generator has the following advantages:
 - a. It is of simple construction similar to that of a squirrel cage motor and thus is cheaper than an equivalent sized synchronous generator.
 - b. As with a squirrel cage motor, its speed is controlled by the *frequency* of the network to which it is connected; thus the turbine need not be equipped with a speed sensing governor which always represents a substantial proportion of the total turbine cost.
 - c. The efficiency of an induction generator is often somewhat higher than that of the equivalent synchronous machine.

- d. It is very easy to connect an induction generator to the system and this can be cheaply incorporated into a semi-automatic control scheme. Synchronizing is not necessary.

There are also disadvantages, namely:

- e. An induction generator cannot operate on its own but can only feed into a synchronous network which must provide the excitation current. Thus, it cannot operate as an independent unit, and if the network (for example, CMP system) breaks down the unit will at once run up to runaway until it is shut down by the turbine overspeed protection.
 - f. An induction generator supplies energy at a lagging power factor, which may require the use of capacitors or other means of correction to offset this condition.
 - g. Care must be taken that the total rating of induction generation does not exceed about 20 percent of the generating capacity of the system to which it is connected. Since this study only contemplates the use of some 2.75 mW of induction generation versus the some 700 mW the CMPC system (for example, 0.0039 percent), it is clear that this last factor is not a problem.
6. It is, therefore, justifiable to retain all the present and repairable synchronous generation (for example, New Dam 600 kW, Old Falls 400 kW, Kessler 150 kW) plus the installation of the ex-Dalton unit at Dane Perkins (80 kW) for a total of 1,230 kW, while any new plant (a possible maximum of about 2.0 mW) can incorporate asynchronous generation without operational penalty.

7. Since the operating owner of the sites will be the utility itself, the coordination of the various protective systems will be relatively simple, requiring close cooperation with the system protection engineering staff of CMPC.
8. The condition of existing switchgear at the present three operating plants varies considerably. At Old Falls the equipment is fairly new and in good repair, requiring only routine overhaul, although the opportunity should be taken to equip the generator with a modern electronic voltage regulator and to standardize the protection system to match that of the other synchronous generators. The present switchgear is capable of extension to accommodate additional generators.

At New Dam it is believed that the present switchgear is of inadequate interrupting capacity for the system growth envisaged, while at Kesslen Mill, there is no doubt that the switchgear represents a major hazard and should be replaced as soon as possible.

9. KL&PD owns a number of 2400 volt Roller-Smith oil circuit breakers manufactured in 1948. The equipment originally comprised a 5-cell switchboard at KL&PD's main substation, but was withdrawn from service a few years ago following a fire in one compartment. One breaker has since been used for other purposes, but three remain and would be capable of low-cost overhaul and rebuilding by the District's own staff for use at New Dam (2 units) and at Kesslen Mill (1 unit). The interrupting capacity of this equipment is 150 MVA, more than adequate for the service envisaged, where fault levels are substantially below 100 MVA.

10. It is proposed that the protection scheme for all the synchronous generators on the system should be standardized and should incorporate the following:

- a. Instantaneous overcurrent (50)*
- b. Time-delay overcurrent (51)
- c. Underfrequency (81)
- d. Undervoltage (27)
- e. Automatic voltage regulation-electronic (90)
- f. Check synchronize (25)
- g. Turbine protection, including as required:
 - i. low water level (63W)
 - ii. low governor (or actuator) oil pressure (63G)
 - iii. bearing over temperature (38)
 - iv. overspeed (12)
- h. Water-level/load controller (65L)

The control scheme will be so arranged that the unit is instantly shut down in event of operation of devices 50, 81 or 27, indicating failure of the CMP system.

It is not considered that the cost of generator winding differential protection (87) or field fault protection (40) can be fully justified on the small synchronous generators at these sites.

11. The used Kaplan unit (for example, Dalton, Mass.) has its own manually operated switchgear, but the opportunity should be taken to update the protection to the standard set forth in paragraph 10.

*Note: The numbers in parenthesis following each component are standard identification numbers for those components. These numbers are accepted by IEEE.

12. For the asynchronous (induction) generators envisioned for any new installations, it is proposed that used circuit breakers and control equipment could be purchased for overhaul and rebuilding by the District's own staff to a standard scheme which would incorporate the following:

- a. Instantaneous overcurrent (50)
- b. Time overcurrent (51)
- c. Underfrequency (81)
- d. Undervoltage (27)
- e. Turbine protection, including
 - i. low water level (63W)
 - ii. low actuator oil pressure (63G)
 - iii. bearing overtemperature
 - iv. overspeed (12)
- f. Water level/load controller (65L)

13. The control schemes, and the protection systems outlined in paragraphs 10 and 12 will allow the plant to run unattended, being manually started and synchronized, but then running at a load determined by available water level. The protection gear will initiate shut-down after a fault, and restarting would be manual after removal of the fault condition. A scheme such as this will require only a brief daily visit to each plant, thus ensuring that the manpower burden is kept to a minimum.

9. GENERAL ECONOMICS AND CONCEPT EVALUATION

9.1 Introduction

This section deals with the economics of the proposed developments along the Mousam. The final figures calculated are the operating cost/kWh, the benefit/cost ratio, and capital cost per installed kW for each site. Many assumptions were made in order to make these calculations but all were discussed with the manager of KL&PD beforehand. Such parameters as amortisation period, cost of capital (interest rate), and labor rates came directly from KL&PD. Costs for major equipment came from quotations supplied by equipment manufacturers. Costs for the dams excluding engineering were obtained from Metcalf and Eddy, Inc. of Boston as part of their subcontract. Operation and maintenance annual costs were estimated at 2.5 percent of the total capital cost. Contingency costs were estimated at 10 percent of the project costs excluding engineering design and project management. The project life is expected to be 50 years.

Table 32 summarizes the results of this section.

The present "go-no go" decision point for redevelopment is \$0.0301/kWh which is the bulk power cost from CMP. Below this figure the redevelopment is presently justified. Above this cost, the development is not justified based on *present costs* of power from CMP, and estimates of when in the future sites 5, 6, and 7 will become economically attractive for redevelopment is extremely difficult to predict because of the uncertainty in the costs of imported crude oil and thus power costs from CMP.

9.2 Technical Discussion

In evaluating the various alternative development concepts, the following assumptions have been made:

Table 32. Cost per Kilowatt-Hour for Each Site Along the Mousam River, Kennebunk, Maine.
Listed in Order Economic Preference

<u>Site No.</u>	<u>Site Name</u>	<u>Benefit/Cost</u>	<u>Cost/kWh</u>	
1.	Kesslen Mill	6.689	\$0.0045	} Redevelopment recommended at present time
2.	New Dam	1.528	0.0197	
3.	Twine Mill	1.420	0.0212	
4.	Old Falls	1.194	0.0252	} Future redevelopment possible
5.	Dane Perkins	0.705	0.0427	
6.	Whichers Mill	0.579	0.0520	
7.	Rogers Mill	0.451	0.0667	

1. All values are based on May, 1979 costs. Escalation rates for construction and equipment costs can be expected to be 15 percent per year. Energy costs are expected to escalate at even higher rates.
2. Permit costs were estimated for procuring a FERC minor permit and other required permits. Discussions with FERC personnel were held to arrive at these estimates.
3. The amortisation period is assumed to be 30 years.
4. The rate of interest is assumed to be 7 percent.
5. Benefit cost ratios are calculated as follows:
 - The "benefit" is the savings of the cost of power from CMP to KL&PD which is \$0.0301/kWh. Other benefits such as the recreational benefits of such redevelopments are difficult to quantify and thus have not been included.
 - The "cost" is the capital, interest, maintenance, and operations cost of each redevelopment. The cost is represented in terms of dollars per kWh.

Tables 33 through 39 show the estimates of cost for the various sites.

It may thus be seen that the undertaking of the recommended work at the first four sites can be justified now, for output from all of them will be at less cost than the present value of bulk power for CMP which is \$0.0301/kWh. Further, it is likely that legal requirements for these four sites will be far less than for the redevelopment of the remaining three sites, all of which require virtually new installations (dams, powerhouses, equipment etc.).

KL&PD does not own two of the four preferred sites, however active negotiations for acquisition of these two plants is presently in progress.

Design should be authorized at once for Kesslen and Twine Mill, so that procurement would allow the relatively minor overhaul program at Kesslen to be undertaken in the summer of 1979 and the construction of Twine Mill to proceed for start-up no later than spring 1980.

No recommendations regarding the program for Whichers Mill, Dane Perkins, or Rogers Mill can be made until there is some clarification of current imported fuel price trends, but it would appear that it may be possible to justify implementation of design following commissioning of the first four sites.

Table 33. Cost Estimates for Redevelopment at
The New Dam Site

Capital Costs

Unit 1

Rewind Generator - Estimated	\$ 14,000
Gate Actuator - Sorenson	9,350
Semi-Auto Control - Estimated (KL&PD Unit)	6,250
Rebuild Switchgear - Estimated (KL&PD Unit)	17,250
Field Labor & Misc. work (960 hrs x \$11.00/hr)	<u>10,560</u>
Subtotal 1	<u>\$ 57,410</u>

Unit 2

New Runner/Shaft Assembly - Estimated	54,500
Rewind Generator - Estimated	14,000
Gate Actuator - Sorenson	9,350
Semi-auto Control - Estimated (KL&PD Unit)	6,250
Rebuild Switchgear - Estimated (KL&PD Unit)	17,250
Field Labor and Misc. work (1,680 hrs x \$11.00/hr)	<u>18,480</u>
Subtotal 2	<u>\$119,830</u>
Subtotal 3	\$177,240
Contingency (10 percent of Subtotal 3)	17,724
Permit Cost	10,000
Engineering Design and Project Management	12,500
Total Capital Cost	<u><u>\$217,464</u></u>

Annual Operating Costs

Interest and Principal	\$ 17,362
Operation and Maintenance (2.5 percent of Total Capital Cost)	5,437
Total Annual Operating Cost	<u>\$ 22,799</u>
Annual Production, kWh	\$1,156,000
Cost/kWh; \$/kWh	0.0197
Benefit/Cost Ratio	1.528
Capital Cost/Installed kW; \$/kW	\$ 724.88

Table 34. Cost Estimates for Redevelopment at
Whichers Mill Site

Capital Costs

Dam Reconstruction	\$ 152,000
Intake Gate	2,775
Trash Rack	3,250
Penstock 300 ft x 8 ft x 0.275 in. wall; 376 lb/ft @ \$1./lb	113,000
P.H. Foundations (55 yd ³ @ \$200/yd ³)	11,000
P.H. Building	12,875
Turbine Generator Units (2) (Allis Chalmers)	535,000
Semi-auto Control	12,500
Substation - Allowance	15,000
Installation (1,248 hr @ \$11.00/hr)	13,728
Engineering - Dam - Allowance	25,000
Subtotal 1	\$ 896,128
Contingency (10 percent of Subtotal 1)	89,613
Permit	25,000
Engineering Design and Project Management	43,000
Total Capital Cost	<u>\$1,053,741</u>

Annual Operating Cost

Interest and Principal	\$ 84,127
Operation and Maintenance (2.5 percent of Total Capital Cost)	26,344
Total Annual Operating Cost	<u>\$ 110,471</u>
Annual Production, kWh	\$2,122,900
Cost/kWh, \$/kWh	\$ 0.0520
Benefit/Cost Ratio	0.579
Capital Cost/Installed kW; \$/kW	\$ 2,450.56

Table 35. Cost Estimates for Redevelopment at
Old Falls Site

Capital Costs

Penstock Modifications	\$ 18,750
Substructure Additions	27,300
Building Extensions	18,650
Newturbine Generator Unit (Allis Chalmers)	445,000
Switchgear	17,250
Semi-auto Control - Unit 1	6,250
Semi-auto Control - Unit 2	6,250
Unit Installation (1,680 hr x \$11.00/hr)	18,480
Substation - Estimated	<u>27,500</u>
Subtotal 1	\$ 585,430
Contingency (10 percent of Subtotal 1)	58,543
Permit Cost	10,000
Engineering Design and Project Management	<u>30,500</u>
Total Capital Cost	<u>\$ 684,473</u>

Annual Operating Cost

Interest and Principal	\$ 54,646
Operation and Maintenance (2.5 percent of Total Capital Cost)	<u>17,112</u>
Total Annual Operating Cost	<u>\$ 71,758</u>
Annual Production, kWh	\$2,848,500
Cost/kWh, \$/kWh	\$ 0.0252
Benefit/Cost Ratio	1.194
Capital Cost/Installed kW; \$/kW	\$ 944.10

Table 36. Cost Estimates for Redevelopment at
Dane Perkins Site

Capital Costs

Dam Restoration	\$ 46,000
Trash Rack	3,250
Intake Gate	2,775
Civil Works	21,650
Building	12,875
Turbine-Generator Unit (Used)	56,000
Semi-auto Control	6,250
Installation (960 hr x \$11.00/hr)	<u>10,560</u>
Subtotal 1	\$ 159,360
Contingency (10 percent of Subtotal 1)	15,936
Permit	4,396
Engineering Design and Project Management	15,500
Total Capital Cost	<u>\$ 195,192</u>

Annual Operating Cost

Interest and Principal	15,583
Operation and Maintenance (2.5 percent of Total Capital Cost)	<u>4,880</u>
Total Annual Operating Cost	<u>\$ 20,463</u>
Annual Production; kWh	479,100
Cost/kWh; \$/kWh	\$ 0.0427
Benefit/Cost Ratio	0.705
Capital Cost/Installed kW; \$/kW	\$ 2430.90

Table 37. Cost Estimates for Redevelopment at
Twine Mill Site

Capital Costs

Dam Reconstruction	\$ 179,000
Intake Gate	2,775
Trash Rack	3,250
Penstock Overhaul	2,600
Turbine Overhaul - Allowance	75,000
Speed Increase and Clutch	9,550
Generator - Allowance (used motor)	20,000
Switchgear	17,250
Semi-auto Control	6,250
Substation - Allowance	15,000
Installation (1,248 hr @ \$11.00/hr)	13,728
Subtotal 1	<u>\$ 344,403</u>
Contingency (10 percent of Subtotal 1)	34,440
Permit	20,604
Engineering Design and Project Management	34,700
Total Capital Cost	<u>\$ 413,147</u>

Annual Operating Cost

Interest and Principal	34,661
Operation and Maintenance (2.5 percent of Total Capital Cost).	<u>10,853</u>
Total Annual Operating Cost	<u>\$ 45,514</u>
Annual Production; kWh	\$1,685,100
Cost/kWh; \$/kWh	\$ 0.0270
Benefit/Cost Ratio	1.114
Capital Cost/Installed kW; \$/kW	\$ 1102.78

Table 38. Cost Estimates for Redevelopment at
Kesslen Mill Site

Capital Costs

New Switchgear	\$ 17,250
Semi Automatic Control	6,250
Turbine Inspection Allowance	<u>3,500</u>
Subtotal 1	\$ 27,000
Contingency (10 percent of Subtotal 1)	2,700
Engineering Design and Project Management	<u>4,000</u>
Total Capital Cost	<u>\$ 33,700</u>

Annual Operating Cost

Interest and Principal	2,690
Operation and Maintenance (2.5 percent of Total Capital Cost)	<u>843</u>
Total Annual Operating Cost	<u>\$ 3,533</u>
Annual Production; kWh (no increase)	778,100
Cost/kWh; \$/KwH	0.0045
Benefit/Cost Ratio	6.689

Table 39. Cost Estimates for Redevelopment at
Rogers Mill Site

Capital Costs

Dam Reconstruction	\$ 208,000
Intake Gate	2,775
Trash Rack	3,250
Canal Cleanout (5,926 yd ³ @ \$15.00/yd ³)	86,890
Penstock (100 ft x 6 ft x 0.375 in. wall, 282 lb/ft @ \$1./lb)	28,260
P.H. Foundation (42 yd ³ @ \$200/yd ³)	8,400
P.H. Building	12,875
Turbine Generator Unit (Allis Chalmers)	279,000
Substation Allowance	15,000
Semi-Auto Control	6,250
Installation (960 hr @ \$11.00/hr)	<u>10,560</u>
Subtotal 1	\$ 661,260
Contingency (10 percent of Subtotal 1)	66,126
Permit	20,000
Engineering Design and Project Management	<u>36,000</u>
Total Capital Cost	<u><u>\$ 783,386</u></u>

Annual Operating Cost

Interest and Principal	62,543
Operation and Maintenance (2.5 percent of Total Capital Cost)	<u>19,585</u>
Total Annual Operating Cost	<u><u>\$ 82,128</u></u>
Annual Production; kWh	\$1,231,500
Cost/kWh; \$/kWh	\$ 0.0667
Benefit/Cost Ratio	0.451
Capital Cost/Installed kW; \$/kW	\$ 1958.47

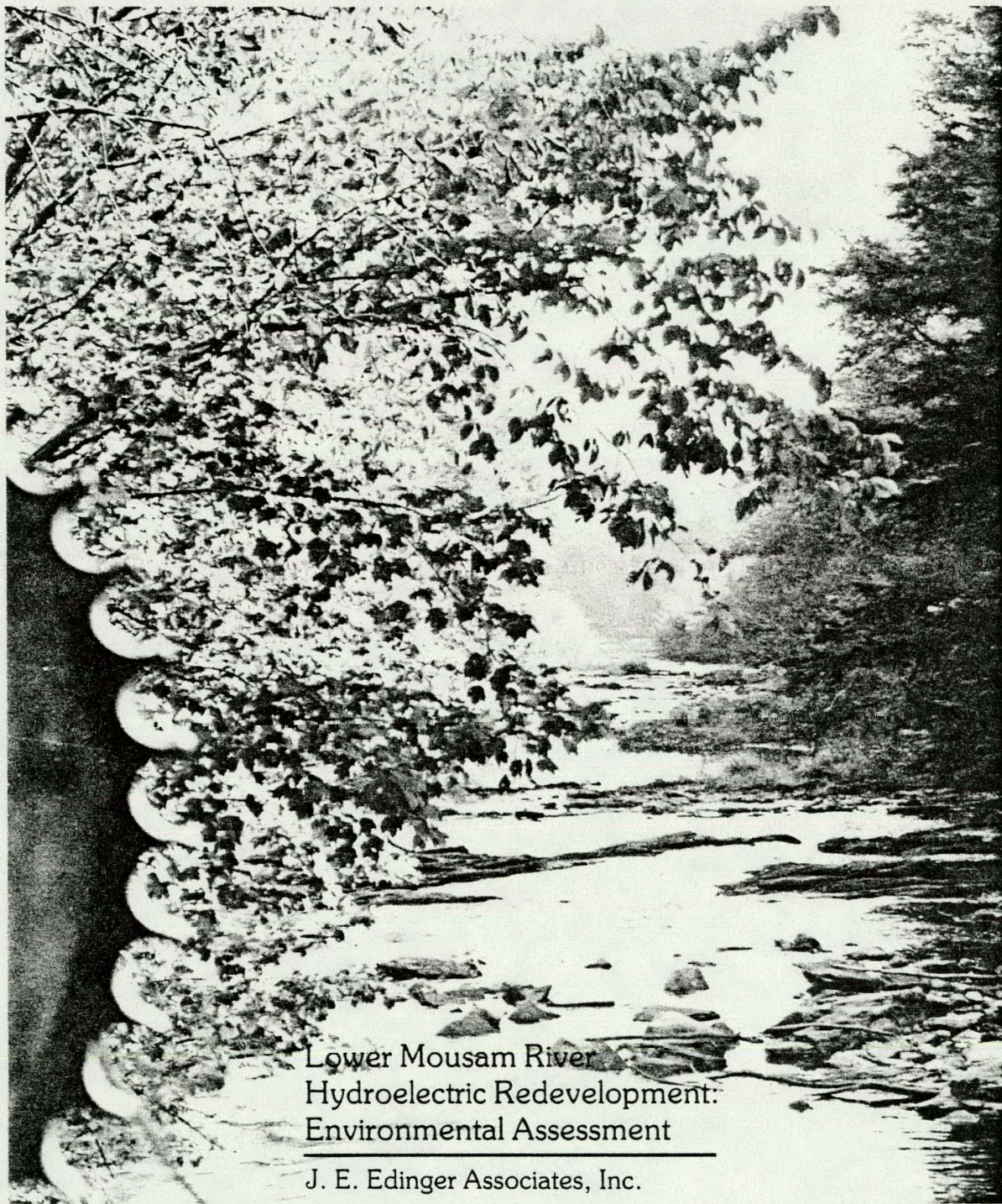
APPENDIX A.

USGS MAP OF THE MOUSAM RIVER PROJECT

Figure A-1. USGS Map of the Mousam River Site System

APPENDIX B.

ENVIRONMENTAL ASSESSMENT OF HYDROELECTRIC REDEVELOPMENT



Lower Mousam River
Hydroelectric Redevelopment:
Environmental Assessment

J. E. Edinger Associates, Inc.

LOWER MOUSAM RIVER HYDROELECTRIC REDEVELOPMENT:
ENVIRONMENTAL ASSESSMENT

Prepared for:
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February 1979

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Lower Mousam River Hydroelectric Redevelopment:
Environmental Assessment

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SUMMARY

This report assesses the impact on the natural and social environment of a proposed restoration of two small hydroelectric impoundments on the lower Mousam River, near Kennebunk, York County, Maine. In addition to raising the two now-breached dams (Rogers Mill Dam and Twine Mill Dam) to their original height, the plan also considers extending Twine Mill Dam 10 feet above its former height and re-regulation of a number of other impoundments in order to operate a total of five dams to maximize useful electric power output.

This report begins with the presentation of basic data and text describing the existing natural and social settings for the restoration. Descriptions of geology and soils, climatology, vegetation and land use, hydrology and water quality constitute the first section of this report. A discussion of recreational, historic, and archeologic resources, as well as population and water use forms the report's second section. The projected impact of the hydroelectric redevelopment plan on these natural and social environments is characterized in the final section of the report.

Much of the available information on the Mousam is basin-wide in scope. Reports available from state and local governments provide data on a county-wide or municipality basis. For these reasons, a field investigation was conducted by the authors during late September 1978. This investigation included both primary data collection in the vicinity of the sites and interviews with county and municipal authorities.

This report, therefore, combines site-specific information with basin-wide descriptive material.

The geology and soils of the Mousam basin are dominated by features associated with the Wisconsin glaciation. The topography of the lower Mousam basin, which lies in the physiographic region known as the Seaboard Lowland, is relatively flat. The Mousam valley is generally V-shaped with small flood plains and the drainage basin as a whole is only moderately integrated with prominent marshes and natural ponds in the upper reaches. These are characteristic of a river in an advanced youthful stage and result from a drainage pattern post-glacial in origin.

Bedrock geology in the Mousam basin is essentially metamorphic with igneous intrusions. Bedrock is believed to be derived from metamorphism of material deposited as a result of repeated marine transgressions, erosion and vulcanism. These bedrock materials are found in both synclinal and anticlinal features in the vicinity of the lower Mousam River.

Soils are primarily sandy loams, with internal drainage properties related to particle size and irregular distribution of glacial drift.

The climate of the Mousam basin is dominated by the frequent movement through the region of three types of air masses: cold, dry polar air; warm and humid air with its source in the Gulf of Mexico; and cool moist air from the North Atlantic. These synoptic characteristics result in two important features of the local climate: changeable weather, with twice-weekly alterations, on the average, between clear, cloudy, and stormy

conditions; and, even distribution of rainfall throughout the year. Average annual precipitation is 40.80 inches and the mean annual temperature is 45.0 F.

Greater than half the Mousam basin, 51%, is forest land. Approximately one-third, 32%, of the basin is urban or built-up, 9% is agricultural land, and the remaining 8% is water, wetland, barren land and rangeland.

The Rogers Mill Dam site is dominated by mixed hardwoods at higher elevations on the north facing slope, while the shallow soils and exposed bedrock at lower elevations support relatively undifferentiated intergrading communities of herbaceous species, alders, and gray birch. The south facing slope supports predominately weedy species, alder, and hardwood saplings.

The more gently sloping north facing slope at the Twine Mill site includes mixed hardwoods and alders down to the water's edge. The south facing slope is zoned into an herbaceous riverine community, an alder zone, and a mixed hardwood-softwood zone.

Extensive forest fires occur at irregular intervals, but with increasing frequency in recent time in southeastern Maine. The most recent large fire occurred in October 1947 and burned approximately 130,000 acres. Large fires were reported as early as 1761 and major fires in the 20th century occurred in 1908, 1941, 1947, 1953, and 1957.

The Mousam River drains an area of 125 mi², dropping a total of 522 feet over its length of 276 miles. The final 3.6 mi, between Kennebunk and the Atlantic Ocean, are considered

to be under the influence of the tide. Mean annual flow for the Mousam is 179 cfs, unadjusted for changes in storage of three large impoundments upstream of the study area. The record low flow was 0.4 cfs, which occurred during the Northeastern U.S. drought of 1964. Two small impoundments, Old Falls Dam and Kesslen Mill Dam, currently generate hydropower in the study area.

Water quality in the Mousam River Drainage Basin is generally considered to be satisfactory. Eutrophication in Estes Lake, upstream of the study area, is thought to be caused primarily by nutrient discharges from the Sanford, Maine waste treatment plant, which uses lagoons to effect secondary-level treatment. This discharge causes high nutrient levels and occasional low dissolved oxygen levels in the Mousam River immediately downstream of Sanford. Dissolved oxygen recovers to satisfactory levels near Kennebunk, a distance of 14 miles. Current plans call for upgrading the Sanford waste treatment plant to remove nutrients.

The Mousam River in the study area is classified as B-2, meaning waters are suitable for water contact recreation, water supply (with treatment), and fish and wildlife habitat. Water quality standards, primarily limits on fecal coliform, dissolved oxygen, and offensive or toxic discharges, to effect these uses are enforced by the Maine Department of Environmental Protection.

There are 38 sites in York County on the national and state registers of historic places. Only the Kennebunk Historic District is close to either the Twine Mill or Rogers Mill Dam sites.

There are no known prehistoric sites of significance in York County. The State Historic Preservation Officer notes that there has been no thorough investigation for such sites in southeastern Maine; the Mousam River drainage basin is therefore considered to be a "sensitive" area. Since both sites have been in prior operation, however, it is doubtful that prehistoric cultural sites remain intact.

Although there are two plant species present in York County being considered for threatened status by the U.S. Fish and Wildlife Service (yellow rein orchis and ram's head lady's slipper), neither was observed at either the Twine Mill or Rogers Mill site. A number of endangered and threatened plant species found in Maine may occur in the Mousam basin, although none was observed at either dam site. No rare, threatened, or endangered fish or bird species are known to inhabit the Mousam River area under study in this investigation. There are nine areas in proximity to the sites which were inventoried for the Maine critical areas list but none was placed on the list and none would be affected by construction. The anadromous fishery on the Mousam is limited by the number of dams that prevent freshwater spawning by such species as Atlantic Salmon. Because of the large number of dams on the lower Mousam, installation of fishways to permit fish runs was considered impractical by the State of Maine in 1955.

The effects of the proposed restoration of dams on the lower Mousam River can be summarized as including effects on soils and vegetation, water quality, and cultural resources.

Because the plan centers upon the restoration of recently breached dams, certain environmental impacts have already occurred. It should be noted that small dams such as those considered here have been in existence on the Mousam continuously since 1670.

Of the two sites proposed for restoration, the Rogers Mill Dam restoration will probably have a lesser impact. The area to be flooded is less than half that for the Twine Mill Dam, and the site is occupied by predominantly weedy vegetation in shallow soil pockets which have been considerably altered.

The effects on vegetation and soils at the proposed Twine Mill Dam site restoration will be more extensive. The pool is to be larger and therefore more habitat will be altered from woodland to impoundment. In addition, the raising of the dam beyond the former 18 feet will change the composition of previously slightly altered woodland community to riverine habitat, i.e. the current zonation will appear, over time, at higher elevations. Because there are undisturbed soils below the Twine Mill site, erosive properties of the water immediately downstream of the dam will increase, particularly as a result of elevation of the structure.

The impact of the dams and pools on water quality is expected to be small. Chronic changes in water quality are found at large impoundments where average residence times exceed 200 days. The impoundments being considered here will have residence times of 1 day or less; hence, thermal stratification and the associated retention of poorly oxygenated bottom waters which are responsible for deteriorative water quality impacts in a large impoundment are not likely to occur here.

Groundwater effects will be confined to localized rises in the water table in response to filling of the impoundments.

No known threatened or endangered species are found on either site and prehistoric cultural sites are not known in the immediate area of the proposed impoundment restorations. Further, it is believed that the restoration of these two pools will enhance certain recreational opportunities for water sports such as canoeing and fishing.

1. NATURAL ENVIRONMENT

The natural environment of the Mousam River basin can be characterized in terms of the geology of the area, the regional climatology, soils, vegetation, and hydrology. Man's impact is quantified in terms of land use and water quality. This section details these aspects on both a basin-wide scale and, where possible, in the specific area under study, an eight mile long portion of the Mousam River, upstream of the head of tide.

1.1 Geology and Soils

The Mousam River drainage basin is in an advanced stage of youth. The river valley is generally V-shaped with small flood plains and meanders typical of a youthful stage. The portion of the Mousam River which includes the dam sites lies within a coastal strip known as the Seaboard Lowland which extends inland for 15-20 miles. It is characterized by features associated with the Wisconsin glaciation as well as by marine transgression including the presence of extensive outwash plains, marine or lacustrine silts and clays deposited over glacial till, and lowlands dissected by many streams and rivers. Underlying glacial till soils form the hills and ridges while erosion caused the hills and ridges to be relatively small and rounded. Much of the pre-glacial drainage was effaced and the new pattern has not developed a high degree of integration. Flat interstream tracts with impermeable subsurface marine deposits combine to restrict drainage. (NEECo, 1974).

Geology

The following account is taken largely from Hussey, 1962. In the vicinity of the proposed dam sites, bedrock is metamorphic (Fig. 1.1-1, Fig. 1.1-2) generally corresponding to the Kittery formation (quartzite), Eliot formation (slate) and the Berwick formation (gneiss). These metamorphic rocks are of Silurian Age, a period of slow submergence and a time when Appalachia was still mountainous, but the rest of the continent was almost flat (Hussey, 1962). Underlying rock is

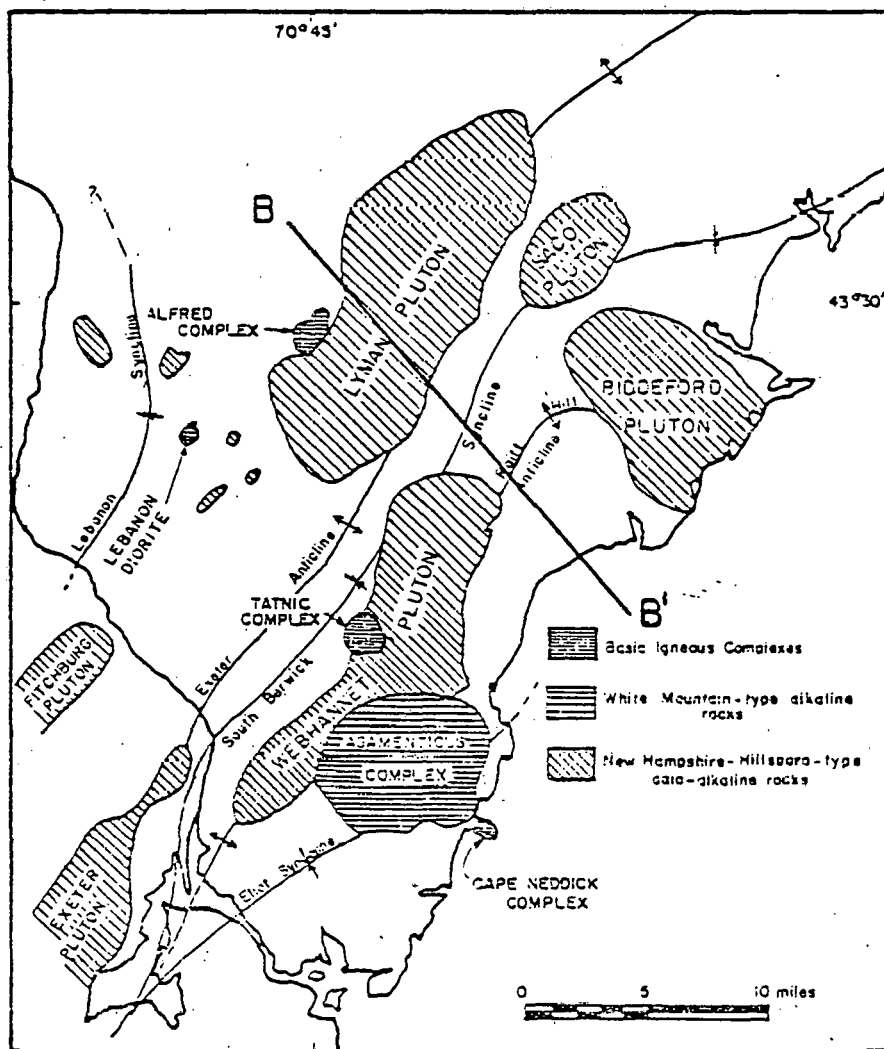


Figure 1.1-1. Sketch map of southwestern Maine showing major folds and igneous bodies. (From Hussey, 1962).

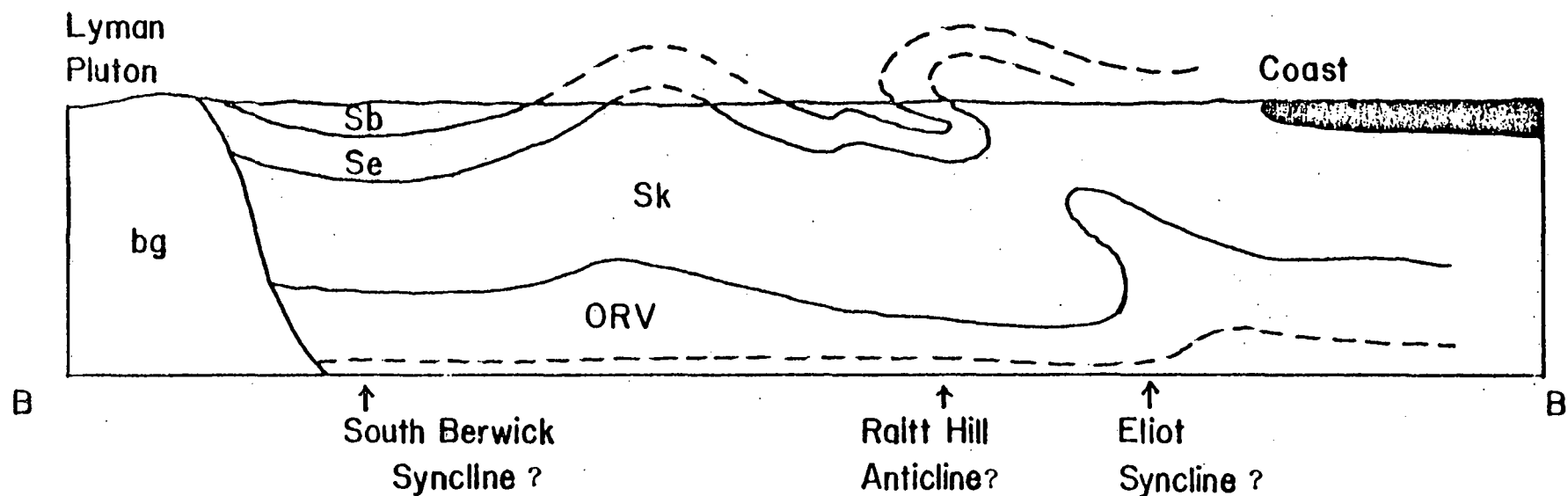


Figure 1.1-2. Geologic cross-section along intercept B-B' illustrating position of geologic formations: (S_k) Kittery formation, Silurian, quartzite; (S_e) Eliot formation, Silurian, slate; (S_b) Berwick formation, Silurian, gneiss; (b_g) biotite and biotite-muscovite granite and associated pegmatites, Late-Devonian; (ORV) Rye formation, Ordovician(?), metavolcanic member. (Redrawn from Hussey, 1962).

of Ordovician Age, a period of submergence which brought marine waters in over the lowlands, flooding geosynclines and spreading over much of the interior of the North American Continent. Both anticlinal and synclinal features are present in these rocks. According to Hussey, minor faults and shear zones are commonly observed along the coastline but none with apparent displacement of more than a few feet.

Igneous rock in the area corresponds to the New Hampshire - Hillsboro plutonic series including plutons which are elongated parallel to the structural trend of the surrounding metasediments. The Lyman pluton found in the area is such a biotite and biotite-muscovite granite and associated pegmatite of late Devonian Age. This granite mass contains mica with only minor amounts of muscovite at the southern end, while northward it becomes richer in muscovite and progressively more foliated. Small pegmatite and aplite stringers, similar in mineralogy to the main mass, are found in almost every outcrop of the Lyman pluton, but appear to be more abundant toward the margins of the body.

Three plunging features dominate the landscape along the course of the Mousam River in the vicinity of the proposed dam sites: the Eliot syncline, a branch of the Great Bay syncline, plunges southwest; the Raitt Hill anticline, a broad southwest plunging flexure that may have been caused by doming resulting from forceful injection of the quartz monzonite of the pluton; and the South Berwick syncline, a doubly plunging structure culminating in the vicinity of Dover, New Hampshire.

According to Hussey the bedrock which dominates the plunging features was deposited as sediment during the geosynclinal phase of geologic history. This stage was marked by deposition of interbedded volcanics and sediments of the Rye formation (Ordovician) which underlies the Silurian Age deposits. Vulcanism occurred during this stage with the eruption of pyroclastics, first andesitic then rhyolitic. At one stage in the sedimentation, deposition of the acid volcanics ceased and carbonaceous argillaceous sediments accumulated followed by a period in which a thin limestone accumulated. After this event, deposition of acid volcanics and argillaceous sediments resumed and continued until sedimentation of the Kittery type began.

During early Silurian time, pyroclastic vulcanism ceased and the Kittery sediments were deposited. A well developed, graded bedding suggests that deposition may have been brought about by turbidity currents.

Later in Silurian time, the Kittery gave way to the Eliot type sedimentation, differing principally in the amount of quartz delivered to the basin of deposition and consisting of rather chloritic and aluminous argillaceous material. Eliot sediments may have been deposited by turbidity current action.

Toward the end of Silurian time, Berwick type sedimentation appeared, differing from the Eliot in that quartz again became more abundant. Limy or dolomitic beds were more commonly formed and aluminous materials were lacking. Chloritic materials were still dominant and gave rise later to biotite rich

metasediments. In early Devonian time, Berwick type sedimentation ceased.

The volcanic activity associated with the Rye formation may have been a side effect associated with the Taconic disturbance of late Ordovician time. The deformation of the area probably is related to the Acadian Revolution of middle or late Devonian. The primary mechanism involved is thought to be the deformation of relatively broad open folds and drag folds superimposed on the larger folds and the metamorphosis of sedimentary rock. Towards the close of the tectonic stage, after the forces had largely subsided, large masses of calcareous alkaline granitic material were emplaced to form plutons which are exposed in the area today. That these are tectonic is shown by their slight foliation.

Further northwest, the Lyman pluton does not appear to have exerted much control on the major drainage because both the main branch Mousam River and Middle Branch Mousam River cut directly across the pluton.

Following the emplacement of the alkaline complex, the great majority of the basaltic to rhyolitic dikes were probably injected within a relatively short period of time, possibly triassic in age. After an unknown lapse of time, volcanic activity was resumed with the injection of basic magmas and crystallization differentiation giving rise to different phases in various basic complexes. The intrusion of basic magmas and their subsequent solidification brought to a close the bedrock history of the area. Since that time, extensive denudation, recent glaciation and postglacial sedimentation has occurred.

Soils

While the mature soils in the area are zonal soils corresponding to podzols of the Gray-Brown Podzolic group, those found in the cultivated areas are Brown Podzolic soils. Soils along the rivers are younger, varying in drainage properties, and exposure and slope, and vegetative cover. Consequently, they do not necessarily correspond to the modal descriptions for such soils. Preliminary information prepared by the Soil Conservation Service is presented in Tables 1.1-1 and 1.1-2, in which salient properties of the soils in the proposed impoundment are characterized.

The soils in the immediate vicinity of the proposed dam sites are loams, loamy sands, sandy loams, silt loams and man-made or urban soils as described hereinafter.

<u>Approved Mapping Unit Name</u>	<u>Field Symbol</u>	<u>Proposed Publication Symbol</u>
1. ADAMS LOAMY SAND	(51 XD)	(Ad D)

The Adams Series consist of deep, well drained to excessively drained soils on sand plains. They formed in deltaic or outwash sand. Typically, these soils have a pinkish gray loamy sand surface layer 4 inches thick. The subsoil from 4-10 inches is dark reddish brown and brown loamy sand and from 10-26 inches is brown and yellowish brown loose sand. The substratum from 26-40 inches is grayish brown loose sand. Slopes range from 0-49%. Droughtiness and slope are the main limitations for most uses.

2. MADAWASKA FINE SANDY LOAM (93 B) (Ma B)

The Madawaska Series consists of deep, moderately well drained soils on terraces and outwash plains. They formed in thick sand deposits. Typically these soils in a wooded area have a light gray to gray fine sandy loam or very fine sandy loam surface layer 2" thick. The fine sandy loam subsoil from 2-4" is dark reddish brown, from 4-12" is reddish brown, from 12-21" is mottled yellowish brown, and from 21-28" is mottled olive brown. The substratum from 28-60" is mottled olive gray sand and fine sand. Slopes range from 0-15 percent. Wetness and slope are the main limitations for most uses.

3. NAUMBERG SAND (54 A) (Na)

The Naumberg Series consists of deep, poorly and somewhat poorly drained soils on sand plains. They formed in deltaic or outwash material. Typically, these soils in a wooded area have a black surface layer of organic material 6 inches thick over 6 inches of reddish-gray sand. The mottled subsoil layers from 6 to 30 inches are dark reddish-brown loamy fine sand, dark brown loamy sand, and yellowish-brown sand. The substratum from 30-60 inches is light brownish-gray sand. Slopes range from 0-8 percent. Wetness is the main limitation for most uses.

4. RUMNEY LOAM (5 XA) (Ru)

The Rumney Series consists of deep, poorly drained soils on floodplains. They formed in recent alluvial material. Typically, these soils have a very dark grayish brown fine sandy loam surface layer 7 inches thick. The mottled subsoil from 7-26 inches is dark grayish brown fine sandy loam. The substratum from

26-60 inches is strata of olive gray and light gray loamy sand and gravelly sand. Slopes range from 0-3%. Flooding and wetness are the main limitations for most uses.

5. SCIO SILT LOAM (68) (Se B)

Deep, moderately well drained soils or terraces formed in silty lacustrine sediments, typically, these soils have a dark grayish brown very fine sandy loam surface layer 8 inches thick, underlain by a light olive brown very fine sandy loam subsurface layer 2 inches thick. The subsoil from 10-13 inches is strong brown very fine sandy loam and from 13-22 inches is mottled olive silt loam. The substratum from 22-26 inches is mottled light brown very fine sandy loam and silt loam. Slopes range from 3-15%. Wetness and slope are the main limitations for most uses.

6. URBAN LAND (9 ML 2) (U R)

Urban land consists of areas where about 85% of the surface is covered by asphalt, concrete, buildings, or other impervious structures. These areas are in populated cities and towns. They are on the coastal plain primarily on outwash plains and marine or lacustrine sediments. A few areas are on glaciated uplands. Slopes range from 0-15%. Existing man-made structures are the main limitations for most uses.

Table 1.1-1

Soils of York County
in the Vicinity of Proposed Dam Sites

Soil Series	Vicinity	
	Rogers Mill	Twine Mill
1. Adams Loamy Sand		x
2. Madawaska Fine Sandy Loam		x
3. Naumberg Sand	x	x
4. Rumney Loam	x	
5. Scio Silt Loam		x
6. Urban Land	x	x

Table 1.1-2

Selected Soil Properties¹

Soil Name	Texture	Permeability (In./Hr.)	Avail. Water Capacity (in/in)	Soil Reaction
1. Adams (Ad)	Loamy Sand	6.0 - >20	.03-.10	4.5-6.0
2. Madawaska (Ma)	Fine Sandy Loam	2.0- 20.	.02-.11	4.5-6.0
3. Naumberg (Na)	Sand	2.0- 20	.04-.09	3.6-6.5
4. Rumney (Ru)	Loam	2.0- >6.0	.02-.24	4.5-5.5
5. Scio (Se B)	Silt Loam	0.6- 2.0	.15-.30	5.1-6.5
6. Urban Land (UR)	← No Specifications Reported →			

1. Soil Survey of York County. (From Advance Preliminary Copy). 1978.

Table 1.1-2

Selected Soil Properties
(Con't.)

	Shrink-Swell Potential	Corrosivity		Erosion Factors		High Water Table	Bedrock	Hydrologic Group	Flooding Frequency	Potential Frost Action
		Steel	Concrete	K	T					
1.	Low	Low	High	.17	5	>6.0'	>6.0"	A	None	Low
2.	Low	Moderate- Low	High	.28	3	1.0-3.0' (Nov.-May)	>60"	B	None	Moderate
3.	Low	High	High	.17	5	0.-1.5' (Nov.-May)	>60"	C	None	Moderate
4.	Low	High	High	-	-	0.-1.5' (Oct.-Mar.)	>60"	C	Frequent	High
5.	Low	Moderate	Low	.49-.64	3	1.5-3.5' (Nov.-Apr.)	>60"	B	None	High
6.	← No Specifications Reported →									

1.2 Climatology

Maine's climate is dominated by three types of air masses: (1) cold, dry air associated with the polar continental high pressure system, (2) warm and humid air with its source in the Gulf of Mexico and Caribbean, and (3) cool, moist air from the North Atlantic. Since the prevailing winds are from west to east, it is the first two air masses that are most responsible for Maine's climate.

These synoptic characteristics result in several distinct features of Maine's climate. Twice-weekly alternations between clear, cloudy, and stormy conditions are the general rule throughout the year. Temperature ranges are large, both diurnally and seasonally. Seasonal variations from year to year are also great; for example, the relatively cool summer of 1972 was followed the next year by a particularly warm summer. Finally, the frequent passing of storms throughout the year results in a generally even distribution of rainfall by month.

The Mousam River basin lies in the Coastal Climatological Division, generally an area 20 to 30 miles wide. This region is affected to a greater extent than the rest of Maine by maritime influences, although polar and tropical air masses are still dominant.

Table 1.2-1 shows monthly average precipitation and maximum, mean, and minimum air temperature over forty years of record at Portland, the nearest major weather station. Also shown are corresponding data for the year 1977. These data show the

even distribution of rainfall amounts by month over the long term and significant month-to-month variation in rainfall for the year 1977.

Figure 1.2-1 shows resultant wind direction and speed for the year 1977. Winds come generally from either the northwest or southwest, corresponding to the passage of polar or tropical air masses, respectively.

Table 1.2-1

Long Term and 1977 Precipitation and Air Temperatures
for Portland, Maine

Month	Long Term				1977			
	Precipitation, in.	Air Temperature, F			Precipitation, in.	Air Temperature, F		
		Daily Max	Daily Min	Mean		Daily Max	Daily Min	Mean
January	3.38	31.2	11.7	21.5	6.46	25.3	3.8	14.6
February	3.52	33.3	12.5	22.9	3.75	31.6	12.2	21.9
March	3.60	40.8	22.8	31.8	6.92	44.4	27.9	36.2
April	3.34	52.8	32.5	42.7	3.46	53.1	31.6	42.4
May	3.33	63.6	41.7	52.7	2.04	66.9	41.9	54.4
June	3.10	73.2	51.1	62.2	3.38	67.4	50.6	59.0
July	2.61	79.1	56.9	68.0	2.83	79.5	56.9	68.2
August	2.60	77.6	55.2	66.4	2.79	76.6	56.5	66.6
September	3.09	69.9	47.4	58.7	4.63	67.0	48.2	57.6
October	3.31	60.2	38.0	49.1	8.30	58.1	38.1	48.1
November	4.86	47.5	29.7	38.6	6.46	47.9	30.9	39.4
December	4.06	34.9	16.4	25.7	6.61	33.9	16.9	25.4
Year	40.80	55.3	34.7	45.0	57.63	54.3	34.6	44.5

Source: Local Climatological Data, 1977. Portland, Maine
National Climatic Center, Asheville, N.C.

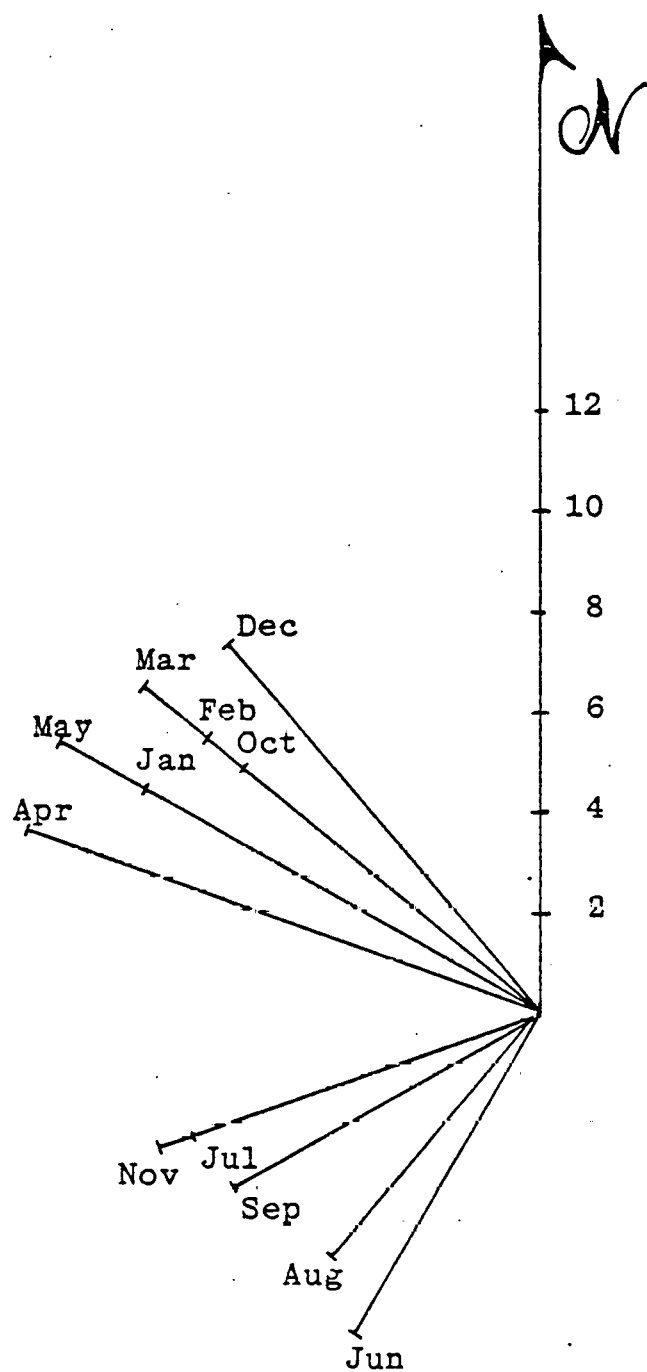


Figure 1.2-1. Resultant wind direction and speed (mph), Portland, Maine 1977.

1.3 Vegetation and Land Use

The basin area is over 50% forested with one estimate as high as 65% (Table 1.3-1). Agricultural land comprises approximately 10% while the water area is under 5%. Wetlands, barren land and rangeland together comprise under 8% of the total. Urban or built-up land represents a consolidation of six categories developed by the United States Geological Survey (USGS), together totaling 32%, a value greater than that reported in the NEECo Study. Three main reasons probably exist for disparity between areal estimates of land use between the respective studies:

(1) Broader criteria may be inherent in the USGS categories which include residential, commercial and services, industrial, transportation, communication and utilities, industrial and commercial complexes, mixed urban, other urban and built-up lands; (2) A difference approximately 9% between the measured value (114 mi²) for this study and the watershed size of 125 mi²; and (3) a probable difference in areal estimate of the 208 service area. It appears probable, however, that a sum total of up to approximately one third of the land area illustrates direct, contemporary conversion to human uses.

Rogers Mill Dam

In order to assess the vegetation currently on the sites, a preliminary reconnaissance was conducted and line intercepts were placed at the Rogers Mill, Twine Mill and Dane Perkins Dam sites on the 25 and 26 of September, 1978. Intercepts extended from the river bank (ripa) through the zone to be flooded and

Table 1.3-1 Comparison of Land Use Categories
Between Current Study and Similar Studies

<u>Land Use Category</u> ¹	<u>This Study</u> ²	<u>NEECo</u> ^{2,3}	<u>RPC</u> ^{2,3,4}
1. Forest Land	51.	65.	69.1
2. Urban or Built-up	32.	9.9	10.
3. Agricultural Land	9.	12.	12.9
4. Water	3.	4.6	NR
5. Wetland	2.	7.2	5.7
6. Barren Land	2.	0.5	1.3
7. Rangeland	1.	NR ⁵	NR ⁵
	<u>100.0%</u>	<u>100.2%</u>	<u>99.0%</u>

1. Land use categories adopted from USGS land use mapping (1976).
2. Measurements consolidated to arrive at percentages.
A drainage basin size of $\approx 114 \text{ mi}^2$ was estimated.
3. NEECo Report 1974 and Southern Maine Regional Planning Commission assume drainage basin size of 125 mi^2 , as does USGS.
4. The entire 208 service area, including a portion of the Mousam River basin, but extending along the coast from Biddeford/Saco to Kittery. Southern Maine Regional Planning Commission (RPC) data, therefore, are not comparable to either this study or NEECo.
5. NR - Not recognized as a mapping unit.

which was flooded in the past when the dams were in operation. Cover of vascular plants upon the line was recorded (Table 1.3-2).

The former Rogers Mill Dam site is immediately downstream of Kesslen Mill. It is now totally breached and according to P. Davis (personal communication, 1978) has been for some 15 years. Fig. 1.3-1 is illustrative of the northeast facing slope at Rogers Mill and Fig. 1.3-2 is a view of the west facing slope at Rogers Mill. Plant nomenclature follows Fernald (1950).

Downriver of the former Rogers Mill Dam, the steeper north facing slopes at higher elevations support a mixed hardwood community presently dominated by such tree species as northern red oak (Quercus borealis var. rubra), red maple (Acer rubrum) and gray birch (Betula populifolia). The shrub layer contains maple leaved viburnum (Viburnum acerifolium) and virginia creeper (Parthenocissus quinquefolia). More mesic sites near the Mousam River support populations of oak seedlings while the river bank itself illustrates species such as white pine (Pinus strobus). Because dams also exert a downstream effect, predominately causing a change in the river gradient and consequent erosion, (Leopold et al., 1964) there has probably been an enlargement of the river channel with attendant uprooting of trees, removal of fine materials from the river bed and exposure of the large rocks within the bed. In selected locations, sugar maple (Acer rubrum) and pin cherry (Prunus pensylvanica) may be found. Because the forest has been intensively altered by selective cutting, species of aster (Aster sp.), golden rod (Solidago sp.), bracken fern (Pteridium aquilinum) and joe pye weed (Eupatorium sp.) are found in uncanopied openings.

Table 1.3-2 Cover Values (Meters) For Taxa Occurring On
East and West Exposures Along the Mousam River.

Taxa	A.	B.	C.	D.
	Rogers Mill North Facing Slope	Rogers Mill South Facing Slope	Twine Mill South Facing Slope	Dane Perkins North Facing Slope
1. <u>Agrostis stolonifera</u>	0.5	-	-	-
2. <u>Acer rubrum</u>	-	10.0	10.0	2.9
3. <u>Alnus rugosa</u>	6.2	2.1	18.3	2.0
4. <u>Arctium minus</u>	-	0.6	-	-
5. <u>Aster sp.</u>	-	-	0.1	0.4
6. <u>Berberis vulgaris</u>	-	1.0	-	-
7. <u>Betula populifolia</u>	2.0	-	9.9	-
8. <u>Bidens sp.</u>	-	-	0.1	0.2
9. <u>Conyza canadensis</u>	0.1	-	-	-
10. <u>Cornus sp.</u>	0.1	0.7	5.0	-
11. <u>Cuscuta sp.</u>	-	-	0.1	-
12. <u>Cyperus sp.</u>	-	-	2.0	0.1
13. <u>Dactylis glomerata</u>	-	0.2	-	-
14. <u>Daucus carota</u>	-	0.3	-	-
15. <u>Digitaria sanguinalis</u>	-	0.2	-	-
16. <u>Echinochloa sp.</u>	-	0.3	2.0	-
17. <u>Erigeron sp.</u>	0.7	-	-	-
18. <u>Equisetum sp.</u>	-	-	1.6	-
19. <u>Fraxinus sp.</u>	-	-	2.0	-
20. <u>Galium sp.</u>	-	-	0.2	-
21. <u>Gramineae sp.</u>	-	-	2.2	-
22. <u>Hypericum sp.</u>	-	-	0.2	-
23. <u>Impatiens sp.</u>	-	-	7.4	0.1
24. <u>Lolium perenne</u>	-	1.0	-	-
25. <u>Lysimachia quadrifolia</u>	-	-	0.2	-
26. <u>Myrica pensylvanica</u>	-	-	0.2	-
27. <u>Nuphar sp.</u>	-	-	-	0.2
28. <u>Panicum sp.</u>	0.5	0.2	-	-

Table 1.3-2
(Con't.)

Taxa	A.	B.	C.	D.
	Rogers Mill North Facing Slope	Rogers Mill South Facing Slope	Twine Mill South Facing Slope	Dane Perkins North Facing Slope
29. <u>Phleum pratense</u>	0.1	0.3	-	-
30. <u>Pinus strobus</u>	-	-	3.2	-
31. <u>Poa compressa</u>	0.7	0.8	1.5	-
32. <u>Polygonum</u> sp.	0.1	-	-	-
33. <u>Polypodium</u> sp.	-	-	-	0.1
34. <u>Pteridium aquilinum</u>	-	-	1.6	-
35. <u>Pyrus</u> sp.	-	3.0	-	-
36. <u>Quercus alba</u>	-	-	6.1	-
37. <u>Quercus rubra</u> var. <u>borealis</u>	-	2.5	-	0.2
38. <u>Rhus radicans</u>	-	-	0.1	-
39. <u>Rubus</u> sp.	-	0.9	-	-
40. <u>Rumex</u> sp.	-	-	0.1	-
41. <u>Solanum dulcamara</u>	-	0.3	-	-
42. <u>Solidago</u> sp.	0.5	2.1	1.0	-
43. <u>Spiraea</u> sp.	-	-	-	0.1
44. <u>Taraxacum</u> sp.	0.1	-	-	-
45. <u>Tsuga canadensis</u>	-	-	-	15.1
46. <u>Ulmus americana</u>	-	1.2	0.1	-
Number of Species	12	19	25	11
Total Cover (Meters)	11.6	27.7	76.0	21.4
Line Intercept Length (Meters)	20.0	20.0	60.0	20.0



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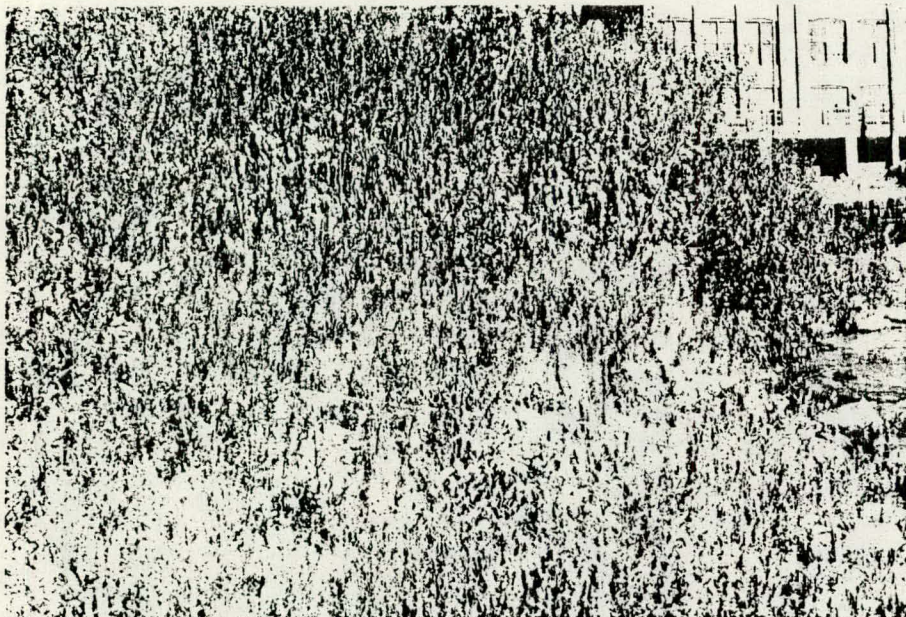


Figure 1.3-1. Rogers Mill north facing slope.



Figure 1.3-2. Rogers Mill south facing slope.

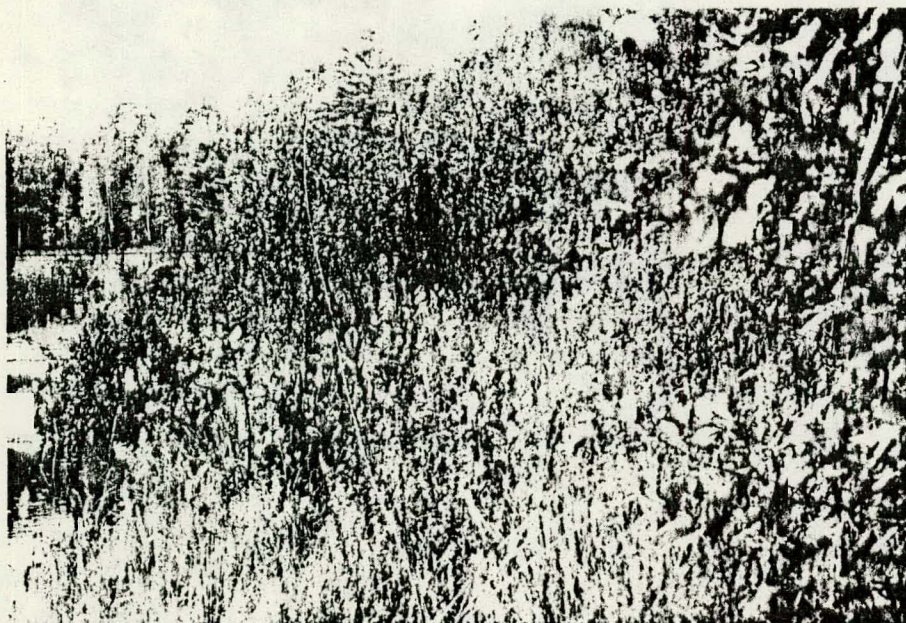


Figure 1.3-3. Twine Mill south facing slope.

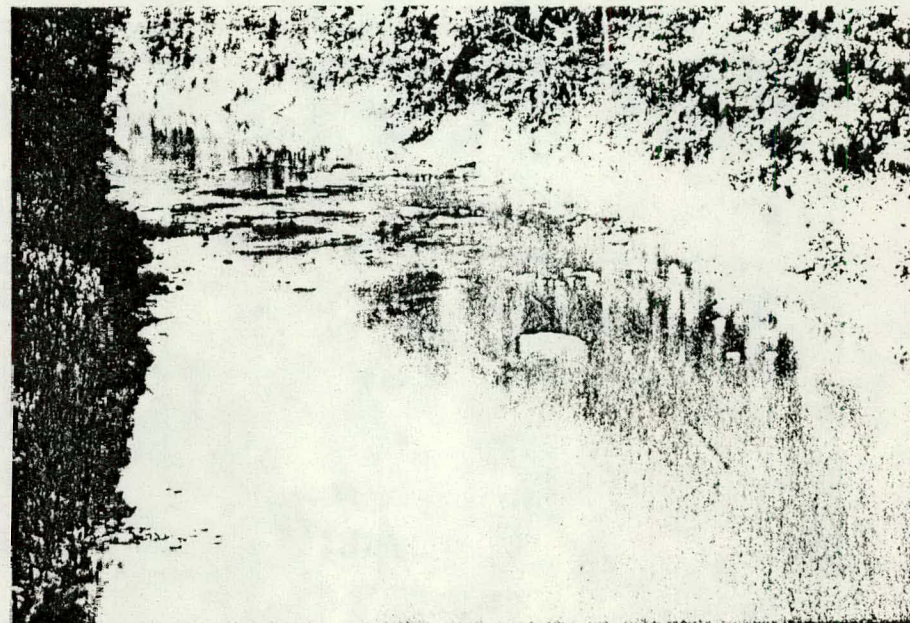


Figure 1.3-4. View upstream along river from Dane Perkins site.

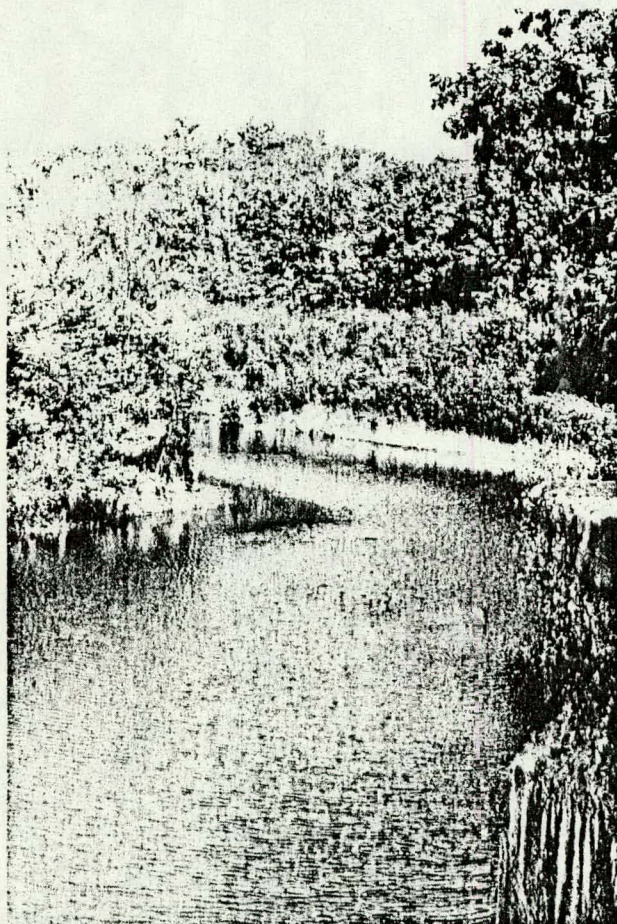


Figure 1.3-5. View upstream along Mousam River at Twine Mill site.

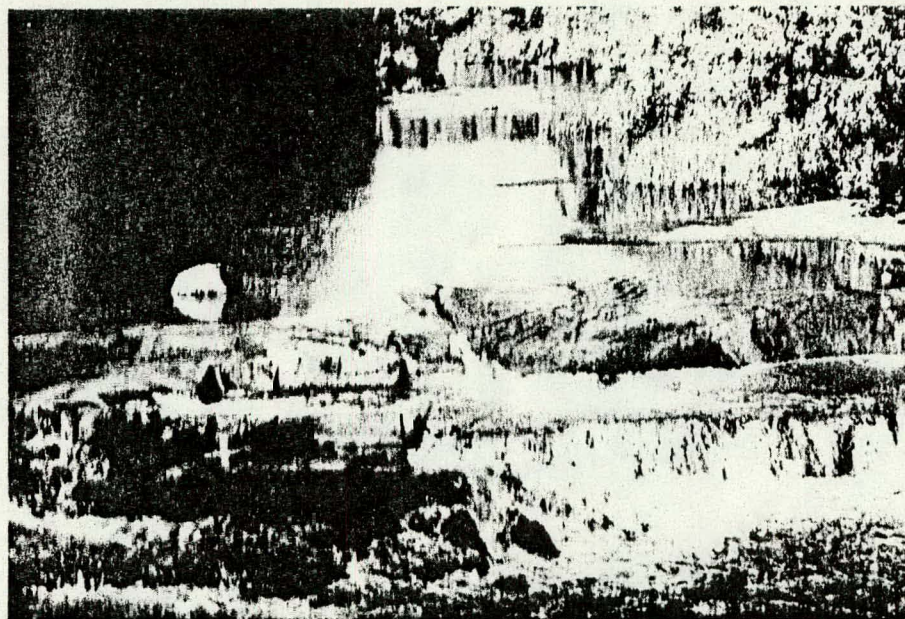


Figure 1.3-6. View upstream in general vicinity gauging station (Whicher's Mill) site.

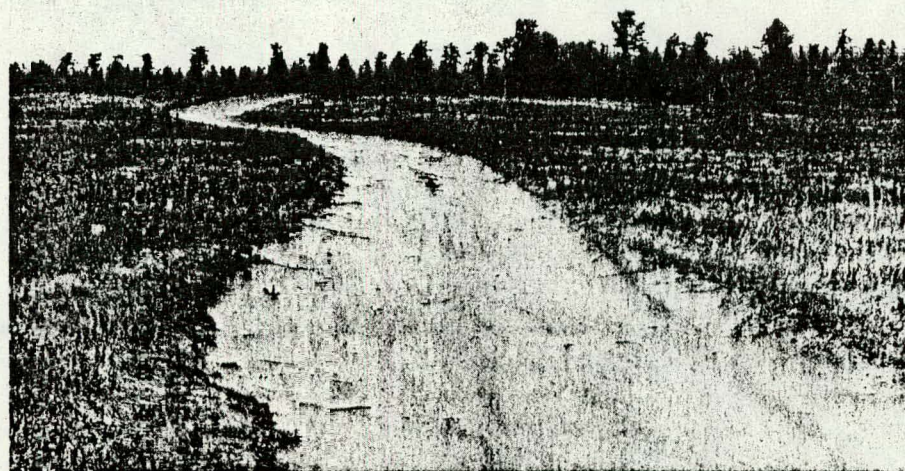


Figure 1.3-7. View north in the pine plains.

The north facing slope at Rogers Mill (Fig. 1.3-1) illustrates the shallow soil and exposed outcrops of bedrock with shallow pockets of soil filling the interstices. The riverine community shows little differentiation or structure. Red osier dogwood (Cornus stolonifera) extends to the river's edge mixed with herbaceous species of Polygonum, Solidago, Taraxacum, Conyza, and Erigeron. The next intergrading community begins with low growing species of alder (Alnus rugosa) under which grows a mixture of bluegrass (Poa sp.), timothy (Phleum pratense), bent grass (Agrostis sp.) goldenrod (Solidago sp.), and panic grass (Panicum clandestinum). Within a short distance the height of the alders increases and this species is mixed with gray birch.

South facing slopes support weedy species such as barnyard grass (Echinochloa sp.), crab grass (Digitaria sp.), wild carrot (Daucus carota), nightshade (Solanum sp.), bluegrass (Poa sp.), cocksfoot (Dactylis glomerata), rye grass (Lolium), burdock (Arctium sp.) and goldenrod (Solidago sp.) to the waters edge. The shrub zone may begin within the first meter consisting principally of alder with species of blackberry (Rubus sp.), poison ivy (Rhus radicans) and barberry (Berberis thunbergii). The principal tree species, few of which are present as trees but are present as saplings, are american elm (Ulmus americana), red maple (Acer rubrum), apple (Pyrus malus) and northern red oak (Quercus borealis var. rubra).

Twine Mill

The Twine Mill Dam site was breached 17-18 years before present (Fig. 1.3-3, 1.3-5). The north facing slope (Fig. 1.3-3)

is more gently sloping than the south facing slope (Fig. 1.3-5). Mixed hardwoods may reach to the waters edge on the north facing slope, but the south facing slope is divided into three general zones: an herbaceous riverine community, an alder zone, and a mixed hardwood-softwood zone.

The shallow river bottom near the shore in the former location of the old dam pool contains fine sediment. In this environment may be found species of pond weed (Potamogeton sp.) and waterweed (Elodea canadensis).

Species on the river bank in the herbaceous zone include barnyard grass (Echinochloa sp.), sedge (Cyperus sp.), goldenrod (Solidago sp.), grass species (Gramineae) and St. Johns wort (Hypericum sp.).

The alder zone begins at the 5 meter mark extending to 23 meters. Within this zone species of bur-marigold (Bidens sp.), dodder (Cuscuta sp.), jewel weed (Impatiens balsamina), goldenrod (Solidago sp.), gray birch (Betula populifolia), bluegrass (Poa sp.), dogwood (Cornus sp.), and bracken fern (Pteridium aquilinum) may be found. A few individuals of white pine are also present and these continue up a 42% slope mixed with species of red maple (Acer rubrum), gray birch (Betula populifolia), white oak (Quercus alba), pin cherry (Prunus pensylvanica) and american elm (Ulmus americana) to the road at the top of the hill. Within the predominately hardwood community woodland species of Aster (Aster sp.), bedstraw (Galium sp.), horsetail (Equisetum sp.), may also be found, mixed with a few ruderal species such as dock (Rumex sp.) and loosestrife (Lysimachia sp.).

If the Twine Mill site is damned again, it will flood upstream to the former location of the Dane Perkins Dam (Fig. 1.3-4), which was breached 18 months before the present. The Dane Perkins hydropower operated a saw mill (cover photo and legend). A mixed hardwood community dominates the south facing slope extending to the waters edge and a hemlock forest is found on the north slope.

The river bottom at the old dam pool is shallow and laden with fine sediment in which living tubers of spatterdock (Nuphar sp.) may be seen.

The north facing slope contains seedlings of red maple (Acer rubrum) within the first meter from the riverbank and saplings/trees extend to 20 meters (m) from the river. There is not a shrub layer but species of bur-marigold (Bidens sp.), jewel weed (Impatiens sp.) and Aster (Aster sp.) are found within the first seven m. The shrub zone is truncated to a relatively few meters, two in this example, where alder (Alnus rugosa) dominates between meters 8 and 10. The most conspicuous aspect of the forest community is the extensive stand of hemlock (Tsuga canadensis) to be found lining the bank (cover illustration). This species is accompanied by northern red oak (Quercus borealis var. rubra) within the 20 m mark.

The old gate wheel at the Dane Perkins Dam site may be seen on the cover photo.

Both number of species and total cover of species was greater on the south facing slopes than on the north facing slopes. The Twine Mill (south) intercept illustrates 25 species within a 60 m intercept length. Overlap, however, increased

the cover to 76 m. Rogers Fiber (south) intercept traversed 19 species within 20 m while overlap increased the value to 27.7 m. The north facing slope of Rogers Mill contained 12 species within an intercept of 20 m and only 11.6 m of total cover. Dane Perkins with 11 species in 20 m had a total cover of 21.4 m for both least number of species and least cover of the four intercepts.

South facing slopes with warmer microclimates supported a diverse assemblage of species many of which may be characterized as having weedy or ruderal characteristics. North facing slopes with cooler microclimates supported fewer species.

Community coefficients (Table 1.3-3) were determined for east and west facing intercepts utilizing Kulczynski's (1937) formula:

$$\frac{2w}{a+b} \times 100$$

w = sum of lower pair of species common to stands,
(intercept) common to two intercepts

a = number of species of intercept A,

b = number of species of intercept B.

Results indicate that all intercepts have a relatively low relationship with one another. Rogers Mill (north and south) has a similarity of 10.3% in species occurrence. Dane Perkins (north) and Twine Mill (south) show 7.7% similarity which is approximately the same, 7.4%, as Rogers Mill (south) and Twine Mill (south). Rogers Mill (north) and Dane Perkins (north) show the least similarity of all, 2.1%.

Table 1.3-3 Community Coefficients¹ Determined For
Selected Slopes Along The Mousam River

Site/Slope Comparison	% Similarity
1. Rogers Mill (North), Rogers Mill (South)	10.3
2. Dane Perkins (North), Twine Mill (South)	7.7
3. Rogers Mill (North), Twine Mill (South)	7.4
4. Rogers Mill (North), Dane Perkins (South)	2.1

¹Oosting (1956) after Kulczynski (1937)

Fire

A major fire occurred in southwestern Maine during October of 1947. Initial estimates of the extent indicated that 130,000 acres (ac) of forested land had been damaged out of a total of 150,000 ac (Nutting and McGuire, 1948). Forty-eight thousand ac of merchantable timber was included within the fire area of which 75% of the saw timber was white pine (Pinus strobus L.). It was estimated that crown fires killed almost every tree of pole and saw timber on 4,000 ac, while 44,000 ac were scorched by surface fires. Surface fires killed most of the understory species, but many of the larger trees are reported to have escaped with only light damage to upper roots and lower stems.

At the time of the fire the water table in southwestern Maine was considered to be extremely low. As a result, fires were reported to have burned deeply into accumulated organic debris of swamps and low places causing extensive root damage. Heave slash, growths of bracken fern and prior flammability were reported to account for the most conspicuous site changes.

Where the fire was intense, the incoming growth is reported to consist of gray birch, red maple and oak sprouts and seedlings. Where surface fires were reported as moderate to light, pine and hemlock seedlings were to be found among incoming growth. Hemlock seedlings were reported to be more abundant than white pine seedlings because hemlock cones had not opened before the fire.

Principal taxa and stand types in the 1947 fire-affected area in southwestern Maine are reported in Table 1.3-4.

Table 1.3-4 Species, Stand Type, Acreage and Percentage of Forest Burned in the Fire of October 1947.

Species	Softwood	Softwood- Hardwood	Hardwood- Softwood	Hardwood
<u>Pinus strobus</u>	✓	✓	✓	
<u>Picea</u> sp.	✓	✓	✓	
<u>Abies</u> sp.	✓	✓	✓	
<u>Pinus rigida</u>	✓			
<u>Tsuga canadensis</u>	✓			
Hardwood (undifferentiated)		✓	✓	✓
Burned Acreage (All SW Maine)	28,590	8,290	930	10,140
% of Total Acreage	60%	17%	2%	21%

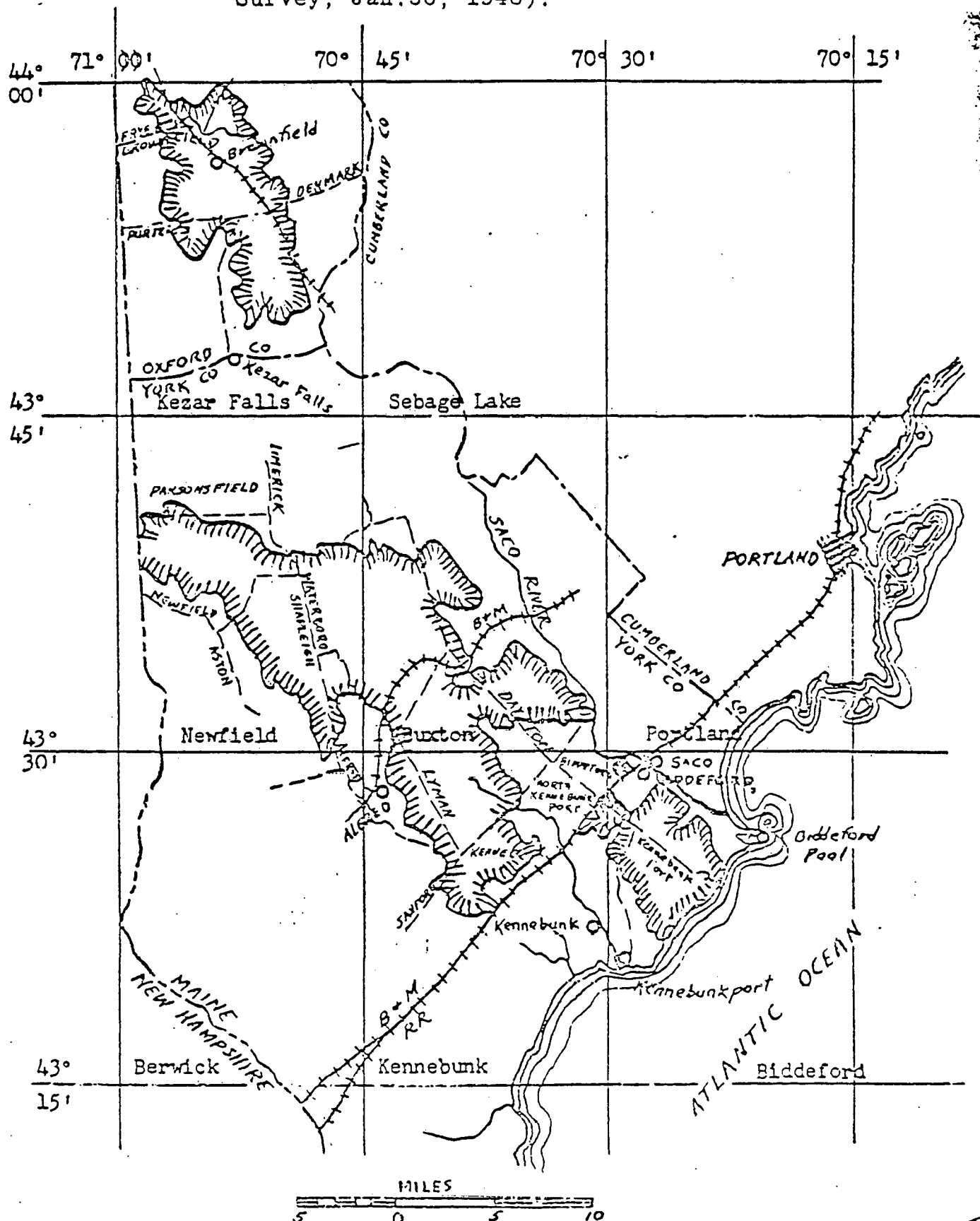
Gross return to land owners who sold fire killed timber was estimated to have exceeded one million dollars. In turn timber saved from fire-killed saw timber was reported to have been sold with gross proceeds estimated at six million dollars.

Maps illustrative of the fire of 1947 designate that the Mousam River drainage basin was affected by the fire (Fig. 1.3-6). The area north of Square Pond, the forests in the vicinity of the eastern shore of Mousam Lake and Shapleigh Town, the area from Ossippee Hill to Alfred Town, and the area in the vicinity of Old Falls Pond and from Twine Mill to The Plains (a predominately pitch pine forest on sandy glacio-fluvial soils south and west of the Mousam River) were burned with unspecified intensity. Approximately 25-33% of the Mousam River drainage basin was affected by the fire which was not the only one to have occurred in the area within recent historical time.

Forest fires have been reported in the area during Colonial Times. In 1761, fire was reported to have swept across the New Hampshire border from Acton on the south, north to Parsonfield. The fire burned east to Buxton and Saco. It crossed Cumberland County and reached the Atlantic Ocean in the vicinity of Falmouth, north of Portland. In 1762, fire covered much of the same area, but extended southward to Wells and Kennebunkport. These fires prompted at least twenty-five persons from Scarborough Town (then a portion in York County) to move to Machias to cut hay and timber. (Sewall Co., 1963).

In the 20th century, major fires have been recorded in York County as follows: 1908, 18,000 ac; 1941, 5,026 ac; 1947, 132,835 ac (Fig. 1.3-6); 1953, 2,361 ac; 1957, 12,190 ac.

Fig. 1.3-6. Extent of Forest Fires of October 1947 in Southeastern Maine. The forest fires of 1761 and 1762 reportedly burned over a larger area than the fires which occurred 187 years later. (From Maine Fire Damage Survey, Jan. 30, 1948).



During the Fall, prevailing winds are likely to be from the northwest and southwest quadrants (Fig. 1.2-1). If this accompanies low rainfall, low soil moisture and the customary onset of the dormant season with attendant loss of leaves and drying of shrubby and herbaceous vegetation, ideal conditions for forest fires may result.

1.4 Hydrology and Water Quality

The Mousam River watershed is located in southern Maine between $43^{\circ} 20'$ and $43^{\circ} 35'$ north latitude and between $70^{\circ} 30'$ and $70^{\circ} 55'$ west longitude. The basin encompasses approximately 125 mi^2 of drainage area. The Mousam River flows in a southeasterly direction from its origin in Square Pond to the Atlantic Ocean at Kennebunk Beach, dropping 522 ft over its length of approximately 27.6 mi. The final 3.6 mi, between Kennebunk and the Atlantic Ocean, are considered to be subject to the influence of the tide.

Basin topography includes three physiographic regions. The upper portion of the basin lies in the Foothills of the White Mountains. The middle portion of the basin centered on Sanford is characterized by modest relief and is part of the physiographic region called the Middle Ground. The portion of the basin southeast of Estes Lake lies in the Seaboard Lowland. This region is relatively flat and contains the area under consideration in this study.

The Mousam River can be described as being in an advanced stage of youth as regards the development of its drainage pattern, which is post-glacial in age. This advanced youthful stage is characterized by the presence of poorly developed drainage features such as the prominent swamps and natural ponds in the upper portion of the basin. The relatively early stage of downcutting results in the absence of a significant flood plain in the non-tidal portion of the Mousam River in the

Coastal Plain region. Instead, relatively deep and steep valleys exist that have long been recognized as good impoundment sites.

The two major tributaries of the Mousam are the Littlefield River and the Middle Branch Mousam River, which join to form the upper reaches of Estes Lake, into which the mainstem Mousam also flows (Figure 1.4-1).

The Mousam basin contains a number of impoundments that provide storage and regulate flow. The three largest impoundments or controlled waterbodies are Square Pond and Mousam Lake, both controlled by the City of Sanford for water supply (Sewall, 1963, p. 15 of Chapter Two) and Estes Lake, used primarily for power generation. The latter is formed by New Dam, with a height of approximately 36 feet. New Dam is located at Mousam River mile 10.1 and forms the upstream boundary of the river section under consideration in this study.

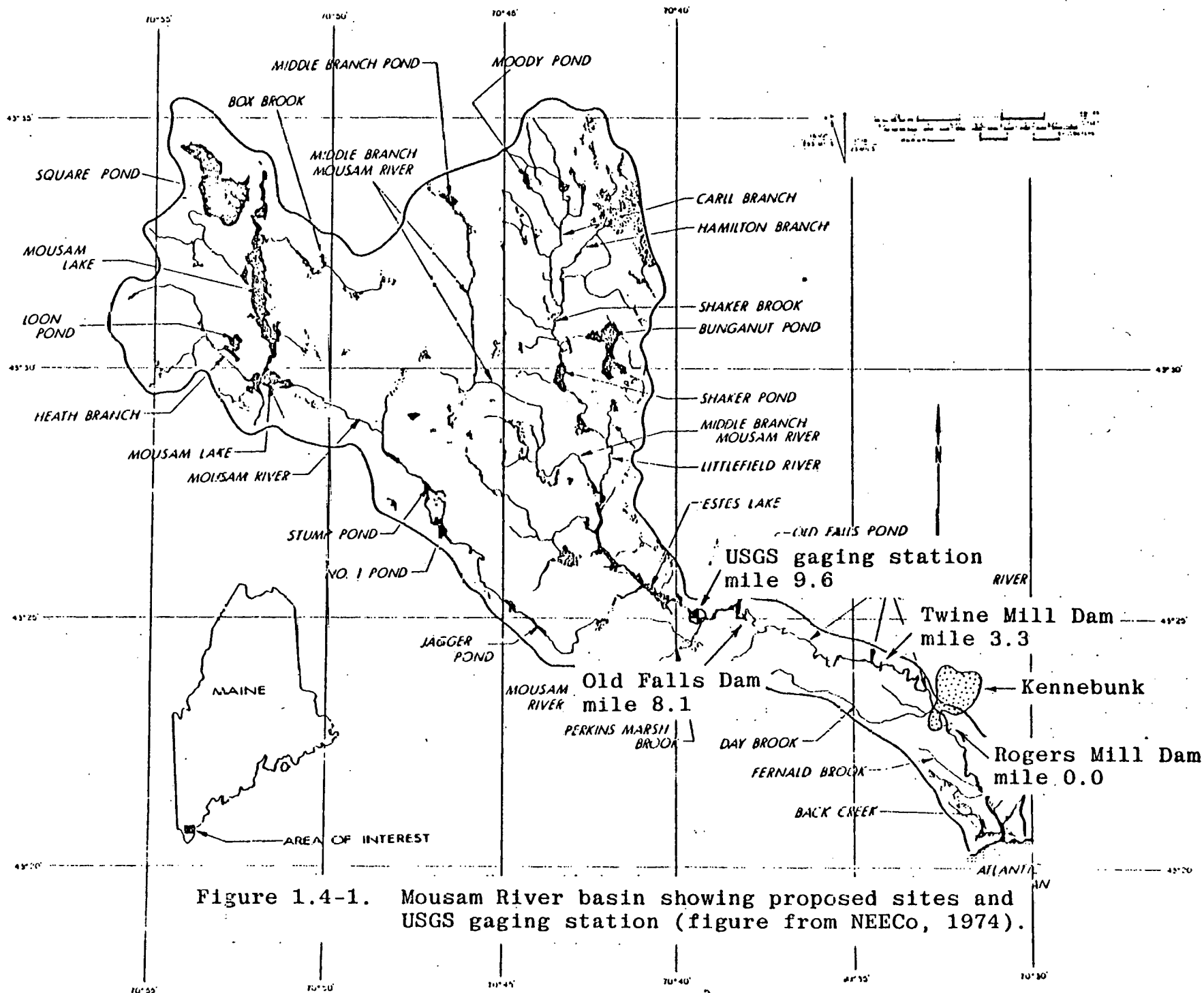
Two small hydropower impoundments are located downstream of New Dam and upstream of the proposed Rogers Mill Dam restoration, the downstream limit of this study. These are Old Falls Dam at Mousam River mile 8.1 with a height of 63 feet which forms Old Falls Pond, and Kesslen Mill Dam at mile 0.1 (just upstream of the Route 1 bridge at Kennebunk) with a height of 17 feet. In addition, two breached dams, former sites of small impoundments, are located in this reach of the Mousam River. The first is located between New Dam and Old Falls Dam at the site of the USGS gaging station at Whicher's Mill Road (mile 9.6). The second breached dam is Dane Perkins, at Mousam River mile 3.8.

Flow measurements for the Mousam are taken by the United States Geological Survey (USGS) at Whicher's Mill Road (mile 9.6). At this point the Mousam drains 105 mi² (Figure 1.4-1). Records are available as daily average flow, unadjusted for changes in storage at the upstream impoundments, since October 1939. The mean discharge since that time is 179 cfs with a maximum recorded discharge of 2830 cfs on September 12, 1954 and a minimum of 0.4 cfs on November 10, 15, and 16, 1964. The latter coincided with the general northeastern United States drought of 1961 to 1965. Monthly flow data for the water year 1977 (October 1976 to September 1977) is shown in Figure 1.4-2. This period is a representative one for the Mousam River in that the mean for this water year, 181 cfs, closely matches the period of record mean, and the high flows of March and April and the low flows of August correspond to the high and low flow month over the period of record (NEEC Co, 1974, p. 4-28). Significant year to year variations occur, and, of course, instantaneous flow rates vary considerably.

The mean discharge of 179 cfs is equivalent to 57% of the precipitation that fell on the basin above Whicher's Mill Road during the period 1939 to 1977.

Water Quality Data

Water quality problems on the Mousam River have been recognized by the Maine Department of Health and Welfare (DHW) as early as 1950. The DHW established water quality sampling stations on the Mousam from Springvale to Kennebunk and measured



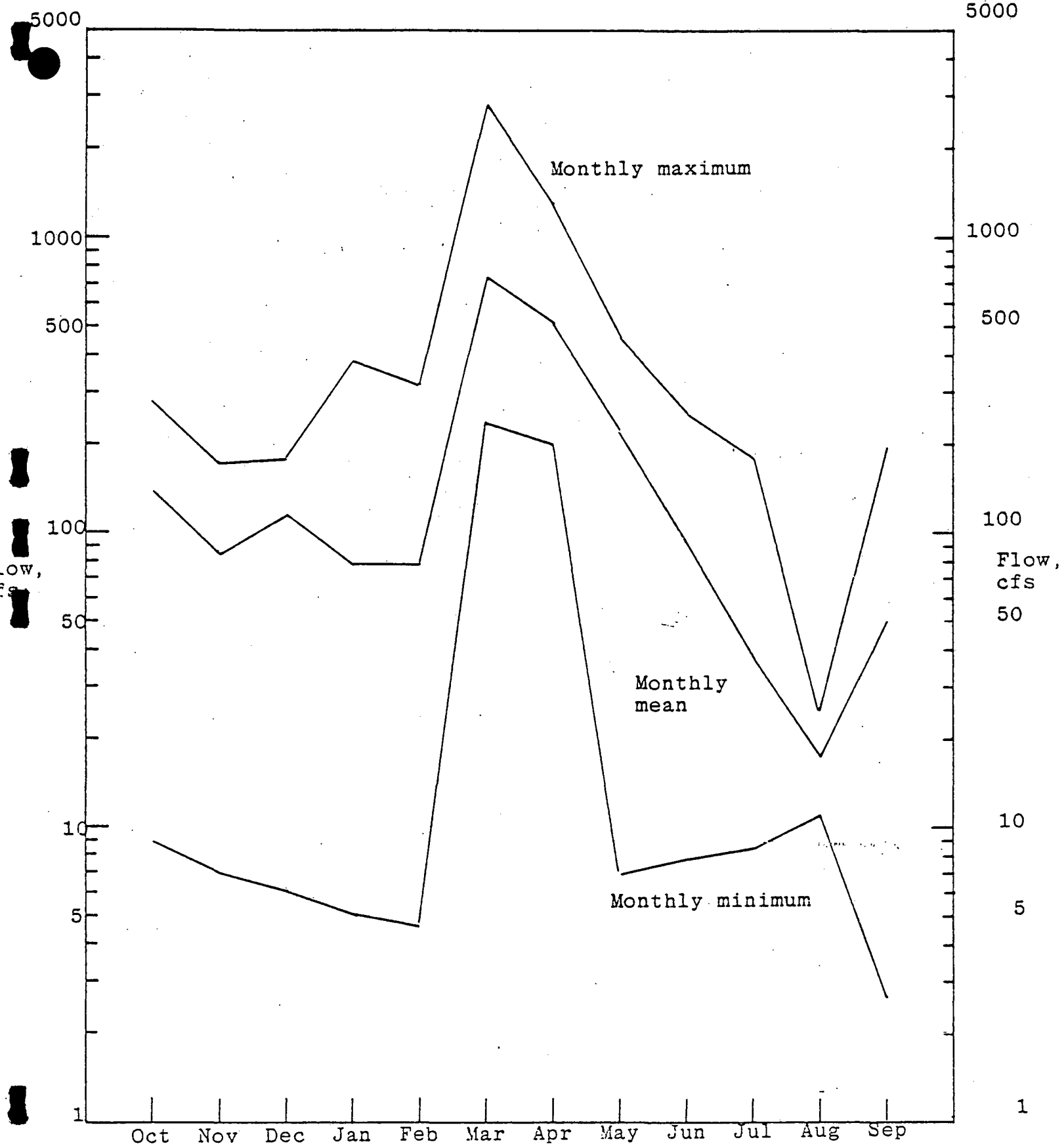


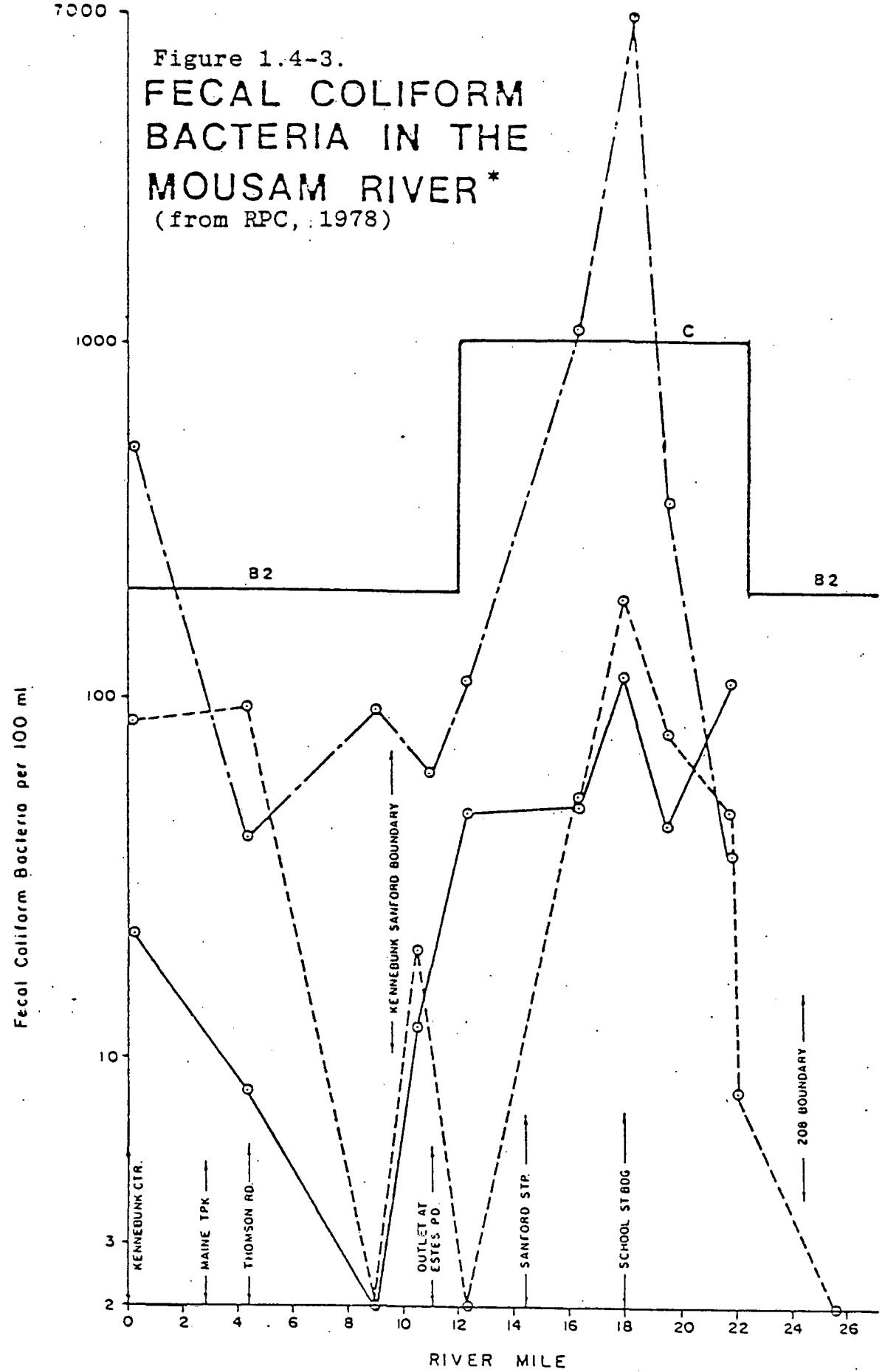
Figure 1.4-2. Monthly average flows, Mousam River at mile 9.6, water year 1977.

temperature and dissolved oxygen during the period July 26, 1945 to August 30, 1946 (DHW, 1950). These data showed dissolved oxygen concentrations falling from 86% of saturation at Springvale to 34% of saturation values immediately downstream of Sanford and recovering to 91% of saturation in Kennebunk.

The Maine Department of Environmental Protection conducted approximately 20 water quality surveys at up to 15 stations on the Mousam during the period beginning June 11, 1969 to September 15, 1975. Traditional sanitary parameters including dissolved oxygen, biochemical oxygen demand, bacteria, and pH as well as nutrients, heavy metals, and total and dissolved solids were measured. The results of these surveys are summarized in the Areawide Waste Treatment Management Plan (March 1978) and in the NEECo (1974) report. Results of these surveys for fecal coliform and total nitrogen are summarized in Figures 1.4-3 and 1.4-4. These figures show significant deterioration in both the upper reaches of the Mousam and in the vicinity of Sanford. Recovery occurs approximately 10 miles above the head of tide at Kennebunk.

The third major water quality survey was conducted by NEECo (1974) at four stations on the Mousam and three stations on Estes Lake. Parameters measured were similar to those measured in the Maine Department of Environmental Protection surveys, but included some vertical profiles in Estes Lake. These surveys were conducted from December 29, 1973 to March 26, 1974. The results confirmed water quality problems in the Mousam downstream of Sanford.

Figure 1.4-3.
**FECAL COLIFORM BACTERIA IN THE
 MOUSAM RIVER***
 (from RPC, 1978)



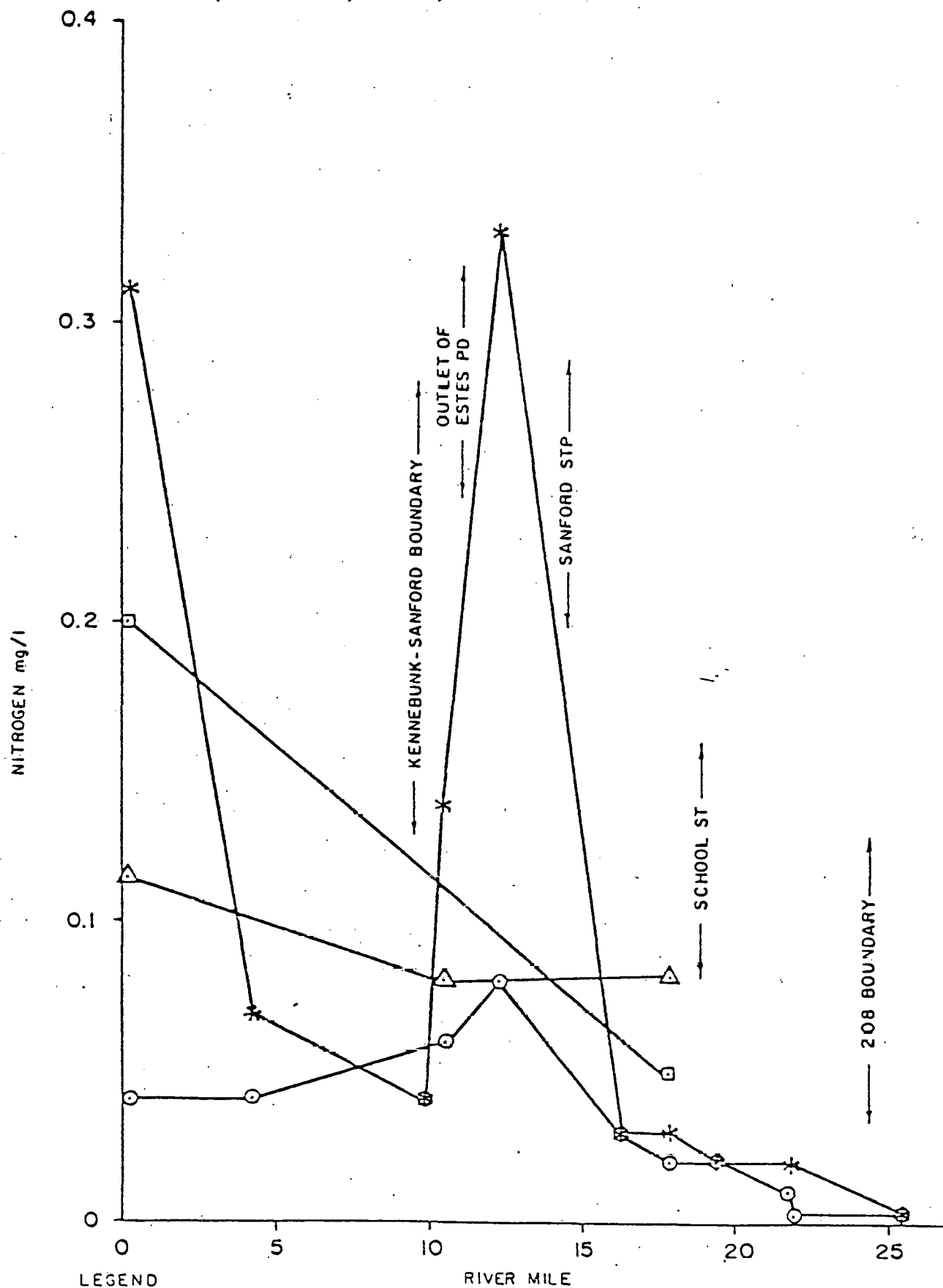
LEGEND

- June 10, 1975
- - - September 15, 1975
- · - Average of 5 sampling days between 6/25/73 & 8/14/73
- Classification Limit

* SOURCE Maine Department of Environmental Protection

Figure
1.4-4.

NITRATE, NITRITE & ORGANIC NITROGEN⁴⁹ IN THE MOUSAM RIVER-1975* (from RPC, 1978)



- LEGEND
- 6/10/75
 - △ Average of 12 samples from 6/16-17/75
 - Average of 12 samples from 8/25-27/75
 - * 9/15/75

Three other water quality studies, dealing exclusively with Estes Lake, have been completed in this decade. Two field programs conducted by Dr. Ciullo of Nasson College have studied the sewage stabilization ponds at Sanford (thought to be a major source of coliforms and nutrients in Estes Lake) and Estes Lake in particular. Both these studies are summarized in NEECo (1974). A study performed by the Environmental Protection Agency (EPA) in 1974 as part of its national eutrophication survey, quantified nutrient inputs to Estes Lake (EPA, 1974).

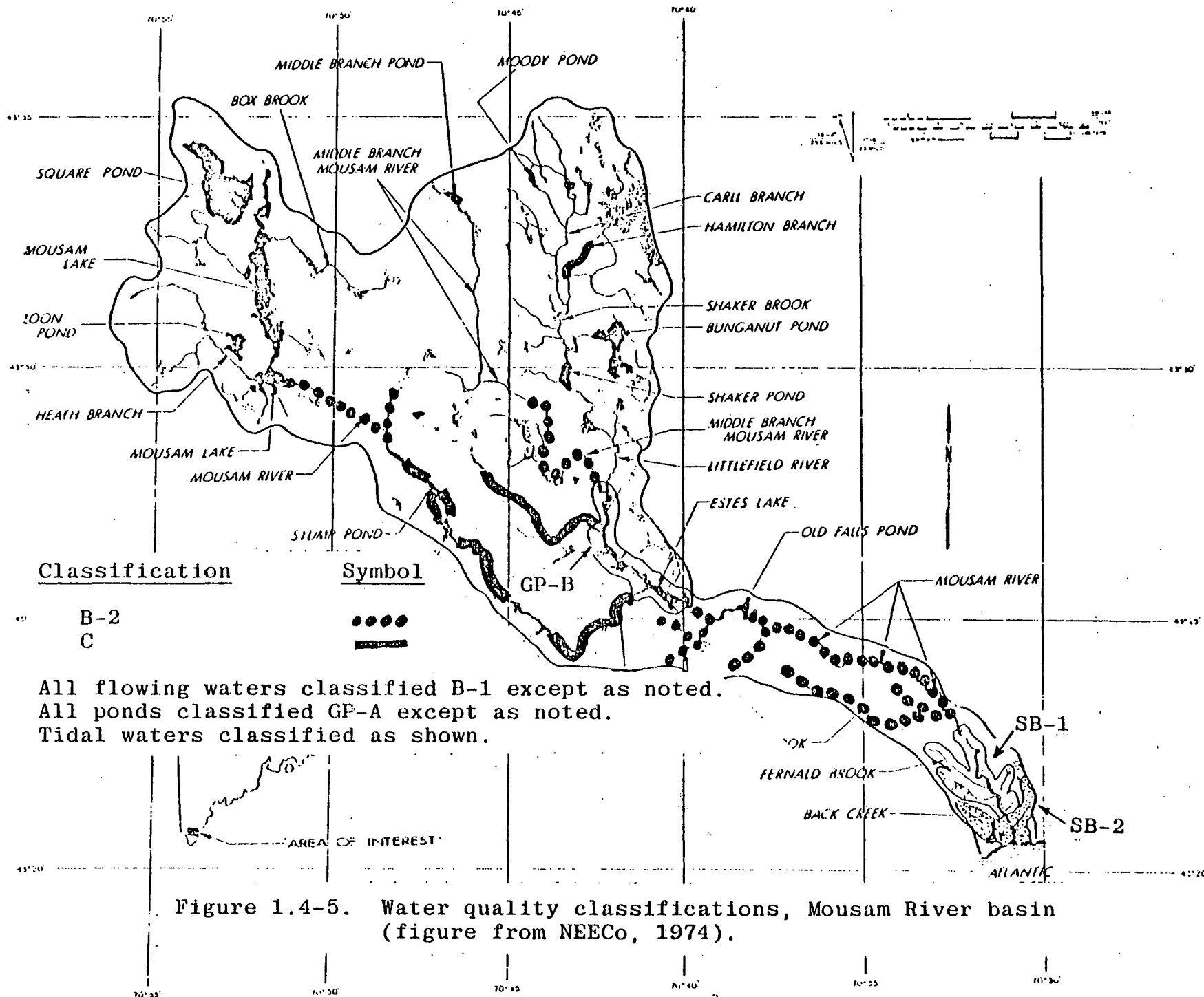
Water Quality Standards

Water quality standards for the Mousam River basin are found in the Maine Revised Statutes Annotated, Title 38, Chapter 3, "Classification of Surface Water" (Department of Environmental Protection, 1977). The standards are applied in the following manner. In each of the categories of inland waters, ponds, and tidal waters, a number of use classifications, such as contact recreation, public water supply, industrial process, and navigation, can be applied. Each of these classifications for each category of waterbody has a set of specific water quality standards. A particular watershed may contain numerous classifications and several categories. Figure 1.4-5 shows the classifications for the Mousam basin. Most of the basin receives a B-1 classification, which means the waters are acceptable for water contact recreation, potable water supply after treatment and as fish and wildlife habitat. Most of the ponds are classified GP-A, which is the higher classification in the pond category. The tidal waters are classified SB-1

and SB-2, which correspond to the freshwater classifications B-1 and B-2. Four segments of the Mousam are classified B-2: a portion of the River above Sanford, the Middle Branch above Estes Lake, the Mousam below Estes Lake, and Day Brook. The projected uses of these waters are the same as the classification B-1, except that dissolved oxygen concentrations may fall to lower levels and fecal coliform bacterial counts may be higher. Finally, three sections of the river are classified C: the Mousam from Sanford to Estes Lake, a portion of the Hamilton Branch, and the Hay Brook. This classification does not permit water contact recreation nor potable water supply except with treatment, and waters in this classification may have even higher bacterial counts and lower dissolved oxygen concentrations. Estes Lake itself is classified GP-B, the lower classification for ponds, which differs from GP-A in permitting higher bacterial counts and higher phosphorus concentrations.

These classifications and their application appear to be based on existing conditions in the basin. Water quality data clearly show deterioration in the Sanford region and Estes Lake, followed by some downstream improvement. The apparent policy expressed in these regulations is one of limiting the extent of new deterioration.

In addition to the standards imposed during the classification of waters, specific regulations concerning zone of passage around discharges, species diversity, thermal discharges, and phosphorous discharges have been established.



Water quality standards for the portion of the Mousam under consideration in this study (mile 10.1 to mile 0.0, Old Falls Pond Dam to the head of tide) are those associated with Class B-2. These are that dissolved oxygen "shall not be less than 60% of saturation and not less than 5 parts per million" (Maine Revised Statutes, Title 38, Chapter 3, p.6) and that fecal coliform bacteria shall not exceed 200 per 100 milliliters. In addition, general standards bar unsightly or foul-smelling material (scum, grease, etc.), toxic chemicals, radioactive materials exceeding drinking water standards, and high temperature discharges. Materials, such as sludges, which may destroy benthic habitat, are prohibited. All wastes, including industrial wastes and sewage are to be treated prior to discharge. The continuing satisfaction of these standards by water users will presumably guarantee that the Mousam will be suitable for water contact recreation, industrial and potable water supplies (after treatment) and fish and wildlife habitat. These are uses that constitute Class B-2 waters.

2. SOCIAL ENVIRONMENT

The social environment of the Mousam basin is presented in terms of man's use of natural resources described in the preceeding chapter. In particular, the institutional arrangements for managing these resources are discussed here. These include recreational, historic, and archeologic features, demographic characteristics, and water use information.

2.1 Recreational, Historic, and Archeologic Resources

Recreation

Recreation is important both for the degree with which it differs from workaday life and the intensity (Leopold, 1949). The State of Maine has provided both financial and technical assistance for the development of recreation as well as administering the federally funded Land and Water Conservation Fund. Behind education, recreation was the second highest category of expenditures while 33% of Maine residents felt that local recreational facilities were below average.

According to the Maine Statewide Comprehensive Outdoor Recreation Plan (SCORP), the value of local parks lies in their contribution to the aesthetic and general quality of life within a town. There are reported to be three general reasons for this. First, those municipalities with parks are likely to be more desirable places for siting new business. Second, residents of municipalities with abundance of parks often consider the municipality a very attractive place to live. Third, and as a result, people tend to afford themselves a greater amount of time within the municipality.

To cope with increased demand for recreation in recent years, municipalities have provided "greenways," continuous open space along the banks of rivers, tops of ridges, along utility line rights-of-way or other natural or man-made features.

Determination of urban and municipal outdoor recreation relies, traditionally, upon National Park, Recreation and Open

Space Standards. Several methods have been used to determine recreation needs including: (1) population ratios that employ a set acreage of 10 Ac./1000 population. This value is probably the best known and most commonly applied measure. It applies, however, only to public recreation areas located within or immediately adjacent to population centers. Other methods have also been used such as, (2) recreation space based on percentage of urban land area, user characteristics or demand projections placing emphasis upon the proclivities of the user population. Approaches based upon (3) the number of schools in relation to the number of recreational opportunities, (4) socio-economic status in relation to recreation activities including supply, travel distance, available leisure time and discretionary income are also utilized. Finally, (5) town resources may be inventoried and goals set.

The approach taken by the Maine SCORP (1977) is to assess urban and municipal recreational land deficiencies through the use of arbitrary but nationally accepted standards for additional park land and additional recreation facilities.

The Mousam River drainage basin lies within the SCORP defined Sanford urban area which, with its principal cities or towns of Sanford, North Berwick, Lebanon, Alfred, Waterboro, Acton and Shapleigh, has a total resident population of 23,694.

Utilizing a value of 20 Ac./1000 resident population, 474 Ac. would be required for regional parks. This urban area already has 195 Ac. in the form of Vaughn Woods, (165 Ac.) in South Berwick which has both trails and picnic areas, and the municipal

Moody Beach within Wells which has 30 Ac. largely devoted to swimming and picnic facilities. The difference between these values, (474 Ac. less 195 Ac.) constitutes a recreational land deficiency of 279 Ac., the value derived in the SCORP. The undeveloped acreage corresponds to an additional 378 Ac. or enough, seemingly, to meet the current regional park deficiency. However, the Great Ponds Act, effective July 6, 1978, places restrictions upon the environmental alteration of natural bodies of water in excess of 10 Ac. or artificial bodies of water in excess of 30 Ac. Consequently, if these bodies of water are in excess of the mandated acreage, development for water oriented recreation may be precluded.

Of the activity deficiencies which are included in the Maine SCORP, the one of principal importance to this investigation is nature study. In particular, the Maine Resource Conservation and Development Plan of 1970 recommended that Sanford develop a 100 Ac. nature park on the Mousam River. Even if this nature park were to be constructed with land acreage of 200 ft bordering the Mousam River, a linear distance of 2.1 mi. along the Mousam River would be necessary to make up the proposed 100 Ac. of land.

Historic and Archeologic Resources

Preservation of historic properties has been afforded prominence by federal action. The Historic Properties - Preservation Act, Public Law 89-665, as amended, authorized the Secretary of the Interior to expand and maintain a national register of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology and culture and to grant funds

to the states for preservation, acquisition, and development of such properties. Executive Order 11593 for the protection and enhancement of the cultural environment, dated May 13, 1971, further expands the purpose and policies of NEPA (1969), The National Historic Preservation Act (1966), The Historic Sites Act of 1935, and The Antiquities Act of 1906, one goal being that the federal government shall provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the nation.

In Maine, two acts have been passed which are coordinated with federal action. Public Law 398 (June 16, 1969) provides for the preservation and interpretation of archaeological artifacts and natural science specimens for the benefit of the people of the State and designates the State Museum to carry out this role. Public Law 536 (June 28, 1971) created the Maine Historic Preservation Commission which administers the program of The National Historic Preservation Act of 1966 and prepares a state register of historic places, accepts gifts and bequests, prepares biennial reports and promulgates, from time to time, various rules and regulations to effectuate the purposes of the charter.

In Maine, the National Register and the State Register of Historic Places are one and the same list. There are 38 sites in York County on the national register as of July 12, 1978 (Table 2.1-1). Of these sites only the Kennebunk Historic District lies close to the proposed Rogers Mill or Twine Mill Dam Sites.

According to the State Historic Preservation Officer (correspondence September 5, 1978), there are no known prehistoric

sites of significance in York County. He notes, however, that there has been little professional survey by archaeologists, to date, in southeastern Maine. In the opinion of the Commission, the Mousam River, as well as other York County drainages, is considered a "sensitive" area for prehistoric sites.

Of the two sites currently under consideration, Rogers Mill and Twine Mill, both have been in prior operation. Bedrock at Rogers Mill lies close to the surface and the site has been highly disturbed. It is improbable that prehistoric cultural remains will be found by further excavation. The Twine Mill site is also the former location of a dam, now breached. In the vicinity of the former dam pool, the eroded steeply sloping west facing slope and the more gently sloping east facing slope both exhibit effects of drawdown, following breaching of the dam, in the nature of extensive alder thickets which stretch from river edge to the former upward limit of the reservoir pool. It is improbable that cultural remains would have survived the prior flooding.

In the event that cultural remains are found during the process of construction, the State Historic Preservation Officer should be contacted and construction or excavation activities must cease until both the importance and extent of the find is determined.

Table 2.1-1
Maine Sites on the National Register of Historic Places
in York County

Date	Location	Town	County
10/1/69	Fort McClary	Kittery	York
12/3/69	John Hancock Warehouse	York	York
7/27/71	Frost Garrisons and House	Eliot	York
10/26/72	First Parish Meetinghouse	Biddeford	York
4/2/73	Lord Mansion	Kennebunk	York
4/2/73	Old Schoolhouse	York	York
4/24/73	Biddeford City Hall	Biddeford	York
5/7/73	U.S. Post Office	Biddeford	York
6/4/73	Sarah Anne Jewett House	South Berwick	York
7/16/73	York Historic District	York	York
8/14/73	William Peperrell House	Kittery	York
9/7/73	Perkins Tide Mill	Kennebunkport	York
9/20/73	Capt. Nathaniel Lord Mansion	Kennebunkport	York
1/18/74	U.S. Custom House	Kennebunkport	York
6/5/74	Kennebunk Historic District	Kennebunk	York
11/1/74	Fletchers Neck Lifesaving Station	Biddeford	York
4/24/75	Sen. John Holmes House	Alfred	York
4/28/75	Thomas Goodall House	Sanford	York
4/28/75	The Temple	Old Orchard Beach	York
4/28/75	Moody Homestead	York	York
6/5/75	Old Grist Mill	E. Lebanon	York
6/5/75	Royal Brewster House	Buxton	York
6/5/75	West Lebanon Historic District	Lebanon	York
9/9/75	Kennebunk River Club	Kennebunkport	York
10/10/75	Portsmouth Company Cotton Mills: Counting House	South Berwick	York
10/10/75	Rose, Robert, Tavern	York Vicinity	York
1/2/76	Buxton Powder House	Buxton	York
1/2/76	John Sedgley	York	York
5/6/76	Kennebunkport Historic District	Kennebunkport	York
9/29/76	Morrell House	North Berwick	York
11/21/76	Thacher-Goodale House	Saco	York
12/15/76	Barrell Homestead	York	York
5/26/77	Gennish Homestead	Kittery	York
9/16/77	"Quillcote"-Kate Douglas Wiggin House	Hollis	York
11/17/77	Portsmouth Naval Shipyard	Kittery	York
3/29/78	Berwick Academy	South Berwick	York
3/31/78	Seavey, A.B., House	Saco	York
7/12/78	Morison, Capt. James, House	Parsonsfield	York

2.2 Population and Water Use

The population of the 12 Towns that were included in the 1978 Areawide Waste Treatment Management Plan (Southern Maine Regional Planning Commission, 1978) and that cover most of the Mousam basin was 103,000 in 1975. This population is expected to increase by 15% by 1980 and by an additional 29% by 2000. The summer recreational population of the area doubles the permanent population, with half this increase occupying seasonal homes and the other half in camp grounds and commercial lodgings (SMRPC, p. I-43).

For the Town of Kennebunk, 1975 population was 6600, with a projected increase of 19% to 1980 and an additional 36% to 2000.

The Town of Kennebunk is provided water by a quasi-municipal corporation, The Kennebunk, Kennebunkport, and Wells Water District (KK&W). The source of water for the district is the Branch Brook, the watershed immediately south of the Mousam.

The Mousam River from Sanford downstream to the ocean receives five major point source discharges:

<u>Discharge</u>	<u>Location</u>
Combined sewer overflows Sanford	Approximately 6 points between Mill Street in Springvale and the Mousam River pumping station near the treatment plant.
Sanford Sewerage District Lagoons	2.4 miles upstream from confluence with Middle Branch.
Combined sewer overflows, Kennebunk	Sayward Street and Brown Street, Kennebunk.

DischargeLocation

(Continued)

Kennebunk primary treatment
plantWater Street, Kennebunk, 0.7 mile
downstream from U.S. Route 1 bridge.Keuffel and Esser industrial
waste treatment plantApproximately 1/4 mile below head
tide.

(Source: SMRPC, p. II-185)

2.3 Endangered Species and Critical Areas

The Endangered Species Act of 1973, 87 Stat. 884, 16 U.S.C. 1531-43, (PL 93-205) as amended by PL 94-32 (June 30, 1976) and PL 94-359 (July 12, 1976) provides a means for conservation of ecosystems upon which endangered and threatened species depend, and a program for the conservation of such endangered and threatened species. The current U.S. list of endangered and threatened wildlife may be found in the Code of Regulations, Title 50, Part 17.

According to the U.S. Fish and Wildlife Service (correspondence, September 22, 1978) two species of plants are currently being considered for threatened status by the Service in York County. These are the yellow rein orchis (Habenaria flava) and the ram's head lady's slipper (Cypripedium arietinum). Table 2.3-1 lists those species of animals and plants currently on or being considered as threatened or endangered in the State of Maine.

Coordinate legislation to that of the Endangered Species Act is embodied in Endangered Species (Chapter 337, p. 164-167) of Maine statutes. Inventory of the State's plants and animals has begun and the list of the "rare" plants of Maine will be completed during the fall of 1978. Preliminary information suggests that more than 30 plant taxa within York County occur in three or fewer locations in the state.

Among the birds (Table 2.3-1), both the bald eagle and the peregrine falcons are migrant and are not known to nest in the Lower Mousam River area. The presence of the shortnose sturgeon

Table 2.3-1
Preliminary List of Endangered
Species of Plants and Animals Within
The State of Maine

Common Name	Scientific Name	Distribution	
		U.S.	ME
I. Birds (Aves)			
Eagle, American Bald	<u>Haliaeetus leucocephalus</u>	E	migrant
Falcon, American Peregrine	<u>Falco peregrinus anatum</u>	E	migrant
Falcon, Arctic Peregrine	<u>Falco peregrinus tundrius</u>	E	migrant
II. Fish (Pisces)			
Sturgeon, Shortnose	<u>Acipenser brevirostrum</u>	E	not recorded from Mousam River estuary
III. Sedge Family (Cyperaceae)			
Sedge (Unnamed)	<u>Carex elachycarpa</u>	E	Riverbanks, known from Aroostook County
IV. Orchid Family (Orchidaceae)			
Pogonia, Small Whorled	<u>Isotria medeoloides</u>	E	Records from Cumberland, Oxford Co.
Lady's Slipper, Ram's Head	<u>Cypripedium arietinum</u>	T	swampy woods
Orchis, Yellow Rein	<u>Habenaria flava</u>	T	in southern half of state
V. Grass Family (Poaceae)			
Reed Bent Grass	<u>Calamagrostis inexpansa</u> var. <u>novae-angliae</u>	E	Records from a majority of counties
VI. Buttercup Family (Ranunculaceae)			
Globeflower, Spreading	<u>Trollius laxus</u>	E	
VII. Figwort Family (Scrophulariaceae)			
Lousewort, Furbish	<u>Pedicularis furbishiae</u>	E	Record from Aroostook County

E - Endangered Species

- Threatened Species

- Being considered for threatened status

has not been recorded in the lower Mousam River although Maine is currently studying the distribution and abundance of the species in the Kennebec River - Sheepscot River complex as well as the Piscataqua River. These rivers are of appreciably greater extent than the Mousam River.

Among the plant species thought to be endangered or threatened in the State of Maine, none was seen in the vicinity of either the Rogers Mill nor the Twine Mill Dam sites.

Of the endangered species, Carex elachycarpa Fern., possibly a hybrid between Carex muricata L. and some other species, is known to occur on wet river banks in northern Maine. Isotria medeoloides (Pursh) Raf. is found on acid soil in dry woods and flowers in May and June. Cypripedium arietinum R.Br., a candidate for threatened status, may be found in moist, usually acid soils in coniferous woods and flowers in May and June. Habenaria flava (L.) R.Br., also a potentially threatened species, is found in boggy or swampy ground and flood-plains flowering from June-September. Calamagrostis inexpansa Gray. var. novae-angliae Stebbins. is found in wet meadows and marshes. Trollius laxus Salisb. is found in swamps, wet woods and wet meadows and flowers in May. Pedicularis furbishiae S. Wats. is found in swamps and wet woods and flowers in July and August.

The sites were visited on September 25-27, which is after the flowering period of the majority of these species. Consequently, it is not possible to make a categorical statement that these are not to be found in the area to be flooded. A re-survey during spring and early summer would be necessary in the event

that the publication of rare species establishes that the Mousam River drainage harbors such species.

Fish restoration was examined by De Roche (1955) as part of a state-wide study of obstructions to fish migration on the Mousam River. It was noted that there were no fishways present in any of the then 13 dams on the main river. Consequently, all dams were considered to be major obstructions with fish passage impossible at all water levels.

In 1978, the Rogers Mill Dam which presented a 16 ft vertical spillway in 1955, was totally breached. The Kesslen Dam creates over 17 ft of vertical drop in 1978 as it did in 1955. Both the proposed Twine Mill Dam with its 18 ft vertical spillway and the Dane Perkins Dam with its 10 ft vertical spillway were also totally breached in 1978, but were obstacles in 1955. Above Dane Perkins on the Mousam River, Old Falls and New Dam are still standing. Further upstream on the Mousam River seven additional dams were present in 1955 extending to Mousam Lake Dam.

The views that were expressed by De Roche in 1955 appear to be true today; currently, there is no State plan to restore anadromous fish runs in the Mousam River because of the large number of dams that would require fishways.

The possibility of including fish ladders, for anadromous fish passage, in new construction proposals should not be ignored because improvements in water quality within the Mousam drainage as well as new dam construction to replace deteriorated or

breached structures may allow the Mousam River to sustain a restored Atlantic salmon fishery with appropriate environmental management.

It is to be noted, however, that there is a small fishery for alewives and blueback herring and a commercial fishery of some size for juvenile eel. The tidal portion of the Mousam River supports a striped bass sportfishery and there may be runs of anadromous rainbow smelt in the lower river. According to the Maine Department of Environmental Protection, shellfishing areas in the Mousam River estuary exhibited high bacterial counts (1100 organisms/100 ml) and were closed to shellfishing in 1973. The Mousam River from Rogers Mill Dam up to Old Falls Dam was designated as potentially supportive of a warm water fishery in 1955.

Critical Areas

The State of Maine has established a state register of critical areas (Chapter 778, p. 1138-1 - 1138-3, 1974) for sites or areas of unusual natural, scenic, scientific or historical significance. A critical area is defined as an area (or site) containing or potentially containing plant and animal life or geological features worthy of preservation in their natural condition, or other natural features of significant scenic, scientific or historical value. In order to promote preservation and utilization of these area through appropriate land use planning, regulation, protective acquisition and/or management, the state has inventoried its critical areas and commissioned

the preparation of a preliminary listing of noteworthy natural features (Center for Natural Areas, 1976).

There are, at present, two critical areas within York County on the Register of Critical Areas; one seeks to protect a plant community containing a rare spicebush stand (Lindera benzoin) while the other protects the ram's head lady's slipper (Cypripedium arietinum), a species candidate for threatened status which is endangered within the state. Neither site is in proximity to the proposed dam sites.

The natural areas inventory, which is maintained by the state, lists 20 natural areas within York County in addition to those on the Register of Critical Areas. Of these sites, nine are within proximity to the proposed dam sites (Table 2.3-2) although none would be directly affected by the proposed construction. Three of the sites identify plants or plant communities while six identify geologic or hydrologic features. Among the latter are the mouth of the Mousam River and whitewater stretches of the river that may be suitable for recreation.

Table 2.3-2
Natural Areas Inventory¹

<u>Date</u>	<u>Town</u>	<u>Natural Feature</u>	<u>Area, acres</u>
5/19/78	Alfred	Atlantic White Cedar (Rare Vascular Plants)	1.0
5/19/78	Kennebunk	Mousam River Mouth (Hydrologic Feature River)	30.0
5/19/78	The Plains	Sand Plains (Rare Plant Communities)	600.0
5/19/78	Sanford	Mousam River (Whitewater)	1500 ft
5/19/78	Sanford	Jaggers Mills to Estes Lake (Whitewater)	40.0
5/19/78	Sanford	Sanford Geologic Area (Geology, Minerals)	10.0
5/19/78	Sanford	Indians Last Leap (Geology, Gorges)	1.0
5/19/78	Sanford	Springvale Rhododendron (Rare Vascular Plants)	0.1
5/19/78	Waterboro	Old Corner (Geology, Outwash Plain)	10.0

1. Areas in the Mousam River Basin within York County in proximity to proposed dam sites which have been inventoried but are not on the State Register of Critical Areas as of May 19, 1978.

3. EFFECTS OF CONSTRUCTION AND OPERATION

The specific impacts of construction and operation of the proposed Mousam River hydroelectric redevelopment on the natural and social environments described earlier are detailed in this chapter.

Placing these impacts in perspective, two facts should be noted. First, the proposed dams have been in operation previously. Therefore the majority of the impacts of construction and operation have already been experienced. Second, the whole of the Mousam basin contains numerous dams. In fact, the history of small impoundments on the Mousam goes back to July 12, 1670, when the first dam was completed (Remich, 1911). There have been dams in existence on the Mousam continuously since a few years after this date.

Following is a description of the proposed projects.

3.1 Proposed Redevelopment

The redevelopment plan involves the restoration or raising of two dams and the reregulation of some existing dams as a consequence of enlargement of turbine generators. Reregulation involves coordination of impoundment releases for maximum useful power generation. Since hydroelectric power generation is not a consumer of water, the impact of this type of operation on the water budget of the Mousam is small, changing only the temporal distribution of flow within a daily cycle. The environmental assessment of this project therefore concentrates on the two proposed impoundments. These are described below.

Twine Mill Dam

The Twine Mill Dam, located approximately at Mousam River mile 3.3, is currently completely breached. The proposed hydroelectric redevelopment for this site includes rebuilding the dam to its original height of 18 feet or increasing the original height by 10 feet to a total of 28 feet. Detailed topography is not available for the site, but estimates made from the United States Geological Survey 1:62500 scale topographic map (USGS, 1956) show the following depth - area - volume relationship:

<u>elevation above streambed, feet</u>	<u>impoundment surface area, acres</u>	<u>impoundment volume, acre-feet</u>
0 (existing)	6	0
18 (first option)	12	170
28 (second option)	25	360

The impoundment backwater would extend approximately 2700 feet from the dam for the first option.

The first option results in a restoration of a pool that existed on the Mousam from 1937 until approximately 1960. The second entails doubling both the surface area and volume of the former pool.

Rogers Mill Dam

Rogers Mill Dam is immediately downstream of the Kesslen Mill Dam in Kennebunk, at Mousam River mile 0.0, at the upstream extent of tidal influence. It is proposed that Rogers Mill Dam be restored to its original height of 16 feet. The impoundment is smaller than the proposed Twine Mill restoration and encompasses 6 acres of surface area and approximately 93 acre-feet in volume. The pool length would be 820 ft, or to the foot of the Kesslen Mill Dam.

3.2 Effects on Soils and Vegetation

The proposed Rogers Mill Dam restoration appears to be one which would cause less environmental alteration because bedrock is close to the surface and there is little soil to be eroded. In addition, there is a generally weedy and ruderal assemblage of plant species to be affected by inundation in an area which has already been previously altered both as a consequence of chronic changes from the now breached dam as well as the downstream erosion caused by Kesslen Mill Dam, particularly upon the relatively steep slopes.

For the proposed Twine Mill restoration, if flooding is confined to the extent of the preexisting pool, now predominantly vegetated as an alder thicket with a narrow riverine herbaceous marsh, it will be necessary to clear and remove vegetation on the slopes in order to avoid organic sediment accumulation in the newly created pool. It would be expected that a similar vegetation zonation would reestablish at the higher elevation of the dam pool. At the present time, however, no known endangered, threatened or rare species were seen in the area.

The probable impact of an elevated dam pool at Twine Mill would cause the most pervasive and less predictable environmental alterations, the full extent of which can be evaluated only upon completion of engineering specifications, detailed aerial photographic interpretation and field surveys. In general, there would be both greater sedimentation of an organic/inorganic nature and more extensive removal of older growth forests of hardwood and hemlock.

3.3 Water Quality Effects

The effects of large impoundments on reservoir and downstream water quality are generally well known. These effects are related to the hydrology of the impounded river system, the climatology of the region, and the design and operation of the dam and reservoir. Among the possible water quality effects are (1) dissolved oxygen depletion in hypolimnetic waters of thermally-stratified impoundments; (2) release of cold, nutrient rich and oxygen depleted waters from low level outlets and consequent impacts on downstream riverine wildlife communities, and (3) retention of sediment and nutrients in the impoundment, the latter associated with the problem of over-enrichment or eutrophication. Eutrophication, in turn, contributes to the oxygen-depletion of bottom waters. These effects result from stable summer thermal stratification which limits flushing of reservoir bottom waters.

The effects of small impoundments such as those proposed for the Mousam River have not been thoroughly studied. The processes that establish summer thermal stratification, fall overturn, and winter and spring fully mixed conditions in the typical large reservoir or lake are also present in smaller impoundments. It is the scale of the hydrologic and climatologic processes relative to the depth and volume of the smaller impoundments that determines if thermal stratification will be present.

The proposed Twine Mill Dam restoration includes as a first option an impoundment up to 18 feet deep with a volume of 170 acre-feet and, as a second option, an impoundment with

a maximum depth of 28 feet and a volume of 360 acre-feet. Using the mean annual Mousam River flow of 179 cfs at Whichers Mill Road (Section 1.4), the average residence time for option 1 is 0.5 day and for option 2 is 1.0 day. Residence times in excess of 40 days and generally at least 200 days indicate summer thermal stratification for Tennessee, Ohio, and Columbia River impoundments (Ryan, 1972, p. 2-4). For the Rogers Mill Dam, with a volume of 93 acre-feet, a residence time of 0.3 day is computed. Based on the retention characteristics of these two impoundments, therefore, thermal stratification is not expected.

A second factor in thermal stratification is depth. In large reservoirs, the depth of summer thermal stratification is dependent on the rate of attenuation of solar radiation from the surface of the impoundment downwards and also on the effectiveness of wind mixing. Tests in Cherokee Reservoir, Tennessee, show that 99% of solar radiation is absorbed in the top 32 feet of the water column (Ryan, 1972, p. 2-19). The warming of this top layer of water and consequent wind mixing to a similar depth create the warm top layer in thermally stratified reservoirs known as the epilimnion. Since the warmer water is less dense than the underlying cool water, mixing is inhibited and thermal stratification increases in intensity. This process is reversed in the fall with atmospheric cooling of the surface layer to the point of equal densities in the top and bottom layers permitting complete vertical mixing.

The relatively shallow depth of these two impoundments implies that both solar radiation and wind mixing will be effective

to the full depth and thermal stratification is not likely. The consequence of this fully mixed behavior on impoundment and downstream water quality is that the water quality conditions, both in the impoundments and downstream, will not change significantly from current riverine conditions after the impoundments are completed. Post operational water quality therefore should satisfy water quality standards (Section 1.4) to the same extent as current conditions.

The impoundments will act as sediment traps, but the relatively low-yield of sediment from the basin (Sections 1.1 and 1.3 makes the impact of the redistribution of this sediment minimal. The increased water surface area exposed as a result of the impoundments will increase the total evaporation from the basin as well as result in a small increase in water temperature. This will not be detectable among the large normal diurnal and seasonal water temperature variations.

3.4 Cultural Effects

Although the cultural effects of the proposed dam restorations cannot be predicted with complete certainty, it is probable that recreation opportunities, in general, will be enhanced. This enhancement will probably take the form of increased sport fishing and water based activity such as canoeing and ice skating.

At the present writing, no known endangered or threatened species will be affected by the proposed dam reconstruction. The possibility that rare species or ones in the above categories exist, however, should not be eliminated.

Since portions of the sites were previously flooded, it is less likely that cultural archaeological artifacts remained intact. New areas to be flooded should be examined for cultural remains because the general area along the Mousam River has been identified as a possible source of such remains.

Particular attention should be given to appropriate fee title acquisition to land bordering upon, in proximity, and accessible to the proposed dam pools and certain areas down river of and subject to the presence and influence of the dams.

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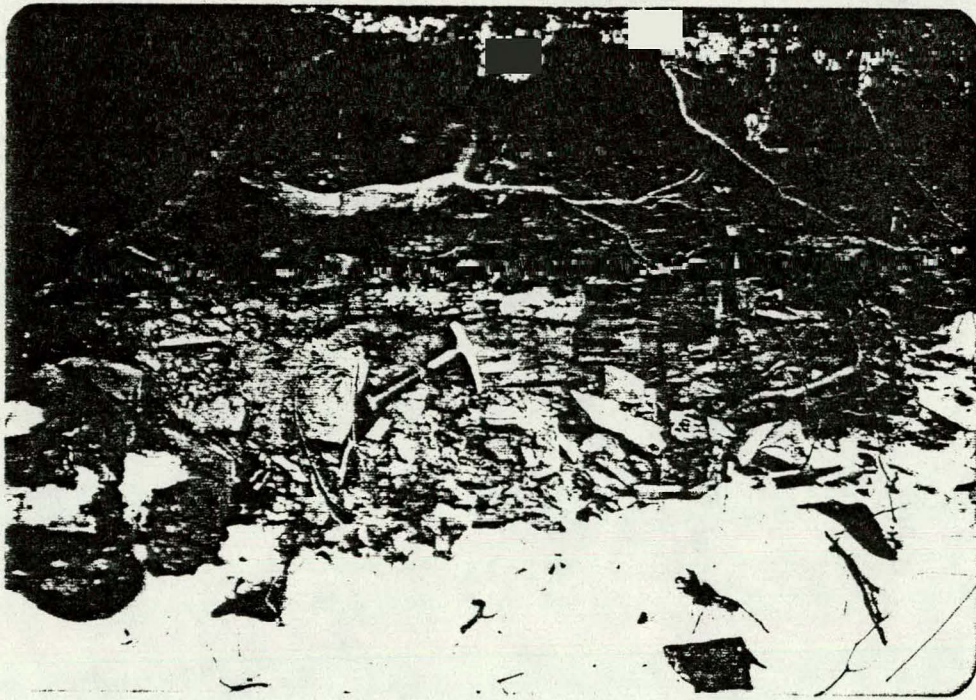
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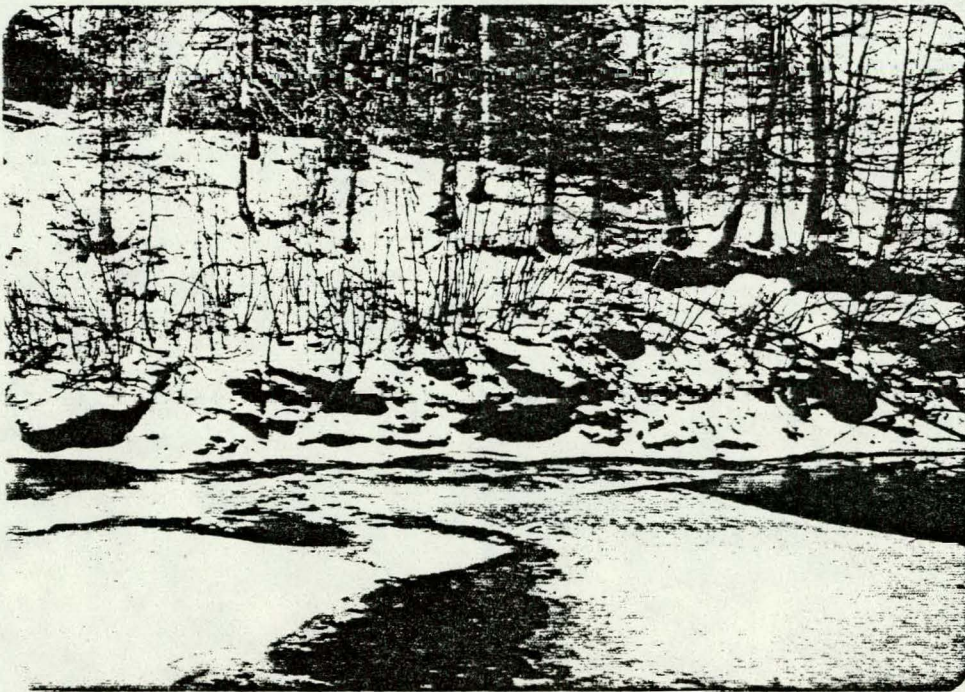
APPENDIX C.
CIVIL CONSTRUCTION REQUIREMENTS



PHOTOGRAPH NO. 1

TWINE MILLS DAM

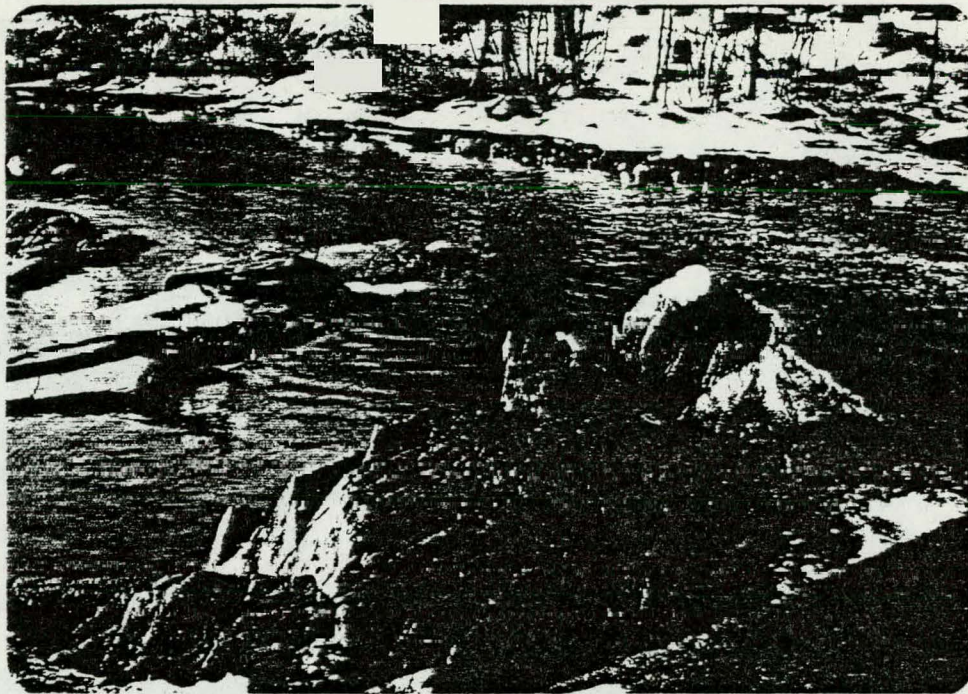
JOINTED BEDROCK SOUTH BANK OF
RIVER JUST DOWNSTREAM OF DAM



PHOTOGRAPH NO. 2

TWINE MILLS DAM

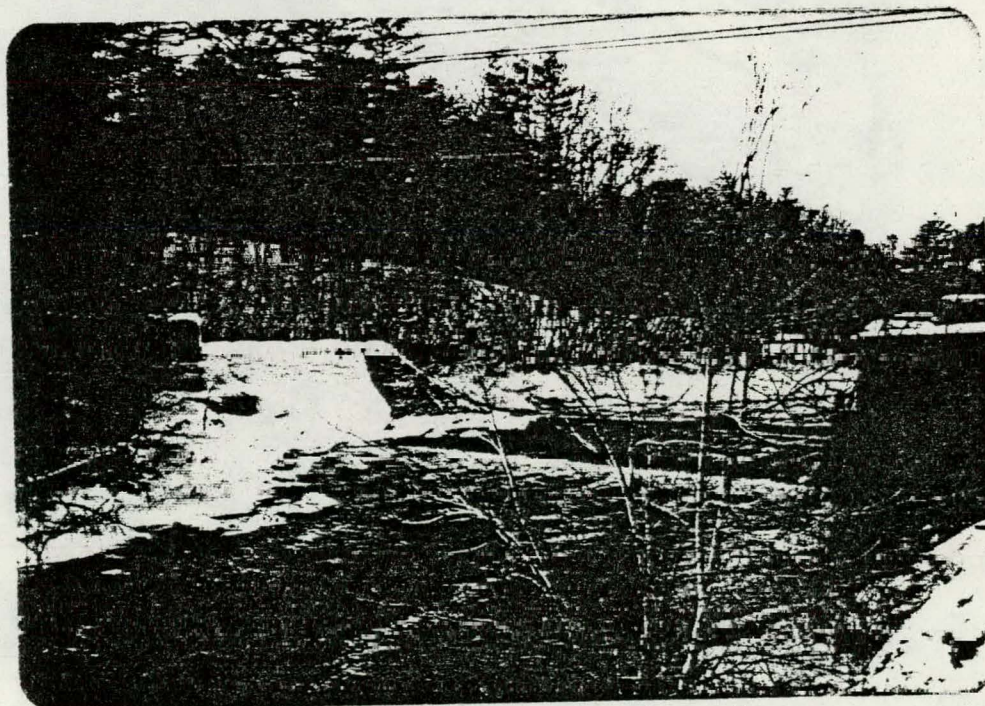
BEDROCK OUTCROP NORTH BANK
OF RIVER JUST UPSTREAM OF DAM



PHOTOGRAPH NO. 3

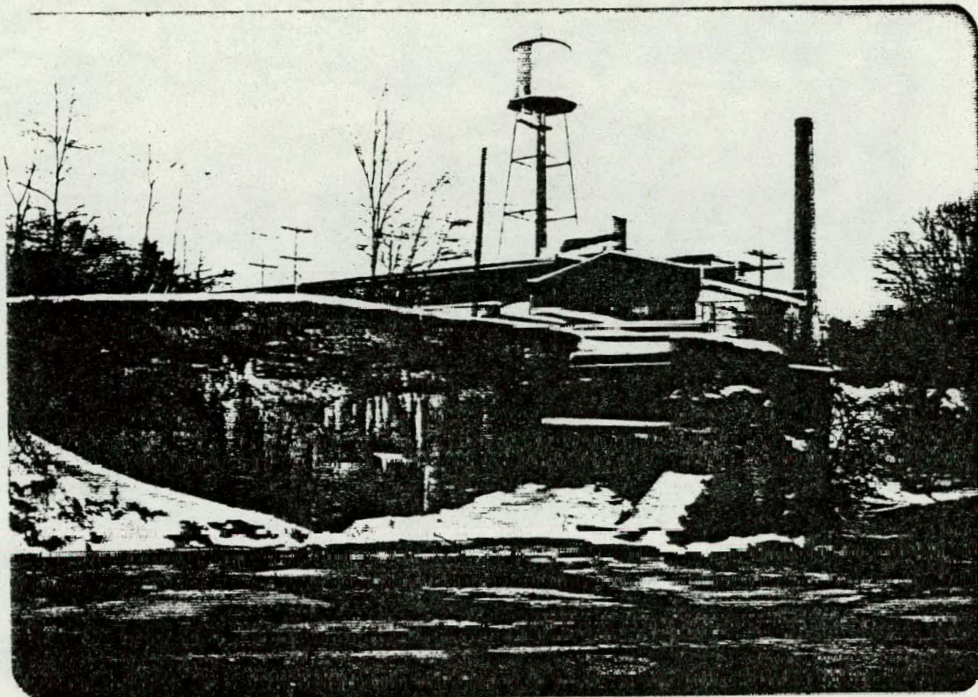
ROGERS FIBER DAM

BEDROCK UNDERLYING BASE SLAB
OF DAM



PHOTOGRAPH NO. 4

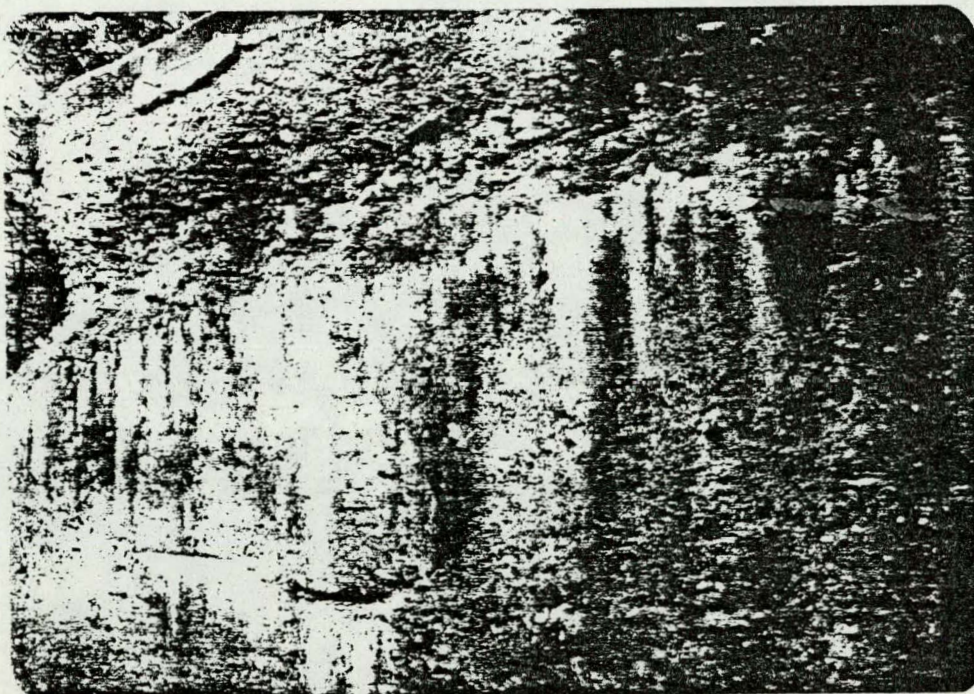
GENERAL VIEW OF TWINE MILLS DAM SITE
LOOKING UPSTREAM



PHOTOGRAPH NO. 5

NORTH WING WALL & NORTH ABUTMENT WALL

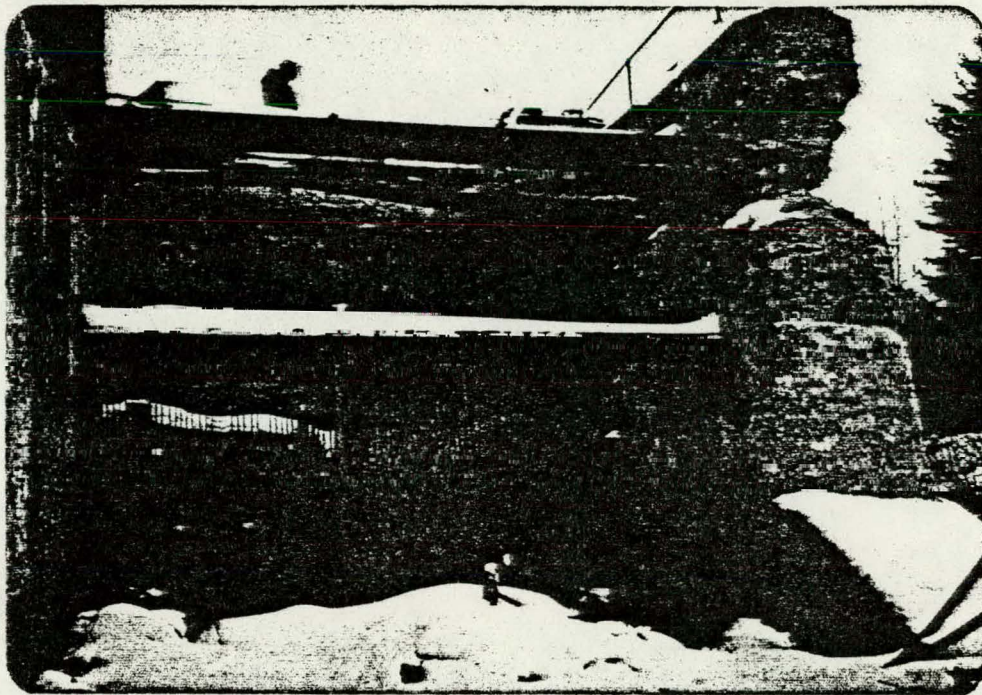
NOTE: JOINT SPALL, EROSION AND EXPOSED
STEEL AND WHITISH EXHUDATIONS AND
EFFLORESCENCE.



PHOTOGRAPH NO. 6

NORTH ABUTMENT WALL

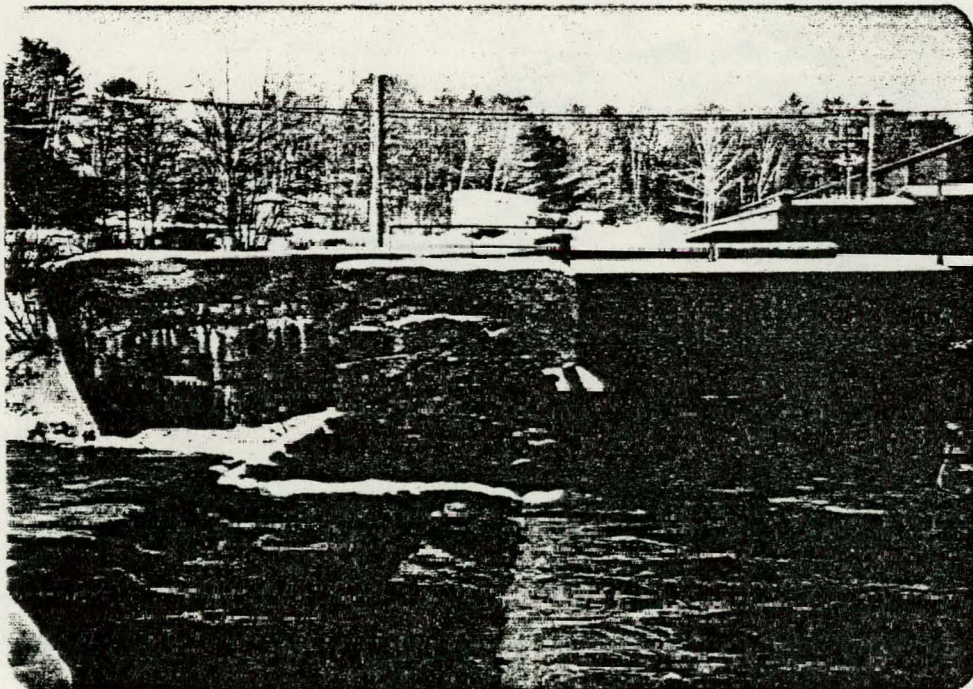
NOTE: BAND OF EROSION AT CREST LEVEL
AND GENERAL SCALING.



PHOTOGRAPH NO. 7

GATEWAY, GATEWAY WALL, & GRATES

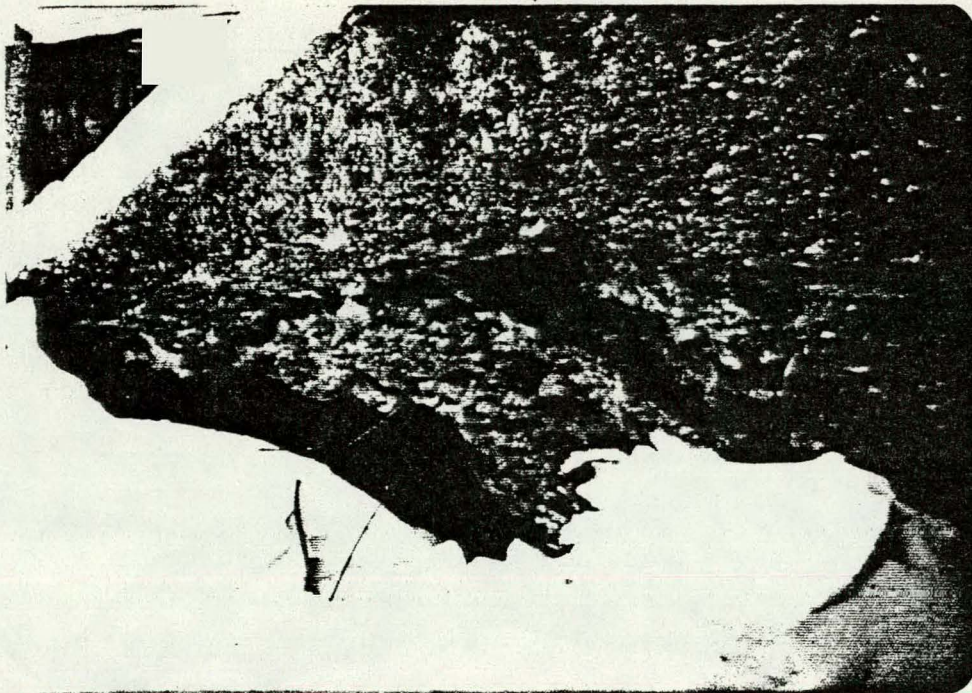
THIS VIEW SHOWS DEEP EROSION AT CREST LEVEL
AND GENERAL SCALE AND JOINT SPALL ON NORTH
SIDE, AND DETERIORATED GRATES AND GATE.



PHOTOGRAPH NO. 8

NORTH ABUTMENT AND GATEWAY WALLS SOUTH SIDE

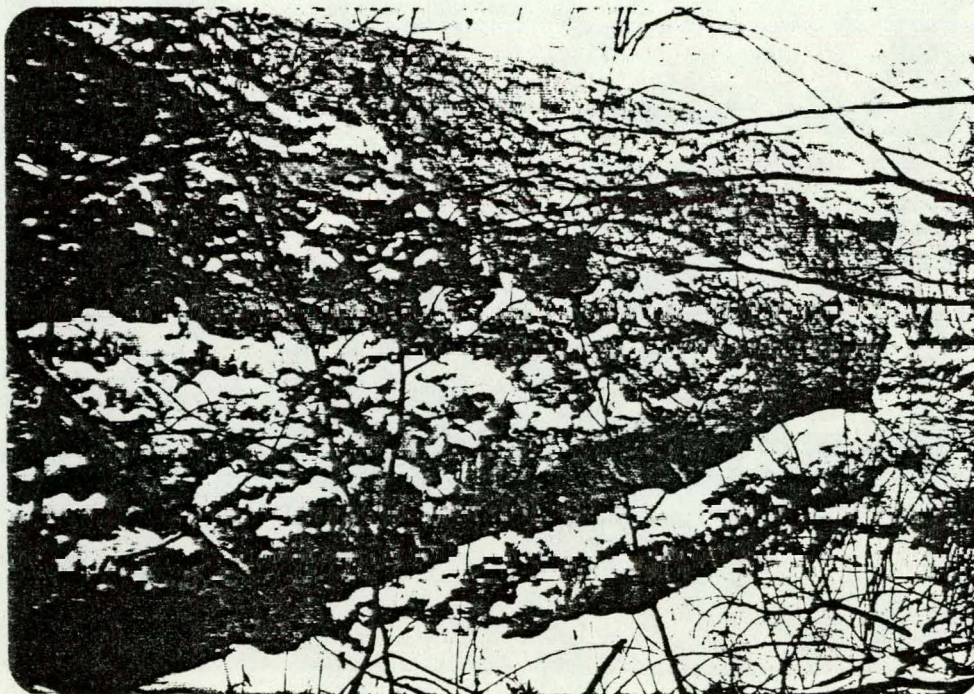
NOTE: EROSION AT CREST LEVEL, JOINT EROSION AND SPALL.



PHOTOGRAPH NO. 9

GATEWAY WALL EXTENSION

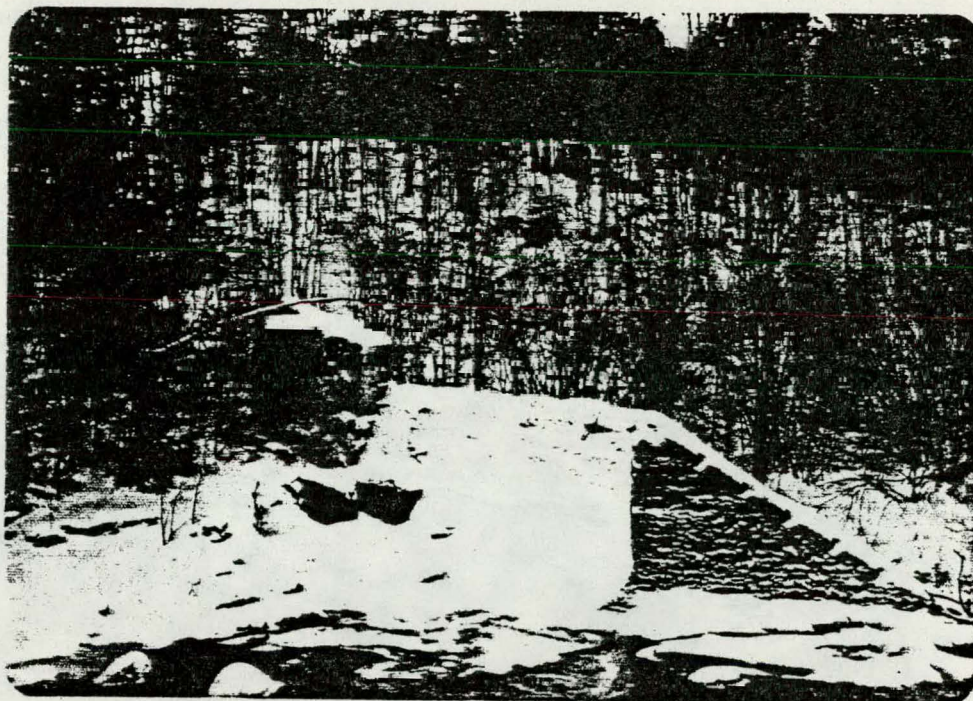
SHOWS DEEP EROSION THAT OCCURS BOTH SIDES



PHOTOGRAPH NO. 10

UPSTREAM FACE OF SOUTH WINGWALL

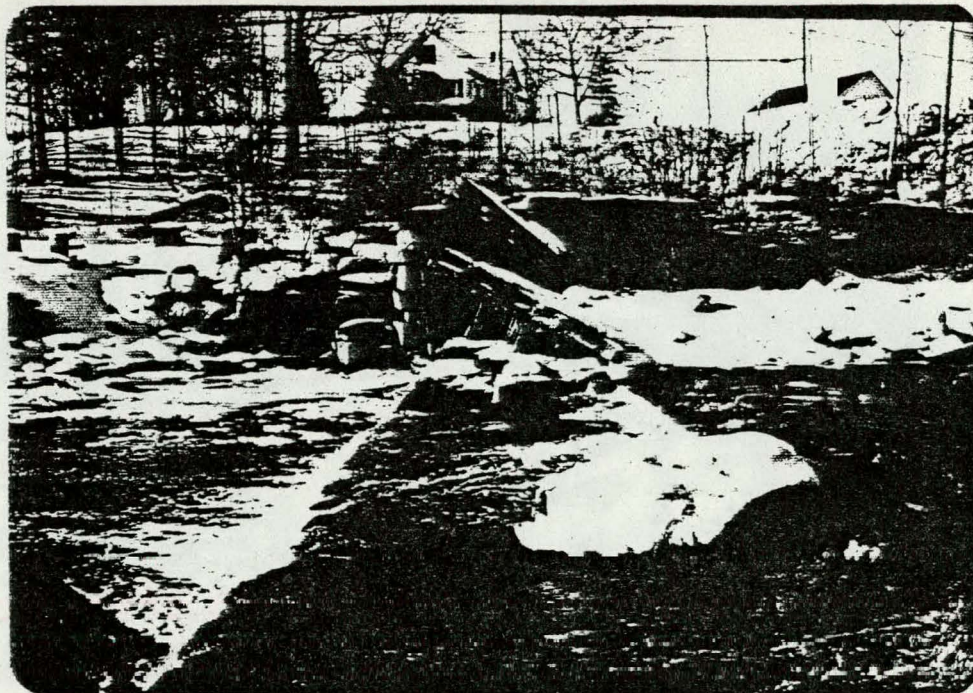
NOTE: SCALE AND EROSION



PHOTOGRAPH NO. 11
DOWNSTREAM SIDE OF SOUTH WINGWALL
AND ABUTMENT

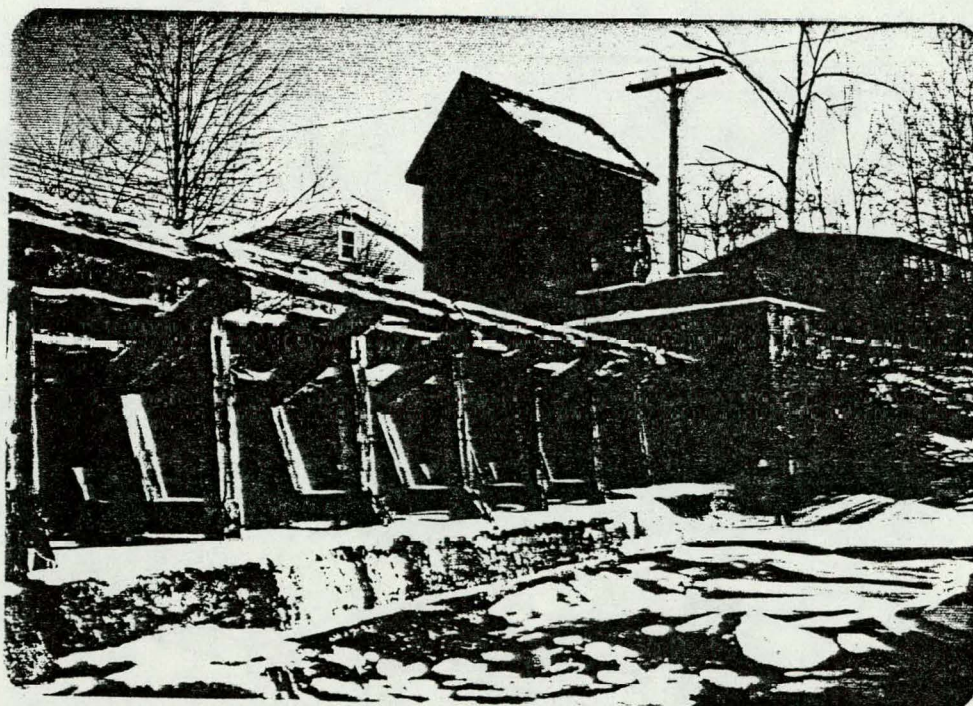


PHOTOGRAPH NO. 12
ROGERS FIBER DAM
NORTH WINGWALL CRIBWORK



PHOTOGRAPH NO. 13

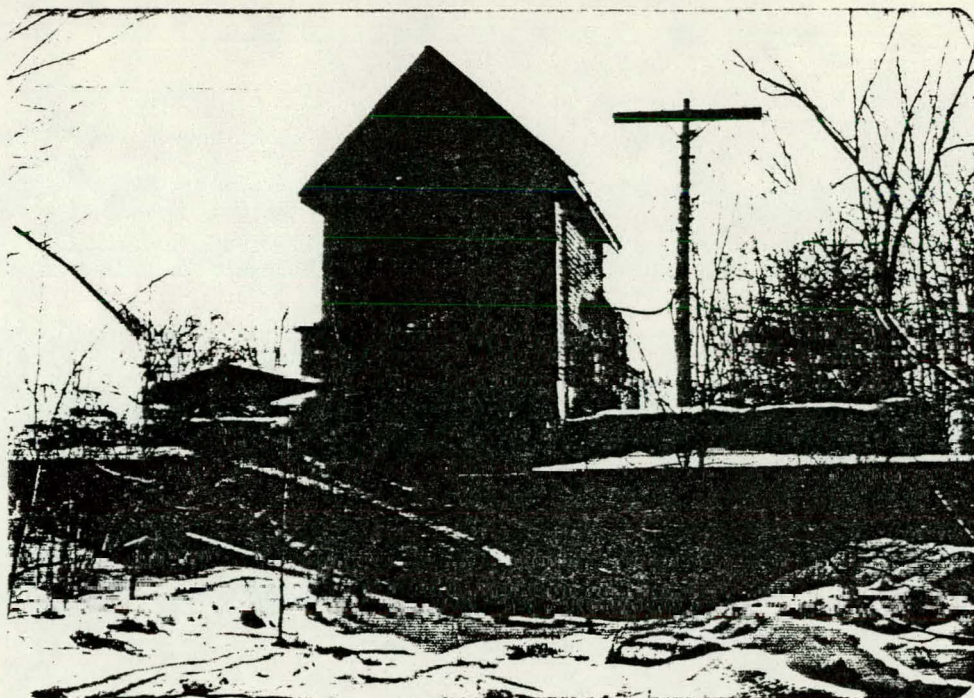
ROGERS FIBER DAM
CENTRAL BASE OF DAM AND SOUTH WINGWALL



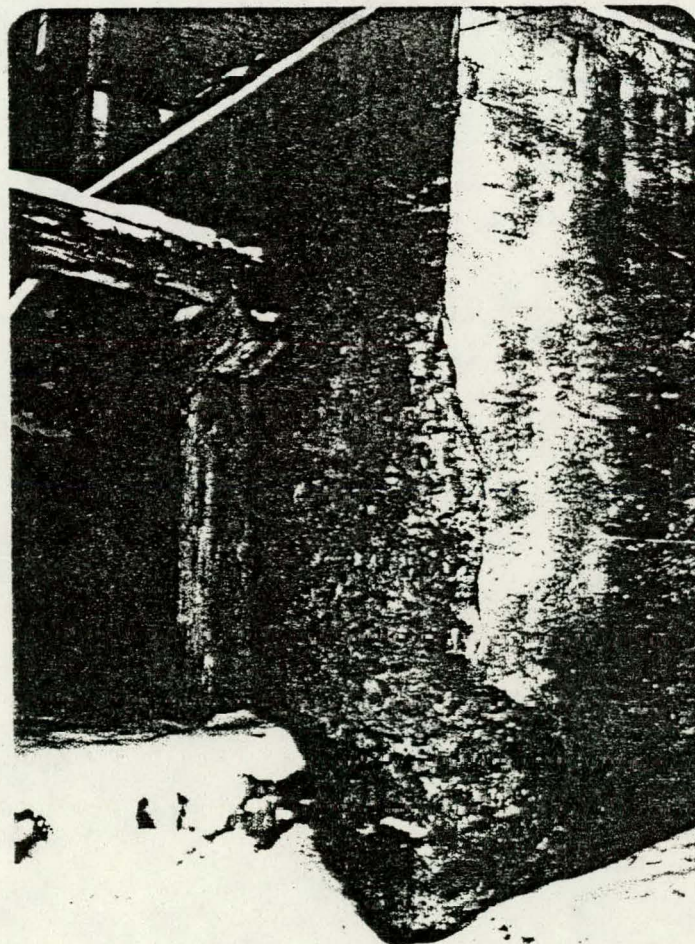
PHOTOGRAPH NO. 14

ROGERS FIBER DAM
NORTH SEGMENT OF BASE SLAB

NOTE: EROSION AND SCALING ON FACE OF BASE SLAB



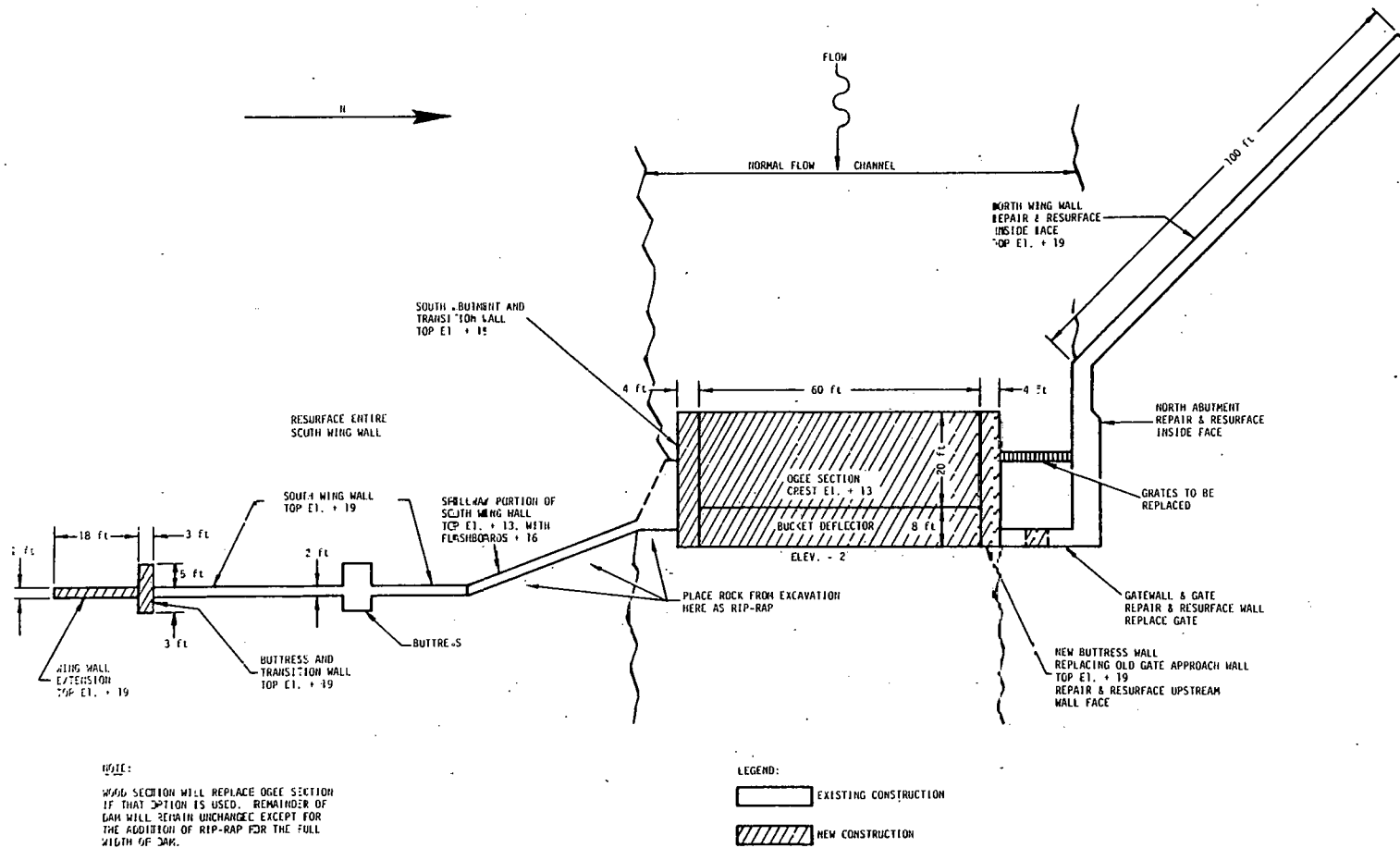
PHOTOGRAPH NO. 15
ROGERS FIBER DAM
NORTH WINGWALL AND GATE INLET



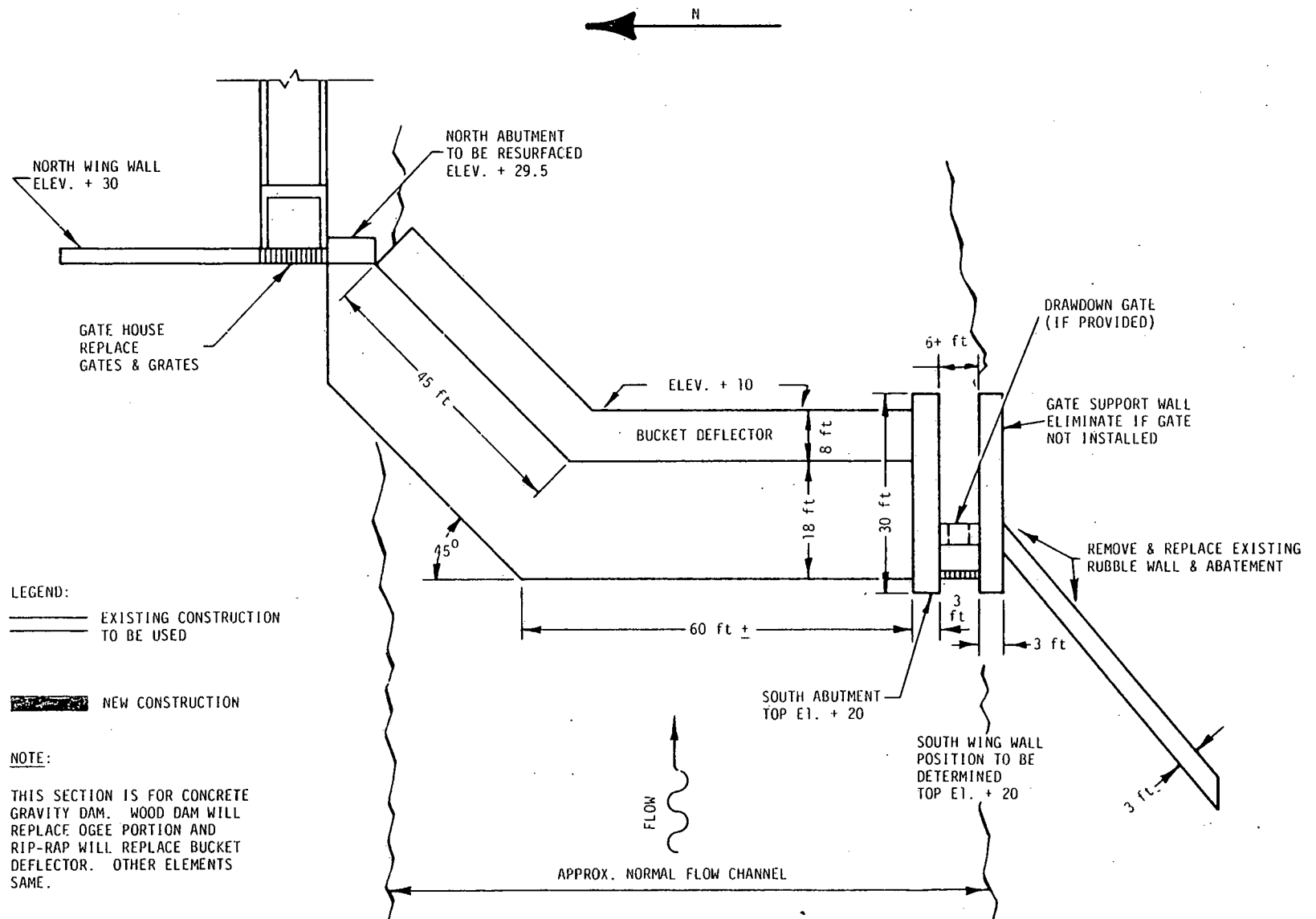
PHOTOGRAPH NO. 16
ROGERS FIBER DAM
ERODED CORNER OF NORTH ABUTMENT

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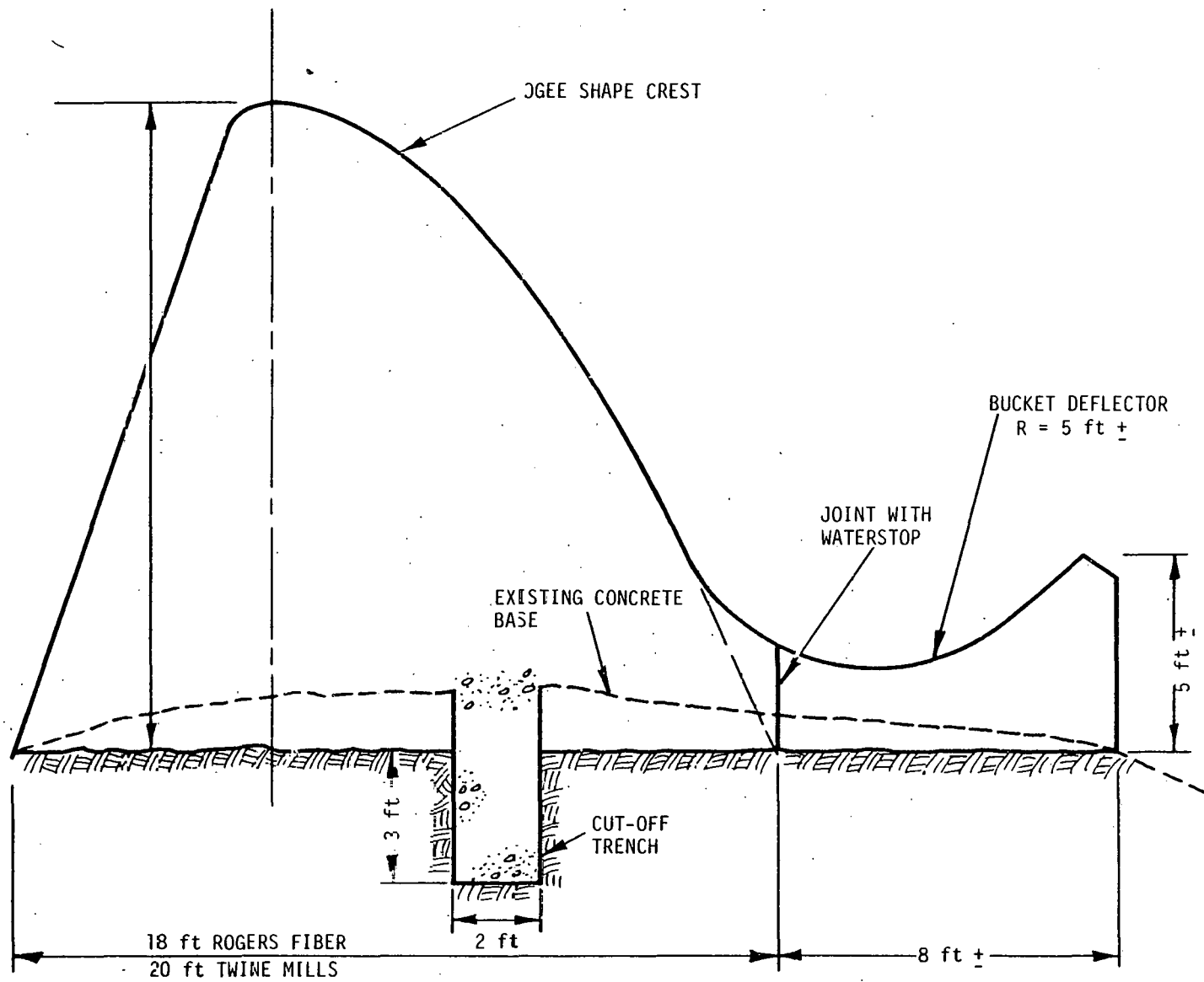
APPENDIX D.
PLAN AND SECTION OF DAMS



Appendix D-1. Plan of Twine Mills Dam.

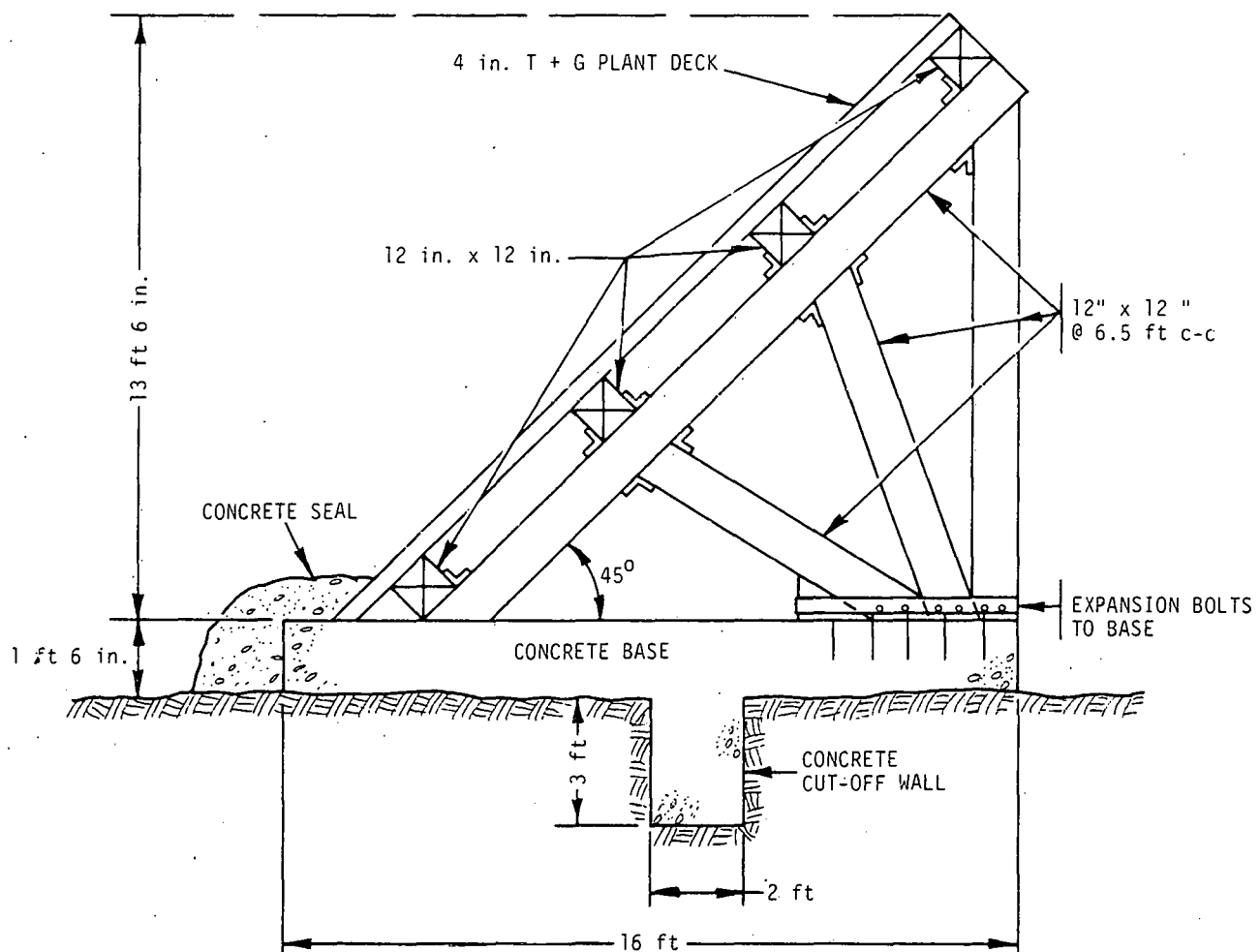


Appendix D-2. Plan of Rogers Fiber Dam



Appendix D-3. Concrete Gravity Dam Section

MAXIMUM WATER SURFACE



Appendix D-4. Deck and Frame Dam Section