EXETER RIVER STUDY
INTERIM 2005 REPORT

for the

TOWN OF EXETER, NH

February 3, 2006

Wright-Pierce
Civil and Environmental Engineering Services

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

Wright-Pierce

February 3, 2006
W-P 10613A

Ms. Jennifer Perry, P.E.
Town Engineer
Town of Exeter
13 Newfields Road
Exeter, NH 03833-2792

Subject: Exeter River Study
Interim 2005 Phase I Report

Dear Ms. Perry:

Wright-Pierce is pleased to submit this Interim 2005 Phase I Report for the Exeter River Study to the Town of Exeter. The objective of activities summarized in this report was to generate information that will allow the Town to better understand and quantify existing water quality and quantity concerns of the Exeter River. We believe you will find this report contains a wide array of very useful information that helps achieve this goal. Activities summarized in the report were conducted as a collaborative effort with Woodlot Alternatives, Inc.

After you and other stakeholders have had the opportunity to review this report, we would be happy to meet with you to discuss our findings. We also believe now is a good time to discuss how 2005 study results could affect the Exeter River Study activities for 2006 as first proposed in our September 15, 2005 letter.

It has been a pleasure working with you and the Town of Exeter on this project and we look forward to starting Phase I - 2006 activities of the Exeter River Study.

Sincerely,

WRIGHT-PIERCE

Richard N. Davee
Vice President

RND/JAH/als

Enclosure

135 Commerce Way . Portsmouth, New Hampshire USA 03801 . (603) 430-3728 . Fax (603) 430-4083
Offices in Maine, New Hampshire, Massachusetts, Connecticut and Vermont
E-mail: wp@wright-pierce.com
Website: www.wright-pierce.com

EXETER RIVER STUDY

INTERIM 2005 REPORT

FOR THE

TOWN OF EXETER, NEW HAMPSHIRE

FEBRUARY 3, 2006

Prepared By:

Wright-Pierce
135 Commerce Way
Portsmouth, NH 03801

EXETER RIVER STUDY
INTERIM 2005 REPORT

TABLE OF CONTENTS

LIST OF TABLES **PAGE**

LIST OF FIGURES

SECTION 1

Introduction

SECTION 1

INTRODUCTION

This interim report presents the results of Phase I Exeter River Study activities conducted in 2005 by Wright-Pierce and Woodlot Alternatives, Inc. This is an interim report as Phase I Exeter River Study activities are also planned for 2006. Therefore, general conclusions and recommendations are not included in this report. This information will be presented in the final report that will be prepared following the completion of 2006 activities.

The primary purpose of these activities was to generate information that will allow the Town of Exeter to better understand and quantify existing water quality and quantity issues on the Exeter River.

A description of the 2005 Phase I and 2006 Phase I activities was presented in our September 15, 2005 letter to the Town of Exeter. The major 2005 Phase I activities included the following tasks:

- Structural inspection of the Great Dam, Colcord's Pond Dam and Pickpocket Dam;
- A field survey of each dam to produce input data for the hydraulic model;
- A backwater analysis of the Great Dam;
- Dissolved oxygen and temperature monitoring of the Exeter River;
- Assessment of funding opportunities for Exeter River infrastructure improvements;
- Develop a hydraulic model that predicts river profiles at 1, 10, 50 and 100-year storms;
- Evaluate the feasibility and costs of automated impoundment level monitoring equipment; and
- Conduct a hydraulic analysis of the Great Dam low level gate.

With the exception of the dam structural inspections, these activities were successfully completed as planned. Record precipitation in the fall of 2005 prevented the dam inspections because impoundment levels could not be lowered. See Task B of the report for further discussion on the dam inspections.

Due to the highly varied nature of the individual tasks, the reader is referred to each section for task summaries and conclusions. Based on information generated by this report, Wright-Pierce and Woodlot Alternatives, Inc. recommend that proposed 2006 Phase I activities be reviewed with the Town of Exeter to determine if they should be modified to better achieve the goals of the Exeter River Study.

SECTION 2

Task A
Preliminary Dam Base Plans

SECTION 2

TASK A
PRELIMINARY DAM BASE PLANS

A field survey of Great Dam, Colcords Pond Dam and Pickpocket Dam was conducted on November 15 and 16, 2005. The purpose of this survey was to acquire critical elevation and dimensional details of the dams that are necessary for hydraulic modeling. The intent of this survey work was to document information for use in the development of the project hydraulic models. Preliminary base plans for each dam are attached.

NOTES:

SURVEY PERFORMED BY WRIGHT–PIERCE, NOVEMBER 15, 2005.

GRAPHIC SCALE

(IN FEET)
1 inch = 40 ft.

NO	REVISIONS	APP'D	DATE
1			
2			
3			
4			
5			

PROGRESS PRINTS
ISSUED FOR REVIEW: N/A
ISSUED FOR BIDDING: N/A
VAULT LOCATION:
LAST WORKED ON:
FILENAME:

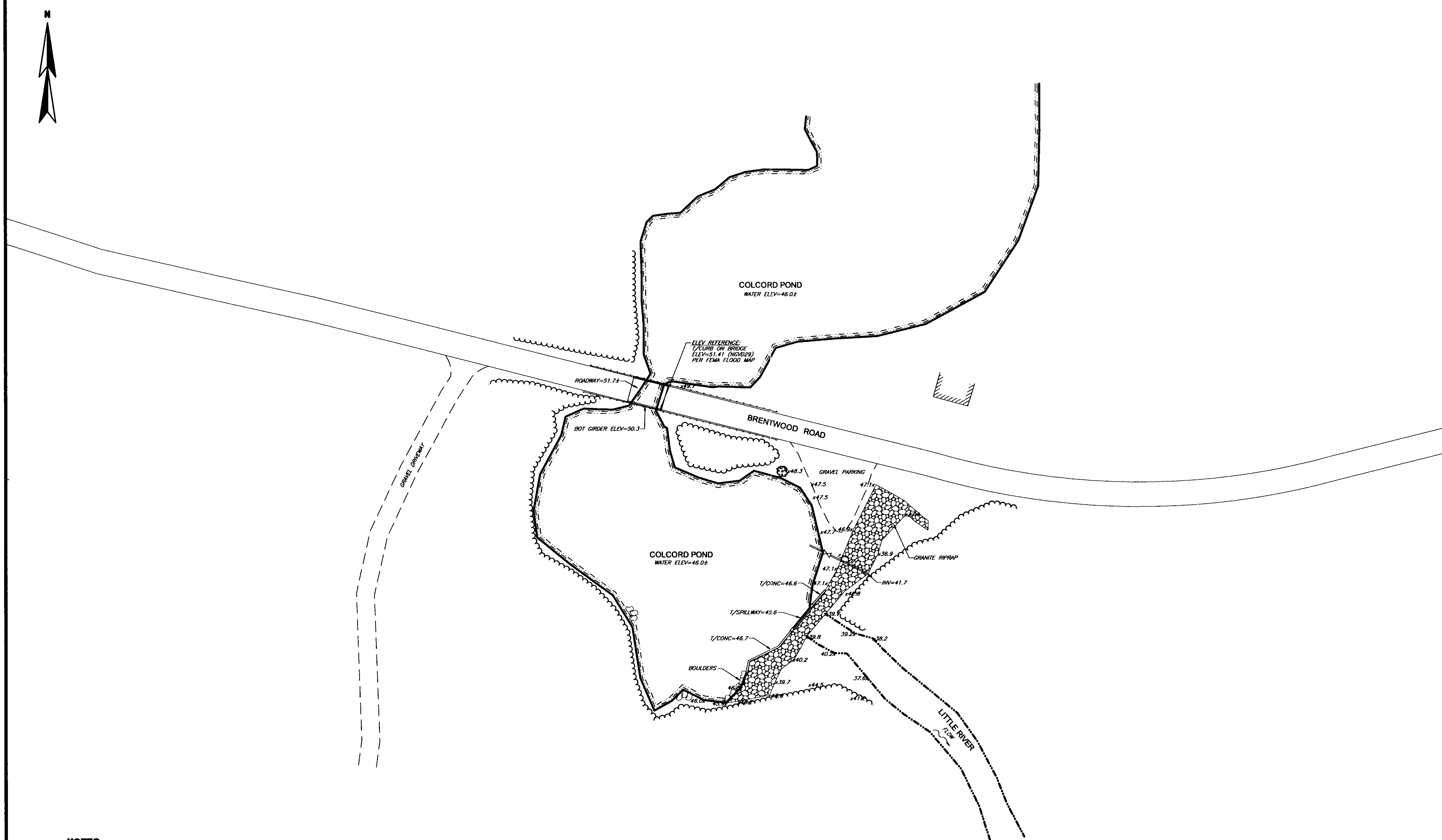
DRAWN BY KAV
CHECKED BY
DATE
APPROVED BY
DATE
BOOK NO. 1552
PROJECT NO. 10613A
SCALE AS NOTED

Wright-Pierce
Offices throughout New England
www.wright-pierce.com

TOWN OF EXETER, NEW HAMPSHIRE
RIVER STUDY

GREAT DAM EXISTING CONDITIONS

DWG C–1
1 OF 3



NOTES:

SURVEY PERFORMED BY WRIGHT-PIERCE, NOVEMBER 15, 2005.

GRAPHIC SCALE

40 0 20 40 80 100

(IN FEET)
1 inch = 40 ft.

PROGRESS PRINTS	
ISSUED FOR REVIEW:	N/A
ISSUED FOR BIDDING:	N/A
VAULT LOCATION:	
LAST WORKED ON:	
FILENAME:	

NO	REVISIONS	APP'D	DATE
1			
2			
3			
4			
5			

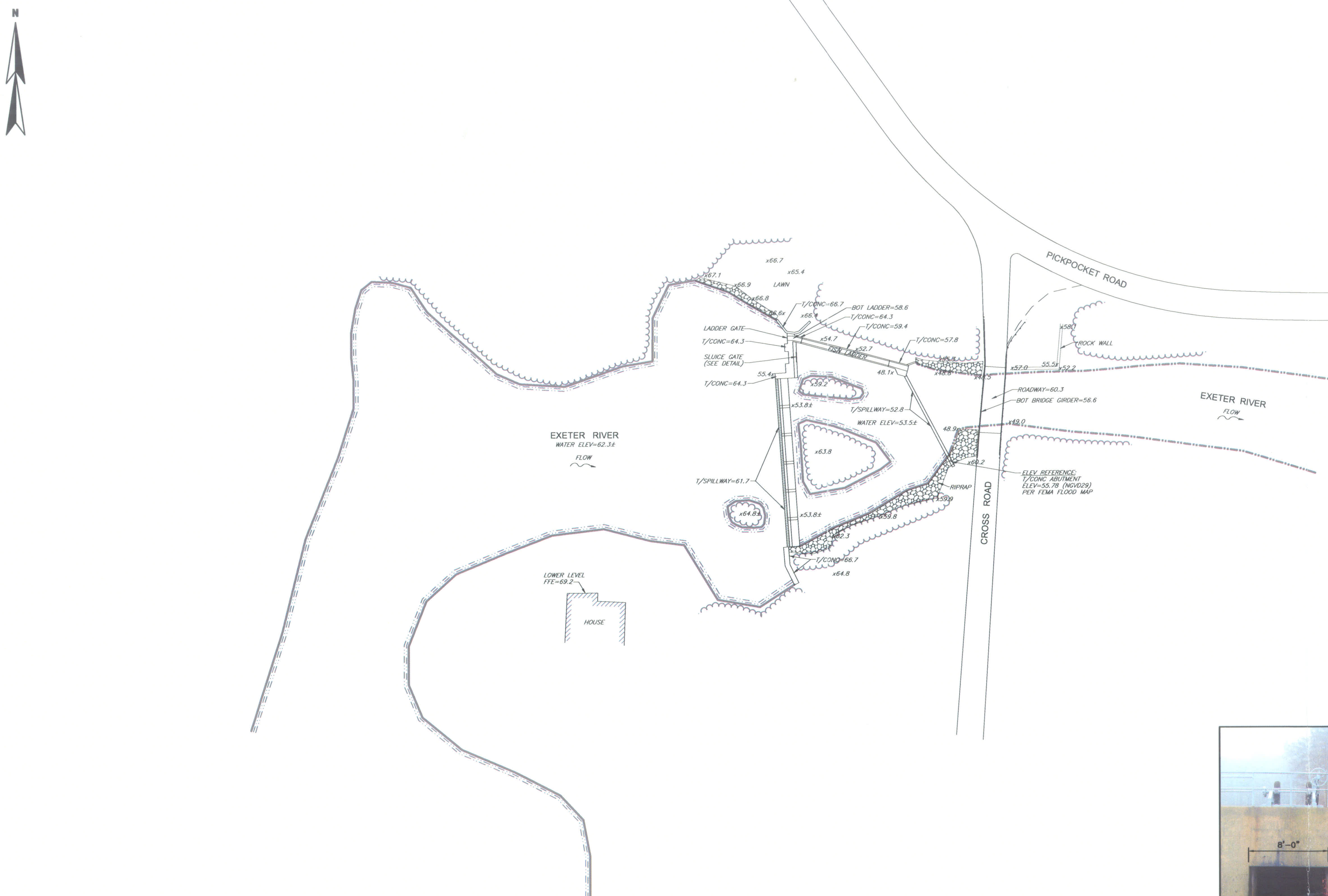
DRAWN BY KAV
CHECKED BY
DATE
APPROVED BY
DATE
BOOK NO. 1552
PROJECT NO. 10613A
SCALE AS NOTED

Wright-Pierce
Offices throughout New England
www.wright-pierce.com

TOWN OF EXETER, NEW HAMPSHIRE
RIVER STUDY

COLCORD POND DAM EXISTING CONDITIONS

DWG C-2
2 OF 3



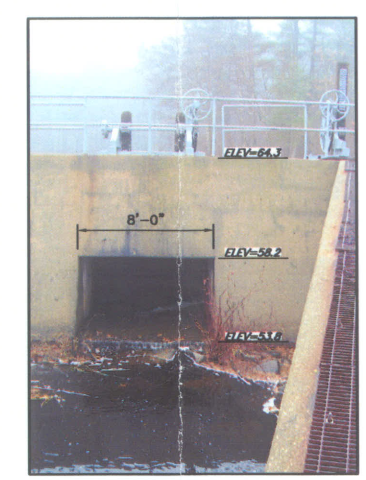
NOTES:

SURVEY PERFORMED BY WRIGHT–PIERCE, NOVEMBER 16, 2005.

GRAPHIC SCALE

40 0 20 40 80 120

(IN FEET)
1 inch = 40 ft.



SLUICE GATE OPENING

NTS

TOWN OF EXETER, NEW HAMPSHIRE
RIVER STUDY

PICKPOCKET DAM EXISTING CONDITIONS

Wright-Pierce
Offices throughout New England
www.wright-pierce.com

DRAWN BY KAV
CHECKED BY
DATE
APPROVED BY
DATE
BOOK NO. 1552
PROJECT NO. 10613A
SCALE AS NOTED

PROGRESS PRINTS
ISSUED FOR REVIEW: N/A
ISSUED FOR BIDDING: N/A

NO | REVISIONS | APP'D | DATE

DWG C–3
3 OF 3

SECTION 3

Task B
Dam Structural Evaluations

SECTION 3

TASK B
DAM STRUCTURAL EVALUATIONS

Task B entailed visual structure inspections of the Great Dam, Colcords Pond Dam and the Pickpocket Dam. The purpose of the inspections was to document the overall condition of each dam, including appurtenances such as spillways, discharge works, fish passage facilities. The inspections were intended to be performed with the respective impoundments drawn-down. New Hampshire Fish & Game (NHF&G) was consulted for its recommendation as to what time of year the dams should be lowered to minimize adverse ecological impacts. NHF&G recommended the impoundments be lowered in the late fall.

Because of persistent high water in the Exeter and Little Rivers during the fall of 2005, drawdowns were not achieved at the three impoundments. The high water conditions were initiated by a storm on October 8, 9 and 10 of 2005 and continued throughout the balance of 2005 due to record-breaking precipitation and resultant high river flows. By mid-December, it was determined, through consultation with the Town of Exeter, to focus the 2005 inspection work on the Great Dam, as this is considered the focal-point of the project work. The goal was to lower the water level to 60 inches below the crest of the spillway at the Great Dam to facilitate an inspection.

Despite having the Great Dam discharge gate fully open continuously from December 12, 2005 through January 16, 2006, the lowest level the impoundment dropped was 31.5 inches below the spillway. Based on the potential for the gate freezing in the open position and other concerns, on January 16, 2006 it was agreed to postpone the dam inspections until the fall of 2006. Attached are Great Dam gate operation records from October 8, 2005 to January 30, 2006 produced by Exeter Public Works (Table 3-1).

Although unusually high water flows prevented dam inspections, the process of trying to lower the Great Dam impoundment level generated valuable information regarding the capacity of the low-level sluice gate at the Great Dam and its ability to affect upstream water levels. This information will be used to support anticipated recommendations regarding the low-level gate capacity and operations.

EXETER PUBLIC WORKS

TABLE 3-1.1
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
			(IN)	(IN)	(IN)	(CFS)	(CFS)	(CFS)	(CFS)	(IN/24 Hr)			(IN)	
	10/8/2005	2:00 PM	0	50	5	0	70	70	40					
	10/8/2005	3:00 PM	36	52	3	214	33	246	49		2 Inch Drop	36 Inch Rise		
	10/8/2005	4:00 PM	36	53	2	213	18	230	53		1 Inch Drop	-		
	10/8/2005	6:00 PM	36	53 1/2	1.5	212	12	224	64		0.5 Inch Drop	-		
	10/8/2005	7:00 PM	36	53	2	213	18	230	83		0.5 Inch Rise	-		
	10/8/2005	8:00 PM	36	52 1/2	2.5	213	25	238	123		0.5 Inch Rise	-		
	10/8/2005	9:00 PM	36	52	3	214	33	246	212		0.5 Inch Rise	-		
	10/8/2005	10:00 PM	36	51	4	215	50	265	234		1 Inch Rise	-		
	10/8/2005	11:00 PM	54	50	5	310	70	380	232	2.47	1 Inch Rise	18 Inch Rise		
	10/9/2005	12:00 AM	54	50	5	310	70	380	229		Holding at 5	-		
	10/9/2005	1:00 AM	54	49 1/2	5.5	310	81	391	219		0.5 Inch Rise	-		
	10/9/2005	2:00 AM	54	48	7	313	116	429	219		1.5 Inch Rise	-		
	10/9/2005	3:00 AM	54	47 1/2	7.5	314	129	443	217		0.5 Inch Rise	-		
	10/9/2005	4:00 AM	54	46 1/2	8.5	315	156	471	224		1 Inch Rise	-		
	10/9/2005	5:00 AM	54	44 1/2	10.5	318	214	532	239		2 Inch Rise	-		
	10/9/2005	6:00 AM	54	43 1/2	11.5	320	245	565	252		1 Inch Rise	-		
	10/9/2005	7:00 AM	54	43	12	320	261	582	252		0.5 Inch Rise	-		
	10/9/2005	11:00 AM	54	41	14	324	329	653	245		2 Inch Rise	-		
	10/9/2005	5:00 PM	54	38 1/2	16.5	327	421	748	308	1.1	2.5 Inch Rise	-		
	10/10/2005	1:00 AM	54	39	16	327	402	728	363		0.5 Inch Drop	-		
	10/10/2005	7:00 AM	54	39	16	327	402	728	366		Holding at 16	-		
	10/10/2005	12:00 PM	54	39 1/2	15.5	326	383	709	344		0.5 Inch Drop	-		
	10/10/2005	7:00 PM	54	40	15	325	365	690	308	1.01	0.5 Inch Drop	-		
	10/11/2005	1:00 AM	54	40	15	325	365	690	328		Holding at 15	-		
	10/11/2005	6:00 AM	54	40	15	325	365	690	330		Holding at 15	-		
	10/11/2005	8:00 AM	54	40 1/2	14.5	324	347	671	328		0.5 Inch Drop	-		
	10/11/2005	12:00 PM	54	40	15	325	365	690	328		0.5 Inch Rise	-		
	10/11/2005	2:30 PM	54	40	15	325	365	690	336	0.28	Holding at 15	-		
	10/12/2005	1:00 AM	54	40 1/2	14.5	324	347	671	413		0.5 Inch Drop	-		
	10/12/2005	6:00 AM	54	40 1/2	14.5	324	347	671	399		Holding at 14.5	-		
	10/12/2005	12:00 PM	54	41 1/2	13.5	323	312	634	383		1 Inch Drop	-		
	10/12/2005	4:00 PM	54	42 1/2	12.5	321	278	599	369		1 Inch Drop	-		
	10/13/2005	6:00 AM	54	44	11	319	229	548	339		1.5 Inch Drop	-		
	10/13/2005	2:00 PM	54	44 1/2	10.5	318	214	532	156		0.5 Inch Drop	-		
	10/14/2005	1:00 AM	54	47	8	314	142	456	303		2.5 Inch Drop	-		
	10/14/2005	6:00 AM	54	49 1/2	5.5	310	81	391	289		2.5 Inch Drop	-		
	10/14/2005	9:30 AM	54	49 1/2	5.5	310	81	391	279		Holding at 5.5	-		
	10/14/2005	2:00 PM	36	49 1/2	5.5	216	81	297	186	1.04	Holding at 5.5	18 Inch Drop		
	10/15/2005	2:00 PM	54	38 1/2	16.5	327	421	748	524		11 Inch Rise	18 Inch Rise		
	10/15/2005	6:00 PM	54	35 1/2	19.5	332	541	873	657	1.91	3 Inch Rise	-		
	10/16/2005	6:00 AM	54	29	26	341	833	1174	993		6.5 Inch Rise	-		
	10/16/2005	5:00 PM	54	29	26	341	833	1174	1150		Holding at 26	-		
	10/17/2005	6:00 AM	54	28 1/2	26.5	342	857	1199	940		0.5 Inch Rise	-		
	10/17/2005	8:00 AM	54	28	27	343	881	1224	904		0.5 Inch Rise	-		
	10/17/2005	2:00 PM	54	30	25	340	785	1125	828		2 Inch Drop	-		
	10/18/2005	8:00 AM	54	34	21	334	604	938	690		4 Inch Drop	-		
	10/18/2005	2:00 PM	54	35 1/2	19.5	332	541	873	651	0.03	1.5 Inch Drop	-		

EXETER PUBLIC WORKS

TABLE 3-1.2
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
	10/19/2005	8:00 AM	54	39	16	327	402	728	518		3.5 Inch Drop	-		
	10/19/2005	2:00 PM	54	40 1/2	14.5	324	347	671	476		1.5 Inch Drop	-		
	10/20/2005	8:00 AM	54	44	11	319	229	548	383		3.5 Inch Drop	-		
	10/20/2005	2:00 PM	54	45	10	317	199	516	281		1 Inch Drop	-		
	10/21/2005	8:00 AM	54	49 1/2	5.5	310	81	391	281		4.5 Inch Drop	-		
	10/21/2005	2:00 PM	36	50 1/2	4.5	215	60	275	271		1 Inch Drop	18 Inch Drop		
	10/22/2005	7:00 AM	36	50	5	216	70	286	247		0.5 Inch Rise	-		
	10/22/2005	12:00 PM	36	50	5	216	70	286	239		Holding at 5	-		
	10/22/2005	6:00 PM	36	50	5	216	70	286	147	0.13	Holding at 5	-		
	10/23/2005	6:00 AM	36	50 1/2	4.5	215	60	275	174		0.5 Inch Drop	-		
	10/23/2005	12:00 PM	36	48	7	218	116	334	224		2.5 Inch Rise	-		
	10/23/2005	7:00 PM	36	46	9	220	170	389	245	0.87	2 Inch Rise	-		
	10/24/2005	6:00 AM	36	44 1/2	10.5	221	214	435	268		1.5 Inch Rise	-		
	10/24/2005	8:00 AM	54	44	11	319	229	548	268		0.5 Inch Rise	18 Inch Rise		
	10/24/2005	2:00 PM	54	46	9	316	170	485	333	0.03	2 Inch Drop	-		
	10/25/2005	8:00 AM	54	42 1/2	12.5	321	278	599	344		3.5 Inch Rise	-		
	10/25/2005	12:00 PM	54	41	14	324	329	653	314		1.5 Inch Rise	-		
	10/25/2005	2:00 PM	54	40	15	325	365	690	319	1.54	1 Inch Rise	-		
	10/26/2005	7:00 AM	54	34	21	334	604	938	596		6 Inch Rise	-		
	10/26/2005	9:00 AM	54	34	21	334	604	938	629		Holding at 21	-		
	10/26/2005	2:00 PM	54	33	22	335	648	983	693	0.07	1 Inch Rise	-		
	10/27/2005	8:00 AM	54	33	22	335	648	983	690		Holding at 22	-		
	10/27/2005	2:00 PM	54	33 1/2	21.5	335	626	961	648		0.5 Inch Drop	-		
	10/28/2005	8:00 AM	54	37	18	329	480	809	557		3.5 Inch Drop	-		
	10/28/2005	2:00 PM	54	38	17	328	440	768	533		1 Inch Drop	-		
	10/29/2005	7:00 AM	54	41	14	324	329	653	443		3 Inch Drop	-		
	10/29/2005	5:00 PM	54	42 1/2	12.5	321	278	599	402		1.5 Inch Drop	-		
	10/30/2005	6:00 AM	54	45	10	317	199	516	361		2.5 Inch Drop	-		
	10/30/2005	5:00 PM	54	47	8	314	142	456	276		2 Inch Drop	-		
	10/31/2005	6:00 AM	54	49	6	311	92	403	287		2 Inch Drop	-		
	10/31/2005	8:00 AM	0	49	6	0	92	92	287		Holding at 6	54 Inch Drop		
	10/31/2005	2:00 PM	0	46 1/2	8.5	0	156	156	273		2.5 Inch Rise	-		
	11/1/2005	8:00 AM	0	42 1/2	12.5	0	278	278	250		4 Inch Rise	-		
	11/1/2005	9:00 AM	24	42 1/2	12.5	153	278	430	247		Holding at 12.5	24 Inch Rise		
	11/1/2005	12:00 PM	24	45 1/2	9.5	151	184	335	247		3 Inch Drop	-		
	11/1/2005	2:00 PM	24	45 1/2	9.5	151	184	335	242		Holding at 9.5	-		
	11/2/2005	8:00 AM	24	47 1/2	7.5	149	129	278	215		2 Inch Drop	-		
	11/2/2005	2:00 PM	24	47 1/2	7.5	149	129	278	193	0.02	Holding at 7.5	-		
	11/3/2005	8:00 AM	24	49	6	148	92	241	193		1.5 Inch Drop	-		
	11/3/2005	2:00 PM	24	49	6	148	92	241	188		Holding at 6	-		
	11/4/2005	9:00 AM	24	49	6	148	92	241	171		Holding at 6	-		
	11/4/2005	9:30 AM	0	49	6	0	92	92	169		Holding at 6	24 Inch Drop		
	11/4/2005	2:00 PM	0	46	9	0	170	170	171		3 Inch Rise	-		
	11/5/2005	7:00 AM	0	46	9	0	170	170	164		Holding at 9	-		
	11/5/2005	6:00 PM	0	46	9	0	170	170	160		Holding at 9	-		
	11/6/2005	5:00 AM	0	46	9	0	170	170	153		Holding at 9	-		
	11/6/2005	4:00 PM	0	46	9	0	170	170	147	0.27	Holding at 9	-		
	11/7/2005	6:00 AM	0	46	9	0	170	170	151		Holding at 9	-		

EXETER PUBLIC WORKS

TABLE 3-1.3
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
	11/7/2005	8:00 AM	0	45 1/2	9.5	0	184	184	151		0.5 Inch Rise	-		
	11/7/2005	2:00 PM	0	45 1/2	9.5	0	184	184	142	0.01	Holding at 9.5	-		
	11/8/2005	8:00 AM	0	45 1/2	9.5	0	184	184	153		Holding at 9.5	-		
	11/8/2005	2:00 PM	0	45 1/2	9.5	0	184	184	153		Holding at 9.5	-		
	11/9/2005	8:00 AM	0	45 1/2	9.5	0	184	184	147		Holding at 9.5	-		
	11/9/2005	2:00 PM	0	45 1/2	9.5	0	184	184	142	0.48	Holding at 9.5	-		
	11/10/2005	8:00 AM	0	44	11	0	229	229	171		1.5 Inch Rise	-		
	11/10/2005	2:00 PM	0	43 1/2	11.5	0	245	245	181	0.26	0.5 Inch Rise	-		
	11/11/2005	7:00 AM	0	44	11	0	229	229	207		0.5 Inch Drop	-		
	11/11/2005	4:00 PM	0	44	11	0	229	229	205		Holding at 11	-		
	11/12/2005	6:00 AM	0	44	11	0	229	229	193		Holding at 11	-		
	11/12/2005	6:30 PM	0	44	11	0	229	229	183		Holding at 11	-		
	11/13/2005	7:00 AM	0	45	10	0	199	199	176		1 Inch Drop	-		
	11/13/2005	3:00 PM	0	45	10	0	199	199	169		Holding at 10	-		
	11/14/2005	8:00 AM	0	45	10	0	199	199	160		Holding at 10	-		
	11/14/2005	2:00 PM	0	45	10	0	199	199	162		Holding at 10	-		
	11/15/2005	8:30 AM	24	46	9	150	170	320	147		1 Inch Drop	24 Inch Rise		
	11/15/2005	2:00 PM	24	49 1/2	5.5	148	81	229	145	0.3	3.5 Inch Drop	-		
	11/16/2005	9:00 AM	24	50	5	148	70	218	151		0.5 Inch Drop	-		
	11/16/2005	2:00 PM	24	49 1/2	5.5	148	81	229	151	0.48	0.5 Inch Rise	-		
	11/17/2005	8:00 AM	24	45 1/2	9.5	151	184	335	217		4 Inch Rise	-		
	11/17/2005	2:00 PM	24	44	11	152	229	381	237	0.23	1.5 Inch Rise	-		
	11/18/2005	8:00 AM	36	43	12	223	261	484	311		1 Inch Rise	12 Inch Rise		
	11/18/2005	2:00 PM	36	43 1/2	11.5	222	245	467	314		0.5 Inch Drop	-		
	11/19/2005	10:00 AM	36	45 1/2	9.5	220	184	404	271		2 Inch Drop	-		
	11/20/2005	8:00 AM	36	47 1/2	7.5	218	129	347	247		2 Inch Drop	-		
	11/20/2005	4:30 PM	36	48	7	218	116	334	265		0.5 Inch Drop	-		
	11/21/2005	8:00 AM	36	48	7	218	116	334	227		Holding at 7	-		
	11/21/2005	2:00 PM	36	48	7	218	116	334	268	0.01	Holding at 7	-		
	11/22/2005	8:00 AM	36	47 1/2	7.5	218	129	347	245		0.5 Inch Rise	-		
	11/22/2005	2:00 PM	36	45	10	221	199	419	193	1.43	2.5 Inch Rise	-		
	11/23/2005	8:00 AM	54	39	16	327	402	728	358		6 Inch Rise	18 Inch Rise		
	11/23/2005	2:00 PM	54	39 1/2	15.5	326	383	709	391	0.01	0.5 Inch Drop	-		
	11/24/2005	9:00 AM	54	41	14	324	329	653	363		1.5 Inch Drop	-		
	11/24/2005	3:00 PM	54	41 1/2	13.5	323	312	634	353	0.23	0.5 Inch Drop	-		
	11/25/2005	10:00 AM	54	42 1/2	12.5	321	278	599	328		1 Inch Drop	-		
	11/25/2005	4:00 PM	54	44 1/4	10.75	319	221	540	314		1.75 Inch Drop	-		
	11/26/2005	9:30 AM	54	46	9	316	170	485	281		1.75 Inch Drop	-		
	11/26/2005	4:30 PM	54	47 1/4	7.75	314	136	449	255	0.01	1.25 Inch Drop	-		
	11/27/2005	8:30 AM	54	48 1/2	6.5	312	104	416	250		1.25 Inch Drop	-		
	11/27/2005	3:30 PM	54	49	6	311	92	403	242	0.04	0.5 Inch Drop	-		
	11/28/2005	8:00 AM	54	51	4	308	50	358	224		2 Inch Drop	-		
	11/28/2005	2:00 PM	54	51	4	308	50	358	219	0.02	Holding at 4	-		
	11/29/2005	8:00 AM	54	52	3	306	33	339	212		1 Inch Drop	-		
	11/29/2005	2:00 PM	54	52	3	306	33	339	210		Holding at 3	-		
	11/30/2005	8:00 AM	54	51	4	308	50	358	217		1 Inch Rise	-		
	11/30/2005	2:00 PM	54	50	5	310	70	380	287	0.71	1 Inch Rise	-		
	12/1/2005	8:00 AM	54	43	12	320	261	582	279		7 Inch Rise	-		

TABLE 3-1.4
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
	12/1/2005	2:00 PM	54	43	12	320	261	582	287		Holding at 12	-		
	12/2/2005	8:00 AM	54	43 1/2	11.5	320	245	565	333		0.5 Inch Drop	-		
	12/2/2005	2:00 PM	54	43 1/2	11.5	320	245	565	325	0.02	Holding at 11.5	-		
	12/3/2005	7:00 AM	54	45	10	317	199	516	298		1.5 Inch Drop	-		
	12/3/2005	4:00 PM	54	45 1/2	9.5	317	184	501	289		0.5 Inch Drop	-		
	12/4/2005	7:00 AM	54	48	7	313	116	429	265		2.5 Inch Drop	-		
	12/4/2005	5:00 PM	54	50	5	310	70	380	255		2 Inch Drop	-		
	12/5/2005	7:00 AM	54	53	2	305	18	323	234		3 Inch Drop	-		
	12/5/2005	8:00 AM	54	50	5	310	70	380	234		3 Inch Rise	-		
	12/5/2005	2:00 PM	54	50	5	310	70	380	229	0.03	Holding at 5	-		
	12/6/2005	7:45 AM	54	52 1/2	2.5	306	25	330	212		2.5 Inch Drop	-		Open Colcords
	12/6/2005	8:00 AM	54	52 1/2	2.5	306	25	330	212		Holding at 2.5	-		
	12/6/2005	2:00 PM	54	50 1/2	4.5	309	60	369	212		2 Inch Rise	-		
	12/7/2005	8:00 AM	54	53 1/2	1.5	304	12	316	205		3 Inch Drop	-		
	12/7/2005	2:00 PM	54	54 1/2	0.5	302	2	305	123		1 Inch Drop	-		
	12/8/2005	7:00 AM	54	76 1/2	-21.5	264	0	264	ice		22 Inch Drop	-		
	12/8/2005	8:00 AM	24	76	-21	130	0	130	ice		0.5 Inch Rise	30 Inch Drop		
	12/8/2005	10:00 AM	24	71	-16	133	0	133	ice		5 Inch Rise	-		
	12/8/2005	12:00 PM	24	66	-11	137	0	137	ice		5 Inch Rise	-		
	12/8/2005	2:00 PM	24	62	-7	140	0	140	ice		4 Inch Rise	-		
	12/9/2005	8:00 AM	24	53	2	146	18	164	ice		9 Inch Rise	-		
	12/10/2005	7:00 AM	24	53	2	146	18	164	ice		Holding at 2	-		
	12/10/2005	5:00 PM	24	53	2	146	18	164	ice	0.11	Holding at 2	-		
	12/11/2005	7:00 AM	24	52 1/2	2.5	146	25	171	ice		0.5 Inch Rise	-		
	12/11/2005	3:00 PM	24	52 1/2	2.5	146	25	171	ice	0.04	Holding at 2.5	-		
	12/12/2005	8:00 AM	24	52 1/2	2.5	146	25	171	158		Holding at 2.5	-		
	12/12/2005	10:30 AM	54	54 1/2	0.5	302	2	305	151		2 Inch Drop	30 Inch Rise		
	12/12/2005	12:00 PM	54	56 1/2	-1.5	299	0	299	149		2 Inch Drop	-		
	12/12/2005	2:00 PM	54	58	-3	297	0	297	151	0.04	1.5 Inch Drop	-		
	12/13/2005	8:00 AM	54	68	-13	280	0	280	149		10 Inch Drop	-		
	12/13/2005	12:00 PM	54	72	-17	273	0	273	134		4 Inch Drop	-		
	12/13/2005	2:00 PM	54	72 1/2	-17.5	272	0	272	136		0.5 Inch Drop	-		
	12/14/2005	7:00 AM	54	79	-24	260	0	260	ice		6.5 Inch Drop	-		
	12/14/2005	10:00 AM	54	80 1/2	-25.5	257	0	257	ice		1.5 Inch Drop	-		
	12/14/2005	12:00 PM	54	82	-27	254	0	254	ice		1.5 Inch Drop	-		
	12/14/2005	2:00 PM	54	82 1/2	-27.5	253	0	253	ice		0.5 Inch Drop	-		
	12/15/2005	7:00 AM	54	85	-30	248	0	248	ice		2.5 Inch Drop	-		
	12/15/2005	12:00 PM	54	86 1/2	-31.5	245	0	245	ice		1.5 Inch Drop	-		
	12/15/2005	2:00 PM	54	86 1/2	-31.5	245	0	245	ice		Holding at -31.5	-		
	12/16/2005	8:00 AM	54	87	-32	244	0	244	ice		0.5 Inch Drop	-		
	12/16/2005	12:00 PM	54	84	-29	250	0	250	ice		3 Inch Rise	-		
	12/16/2005	2:00 PM	54	77	-22	264	0	264	ice	2.15	7 Inch Rise	-		
	12/19/2005	8:00 AM	54	47	8	314	142	456	ice		30 Inch Rise	-		
	12/19/2005	12:00 PM	54	47 1/2	7.5	314	129	443	ice		0.5 Inch Drop	-		
	12/19/2005	2:00 PM	54	47 1/2	7.5	314	129	443	ice		Holding at 7.5	-		
	12/20/2005	8:00 AM	54	47 1/2	7.5	314	129	443	ice		Holding at 7.5	-		
	12/20/2005	12:00 PM	54	49 1/2	5.5	310	81	391	ice		2 Inch Drop	-		
	12/20/2005	2:00 PM	54	50 1/2	4.5	309	60	369	ice		1 Inch Drop	-		

EXETER PUBLIC WORKS

TABLE 3-1.5
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
	12/21/2005	8:00 AM	54	52 1/2	2.5	306	25	330	ice		2 Inch Drop	-		
	12/21/2005	2:00 PM	54	53 1/2	1.5	304	12	316	ice		1 Inch Drop	-		
	12/22/2005	8:00 AM	54	55 1/2	-0.5	301	0	301	ice		2 Inch Drop	-		
	12/22/2005	12:00 PM	54	57 1/2	-2.5	298	0	298	ice		2 Inch Drop	-		
	12/22/2005	2:00 PM	54	57 1/2	-2.5	298	0	298	ice		Holding at -2.5	-		
	12/23/2005	8:00 AM	54	63 1/2	-8.5	287	0	287	ice	0.12	6 Inch Drop	-		
	12/23/2005	2:00 PM	54	66	-11	283	0	283	ice	0.04	2.5 Inch Drop	-		
	12/24/2005								ice	0.25				
	12/26/2005								ice	0.8				
	12/27/2005	7:00 AM	54	38 1/2	16.5	327	421	748	590		16.5 Inch Rise			
	12/27/2005	2:30 PM	54	36	19	331	520	851	810		2.5 Inch Rise	-		
	12/28/2005	7:00 AM	54	35 1/2	19.5	332	541	873	726		0.5 Inch Rise	-		
	12/28/2005	12:00 PM	54	35 1/2	19.5	332	541	873	677		Holding at 19.5	-		
	12/28/2005	2:00 PM	54	35 1/2	19.5	332	541	873	641	0.02	Holding at 19.5	-		
	12/29/2005	8:00 AM	54	40	15	325	365	690	484		4.5 Inch Drop	-		
	12/29/2005	2:00 PM	54	40 1/2	14.5	324	347	671	554	0.47	0.5 Inch Drop	-		
	12/30/2005	8:00 AM	54	38 1/2	16.5	327	421	748	554		2 Inch Rise	-		
	12/30/2005	2:00 PM	54	38	17	328	440	768	542		0.5 Inch Rise	-		UNH Wx PPT
	1/1/2006													0.06
	1/2/2006									0.09				
	1/3/2006	7:00 AM	54	48 1/2	6.5	312	104	416	287		10.5 Inch Drop	-		
	1/3/2006	12:00 PM	54	48 3/4	6.25	312	98	410	284		0.25 Inch Drop	-		
	1/3/2006	2:00 PM	54	51	4	308	50	358	281		2.25 Inch Drop	-		
	1/4/2006	8:00 AM	54	51	4	308	50	358	ice		Holding at 4	-		
	1/4/2006	12:00 PM	54	51	4	308	50	358	ice		Holding at 4	-		
	1/4/2006	2:00 PM	54	51	4	308	50	358	276		Holding at 4	-		
	1/5/2006	8:00 AM	54	51	4	308	50	358	239		Holding at 4	-		0.25
	1/5/2006	12:00 PM	54	51 1/2	3.5	307	41	348	234		0.5 Inch Drop	-		
	1/5/2006	2:00 PM	54	51 1/2	3.5	307	41	348	234		Holding at 3.5	-		
	1/6/2006	8:00 AM	54	53 1/2	1.5	304	12	316	ice		2 Inch Drop	-		
	1/6/2006	12:00 PM	54	53 1/2	1.5	304	12	316	ice		Holding at 1.5	-		
	1/6/2006	2:00 PM	54	53	2	305	18	323	210		0.5 Inch Rise	-		
	1/9/2006	8:00 AM	54	78 1/2	-23.5	261	0	261	ice		25.5 Inch Drop	-		
	1/9/2006	12:00 PM	54	79 1/2	-24.5	259	0	259	ice		1 Inch Drop	-		
	1/9/2006	2:00 PM	54	79 1/2	-24.5	259	0	259	ice		Holding at -24.5	-		
	1/10/2006	8:00 AM	54	69 1/2	-14.5	277	0	277	ice		10 Inch Rise	-		
	1/10/2006	12:00 PM	54	70	-15	276	0	276	ice		0.5 Inch Drop	-		
	1/10/2006	2:00 PM	54	70	-15	276	0	276	ice	0.1	Holding at -15	-		
	1/11/2006	8:00 AM	54	70 1/2	-15.5	275	0	275	160		0.5 Inch Drop	-		0.5
	1/11/2006	12:00 PM	54	70	-15	276	0	276	239		0.5 Inch Rise	-		
	1/11/2006	2:00 PM	54	70	-15	276	0	276	198	0.52	Holding at -15	-		
	1/12/2006	8:00 AM	54	54	1	303	6	309	191		16 Inch Rise	-		0.06
	1/12/2006	12:00 PM	54	52	3	306	33	339	138		2 Inch Rise	-		
	1/12/2006	2:00 PM	54	51	4	308	50	358	156	0.08	1 Inch Rise	-		
	1/13/2006	8:00 AM	54	48	7	313	116	429	263		3 Inch Rise	-		
	1/13/2006	12:00 PM	54	48	7	313	116	429	287		Holding at 7	-		
	1/13/2006	2:00 PM	54	48	7	313	116	429	276		Holding at 7	-		
	1/14/2006									0.41				

TABLE 3-1.6
GREAT DAM GATE DATA

DAY	DATE	TIME	GATE OPEN	WATER LEVEL BELOW CREST	WATER HEIGHT OVER SPILLWAY	GATE	SPILLWAY	GREAT DAM	HAIGH ROAD	RAIN	WATER LEVEL CHANGE SINCE LAST OBSERVATION	GATE OPERATION	NHF&G FISH LADDER "DEPTH"	NOTES
	1/15/2006									0.22				
	1/16/2006	8:00 AM	54	35 1/2	19.5	332	541	873	396		12.5 Inch Rise	-		
	1/16/2006	2:00 PM	54	44 1/2	10.5	318	214	532	449		9 Inch Drop	-		
	1/17/2006	7:00 AM	54	48	7	313	116	429	495		3.5 Inch Drop	-		
	1/17/2006	1:00 PM	54	48	7	313	116	429	493		Holding at 7	-		
	1/18/2006	7:00 AM	54	47 1/2	7.5	314	129	443	465		0.5 Inch Rise	-		
	1/18/2006	1:00 PM	54	46	9	316	170	485	443	0.73	1.5 Inch Rise	-		
	1/19/2006	7:00 AM	54	40 1/2	14.5	324	347	671	383		5.5 Inch Rise	-		
	1/19/2006	2:00 PM	54	40 1/2	14.5	324	347	671	410		Holding at 14.5	-		
	1/20/2006	7:00 AM	54	41	14	324	329	653	388		0.5 Inch Drop	-		
	1/20/2006	2:00 PM	54	42	13	322	294	616	363		1 Inch Drop	-		
	1/23/2006	7:00 AM	54	51	4	308	50	358	265		9 Inch Drop	-		
	1/23/2006	2:00 PM	54	51	4	308	50	358	257		Holding at 4	-		
	1/24/2006	8:00 AM	54	51	4	308	50	358	273		Holding at 4	-		
	1/24/2006	1:00 PM	54	50 1/2	4.5	309	60	369	257	0.18	0.5 Inch Rise	-		
	1/25/2006	7:00 AM	54	50 1/2	4.5	309	60	369			Holding at 4.5	-		
	1/25/2006	1:00 AM	54	50 1/2	4.5	309	60	369	220	0.19	Holding at 4.5	-		
	1/26/2006	8:00 AM	54	51 1/2	3.5	307	41	348	210		1 Inch Drop	-		
	1/26/2006	1:00 PM	54	51 1/2	3.5	307	41	348	207	0.08	Holding at 3.5	-		
	1/27/2006	8:00 AM	54	56	-1	300	0	300			4.5 Inch Drop	-		
	1/28/2006									0.4				
	1/29/2006									0.56				
	1/30/2006	8:00 AM	54	49	6	311	92	403			7 Inch Rise	-		

SECTION 4

Task C
Qualitative Backwater Assessment

SECTION 4

TASK C
QUALITATIVE BACKWATER ANALYSIS

This section presents the results of a qualitative backwater analysis performed by Woodlot Alternatives, Inc. (Woodlot) on the Great Dam impoundment reach of the Exeter River in Exeter, New Hampshire. The primary purpose of this analysis is to quantitatively establish the limit of the backwater from the Great Dam on the Exeter and Little Rivers during low-flow conditions. Additional information is presented for high-flow conditions based on information obtained from the Rockingham County, New Hampshire Flood Insurance (FIS) study prepared by the Federal Emergency Management Agency (FEMA) dated May 17, 2005. Note that this study represents a compilation of FISs previously prepared for individual towns within Rockingham County.

Information used in the quantitative backwater analysis was obtained during site visits on August 2 and November 21, 2005. The primary purpose of the August 2 visit was to install water quality monitoring equipment, while the November 21 visit was performed solely as part of the backwater analysis. Reference flow conditions during the site visits were obtained from the United States Geological Survey (USGS) stream gaging station on the Exeter River near Brentwood, New Hampshire (USGS No 01073587). Provisional data from the USGS station reports a daily average flow of 18 cubic-feet-per-second (cfs) during the August 2 site visit, and flow data recorded at 15-minutes yielding an average daily flow of 248-cfs during the November 21 site visit. Observations at the Great Dam during both site visits indicated that the depth of flow over the Great Dam was less than 0.5-feet (ft) on both occasions.

LITTLE RIVER

The Little River was traversed between its confluence with the Exeter River to a point approximately ¼-mile upstream of the Linden Street Bridge in Exeter, approximately 9000-ft upstream of the confluence. Observations made during the site visit suggest that the backwater created by the Great Dam extends upstream to the general vicinity of the Court Street (Route 108) Bridge during periods of low flow. The specific indicator of this condition was swift flow over beaver dams immediately downstream of the bridge. Other observations suggest that the Little River may have aggraded (i.e., filled in with detrital material) at and upstream of this point, and that backwater may have extended upstream of this point following the original construction of the Great Dam. These observations include the presence of unconsolidated sediments downstream and upstream of the Court Street Bridge, and the low marsh elevation relative to the water surface and channel braiding upstream of the Court Street Bridge.

The presence of unconsolidated sediments downstream and upstream of the Court Street Bridge suggests that these may be relatively recent deposits that may have aggraded due to the backwater formed by the Great Dam. Observed sediments included alluvial (e.g., sand) and organic material (e.g., leaves). The deposition of sediments in the marsh upstream of the Court Street Bridge may have filled a primary channel, resulting in overtopping of the channel banks and the formation of the observed network of branched channels. Numerous beaver dams were observed within the branched channel system upstream of the Court Street Bridge, which limit the upstream backwater extent during periods of low flow. Moving upstream through the Linden Street Bridge, marsh elevation increase relative to the stream channel, with a well-established channel observed within a 500-ft upstream of the bridge.

Information presented in the FEMA FIS (Volume 2, Panel 100P) indicates that the backwater extends approximately 3000 to 7000-ft upstream of the Linden Street Bridge during the 10, 50, 100, and 500-year flood events. The specific characteristic of the FIS information indicating the extent of the backwater is that water surface profiles are essentially horizontal between the confluence of the Little and Exeter Rivers and the limits of the backwater extents described above.

EXETER RIVER

The Exeter River was traversed between its confluence with the Little River to the Linden Street Bridge in Exeter, approximately 21,000-ft upstream of the confluence during the November 21, 2005 site visit. No definitive features indicating the limit of the backwater influence of the Great Dam on the Exeter River were observed during this site visit. Observations made during the August 2 and November 21, 2005 site visits suggest that the extent of the Great Dam backwater on the Exeter River is variable and dependent on both water surface elevations at the dam and flows in the Exeter River.

Observations made during this site visit and information presented in the FEMA FIS (Volume 2, Panels 42P and 43P) suggest that the Linden Street Bridge is the upstream limit of the backwater during high flows, and represents that absolute limit of the Great Dam backwater during low flow events. During periods of lower flows, as represented by conditions during the November 21, 2005 site visit (i.e., approximately 250-cfs), hydraulic effects associated with the Great Dam backwater could be augmented by channel control within the reach of the Exeter River downstream of the Court Street Bridge. In this case, water surface elevations in the affected reach of the river would be a function of both the backwater and limited hydraulic conveyance within the channel.

Observed water surface elevations at the Court Street Bridge during the August 2, 2005, site visit were approximately 1.0-ft lower than during the November 21, 2005 site visit. During these site visits, the observed difference in water surface elevations at the Great Dam was less than 0.5-ft, based on observed water levels over the spillway. Water surface profile plots in the FEMA FIS (Volume 2, Panels 42P and 43P) depict the slope of the water surface between the ledge immediately upstream of the Great Dam and the Court Street Bridge as approximately that of the channel invert (bottom) slope. The observation of greater increases in water surface elevations at the Court Street Bridge compared to the Great Dam with increased flows may indicate that hydraulic control is a function of channel control downstream in the Exeter River.

Based on the information presented above, the determination of a specific upstream limit of the backwater using qualitative observations may not be possible. While a more refined determination of the backwater limit may be possible using quantitative methods, such as numerical hydraulic modeling, any such analysis would likely need to consider a variety of flow conditions and operational factors at the Great Dam.

SECTION 5

Task D
Water Quality Sampling Analysis

SECTION 5

TASK D
WATER QUALITY SAMPLING ANALYSIS

This section describes activities conducted as part of the 2005 water quality sampling work for the Exeter River project. This work included in-situ temperature monitoring at five locations and biweekly temperature and dissolved oxygen monitoring at six locations in the Exeter and Little Rivers in and adjacent to the Great Dam impoundment. The purpose of these measurements was to collect baseline information on temperature and oxygen levels. This information will be used to evaluate potential causes and remedial measures associated with impaired water quality.

Existing Exeter River water quality data available on-line from NHDES website was reviewed as part of this task. This data is collected by various academic, government and volunteer organizations, including the Exeter River Local Advisory Committee. Because this data is collected at different locations, different parameters, different methods, and different times, it was difficult to incorporate into this temperature and dissolved oxygen program. We plan to summarize relevant portions of this data as part of 2006 Phase I activities.

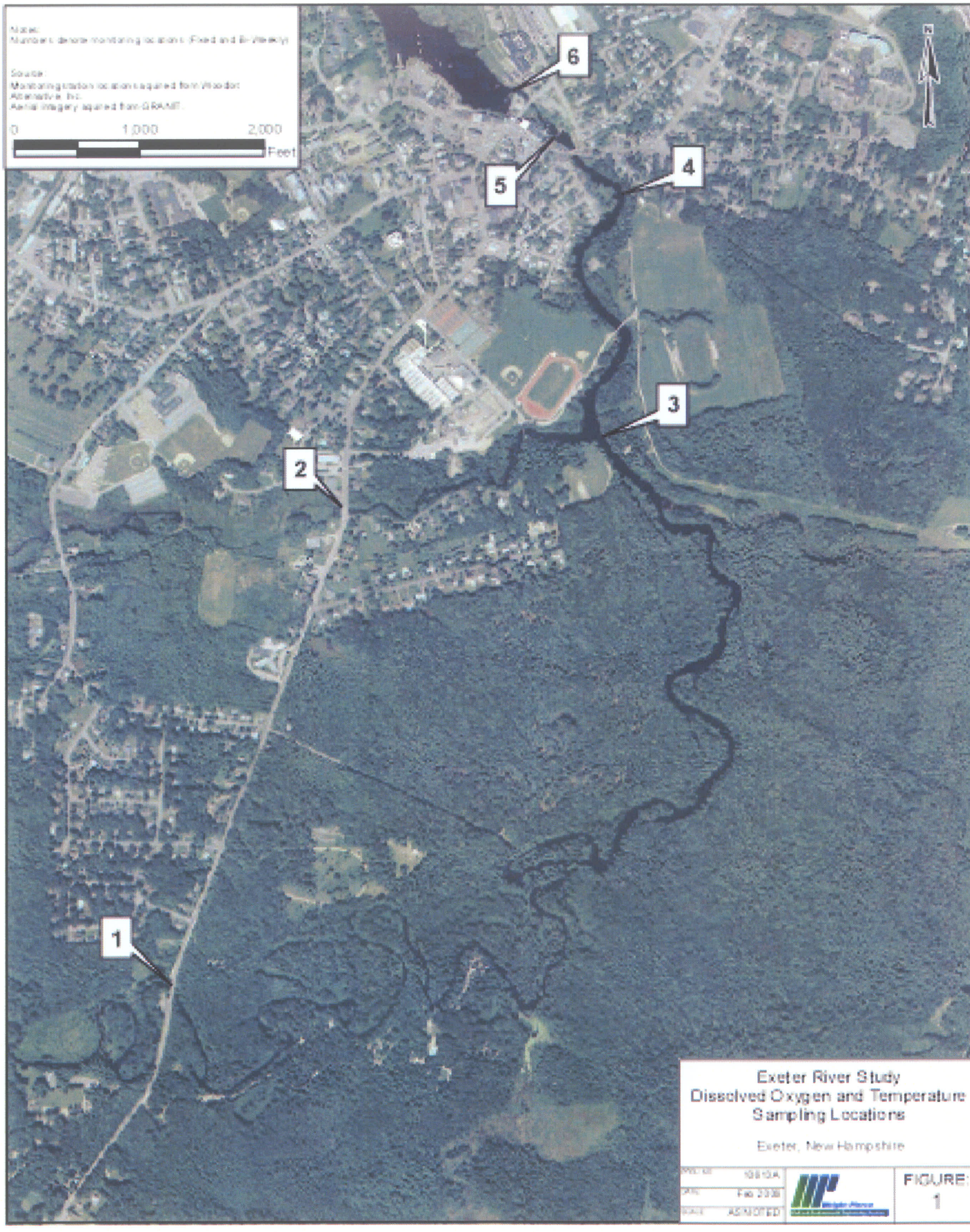
IN-SITU TEMPERATURE DATA LOGGER INSTALLATION

Nine in-situ temperature data loggers were installed at 5 stations along the Exeter River On August 2, 2005. These loggers recorded the water temperature at 6–minute intervals between August 2 and November 7, 2005 (approximately 23,000 recordings for each logger). The locations of the five in-situ temperature datalogger stations are described as follows:

Station 1. In the Exeter River where it passes under Court Street (1 logger);
Station 2. In the Little River where it passes under Court Street (1 logger) ;
Station 3. At the confluence of the Exeter and Little Rivers adjacent to the Town of Exeter's river pump station (3 loggers) ;
Station 4. At the bend in the Exeter River approximately 200 yards upstream of the Great Bridge (3 loggers) ; and
Station 5. In the pool on the Exeter River between the Great Dam and the downstream weir (1 logger).

Single in-situ devices were installed at Stations 1, 2, and 5 in accordance with the task work plan, as it was assumed that there would be minimal temperature stratification at these locations. Arrays of three in-situ devices were installed at Stations 3 and 4. Each array consisted of temperature data loggers installed at the top, middle and bottom of the water column. An array consists of a length of ¼-inch cable on to which 3 in-situ loggers are attached. This cable is then laid on the river bottom, from the shore to the middle the river, such that a logger is situated at top, middle and bottom of the water column. The purpose of the arrays was to provide information for the evaluation of thermal stratification within the Great Dam impoundment. This condition was confirmed at the time of installation using a hand-held temperature probe by taking water temperature measurements at 3-foot intervals in the middle of the river channel at Stations 3 and 4. See Figure 5.1 for sampling locations.

FIGURE 5.1
SAMPLING LOCATIONS

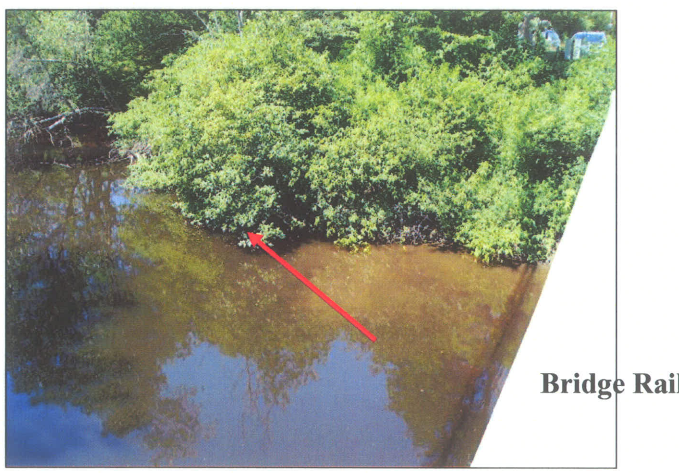


Device Installation Notes

The following information describes the installation of the devices at each station, including photographs, as well as retrieval information. The devices were all installed in general accordance with the work plan, and with the exception of the installation at Station 5, are not readily visible and should not be subject to vandalism. While the cable hanging from the fishway at Station 5 is visible, the restricted access at this location should preclude vandalism.

Station 1: Device EX 2 was installed adjacent to the Court Street bridge over the Exeter River along the left (facing downstream) bank of the river approximately 40 feet upstream of the bridge. The device was installed in a section of black-iron pipe and attached to a 2-foot length of steel reinforcing rod (rebar) by 2-foot length of 1/8-inch galvanized cable. The rebar was installed under overhanging brush approximately 1 foot below the water surface. A length of bailing wire was attached to the cable and tied to live brush along the bank. The device was situated approximately 1.5 feet below the water surface at the time of installation. The approximate location of the device is shown in Photo 1.

Photo 1: Station 1 Device Location



Station 2: Device EX 1 was installed adjacent to the Court Street culvert over the Little River at the upstream face of the pier between the left and left/center culvert. The device was installed in a section of black-iron pipe and attached vegetation by 4-foot length of 1/8-inch galvanized cable. Rebar was not used at this location as there was not suitable material into which it could be driven. The Exeter Town Engineer was notified of this installation and asked to request that vegetation not be cut for maintenance purposes prior to the removal of the device. The device was situated approximately 1.5 feet below the water surface at the time of installation. The approximate location of the device is shown in Photo 2.

Photo 2: Station 2 Device Location

Station 3: Devices EX 7, 8, and 9 were installed adjacent to the confluence of the Exeter and Little Rivers along the right (south) bank of the Exeter River. This station is comprised of an array of three devices intended to measure water temperature at the bottom, middle, and top of the water column. The installation was performed using an approximately 60-foot long piece of 1/8-inch galvanized cable anchored by a 10-pound lead weight in the middle of the channel and attached to a 2-foot length of rebar adjacent to the shoreline. The top of the rebar was driven to the water surface. Device EX 7 was attached to the cable at the lead weight at an approximate depth of 10 feet approximately 60 feet from the shoreline. Device EX 8 was fastened to the cable approximately 12 feet from shore at an approximate depth of 4 feet. Device EX 9 was fastened to the cable approximately 5 feet from shore at an approximate depth of 1 foot.

The approximate location of the device is shown in Photo 3 at the base of the yellow rod protruding above the water surface (rod was removed following installation).

Photo 3: Station 3 Shoreline Rebar Location

Station 4: Devices EX 4, 5, and 6 were installed adjacent in a bend of the Exeter approximately 1000 feet upstream of the Great Dam along the right (south) bank of the river. This station is comprised of an array of three devices intended to measure water temperature at the bottom, middle, and top of the water column. The installation was performed using an approximately 60-foot long piece of 1/8-inch galvanized cable anchored by a 10-pound lead weight in the middle of the channel and attached to a 2-foot length of rebar adjacent to the shoreline. The top of the rebar was driven below the water surface. Device EX 4 was attached to the cable at the lead weight at an approximate depth of 14 feet. Device EX 5 was fastened to the cable approximately 12 feet from shore at an approximate depth of 6 feet. Device EX 6 was fastened to the cable approximately 1 foot from shore at an approximate depth of 1 foot.

The approximate location of the device is shown in Photos 4 and 5 at the base of the stone wall, as indicated by the yellow rod protruding above the water surface in Photo 4 (rod was removed following installation). There is a white house in the background (Photo 5) that is not visible due to glare.

Photo 4: Station 4 Shoreline Rebar Location (1)

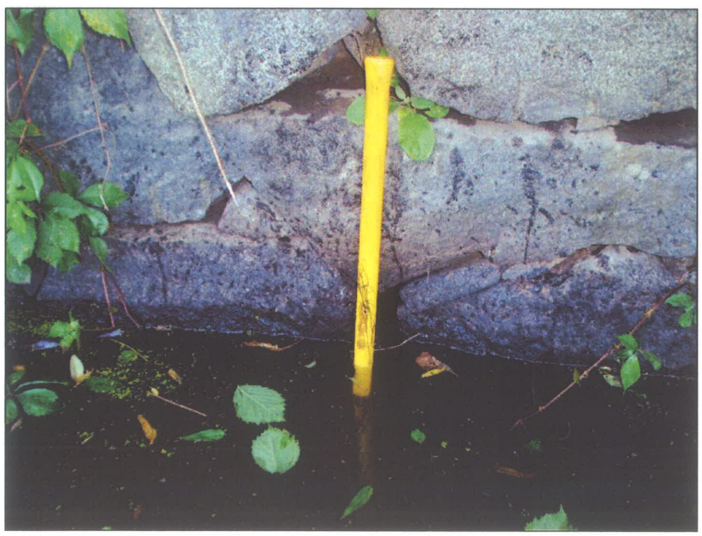


Photo 5: Station 4 Shoreline Rebar Location (2)

Station 5: Device EX 3 was fastened to the New Hampshire Fish and Game Department fishway at the Great Dam. The device was installed in a section of black-iron pipe and attached to the metal grating over the fishway by 10-foot length of 1/8-inch galvanized cable. The device was deployed between the fishway and the left bank of the river and was set approximately one foot above the bottom at the time of installation. The approximate location of the device is shown in Photo 6.

Photo 6: Station 5 Device Location

BI-WEEKLY TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS

Beginning on August 2, 2005, dissolved oxygen and temperature were measured every two weeks at the same stations where the in-situ data loggers had been placed, with the exception of Station 5. Station 5, for the dissolved oxygen measurement, was located adjacent to the upstream end of the fish ladder on Great Dam. In addition, dissolved oxygen and temperature were also measured in the Squamscott River below String Bridge in Exeter (Station 6). These measurements were taken on August 2, August 16, August 30, September 13, September 27 and November 7, 2005. The last round was delayed due to persistent high flows in October. The measurements were taken using a YSI-55 hand-held temperature and dissolved oxygen recorder. The instrument was calibrated by the distributor prior to each use.

RESULTS

The temperature and dissolved oxygen concentration are attached in the following tables. The in-situ temperature logger data and the bi-weekly temperature and dissolved oxygen data was submitted and accepted by NHDES Watershed Management Bureau. The acronym "bws" in the attached tables stands for "below water surface".

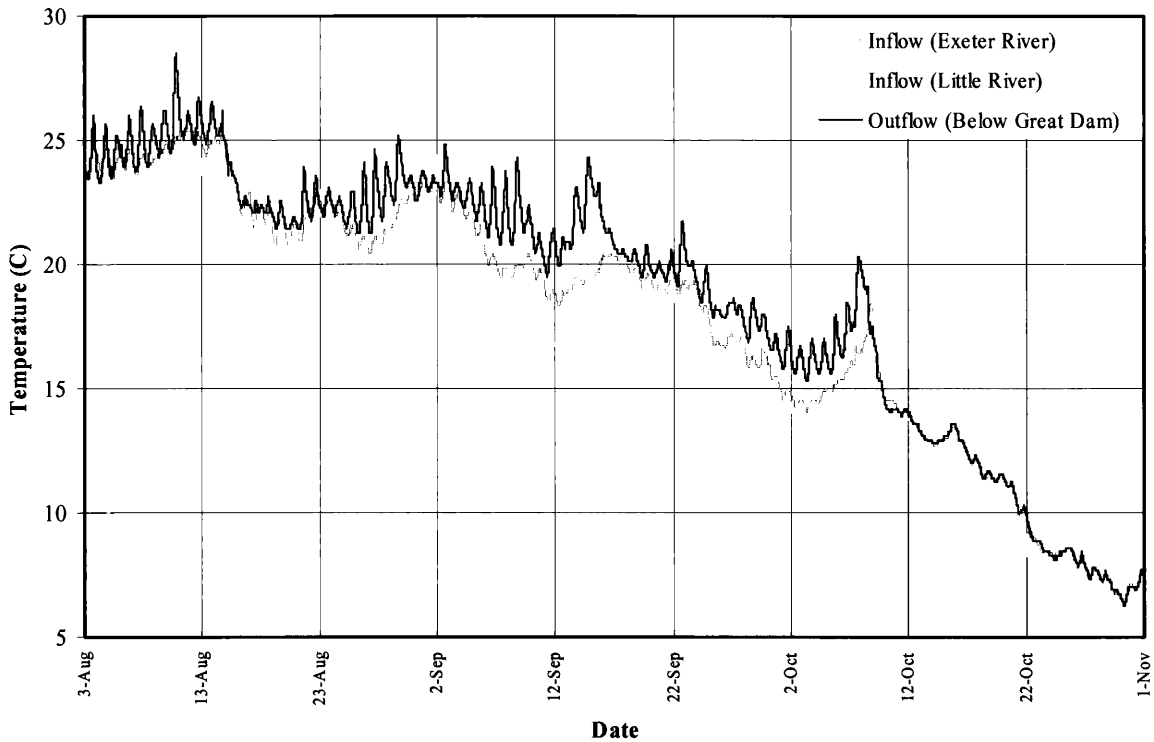
A preliminary evaluation of water quality data obtained in the Great Dam impoundment during the 2005 project work was used to evaluate 1) thermal gain through the impoundment, 2) thermal stratification and "turnover" within the impoundment, 3) dissolved oxygen levels within the impoundment, and 4) apparent dissolved oxygen depletion within the impoundment. The bi-weekly sampling was used to determine the occurrence of thermal "turnover" within the impoundment, indicating the conclusion of 2005 water quality data acquisition and the removal of the in-situ temperature logging equipment.

Thermal Gain and Stratification

Thermal gain across the impoundment was evaluated using information obtained at Stations 1, 2 and 5, representing inflows to the impoundment from the Exeter and Little Rivers and the outlet of the impoundment below the Great Dam, respectively. This information is shown in Figure 5-2, which suggests that some thermal gain occurs within the impoundment.

FIGURE 5-2

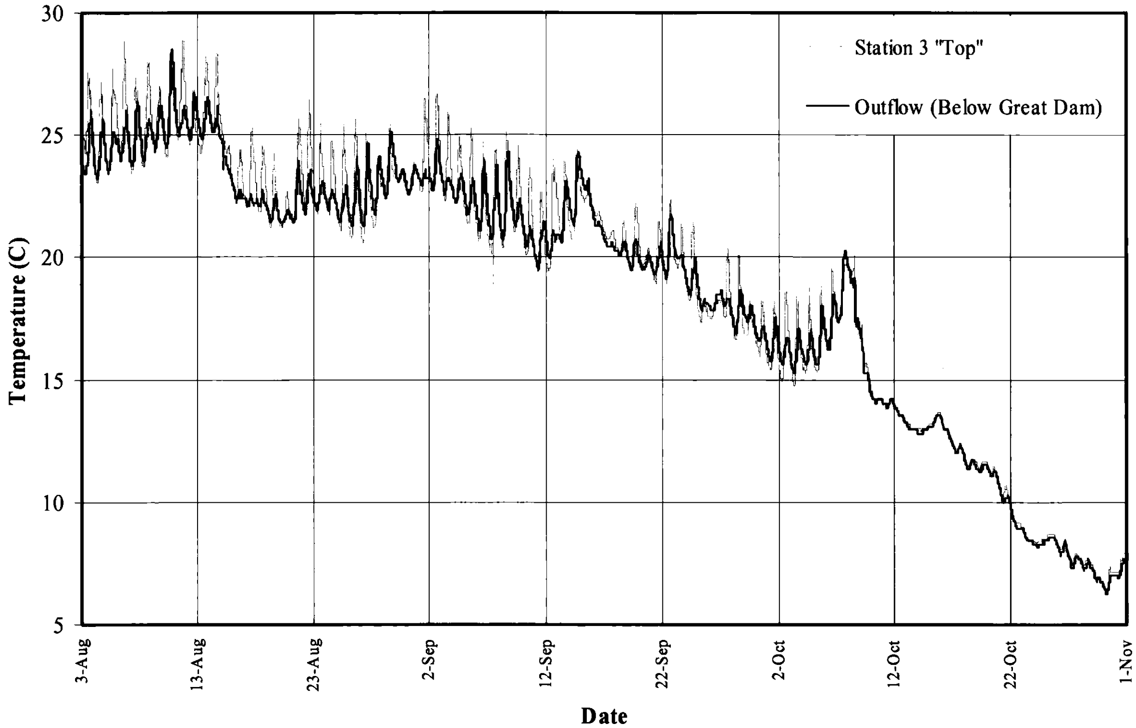
THERMAL GAIN ACROSS GREAT DAM IMPOUNDMENT



Of note in Figure 5-2 is the pronounced diurnal temperatures changes at the "Outflow" location. This condition may be the result of the dam discharging primarily surface water from the impoundment. This was evaluated by comparing the temperature data obtained below the Great Dam (Station 5) with the temperature data obtained from the "top" temperature data logger at Station 4 approximately 300-yards upstream of the dam. A comparison of this data is shown in Figure 5-3. This information suggests that the temperature of the water discharged over the Great Dam is similar to upstream water temperatures at the surface of the impoundment.

FIGURE 5-3

COMPARISON OF WATER TEMPERATURE DATA, GREAT DAM AND STATION 3, "TOP"



Thermal Stratification and Turnover

Thermal stratification within the impoundment was evaluated using information obtained as part of the bi-weekly sampling work and from the two in-situ temperature data logger arrays installed at Stations 3 and 4. Thermal stratification was observed at these fixed-array stations suggests that thermal turnover of the Great Dam impoundment occurred on approximately September 26, 2005. This can be seen in Figure 5-5, which depicts a time-series of temperature data obtained at Station 4. The occurrence of turnover is not as clearly apparent in the data obtained from Station 3, as depicted in Figure 5-4. Of note is that diurnal warming of the top layer of water persisted after the previously noted date of turnover.

Thermal stratification within the impoundment is apparent in the information obtained at Stations 3 and 4, as shown in Figures 5-4 and 5-5. This condition is most apparent at Station 4. Data obtained at Station 3 adjacent to the confluence of the Exeter and Little Rivers suggests less-pronounced stratification. This condition may be the result of increased vertical mixing at this location.

FIGURE 5-4

STATION 3 TEMPERATURE DATA

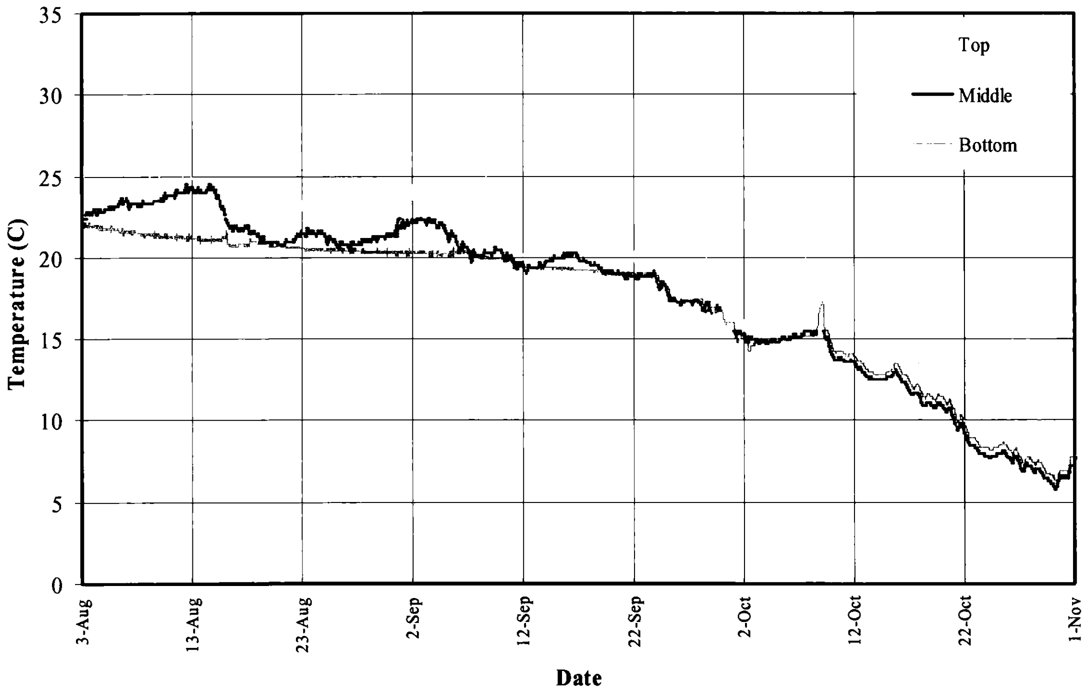


FIGURE 5-5

STATION 4 TEMPERATURE DATA

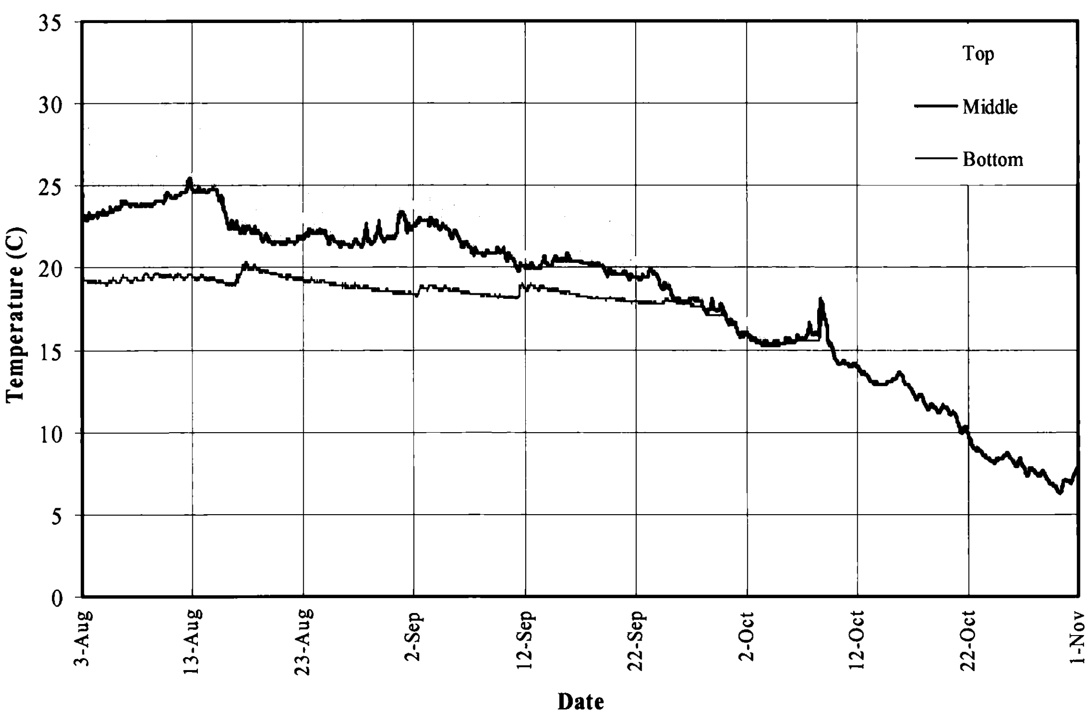


TABLE 5-1.1

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 1- AUGUST 2, 2005 *FINAL*				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**2:05 PM**			
1 ft bws		6.23	74.0	24
6 ft bws		6.00	69.0	23
7 ft deep				
Station 2	**1:30 PM**			
2.5 ft		5.00	59.0	23.4
Station 3	**11:17AM**			
0.5 ft bws		4.50	53.0	24.7
1.5 ft bws		4.26	51.0	23.8
4.5 ft bws		3.88	45.6	22.9
7.5 ft bws		3.55	40.0	22.6
10.5 ft bws		3.66	42.0	22.5
Station 4	**11:45 AM**			
.5 ft bws		5.00	60.0	25.1
3.5 ft bws		3.80	44.5	23.1
6.5 ft bws		3.33	38.0	22.6
9.5 ft bws		2.21	26.1	22.4
12.5ft bws		0.43	4.7	19.4
Station 5	**8:55 AM**			
1 ft bws		3.15	36.7	23.3
6 ft bws		2.10	25.0	22.8
7 ft deep				
Station 6	**8:00 AM**			
.5 ft bws		8.28	98.3	23

TABLE 5-1.2

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 2- AUGUST 16, 2005 *FINAL*				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**9:50 AM**			
1 ft bws		6.57	75.1	21.9
6 ft bws		6.71	76.5	21.8
7 ft deep				
Station 2	**9:35 AM**			
.5ft		6.76	75.1	20.5
Station 3	**8.35 AM**			
0.5 ft bws		3.97	46.1	22.7
2 ft bws		3.90	45.6	22.6
5 ft bws		3.60	42.0	22.6
8 ft bws		3.47	39.0	21.3
11 ft bws		4.04	45.0	20.8
12 ft deep				
Station 4	**8:55 AM**			
.5 ft bws		3.18	36.2	22.4
2 ft bws		3.24	37.5	22.3
5 ft bws		3.13	36.4	22.2
8 ft bws		3.15	36.2	22.1
11 ft bws		3.05	34.6	21.9
12 ft deep				
Station 5	**8:15 AM**			
1 ft bws		3.21	37.1	22.2
6.5 ft bws		3.20	36.4	22.2
7.5 ft deep				
Station 6	**8:00 AM**			
.5 ft bws		8.00	92.0	22.2

TABLE 5-1.3

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 3- AUGUST 30, 2005 **FINAL**				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**1:40 PM**			
1 ft bws		5.66	65.4	22.8
5 ft bws		5.00	59.0	22.4
6 ft deep				
Station 2	**1:30 PM**			
1.5ft		3.07	35.5	23.2
Station 3	**1:15 PM**			
0.5 ft bws		8.00	94.0	23.4
1.50 ft bws		8.00	90.0	23.3
4.5 ft bws		4.20	47.0	21.6
7.5 ft bws		3.70	39.0	21.3
10.5 ft bws		0.52	5.8	20.8
11.5 ft deep				
Station 4	**12:50 PM**			
1 ft bws		8.10	91.0	23.5
3 ft bws		6.20	72.0	22.2
6 ft bws		3.20	34.0	21.3
9 ft bws		0.68	7.8	20.5
12 ft bws		0.54	5.8	18.9
13 ft deep				
Station 5	**12:20 PM**			
1 ft bws		7.20	78.0	23.5
6.0 ft bws		2.95	32.3	21.7
7.0 ft deep				
Station 6	**12:03 PM**			
.5 ft bws		8.35	96.4	23.3

TABLE 5-1.4

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 4- SEPTEMBER 13, 2005 *FINAL*				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**11:05 AM**			
1 ft bws		4.90	54.7	19.4
5 ft bws		3.55	38.0	18.7
6 ft deep				
Station 2	**10:50 AM**			
1.5ft		2.71	29.0	19.2
Station 3	**10.20 AM**			
0.5 ft bws		5.30	61.0	21.7
2 ft bws		5.30	59.5	20.7
5 ft bws		4.40	48.8	19.9
8 ft bws		4.00	45.0	19.6
11 ft bws		4.00	42.5	19.4
11.5 ft deep				
Station 4	**9:50 AM**			
0.5 ft bws		5.60	63.5	21.0
1.50 ft bws		5.50	62.5	20.6
4.5 ft bws		4.10	45.1	20.0
7.5 ft bws		3.45	38.1	19.8
10.5 ft bws		1.60	18.2	19.3
11.5 ft deep				
Station 5	**8:30 AM**			
1 ft bws		4.29	48.0	20.5
6.0 ft bws		2.06	22.5	20.1
7.0 ft deep				
Station 6	**8:15 AM**			
.5 ft bws		8.27	91.5	20.4

TABLE 5-1.5

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 5- SEPTEMBER 27, 2005 *FINAL*				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**3:10 PM**			
1 ft bws		5.93	62.0	17.4
5 ft bws		5.30	54.8	16.8
6 ft deep				
Station 2	**3:00 PM**			
1.5ft		4.61	48.2	17.8
Station 3	**2:35 PM**			
0.5 ft bws		6.30	68.0	19.5
1.5 ft bws		5.90	64.1	19.4
4.5 ft bws		5.30	55.9	17.7
7.5 ft bws		4.70	49.2	17.5
10.5 ft bws		4.10	42.3	17.4
11.5 ft deep				
Station 4	**2:20 PM**			
0.5 ft bws		5.70	61.8	19.3
1ft bws		5.50	58.4	19.0
4ft bws		4.80	51.0	18.0
7 ft bws		4.60	48.5	17.8
10 ft bws		4.70	49.0	17.8
11. ft deep				
Station 5	**1:30 PM**			
1 ft bws		4.88	51.8	18.2
6.0 ft bws		3.59	38.0	18.1
7.0 ft deep				
Station 6	**1:10 PM**			
.5 ft bws		8.91	95.3	18.5

TABLE 5-1.6

EXETER RIVER TEMPERATURE AND DISSOLVED OXYGEN				
ROUND 6- NOVEMBER 7, 2005 *FINAL*				Exeter, NH
	Time	Dissolved O_2 mg/L	Dissolved O_2 %	Temperature C^0
Station 1	**1:00 PM**			
1 ft bws		10.80	95.1	9.7
8 ft bws		10.78	94.9	9.7
9 ft deep				
Station 2	**12:50 PM**			
1.5ft		9.76	87.3	10.4
Station 3	**11:58 AM**			
1 ft bws		9.71	86.0	9.7
2 ft bws		9.66	85.3	9.7
5 ft bws		9.72	85.1	9.7
8 ft bws		9.78	86.1	9.7
11 ft bws		9.90	87.6	9.7
12.4 ft deep				
Station 4	**11:34PM**			
1 ft bws		9.58	84.7	9.7
3 ft bws		9.62	85.4	9.7
6 ft bws		9.68	86.0	9.7
9 ft bws		10.03	88.2	9.6
12 ft bws		10.30	89.2	9.6
13.3 ft deep				
Station 5	**10:35 AM**			
1 ft bws		9.14	81.0	9.6
7.0 ft bws		8.95	78.4	9.6
7.9 ft deep				
Station 6	**10:14 AM**			
.5 ft bws		11.50	100.7	9.6

Dissolved Oxygen Sampling

Six biweekly sampling events were performed as part of the 2005 project work. The purpose of this work was to document existing conditions in the Great Dam impoundment during the summer and through the fall turnover. The biweekly monitoring was performed at the following six locations:

Location 1.	In the Exeter River where it passes under Court Street;
Location 2.	In the Little River where it passes under Court Street;
Location 3.	At the confluence of the Exeter and Little Rivers adjacent to the Town of Exeter's river pump station;
Location 4.	At the bend in the Exeter River approximately 200 yards upstream of the Great Bridge;
Location 5.	In the exit (upstream end) of the fishpass at the Great Dam; and
Location 6.	Below String Bridge on the Exeter River.

The monitoring work was performed on the following dates in 2005:

Monitoring Round 1.	August 2,
Monitoring Round 2.	August 16,
Monitoring Round 3.	August 30,
Monitoring Round 4.	September 13,
Monitoring Round 5.	September 27, and
Monitoring Round 6.	November 7.

Sampling was not performed during the month of October due to persistent high water in the Exeter River.

Discussion

The monitoring work documented temperature stratification and depletion of DO within the Great Dam impoundment. Discussions of spatial and temporal variations in percent-saturation of DO are presented below. Of note are the consistently high levels of dissolved oxygen at Station 6 (greater than 90-percent saturation for all monitoring rounds) suggest that DO levels increase at this location due to flows passing over the Great Dam and the downstream weir.

Spatial Variation in Percent-Saturation of Dissolved Oxygen

An evaluation of spatial variations in percent saturation of DO was performed to provide information on changes in DO that may result from oxygen depletion within the Great Dam impoundment. Figure 5-6 depicts the measured percent-saturation of DO obtained during the six monitoring events at each monitoring station. The plots in Figure 5-6 indicate that DO decreased through the impoundment during the summer monitoring rounds.

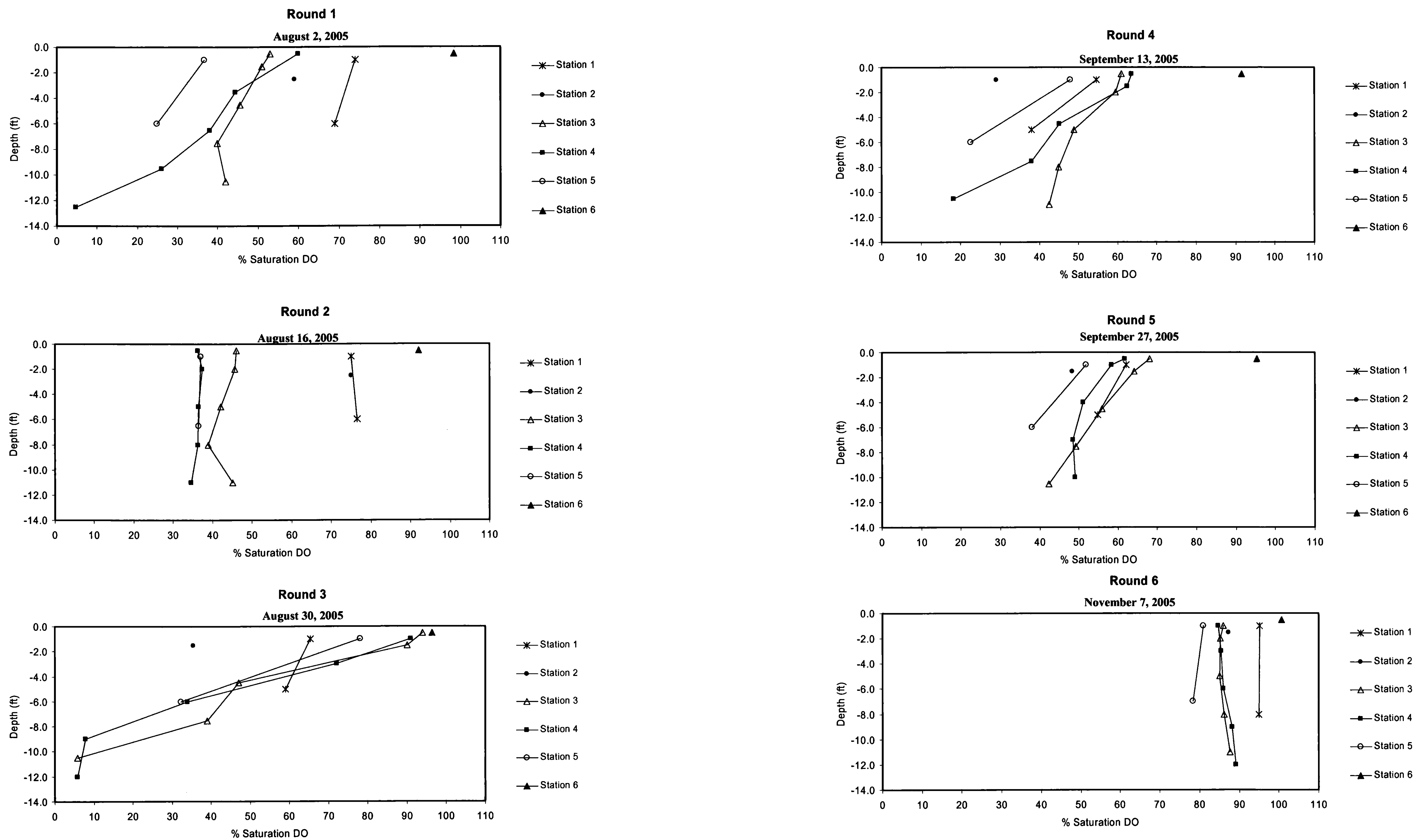
The plot of Round 1 data in Figure 5-6 clearly shows diminished DO saturation within the impoundment relative to that measured at inflow locations upstream on the Exeter and Little Rivers. The relatively homogenous DO percent saturation levels obtained during the Round 2 (August 16) monitoring work may be the result of increased flows following a rainfall event in the Exeter River watershed on August 15. Based on provisional flow data at the USGS stream gaging station on the Exeter River in Brentwood, this event resulted on a four-fold increase in flows. The plot of Round 3 data indicates reestablished stratification within the impoundment and *lower* DO levels at the "inflow" stations. The cause of the diminished DO levels at the inflow stations was not determined. This condition persisted until the final monitoring round in November, when inflowing DO levels increased. Of note is that measured the DO saturation at depth at Station 5 were consistently low.

Temporal Variation in Percent-Saturation of Dissolved Oxygen

An evaluation of temporal variations in percent saturation of DO was performed to provide information on changes in DO at each monitoring station. Figure 5-7 depicts the measured percent-saturation of DO obtained at each monitoring station during the six monitoring events. The plots in Figure 5-7 indicate that DO saturation varied at each station. In particular, the increased flows in mid-August resulted in relative low but homogenous DO saturation at Station 4. After this event, DO stratification was reestablished until the final monitoring round in November.

FIGURE 5-6

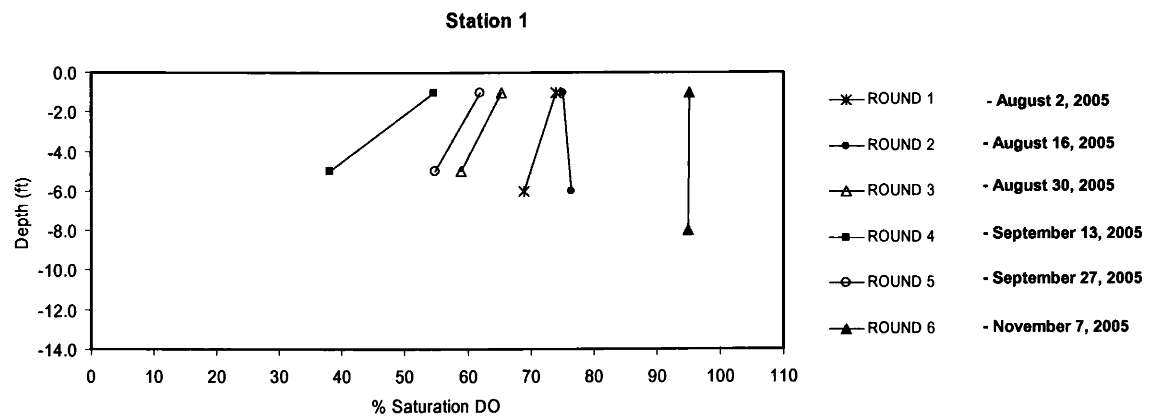
SPATIAL VARIATION OF PERCENT-SATURATION OF DO FOR EACH MONITORING ROUND

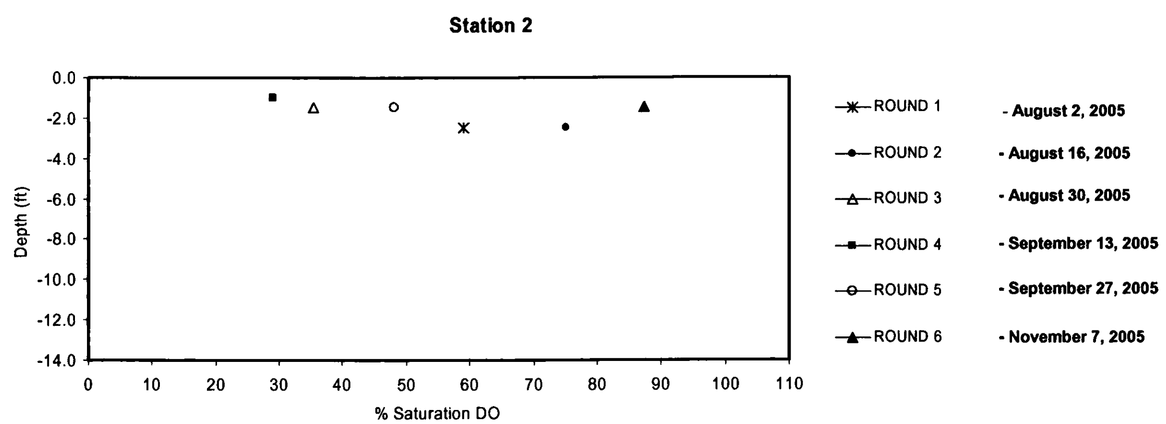


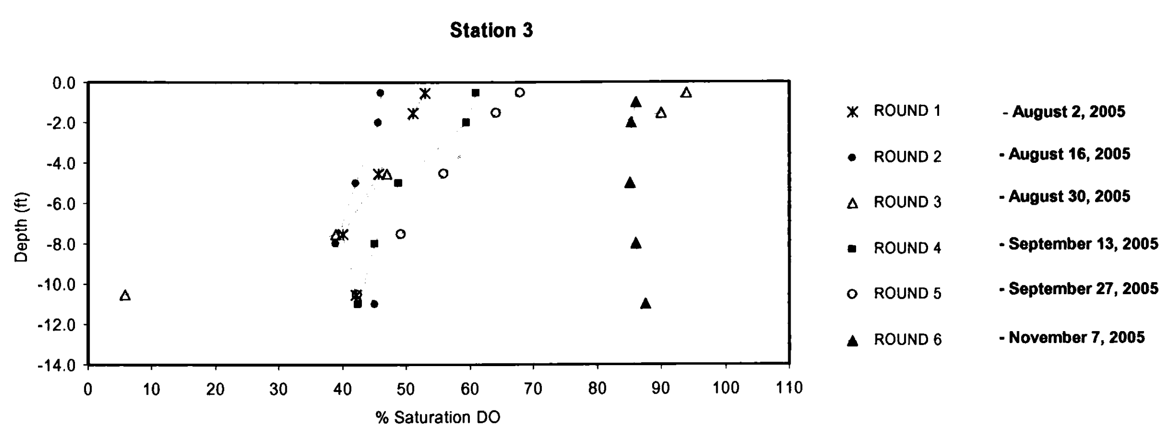
Station 1: Exeter River at State Route 108
Station 2: Little River at State Route 108
Station 3: Confluence of Exeter and Little Rivers
Station 4: Bend in Exeter River Upstream of High Street Bridge
Station 5: Great Dam Fishpass Exit
Station 6: Exeter River below String Bridge

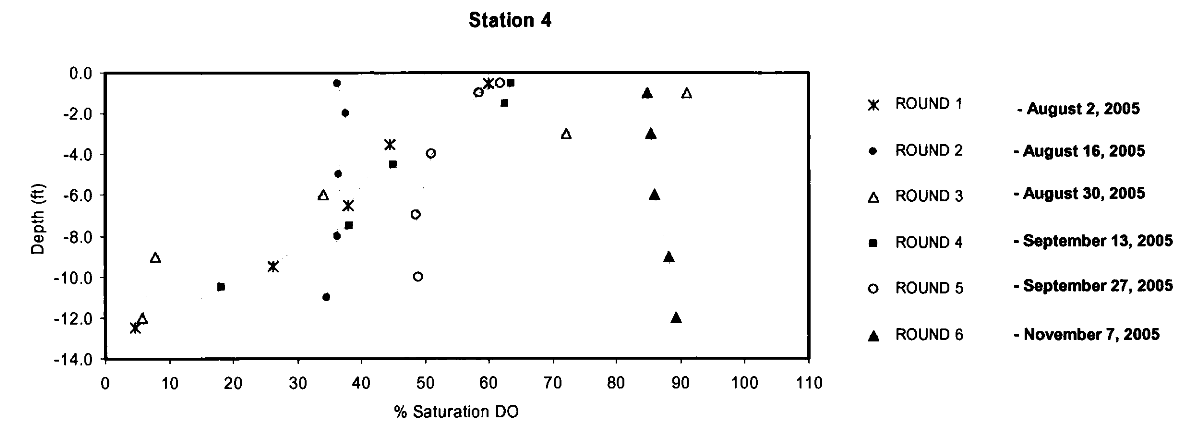
FIGURE 5-7

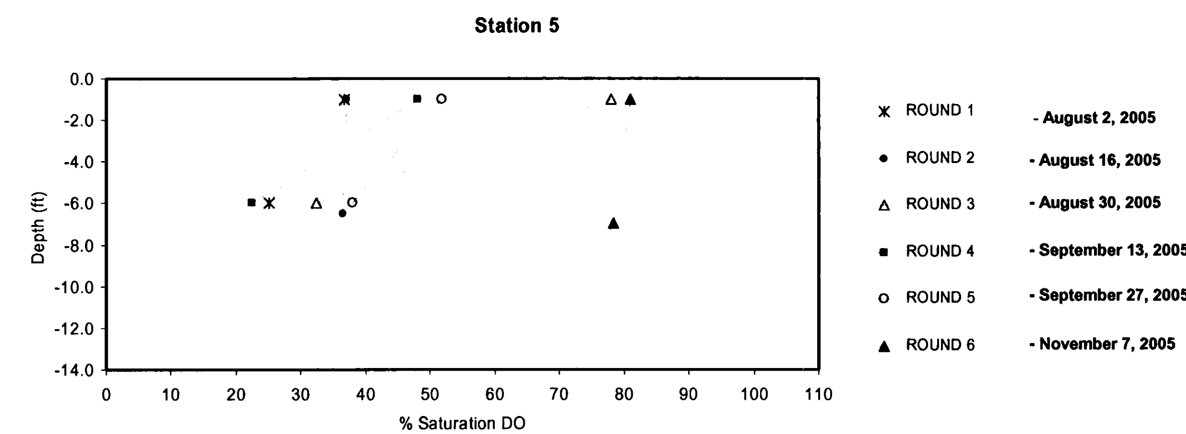
TEMPORAL VARIATION OF PERCENT-SATURATION OF DO AT EACH MONITORING STATION

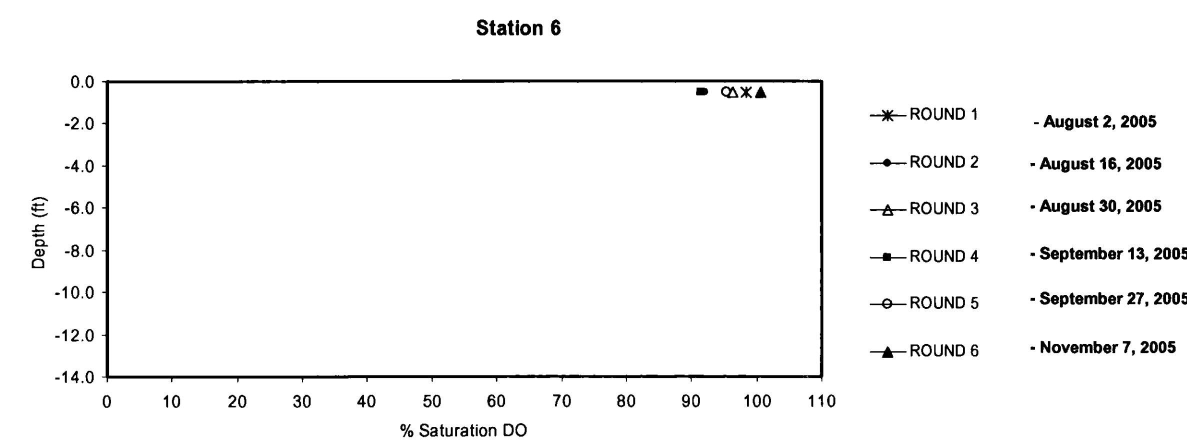












Station 1: Exeter River at State Route 108
Station 2: Little River at State Route 108
Station 3: Confluence of Exeter and Little Rivers
Station 4: Bend in Exeter River Upstream of High Street Bridge
Station 5: Great Dam Fishpass Exit
Station 6: Exeter River below String Bridge

SECTION 6

Task E
Assessment of Relevant Funding Opportunities

SECTION 6

TASK E
ASSESSMENT OF RELEVANT FUNDING OPPORTUNITIES

This section presents the results of the assessment of relevant funding opportunities for the Exeter River project in accordance with Task E, "*Assessment of Relevant Funding Opportunities*" of the project scope of work for 2005. A broad range of potential funding opportunities are presented in the following table. Note that the applicability of the identified funding sources may be project-need specific, such as improvements to water quality and fish passage. It is recommended that the availability and applicability of the identified relevant funding sources be evaluated with the identified contacts in the column labeled "Additional Information." In particular, the required lead time for specific grant opportunities should be determined, as well as particulars of required match requirements.

At this interim stage of the project, we have not identified which of these funding sources would be most appropriate to pursue for future Exeter River studies or infrastructure improvements. A more detailed review of funding sources and recommendations will be made at the time when the nature and scope of these activities and /or improvements are known, which potentially could occur at the conclusion of the 2006 Phase I study.

TABLE 6-1
POTENTIAL RIVER INFRASTRUCTURE FUNDING

Program	Funding Source	Additional Information	Type of Assistance*	Eligibility**	Typical Award Range	Match Required?	Dam Safety	Dam Removal	Drinking Water Treatment/Protection	Fish Passage	Flood Hazard	Habitat Enhancement	Riparian/Wetland Restoration	Water Quality Improvement
Conservation Reserve Program	USDA-Farm Service Agency	Local FSA office. http://www.fsa.usda.gov/dafp/cepd/crp.htm	Tech, Grant, Loan	I								X	X	X
Conservation Reserve Enhancement Program	USDA-Farm Service Agency	Local FSA office. http://www.fsa.usda.gov/dafp/cepd/crep.htm	Tech, Grant	I								X	X	X
Wetlands Reserve Program	USDA-Natural Resource Conservation Service	Local NRCS Office, http://www.nrcs.usda.gov/programs/wrp/	Tech, Grant	I, S, L, O								X	X	
Wildlife Habitat Incentives Program	USDA-Natural Resource Conservation Service	Local NRCS office, http://www.nrcs.usda.gov/programs/whip/	Tech, Grant	I, S, L, O				X		X		X	X	
New Hampshire Corporate Wetlands Restoration Partnership	Coastal America	Ted Diers, NHDES, (603) 559-0027, tdiers@des.state.nh.us	Tech, Grant	S, L, O				X		X		X	X	
Community-based Restoration Program Direct Grant	NOAA-National Marine Fisheries Service	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html	Grant	S, L, O	$50,000 - $200,000	1:1 match strongly encouraged		X		X		X	X	
Community-based Restoration Program Partnership Grant	American Rivers & NOAA	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/americanrivers.html	Grant	S, L, O	$5,000 - $25,000	1:1 match strongly encouraged		X		X			X	
Community-based Restoration Program Partnership Grant	American Sportfishing Association & NOAA	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/fishamerica.html	Grant	S, L, O	$5,000 - $50,000	1:1 match strongly encouraged		X		X		X	X	
Community-based Restoration Program Partnership Grant	Gulf of Maine Council on the Marine Environment & NOAA	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/gulfofmaine.html	Grant	S, L, O	$5,000 - $50,000	1:1 match strongly encouraged		X		X		X	X	
Community-based Restoration Program Partnership Grant	National Fish and Wildlife Foundation & NOAA	http://www.nfwf.org/programs/noaa.cfm	Grant	S, L, O	$10,000 - $100,000	2:1 match required		X		X		X	X	

Notes: * Type of Assistance: Tech = Technical Assistance
** Eligibility: I = Individual; S = State Government; L = Local Government; O = Non-profit Organization

TABLE 6-1
POTENTIAL RIVER INFRASTRUCTURE FUNDING

Program	Funding Source	Additional Information	Type of Assistance*	Eligibility**	Typical Award Range	Match Required?	Dam Safety	Dam Removal	Drinking Water Treatment/Protection	Fish Passage	Flood Hazard	Habitat Enhancement	Riparian/Wetland Restoration	Water Quality Improvement
Community-based Restoration Program Partnership Grant	The Nature Conservancy & NOAA	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/tnc.html	Grant, Tech	Must go to a TNC Chapter	$25,000 - $85,000	1:1 match strongly encouraged		X		X		X	X	
Community-based Restoration Program Partnership Grant	Trout Unlimited & NOAA	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/troutunlimited.html	Grant, Tech	Must go to a TU Chapter	Avg. $5,400	1:1 match strongly encouraged		X		X		X	X	
Open Rivers Initiative Barrier Removal	NOAA-NMFS	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects3.html	Grant	S, L, O	$50,000 - $250,000	1:1 match strongly encouraged		X		X				
Five-Star Restoration Challenge Partnership Grant	National Fish and Wildlife Foundation, NOAA & many other partners	http://www.nfwf.org/programs/5star-rfp.cfm	Grant	S, L, O	$5,000 - $20,000	1:1 match strongly encouraged		X		X		X	X	
General Matching Grants Program	National Fish and Wildlife Foundation	http://www.nfwf.org/guidelines.cfm	Grant	S, L, O	$10,000 - $150,000	2:1 match required		X		X		X	X	
Aquatic Ecosystem Restoration Program (Section 206 of the Water Resources Development Act of 1996)	U.S. Army Corps of Engineers	http://www.nae.usace.army.mil/pservices/206.htm	Grant, Tech	S, L, O	Limit is $5 million	65:35 match for studies and construction costs		X		X		X	X	
Partners for Fish and Wildlife	U.S. Fish and Wildlife Service	Eric Derleth, USFWS Field Office, Concord, NH. (603) 223-2541 x14. eric_derleth@fws.gov	Grant, Tech	I, S, L, O		Goal of 50:50 cost share		X		X		X	X	
Watershed Assistance and Restoration Grants (Section 319 funding)	USEPA through NH DES	http://www.des.nh.gov/wmb/was/grants.htm	Grant	S, L, O	$700,000 TOTAL available	60:40 cost share		X				X	X	X
New Hampshire Coastal Program Restoration Grants	NOAA through NH DES	http://www.des.state.nh.us/Coastal/Restoration/Grants04.htm	Grant	S, L, O	$1 million TOTAL available	None required		X		X		X	X	X
Drinking Water Source Protection	NH DES	http://www.des.state.nh.us/dwspp/grants.htm	Grant	S, L, O	$200,000 TOTAL available				X					X

Notes: * Type of Assistance: Tech = Technical Assistance
** Eligibility: I = Individual; S = State Government; L = Local Government; O = Non-profit Organization

TABLE 6-1
POTENTIAL RIVER INFRASTRUCTURE FUNDING

Program	Funding Source	Additional Information	Type of Assistance*	Eligibility**	Typical Award Range	Match Required?	Dam Safety	Dam Removal	Drinking Water Treatment/Protection	Fish Passage	Flood Hazard	Habitat Enhancement	Riparian/Wetland Restoration	Water Quality Improvement
Clean Water State Revolving Fund (SRF)	USEPA through NH DES	Gretchen Rich, NHDES, (603) 271-3448, grich@des.state.nh.us	Loan	L	Approx. $12 million TOTAL/year	n/a			X					X
Drinking Water State Revolving Fund (SRF)	USEPA through NH DES	Rick Skarinka, NHDES, (603) 271-2948, rskarinka@des.state.nh.us	Loan	L	Approx. $9 million TOTAL/year	n/a			X					X
Conservation Reserve Program	USDA-Farm Service Agency	Local FSA office. http://www.fsa.usda.gov/dafp/cepd/crp.htm	Tech, Grant, Loan	I								X	X	X
Conservation Reserve Enhancement Program	USDA-Farm Service Agency	Local FSA office. http://www.fsa.usda.gov/dafp/cepd/crep.htm	Tech, Grant	I								X	X	X
Wetlands Reserve Program	USDA-Natural Resource Conservation Service	Local NRCS Office, http://www.nrcs.usda.gov/programs/wrp/	Tech, Grant	I, S, L, O								X	X	
Wildlife Habitat Incentives Program	USDA-Natural Resource Conservation Service	Local NRCS office, http://www.nrcs.usda.gov/programs/whip/	Tech, Grant	I, S, L, O				X		X		X	X	
New Hampshire Corporate Wetlands Restoration Partnership	Coastal America	Ted Diers, NHDES, (603) 559-0027, tdiers@des.state.nh.us	Tech, Grant	S, L, O				X		X		X	X	
Community-based Restoration Program Direct Grant	NOAA-National Marine Fisheries Service	http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html	Grant	S, L, O	$50,000 - $200,000	1:1 match strongly encouraged		X		X		X	X	

Notes: * Type of Assistance: Tech = Technical Assistance
** Eligibility: I = Individual; S = State Government; L = Local Government; O = Non-profit Organization

SECTION 7

Task F
Hydraulic Modeling of Great Dam

TASK F.1 AND TASK F.2
OBTAIN 1982 FEMA STUDY AND DEVELOP HEC-RAS MODEL FROM FEMA STUDY

This section describes the development of a numerical hydraulic model (Project model) of the Great Dam impoundment reach of the Exeter River using information obtained from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) previously performed for the Exeter and Little Rivers in Exeter, New Hampshire.

The FEMA FIS was performed using the U.S. Army Corps of Engineers (Corps) Hydrologic Engineering Center (HEC) HEC-2 hydraulic model. Input files used in the FEMA study were obtained in Adobe® Portable Document File format from the "FEMA Project Library," which is currently administered by Michael Baker Jr., Inc. The HEC-2 model data was used to develop the project hydraulic model using the Corps' HEC-River Analysis System (HEC-RAS). This was performed by transcribing the input file data into electronic format and entering it into the HEC-RAS model environment.

The current extents of the Project HEC-RAS model are from the downstream limit of the Exeter River at the head-of-tide in Exeter upstream to the respective Court Street (Route 108) bridges over the Exeter and Little Rivers. These bridges form the approximate upper limits of the Great Dam impoundment and were therefore selected as appropriate limits for the project.

As determined from project needs, model input may need to be reevaluated and/or revised. In particular, the resolution of the model cross-sections defining the impoundment is coarse, as defined by the spacing between the cross sections. While this spacing may be sufficient for the evaluation of peak flow water surface elevations, it does not appear to be sufficient to resolve fundamental characteristics that may be required for future project studies, such as the development of a high-resolution stage-volume relation for the impoundment.

TASK F.3
PEAK FLOW HYDROLOGIC REVIEW

This section presents the results of a review of peak flow hydrology performed by Woodlot Alternatives, Inc. (Woodlot) in accordance with Task F.3, "*Numerical Modeling of Great Dam and Exeter River – Hydrologic Review*" of the project scope of work. The hydrologic review was performed to provide information on peak flows in the Exeter River in the vicinity of the Great Dam in Exeter, New Hampshire (NH).

HYDROLOGIC REVIEW

Three sources of information were evaluated as part of this hydrologic review of peak flows in the Exeter River in the vicinity of the Great Dam in Exeter, including:

1. Information obtained from the New Hampshire Department of Environmental Services (NHDES);
2. Information presented in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for the Exeter River in Exeter, NH;
3. Peak flow regression equations incorporated in the National Flood Frequency (NFF) computer program developed by the United States Geological Survey (USGS); and
4. Information determined from an analysis of peak flows on the Lamprey River.

Note that the USGS stream gaging station on the Exeter River near Brentwood, NH (USGS No 01073587) was not used to evaluate peak flows due to the relatively short gage history of approximately 10 years. Following are explanations of the information sources described above. A summary of this information is presented in Table 7-1.

NHDES Information

Peak flow information was obtained from NHDES files on the Great Dam (Dam No. 082.01). This information was obtained from an inspection report dated July 12, 2000, from Grace Levergood, P.E., Dam Safety Engineer with NHDES. This report presented peak flows for 50 and 100-year events, and the information was apparently developed using both USGS regression equations and peak flows calculated using data obtained from USGS stream gaging stations.

FEMA Information

The FEMA FIS for the Exeter River reports peak flows at a point described as "Exeter River, Downstream of the confluence of the Little River No. 1." The reported peak flows at this location were used by FEMA for the evaluation of flooding on the Exeter River between its confluence with the Little River in Exeter to its downstream terminus at the Squamscott River downstream of the Great Dam. Information presented in the FIS indicates that peak flows at this location were developed from regional regression equations developed by the USGS.

NFF

Peak flow regression equations incorporated in the NFF computer program developed by the USGS were used to develop values of peak flows. The applied regressions are referenced as dating from 1978 in the NFF documentation, and therefore may be the same as those used in the FEMA FIS. However, changes in input parameters from those used by FEMA (not reviewed for this study) would result in different calculated peak flows.

Input parameters required for this analysis include tributary drainage area in square miles, slope of the river channel in feet-per-mile between points located at 10 and 85 percent along the river channel, and the 2-year 24-hour precipitation. The tributary drainage area and slope of the river channel were obtained by Woodlot using USGS topographic quadrangle maps. The tributary drainage area at the Great Dam was determined to be 107.3 square-miles (sq.mi.) for this study. Towle Brook in Chester, NH was selected as the headwater of the Exeter River system for this analysis. The slope of the river channel was determined using 10 and 85-percent points located on the Exeter River downstream of the Court Street (Route 108) Bridge in Exeter and on Towle Brook in Sandown, NH, respectively. The calculated slope of the river channel was 8.2 feet-per-mile. The default 2-year 24-hour precipitation value of 3.2 inches was used for this analysis. The standard estimate of error for the regression equations ranges from 35 to 58 percent for the 2 through 100-year floods, as reported in the NFF documentation.

Analysis of Peak Flows on the Lamprey River

Peak flows in the Exeter River were evaluated using information obtained from the USGS stream gaging station on the Lamprey River near Newmarket, NH (USGS No. 01073500, which has a record of peak flows over a period of record from 1935 through 2004. The Lamprey River watershed is north of and adjacent to the Exeter River watershed and has a reported tributary watershed of 183 sq. mi. Peak flows at the Lamprey River gage were calculated using the Bulletin 17B (log-Pearson Type III method) output from the USGS PeakFQ statistical analysis computer program. Peak flow values in the Exeter River at the Great Dam were determined using the following gage transfer equation, which is referenced in the FEMA FIS for Rockingham County:

$$Q_{Project} = \frac{\left(Drainage\ Area_{Project} / Drainage\ Area_{Gage}\right)^{0.75}}{Q_{Gage}}$$

The use of the Lamprey River gaging station appears reasonable for this analysis based on the general criteria that the reference gage watershed have similar characteristics and that its tributary drainage area be no less than half or greater than two-times that of the desired (e.g., Project) tributary drainage area.

Summary and Recommendations

Peak flows in the Exeter River at the Great Dam determined as part of this review are presented in Table 7-1 and depicted in Figure 7-1. The variation of peak flows for each return interval event appears reasonable.

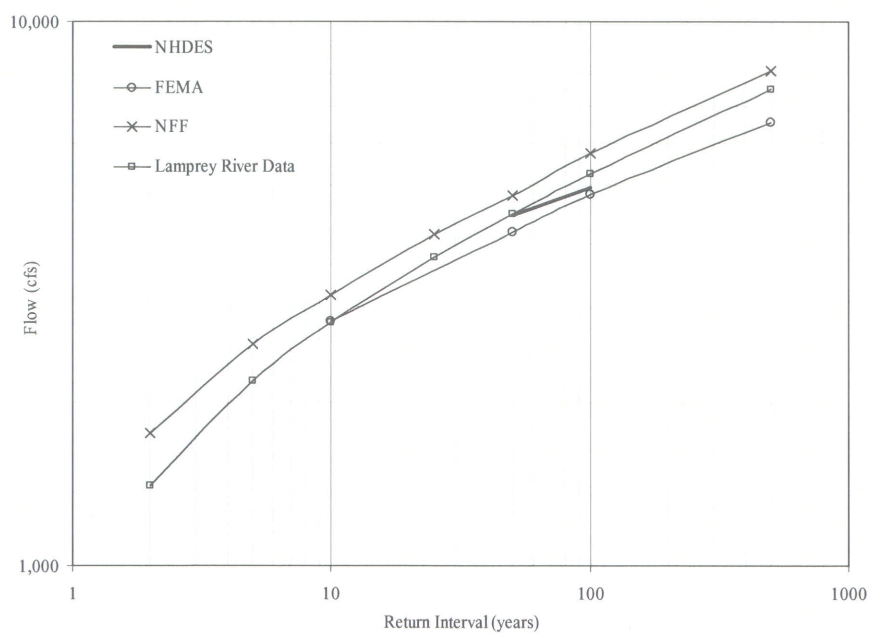
Table 7-1: Reported Drainage Areas and Peak Flows at the Great Dam

Data Source	Drainage Area (sq. mi.)	Return Interval (years)/Peak Flow (cfs*)						
		2	*5*	*10*	*25*	*50*	*100*	*500*
NHDES	102.7	-**	-	-	-	4,416	4,949	-
FEMA	114.6	-	-	2,811	-	4,107	4,827	6,518
NFF	107.3	1,750	2,560	3,140	4,060	4,790	5,730	8,140
Lamprey River Data	107.3	1,400	2,185	2,799	3,687	4,430	5,254	7,506

Notes: ** cfs – "cubic-feet-per-second"
* "-" no value obtained

The variations in reported drainage areas will result in variations in event-specific calculated peak flows. It is therefore recommended that the tributary drainage area delineated for this project be used for all future project analyses. It is recommended that a basis for the determination of peak flows associated with any changes to the Great Dam be reviewed with NHDES Dam Bureau staff, and that event-specific values be agreed upon prior to performing any design work.

Figure 7-1
Plot of Peak Flows



TASK F.4
HYDRAULIC ASSESSMENT FOR EXISTING CONDITIONS AT THE GREAT DAM

This section presents the results of a hydraulic assessment for existing conditions at the Great Dam on the Exeter River in accordance with Task F.4, "*Hydraulic Assessment for Existing Conditions at the Great Dam*" of the project scope of work for 2005.

GREAT DAM

The Great Dam [New Hampshire Department of Environmental Services (NHDES) Dam No. 082.01] is located on the Exeter River in Exeter, New Hampshire at the approximate head-of-tide, and has a tributary drainage area of approximately 107 square miles. Discharge appurtenances for the Great Dam include an uncontrolled spillway, a "low-level" sluice gate, and the existing Denil fishpass. The fishpass is currently not operated on a year-round basis, and its hydraulic capacity was therefore not evaluated here.

SPILLWAY

The elevation of the Great Dam spillway is reported as 23.5 feet (ft) (NGVD[1]), as determined by a site survey performed by Wright-Pierce Engineers (WP) in 2005. The dam has an uncontrolled spillway length of approximately 78 ft and single low-level sluice gate. This length was determined based on the 2005 survey performed by WP and is intended to represent a width of flow accommodating the approximately 45-degree bend on the right (east) side of the spillway and contraction along the left (west) abutment, as represented by the fishpass exit. The length of the spillway was reduced following the construction of the fishpass adjacent to the left (west) abutment in the late 1960s. The original spillway length was not identified for this study, but the width of the fishpass exit (upstream end) suggests that its construction resulted in the loss of approximately 9 feet of spillway length, or approximately 10 percent of the prior spillway length.

The spillway was initially constructed with an "ogee" crest, which was subsequently modified through the placement of a concrete cap approximately 2 ft wide and 1-ft wide on top of the ogee crest. The cap raised the crest of the spillway by approximately 1 foot, thereby reducing the spillway capacity through the loss of approximately 1 foot of freeboard. It is likely that the spillway discharge capacity was further diminished following the replacement of the original ogee shape with the horizontal cap. The cap likely functions as a short-crested weir, which has slightly diminished spillway capacity relative to the original ogee shape.

Based on the information presented above, a spillway discharge coefficient of 3.0 was used for this analysis. This value may result in calculated discharges that are greater than actually occur during periods when flow depths over the weir are relatively shallow, as the spillway would likely function as a broad-crested weir during such conditions. Similarly, the selected coefficient may result in calculated discharges that are smaller than actually occur during periods of higher flow when the spillway functions as a short-crested weir. When functioning as either a broad or

[1] "*National Geodetic Vertical Datum, 1929*". All elevations presented here are referenced to this datum.

short-crested weir, it is not likely that the current spillway functions as efficiently as the ogee spillway.

Low-Level Sluice Gate Geometry

The low-level gate is a manually-operated sluice gate mounted on the right (east) abutment of the dam. The gate intake is set at an angle of approximately 45 degrees to the axis of the river. Due to persistent high waters during late 2005, the dimensions of the gate and adjacent inlet works were not obtained during the site survey performed by WP. Various gate dimensions have been previously reported. This analysis was performed using gate dimensions of 4.5 ft wide and 5 ft high, and an outlet sill invert elevation was set at 15.8 ft. The gate structure inlet geometry appears relatively complex, as it includes an orifice with the top below the spillway elevation and an overflow section entrance into the gate pit set at the spillway elevation. Observations of surface flow conditions adjacent to the gate suggest that inlet conditions are not optimal, resulting in commensurate losses in hydraulic capacity.

Based on the aforementioned observations, the orifice coefficient of 0.8 was used for this evaluation. A weir coefficient of 2.6 was used for non-orifice flow within the gate. Flows overtopping the overflow section may increase the hydraulic capacity of the gate system during periods of relatively low flow (depth of flow over the spillway less than 1 foot), as water levels in the gate chamber, which is open on the top, are below that of the impoundment pool. The potential gains in hydraulic capacity associated with flows over the overflow section are not evaluated here.

There does not appear to be a trash-rack in front of the gate. Given the small size of the gate relative to likely debris, such as tree trunks, there is a high likelihood that the gate could become obstructed, particularly during period of high flows.

Analysis Methodology

The hydraulic assessment of existing conditions at the Great Dam was comprised of an evaluation considering both the spillway and the low-level sluice gate and was performed using the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). The project HEC-RAS model was developed using channel cross-section information obtained from HEC-2 input files used in the development of the Federal Emergency Management Agency Flood Insurance Study for the Exeter River in Exeter, New Hampshire. The model domain extends from the Squamscott River downstream of the Great Dam upstream to the Court Street (State Route 108) Bridge over the Exeter River and the Little River between its confluence with the Exeter River and upstream to the Court Street Bridge over the Little River. This section of the Little River was included in this evaluation to provide information on the general storage of the normal impoundment created by the Great Dam. Geometry data for the Great Dam and the weir located approximately 100 ft downstream was obtained from the 2005 site survey by WP.

Due to persistent high water in the Exeter River during the fall of 2005, WP was not able to document the dimensions of the low-level sluice gate or obtain bathymetric data along the upstream face of the Great Dam. It is therefore recommended that this analysis be revised following the acquisition of this data.

STEADY-STATE ANALYSIS OF GATE CAPACITY

A steady-state analysis was performed to evaluate the hydraulic capacity of the spillway and low-level sluice gate. Three gate configurations were evaluated, including gate-closed, gate open halfway (2.5 ft), and the gate fully open (5 ft). Hydraulic capacity for each of these configurations was evaluated over a range of 12 specified flows ranging from 750 cubic-feet-per-second (cfs) through 4949 cfs. The latter value represents the peak flow associated with the 100-year return interval flood, as presented in the NHDES inspection report dated July 12, 2000, from Grace Levergood, P.E., Dam Safety Engineer of NHDES. The 50-year return interval event peak flow of 4416 cfs, as defined in the aforementioned report, was also evaluated. Gate closed and gate full open conditions were analyzed for the high-flow conditions. The results of this analysis are presented in Table 1, including calculated differences relative to the gate-closed configuration for the gate open halfway and the gate fully open configurations.

Figure 1 presents rating curves for the three evaluated configurations along with reference elevations of the right abutment and the fish pass exit, which effectively form the left abutment.

SUMMARY

The discharge capacity of the Great Dam was evaluated for a range of flows, including values for the 50 and 100-year peak flows obtained from NHDES. The results of this evaluation, as presented in Table 1 and Figure 1, suggest that the hydraulic capacity of the dam is limited. Based on this evaluation, it is apparent that the low-level gate provides marginal benefits during high flows, as noted by the small differences in calculated water surface elevations for the evaluated gate configurations.

Mitigating factors that were not evaluated here include potential storage and consequent attenuation of peak flows in impoundments within the upstream watershed and additional geometry data for the terrain adjacent to the dam.

TABLE 7-2

COMPARATIVE EVALUATION OF HYDRAULIC CAPACITY DURING HIGH FLOW REGIMES

	Gate Closed		Gate Open Halfway (2.5-ft)					Gate Full Open				
Flow	***WSEL****	***Q Weir (cfs)***	***WSEL***	***Q Weir (cfs)***	***Q Gate (cfs)***	***Gate (% of Total)***	***Difference in WSEL (ft)***	***WSEL***	***Q Weir (cfs)***	***Q Gate (cfs)***	***Gate (% of Total)***	***Difference in WSEL (ft)***
750 cfs	25.65	750	25.38	610	140	19%	0.27	25.09	476	274	37%	0.56
1,000 cfs	26.11	1,000	25.86	857	143	14%	0.25	25.59	718	282	28%	0.52
1,250 cfs	26.53	1,250	26.29	1,104	146	12%	0.24	26.04	961	289	23%	0.49
1,500 cfs	26.91	1,500	26.69	1,351	149	10%	0.22	26.45	1,205	295	20%	0.46
1,750 cfs	27.27	1,750	27.05	1,599	151	9%	0.22	26.83	1,449	301	17%	0.44
2,000 cfs	27.6	2,000	27.39	1,846	154	8%	0.21	27.18	1,695	305	15%	0.42
2,250 cfs	27.91	2,250	27.71	2,094	156	7%	0.20	27.51	1,941	309	14%	0.40
2,500 cfs	28.2	2,500	28.02	2,342	158	6%	0.18	27.82	2,187	313	13%	0.38
2,750 cfs	28.46	2,750	28.29	2,590	160	6%	0.17	28.11	2,433	317	12%	0.35
3,000 cfs	28.72	3,000	28.55	2,839	161	5%	0.17	28.38	2,679	321	11%	0.34
4,416 cfs	30.01	4,416	29.86	4,246	170	4%	0.15	29.7	4,078	338	8%	0.31
4,949 cfs	30.46	4,949	30.3	4,776	173	3%	0.16	30.15	4,605	344	7%	0.31

Notes: * "Water Surface Elevation"
** Difference Relative to "Gate Closed" Configuration

FIGURE 7-2

DISCHARGE CAPACITY OF GREAT DAM

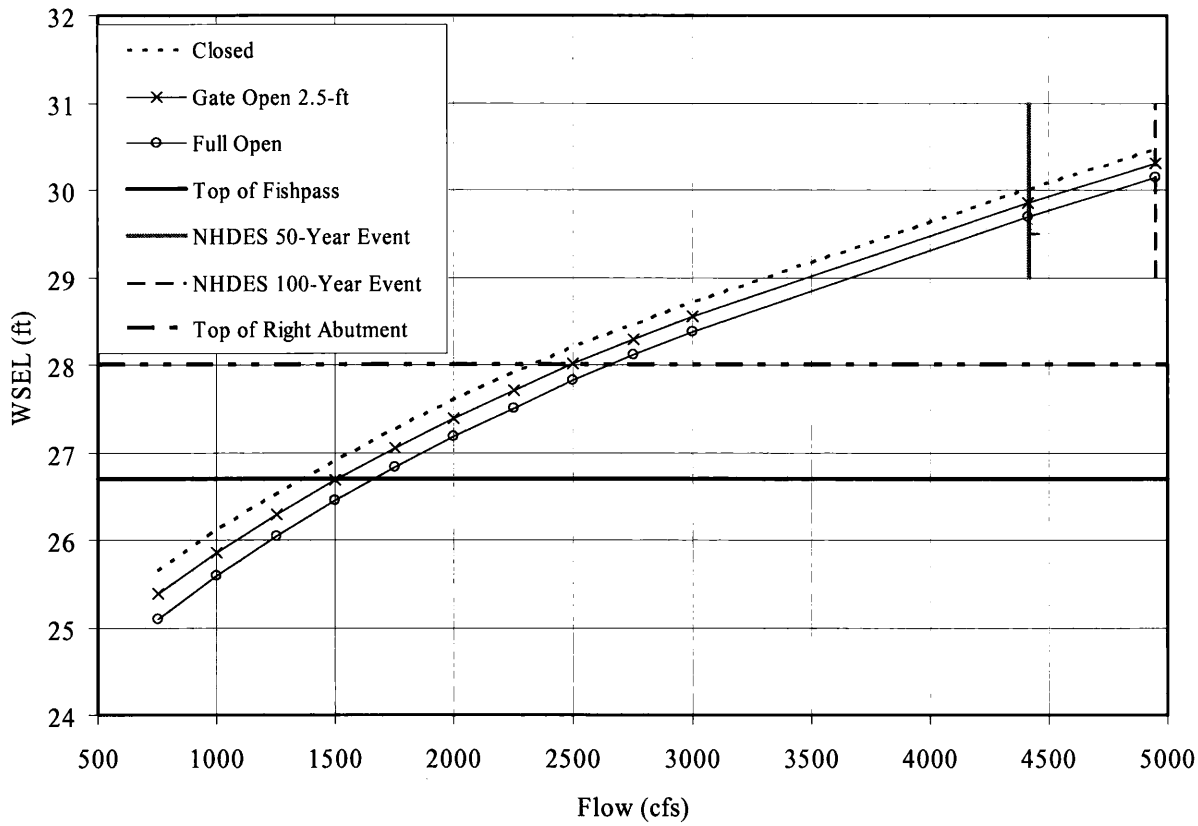


TABLE 7-3

COMPARATIVE ANALYSIS OF GATE EFFECTS DURING NORMAL FLOW REGIMES

Flow (cfs)	Gate Opening [WSEL/Q Weir (cfs)/Q Gate (cfs)/WSEL (ft NGVD29)]																	
	Closed			1-ft			2-ft			3-ft			4-ft			Full Open (5-ft)		
	W.S. Elev	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*
10	24	10	0	17	-	10	17	-	10	17	-	10	17	-	10	17	-	10
20	24	20	0	17	-	20	17	-	20	17	-	20	17	-	20	17	-	20
30	24	30	0	19	-	30	18	-	30	18	-	30	18	-	30	18	-	30
40	24	40	0	21	-	40	18	-	40	18	-	40	18	-	40	18	-	40
50	24	50	0	23	-	50	18	-	50	18	-	50	18	-	50	18	-	50
60	24	60	0	24	9	51	19	-	60	19	-	60	19	-	60	19	-	60
70	24	70	0	24	19	51	20	-	70	19	-	70	19	-	70	19	-	70
80	24	80	0	24	30	50	21	-	80	19	-	80	19	-	80	19	-	80
90	24	90	0	24	40	50	22	-	90	19	-	90	20	-	90	20	-	90
100	24	100	0	24	48	52	23	-	100	19	-	100	20	-	100	20	-	100
120	24	120	0	24	68	52	24	19	101	21	-	120	20	-	120	21	-	120
140	24	140	0	24	88	52	24	39	101	22	-	140	20	-	140	21	-	140
160	24	160	0	24	108	52	24	57	103	24	9	151	21	-	160	21	-	160
180	24	180	0	24	128	52	24	76	104	24	28	152	22	-	180	21	-	180
200	24	200	0	24	148	52	24	97	103	24	46	154	23	-	200	22	-	200
250	25	250	0	24	197	53	24	145	105	24	94	156	24	45	205	23	-	250
300	25	300	0	25	246	54	24	194	106	24	143	157	24	93	207	24	44	256
350	25	350	0	25	296	54	25	243	107	24	192	158	24	140	210	24	91	259
400	25	400	0	25	346	54	25	292	108	25	241	159	24	189	211	24	138	262
450	25	450	0	25	395	55	25	341	109	25	289	161	25	237	213	24	187	263
500	25	500	0	25	445	55	25	391	109	25	338	162	25	286	214	25	235	265

Time-Varying Flow

The preceding analysis does not consider time-varying, or "unsteady-state," flow conditions. This type of analysis would be required to determine impoundment water surface elevations during 1) drawdowns of the Great Dam impoundment and 2) conditions when flows into the impoundment vary (e.g., during floods). With appropriate information on the stage-volume characteristics of the Great Dam impoundment, a time-varying numerical model could be used to evaluate conditions such as mitigating flooding during peak flow events and effects of water withdrawals on impoundment levels.

Discussion

This section presents an evaluation of the existing sluice gate at the Great Dam using available information. The results of the steady-state hydraulic analysis suggest the gate can be operated to achieve specific water levels in the Great Dam impoundment, but that overtopping of the spillway will occur even with the gate at a fully open position when flows exceed approximately 250-cfs. However, the gate has a marginal capacity to regulate upstream water levels at higher flows. This evaluation did not consider gate operations in anticipation of increased inflows, such as those which might result from rainfall events within the Exeter River watershed. Because of the relatively large storage capacity within the impoundment, it is possible that the gate might have some utility in drawing-down the impoundment in anticipation of increased inflows, thereby reducing peak water surface elevations in the impoundment. The likely limit of reduced peak water surface elevations was not evaluated. Based on the qualitative backwater study performed previously by Woodlot as part of this study, however, it is suggested that "channel control" might occur within the reach of the river between the Court Street Bridge and the confluence of the Exeter and Little Rivers, thereby limiting benefits within that reach.

Based on this analysis, the Great Dam does not have adequate spillway capacity. The dam is currently required to pass the 50-year return-interval event, but the analysis of spillway capacity with the low-level gate in the fully-open position indicates that the overtopping of the right abutment will occur at a flow of approximately 2,650 cfs. The return-interval of this event is less than 10-years, based on the hydrologic review performed in Task F.3 of this study. Overtopping of the fishpass exit, which effectively forms the left abutment, with the low-level gate in the fully-open position was determined to occur at a flow of approximately 1,650 cfs, which has a return-interval of approximately two-years.

Of note is that the previously noted NHDES inspection report for the Great Dam, dated July 12, 2000, listed the spillway length as 111-ft with 5-ft of freeboard and 1-ft of non-falling flashboards. It is recommended that the NHDES Dam Bureau be contacted to discuss their interpretation of the dam spillway geometry, particularly 1) the basis for the determination of freeboard, and 2) the apparent determination that the concrete cap over the original ogee spillway is considered a "non-falling flashboard."

TASK F.5
FLOW-DURATION ANALYSIS

This section presents the results of a flow-duration analysis for the Exeter River in accordance with Task F.5, "*Numerical Modeling of Great Dam and Exeter River – Development of Flow-Duration Curves*" of the project scope of work. The flow duration analysis was performed to provide information on flows in the Exeter River in the vicinity of the Great Dam in Exeter, New Hampshire during target fish species migration periods.

DISCUSSION OF FLOW-DURATION DATA AND CURVES

Flow-duration statistics and derived "curves," or plots, are used to provide insight into typical flow conditions over desired periods of time. This information is presented as the percent of time during which a given flow is exceeded. For example, very low flows occur infrequently and are thus exceeded most of the time. The percentile associated with a very low flow might therefore be high (e.g., 99^{th} percentile). Similarly, very high flows also occur infrequently and are rarely exceeded. Therefore, the percentile associated with very high flows might be low (e.g., 1^{st} percentile).

For this analysis, flow-duration data was developed to provide information on typical ranges of flows associated with diadromous fish species in the Exeter and Squamscott Rivers. Flow duration statistics can be used to evaluate or set guidelines for the performance of fish passage facilities over a range of flows. For example, a design intent might be to provide for fish passage over a range of flows between the 10^{th} and 90^{th} percentiles, with the intent of providing fish passage 80-percent of the time during typical flows within a given migration period.

TARGET FISH SPECIES MIGRATION PERIODS

Target fish species for which flow duration information was developed on the Exeter River system (i.e., Exeter and Squamscott Rivers) were determined through informal consultation with the New Hampshire Fish and Game Department (NHF&G) and include both anadromous and catadromous species. Target anadromous fish species include "river herring" (Alewife [*Alosa pseudoharengus*] and blueback herring [*Alosa aestivalis*]), American shad (*Alosa sapidissima*), sea lamprey (*Petromyzon marinus*), and rainbow smelt (*Osmerus mordax*). Migration of these fish species in the Exeter River system is typified by upstream spawning migrations of adult fish with subsequent downstream migration of young-of-year juveniles. Downstream migration of adult anadromous fish after spawning was assumed to occur within the spawning migration period for this analysis. With the exception of rainbow smelt, the target anadromous fish are capable of ascending the Great Dam fishpass under ideal conditions. Rainbow smelt are not capable of ascending the Great Dam fishpass and are therefore confined to the Squamscott River below the dam.

Both adult and juvenile American eel (*Anguilla rostrata*) currently access the Exeter River upstream of the Great Dam, with likely migration pathways including the Great Dam fishpass and overland passage adjacent to the dam. Flow-duration statistics were not developed for American eel because 1) the fishpass at the Great Dam is not currently operated to pass eels and

2) the possibility of seasonal migrations of eels between the Exeter and Squamscott Rivers. It is suggested that the need and subsequent development of flow-duration statistics for eel be discussed with NHF&G.

Information on target fish species migration periods was determined through informal consultation with NHF&G, including information on both adult and juvenile migration in the Exeter River system. Table 1 presents adult and juvenile migration periods for the target fish species.

TABLE 7-4

TARGET FISH SPECIES MIGRATION PERIODS

Target Fish Species	Migration Periods	
	Adult	Juvenile
River herring	April 15 – July 15	July – October
American shad	May 1 – July 7	July – October
Sea Lamprey	April 1 – July 7	November - December
Rainbow Smelt	March 15 – April 30	March 15 – April 30
American Eel	May 1 – September 30	October 1 – February 28

HYDROLOGIC DATA

Hydrologic data for the flow-duration analysis was obtained from the United States Geological Survey (USGS) stream gaging station on the Exeter River near Brentwood, New Hampshire (USGS No 01073587), which has a tributary drainage area of 63.5 square miles (sq.mi.). The analysis was performed using daily-average stream flow data for the station period of record between June 27, 1996, and September 30, 2004, obtained from the USGS online database (http://waterdata.usgs.gov/nh/nwis/nwisman/?site_no=01073587&agency_cd=USGS).

Flow-duration information was developed for adult, or "upstream," migration periods of the four target anadromous fish species and for the juvenile, or "downstream," migration period for the target *Alosid* species (i.e., river herring and American shad) and for sea lamprey. Juvenile migration statistics were not developed for rainbow smelt, as smelt spawn downstream of the Great Dam and larvae emigrate into the Squamscott River estuary soon after hatching. Statistics were not developed for American eel, as the fishpass is not currently operated throughout periods of juvenile eel migration.

Flow duration statistics were developed by ranking daily average stream flow data for USGS station No 01073587 within each migration. Percentile exceedence occurrence statistics were then determined for each migration period. The calculated percentile flows at USGS station No 01073587 were linearly transposed to the Great Dam based on the respective tributary drainage areas of 63.5 and 102.7 sq. mi. (i.e., increased by a factor of 1.62). Note that the drainage area was subsequently delineated as 107.3 sq. mi. for this study. Percentile flow statistics for adult and juvenile migration periods are presented in Tables 2 and 3, respectively. Flow-duration curves for adult and juvenile migration periods are depicted in Figure 1.

TABLE 7-5

FLOW-DURATION STATISTICS FOR ADULT MIGRATION PERIODS

Target Fish Species	Data Points	Percentile/Flow (cfs)						
		5%	*10%*	*20%*	*50%*	*80%*	*90%*	*95%*
River herring	755	507	387	246	121	42	19	12
American shad	555	442	319	226	118	47	24	13
Sea Lamprey	755	667	495	322	150	68	35	16
Rainbow Smelt	376	1034	826	547	294	149	113	102

Note: *"Data Points" refers to the number of average daily flow values used to determine species-specific statistics.

The adult flow duration statistics presented above can be used to evaluate the efficacy of upstream fish passage facilities at the Great Dam. In general, these statistics should be used to evaluate fishpass efficacy over the entire range of target fish species. For example, if a goal is established to pass river herring, American shad and sea lamprey between the 10th and 90th deciles for each species, fishpass performance would be based on the higher 10th decile value [667-cfs (sea lamprey)] and the lower 90th decile value [19-cfs (river herring)].

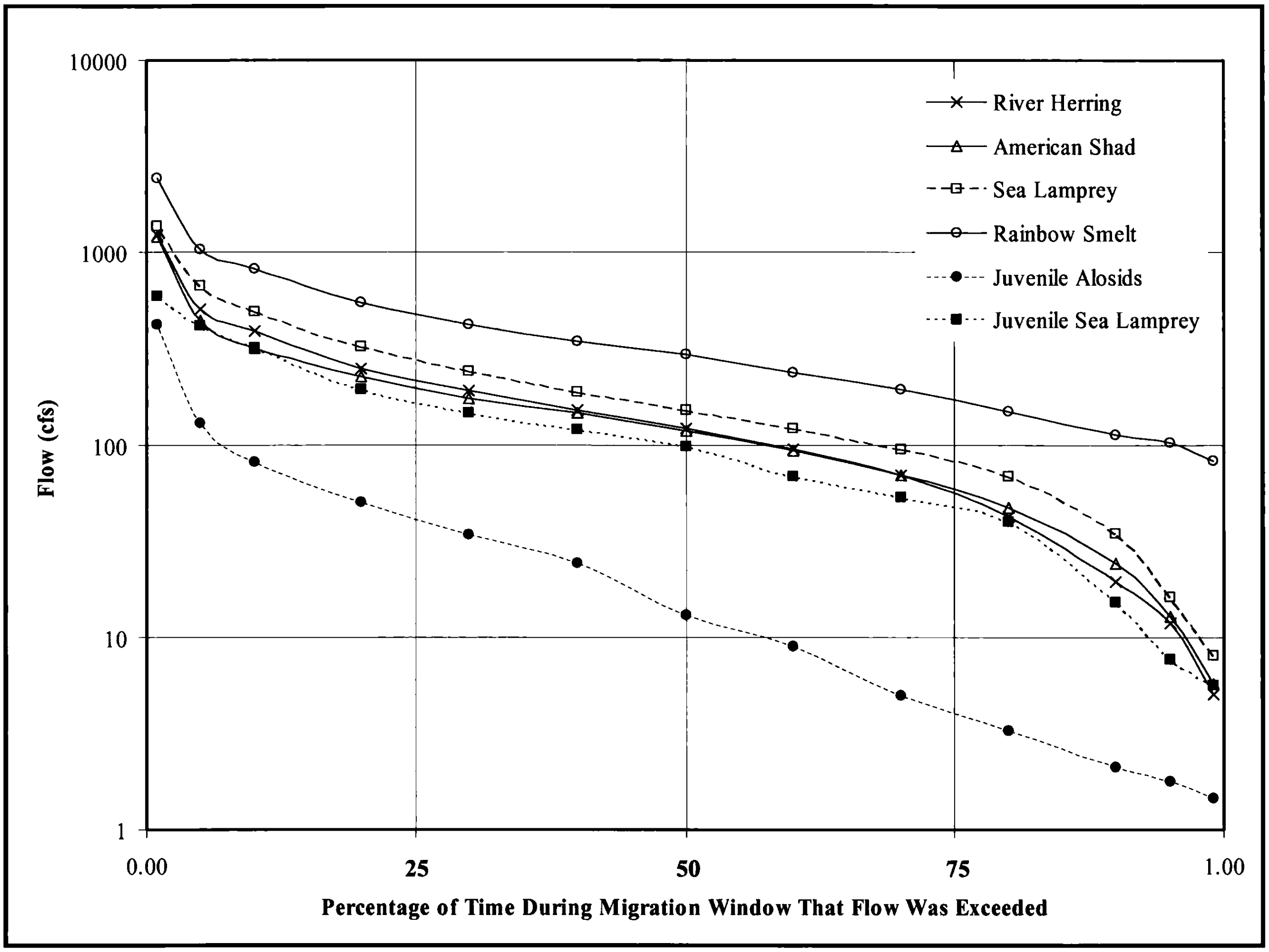
TABLE 7-6

FLOW-DURATION STATISTICS FOR JUVENILE MIGRATION PERIODS

Target Fish Species	Data Points	Percentile/Flow (cfs)						
		5%	*10%*	*20%*	*50%*	*80%*	*90%*	*95%*
River herring/ American Shad	1076	130	81	50	13	3.2	2.1	1.8
Sea Lamprey	488	413	320	194	97	39	15	7.6

FIGURE 7-3

FLOW-DURATION CURVES FOR ADULT AND JUVENILE MIGRATION PERIODS



SECTION 8

Task G
Meetings

SECTION 8

TASK G
MEETINGS

Representatives from Wright-Pierce and Woodlot Alternatives, Inc attended the Exeter River Study public meeting on May 4, 2005 and the NHDES Dam Bureau public hearing on May 25, 2005.

Wright-Pierce and Woodlot Alternatives, Inc. plan to meet with the Town of Exeter and other interested stakeholders in February or March to discuss the 2005 Interim Phase I report and to discuss 2006 Exeter River Study Phase I activities.

SECTION 9

Task H
Water Level Recording Equipment Evaluation

SECTION 9

TASK H
WATER LEVEL RECORDING EQUIPMENT EVALUATION

Task H entailed evaluating the feasibility and costs associated with installing remote automated impoundment level monitoring equipment at each dam. Though this equipment is most needed at the Great Dam to better manage impoundment levels, this evaluation also included monitoring equipment for Colcords Pond and Pickpocket Dam.

During normal river flows, an Exeter Department of Public Works employee typically visits the Great Dam twice a day (8:00 am and 2:00 pm) to record impoundment level. Based on these recordings and expected precipitation in the days ahead, the discharge gate is raised, lowered or left at its present position. The gate is adjusted in an effort to keep the water level several inches above the spillway.

However, during storms and periods of heavy precipitation, DPW personnel often need to visit the Great Dam more frequently, even hourly (including all hours of the night), to observe water levels (see gate operation records on October 8 and 9, 2005 in Task B). These water level recording visits are inconvenient and, due to unpredictable river flows, sometimes not necessary.

Fortunately, modern electronic water level equipment is available that can measure water levels automatically and can transmit this information to a centralized work station, such as the DPW offices. In addition, this equipment can be programmed for certain alarm conditions such as very low or very high water levels, and automatically place a call to DPW staff at any hour of the day.

IMPOUNDMENT LEVEL MONITORING EQUIPMENT

The key components of the automated level monitoring equipment are as follows: 1) Water level measuring devise, 2) Data recorder, 3) Equipment enclosure, 4) Power supply and, 5) Information transmission (telemetry). Water level equipment suppliers, including Sutron Corporation and the Town's present vendor, Environmental Instrument Services Inc, were consulted for this task. In addition, Tim Carney of NHDES Dam Bureau was contacted for input on any standardized equipment NHDES may use on state owned dams.

Common types of water level measuring devices include shaft encoders, ultrasonic transmitters, bubbler pressure system, float gage, pressure transducers, among others. Based on dam size, water depth and climate, a pressure transducer in a seasonally heated stilling well was identified as the most appropriate water level measuring device. Because utility power is available at all sites (including an existing 120V outlet at the Great Dam), it will be used as the power supply. Depending on cell phone service coverage, the water level information will be transmitted either by land line telephone or by equipment that utilizes cellular phone service.

Cost Estimate for Level Monitoring Equipment

A cost estimate to furnish and install the equipment is presented on Table 9-1. The cost estimate also includes a 20% allocation for engineering and construction contingencies.

The total cost for an automated water level monitoring station at the Great Dam would range from approximately $8,400 - $10,200. The cost for a water level monitoring station at Colcords Pond Dam and Pickpocket Dam could be higher due their increased distance from telephone and power utilities.

Table 9-1

Cost Estimate for Level Monitoring Equipment
Great Dam

Item	System Component	Estimated Cost
1	Pressure Transducer, Stilling Well, Cable	$1,500-$1,700
2	Data Recorder	$2,400-$3,000
3	Equipment Enclosure	$2,000-$2,300
4	Power Supply Modifications*	$300-$500
5	Telemetry System*	$800-$1000
Sub-Total		**$7,000-$ 8,500**
20 % contingency		**$1,400-$1,700**
Estimated Total		**$8,400-$10,200**

* Assumes Exeter DPW equipment and staff would dig utility trench from dam to power pole.

SECTION 10

Task I
Low-Level Gate Hydraulic and Gate Operations

SECTION 10

TASK I
LOW-LEVEL GATE HYDRAULIC EVALUATION AND GATE OPERATIONS

This section summarizes the results of a low-level gate hydraulic evaluation and gate operation analysis for the Great Dam on the Exeter River. This work was conducted primarily by Woodlot Alternatives, Inc, and in accordance with Task I, "*Conduct Low-Level Gate Hydraulic Evaluation and Gate Operations*" of the project scope of work for 2005, dated September 15, 2005.

GREAT DAM

The Great Dam (New Hampshire Department of Environmental Services (NHDES) Dam No. 082.01) is located on the Exeter River in Exeter, New Hampshire at the approximate head-of-tide, and has a tributary drainage area of approximately 107 square miles. The dam has an uncontrolled spillway length of approximately 78 feet (ft) and a single low-level sluice gate. The elevation of the dam spillway is reported as 23.5 ft (NGVD[1]), based upon Wright-Pierce's survey conducted in November, 2005. The spillway was initially constructed with an "ogee" crest, which was subsequently modified through the placement of a concrete cap that raised the crest of the spillway by approximately one foot. This cap has a width of approximately 2 ft, and likely results in the spillway functioning as a short-crested weir, potentially resulting in diminished discharge capacity relative to the original ogee shape. In addition, spillway capacity was reduced following the construction of the fish pass along the left (west) abutment in the late 1960s. The original spillway length was not identified for this study, but the width of the fish pass exit (upstream end) suggests that its construction resulted in the loss of approximately 9 feet of spillway, a reduction of almost 10 percent of its total length.

LOW-LEVEL GATE GEOMETRY

The low-level gate is a manually-operated sluice gate mounted on the right (east) abutment of the dam. The gate intake is set at an angle of approximately 45 degrees to the axis of the river. Due to persistent high waters during late 2005, the dimensions of the gate and adjacent inlet works were not obtained during the site field survey. Various gate dimensions have been previously reported. This analysis was performed using gate dimensions of 4.5 ft wide and 5 ft high, and an outlet sill invert elevation was set at 15.8 ft. The gate structure inlet geometry appears relatively complex, as it includes an orifice with the top below the spillway elevation and an overflow section entrance into the gate pit set at the spillway elevation. Observations of surface flow conditions adjacent to the gate suggest that inlet conditions are not optimal, resulting in commensurate losses in hydraulic capacity.

Based on the aforementioned observations, the orifice coefficient of 0.8 was used for this evaluation. A weir coefficient of 2.6 was used for non-orifice flow within the gate. Flows overtopping the overflow section may increase the hydraulic capacity of the gate system during

[1] "*Nation Geodetic Vertical Datum, 1929*". All elevations presented here are referenced to this datum.

periods of relatively low flow (depth of flow over the spillway less than 1 foot), as water levels in the gate chamber, which is open on the top, are below that of the impoundment pool. The potential gains in hydraulic capacity associated with flows over the overflow section are not evaluated here.

There does not appear to be a trash-rack in front of the gate. Given the relatively small size of the gate relative to likely debris, such as tree trunks, there is a high likelihood that the gate could become obstructed, particularly during periods of high flows.

ANALYSIS METHODOLOGY

The low-level gate evaluation was performed with the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). The project HEC-RAS model was developed using channel cross-section information obtained from HEC-2 input files used in the development of the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for the Exeter River in Exeter, New Hampshire. The model domain extends from the Squamscott River downstream of the Great Dam, upstream to the Court Street (State Route 108) Bridge over the Exeter River, and the Little River between its confluence with the Exeter River and upstream to the Court Street Bridge over the Little River. This section of the Little River was included in this evaluation to provide information on the general storage of the normal impoundment created by the Great Dam. Geometry data for the Great Dam and the weir located approximately 100 ft downstream was obtained from our November, 2005 site survey.

GENERAL HYDROLOGY

Monthly average flows for the Exeter River are provided as a general reference. This data was developed using information obtained from the United States Geological Survey (USGS) stream gauging station on the Exeter River near Brentwood, New Hampshire [USGS No 01073587, (http://waterdata.usgs.gov/nh/nwis/nwisman/?site_no=01073587&agency_cd=USGS)]. Monthly average flow statistics at the Great Dam were developed by multiplying the ratio of its reported tributary drainage area [102.7 square miles (sq. mi.) divided by that of the USGS gage (63.5 sq. mi.). Monthly average flow statistics at the USGS gage and at the Great Dam are presented in Table 10-1.

TABLE 10-1

MONTHLY AVERAGE FLOW STATISTICS

Location	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS Gage	85.2	113	227	236	119	100	25.6	13.8	17.1	61.9	58.9	106
Great Dam	138	183	368	382	193	162	41	22	28	100	95	172

Steady-State Analysis of Gate Capacity

A steady-state analysis was performed to evaluate the hydraulic capacity of the low-level gate system. An initial analysis was performed to evaluate effects of gate operation during periods of high flow regimes between 750 and 3,000 cubic-feet-per-second (cfs). The latter value approximates the 10-year return-interval peak flow of 2811 cfs reported in the FEMA study. Gate closed and gate full open conditions were analyzed for the high-flow conditions. The results of this analysis are presented in Table 10-2.

TABLE 10-2

COMPARATIVE ANALYSIS OF GATE EFFECTS DURING HIGH FLOW REGIMES

	Gate Closed		Gate Full Open				
Flow	WSEL*	Flow Weir (cfs)	WSEL	Flow Weir (cfs)	Flow Gate (cfs)	Flow Gate (% of Total)	Difference** in WSEL (ft)
750 cfs	25.65	750	25.09	476	274	37%	0.56
1,000 cfs	26.11	1000	25.59	718	282	28%	0.52
1,250 cfs	26.53	1250	26.04	961	289	23%	0.49
1,500 cfs	26.91	1500	26.45	1205	295	20%	0.46
1,750 cfs	27.27	1750	26.83	1449	301	17%	0.44
2,000 cfs	27.6	2000	27.18	1695	305	15%	0.42
2,250 cfs	27.91	2250	27.51	1941	309	14%	0.40
2,500 cfs	28.2	2500	27.82	2187	313	13%	0.38
2,750 cfs	28.46	2750	28.11	2433	317	12%	0.35
3,000 cfs	28.72	3000	28.38	2679	321	11%	0.34

Notes: * "Water Surface Elevation"
** Difference between "Gate Closed" and "Gate Full Open"

As seen in the calculated differences in water surface elevations in Table 10-1, the gate has a small effect on water surface elevations during high flows conditions.

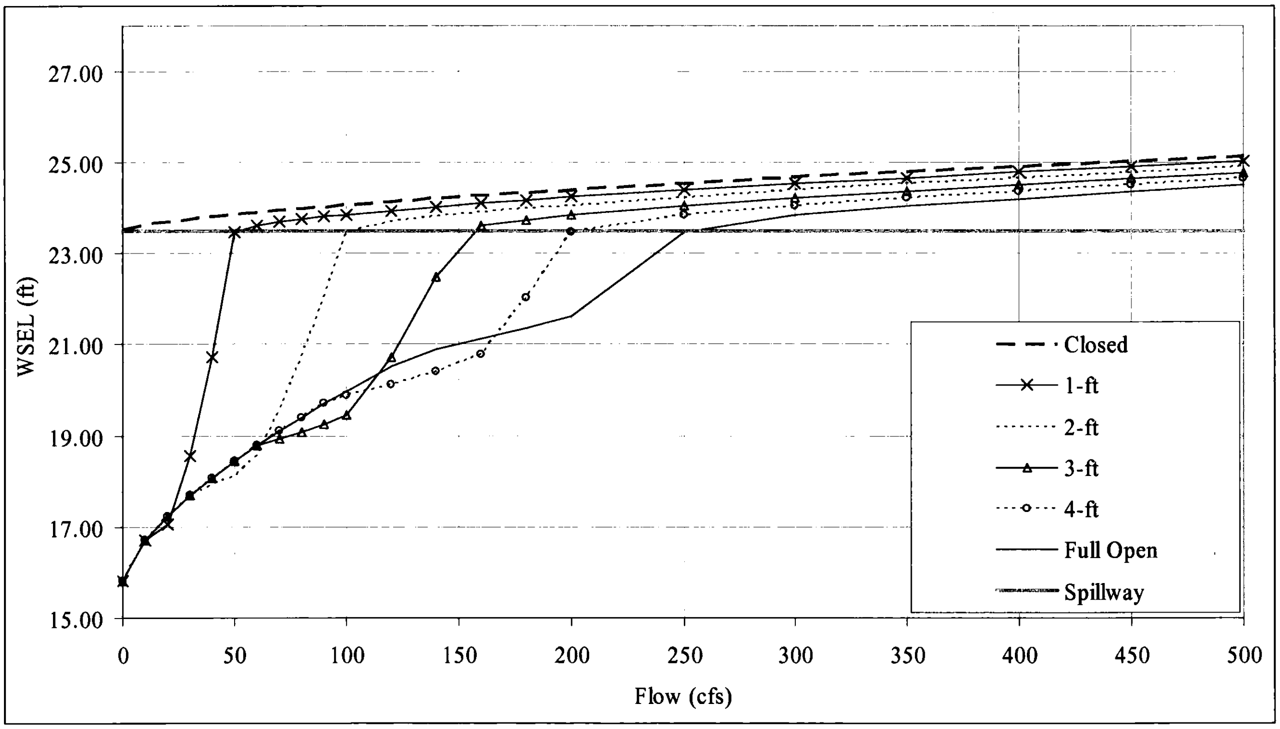
Gate capacity during normal flow regimes was evaluated for 21 distinct flows between 10 and 500-cfs. This range includes the range of normal monthly average flows presented in Table 10-1. This analysis included the evaluation of six gate setting scenarios ranging from "gate closed" to "full open." Intermediate gate openings were evaluated at 1 foot intervals (i.e., 1, 2, 3, and 4 ft). Figure 10-1 shows a set of rating-curves depicting the discharge capacity of the Great Dam for these conditions and flow regimes. Note that Figure 10-1 also shows the spillway elevation.

As shown in Figure 10-1, gate operations have a small effect on upstream water surface elevations for steady-state flow conditions. Data used to develop Figure 10-1 is given in Table 10-3.

Comparisons of calculated water surface elevations upstream of the Great Dam can be determined from Figure 10-1 by selecting a discharge along the "Flow" (bottom) axis and matching this to the calculated water level for each of the six evaluated scenarios. For example, for a discharge of 22-cfs at the Great Dam, which corresponds to the average daily flow in August at the dam (based on Table 10-1), the anticipated steady-state water level in the upstream impoundment with the gate open 3 ft is approximately 17.2 ft.

FIGURE 10-1

DISCHARGE CAPACITY OF GREAT DAM DURING NORMAL FLOW REGIME



Note that minor computational artifacts are shown on this curve, where flows for smaller gate openings show increased flow.

Table 10-3

Comparative Analysis of Gate Effects during Normal Flow Regimes

Flow (cfs)	Gate Opening [WSEL/Q Weir (cfs)/Q Gate (cfs)/WSEL (ft NGVD29)]																	
	Closed			1-ft			2-ft			3-ft			4-ft			Full Open (5-ft)		
	W.S. Elev	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*	*W.S. Elev*	*Q Weir*	*Q Gate*
10	24	10	0	17	-	10	17	-	10	17	-	10	17	-	10	17	-	10
20	24	20	0	17	-	20	17	-	20	17	-	20	17	-	20	17	-	20
30	24	30	0	19	-	30	18	-	30	18	-	30	18	-	30	18	-	30
40	24	40	0	21	-	40	18	-	40	18	-	40	18	-	40	18	-	40
50	24	50	0	23	-	50	18	-	50	18	-	50	18	-	50	18	-	50
60	24	60	0	24	9	51	19	-	60	19	-	60	19	-	60	19	-	60
70	24	70	0	24	19	51	20	-	70	19	-	70	19	-	70	19	-	70
80	24	80	0	24	30	50	21	-	80	19	-	80	19	-	80	19	-	80
90	24	90	0	24	40	50	22	-	90	19	-	90	20	-	90	20	-	90
100	24	100	0	24	48	52	23	-	100	19	-	100	20	-	100	20	-	100
120	24	120	0	24	68	52	24	19	101	21	-	120	20	-	120	21	-	120
140	24	140	0	24	88	52	24	39	101	22	-	140	20	-	140	21	-	140
160	24	160	0	24	108	52	24	57	103	24	9	151	21	-	160	21	-	160
180	24	180	0	24	128	52	24	76	104	24	28	152	22	-	180	21	-	180
200	24	200	0	24	148	52	24	97	103	24	46	154	23	-	200	22	-	200
250	25	250	0	24	197	53	24	145	105	24	94	156	24	45	205	23	-	250
300	25	300	0	25	246	54	24	194	106	24	143	157	24	93	207	24	44	256
350	25	350	0	25	296	54	25	243	107	24	192	158	24	140	210	24	91	259
400	25	400	0	25	346	54	25	292	108	25	241	159	24	189	211	24	138	262
450	25	450	0	25	395	55	25	341	109	25	289	161	25	237	213	24	187	263
500	25	500	0	25	445	55	25	391	109	25	338	162	25	286	214	25	235	265

TIME-VARYING FLOW

The preceding analysis does not consider time-varying, or "unsteady-state," flow conditions. This type of analysis would be required to determine impoundment water surface elevations during: 1) drawdowns of the Great Dam impoundment and; 2) conditions when flows into the impoundment vary (e.g., during floods). With appropriate information on the stage-volume characteristics of the Great Dam impoundment, a time-varying numerical model could be used to evaluate conditions such as mitigating flooding during peak flow events and effects of water withdrawals on impoundment levels.

DISCUSSION

This low level gate hydraulic analysis evaluated the discharge capabilities of the sluice gate at the Great Dam using available information. The results of the steady-state hydraulic analysis suggest that the gate can be operated to achieve specific water levels in the Great Dam impoundment, but that overtopping of the spillway will occur even with the gate at a fully open position when flows exceed approximately 250-cfs. However, the gate has a marginal capacity to regulate upstream water levels at higher flows. This evaluation did not consider gate operations in anticipation of increased inflows, such as that which might result from rainfall events within the Exeter River watershed. Because of the relatively large storage capacity within the impoundment, it is possible that the gate might have some utility in drawing-down the impoundment in anticipation of increased inflows, thereby reducing peak water surface elevations in the impoundment. The likely limit of reduced peak water surface elevations was not evaluated. However, the qualitative backwater study performed previously by Woodlot as part of the Exeter River study suggests that "channel control" might occur within the reach of the river between the Court Street Bridge and the confluence of the Exeter and Little Rivers, thereby limiting benefits within that reach.

This evaluation of the low-level gate operations was performed under the assumption of steady-state hydraulic conditions. This method provided a fundamental understanding of the gate's hydraulic capacity, but is not capable of resolving time-variant characteristics such as the time required to draw down the upstream impoundment. The evaluation of the time required to draw down the impoundment can be evaluated through the development of an unsteady-state (time-variant) hydraulic model.

Various alternatives are available for the development of an unsteady-date hydraulic model, including 1) modifying the project HEC-RAS model to utilize the unsteady-state modeling capabilities incorporated in HEC-RAS, and 2) setting up a "spreadsheet" model. Advantages of the former approach include a single model capable of evaluating a wide range of hydraulic scenarios. Disadvantages of this approach include the need for a user to be familiar with both the unsteady-flow analysis interface in HEC-RAS and the general numerical methods associated with equations used for the calculation of one-dimensional, unsteady-flow. A primary advantage of the latter approach is a familiar user-interface (i.e., spreadsheets). Because of the relatively small hydraulic capacity of the low-level gate, reasonable results should be obtainable from a spreadsheet-based program incorporating the gate's hydraulic characteristics under a variety of operational conditions (i.e., opening heights) and a stage-volume relation for the Great Dam impoundment.

Regardless of the selected method, it was apparent following the development of the steady-state project HEC-RAS model that the level of resolution obtained using the FEMA geometry (e.g., cross-section) data is likely not of suitable resolution for the determination of impoundment stage-volume information. For example, the distance along the thalweg (the line connecting the lowest points on river bottom) of the Exeter River between two of the cross-sections in the FEMA model within the impounded reach of the river is 3,400-feet. It is, therefore, recommended that additional data be obtained to provide for the development of an unsteady-state model. It is suggested that an unsteady-state model would be most useful for the evaluation of gate operations during periods of relatively low water. For this condition, bathymetry data within the impounded reach would likely provide sufficient information, precluding the need for topographic survey data in the adjacent floodplain.

PENSTOCK EVALUATION

On January 13, 2005, representatives of Wright-Pierce, Woodlot Alternatives, Inc., the Town of Exeter and the Exeter Mills Apartments inspected the penstock associated with the Great Dam. An approximately 7 foot tall by 14 foot wide concrete penstock runs from the east side of Great Dam, below Founders Park, below the Exeter Library parking lot, underneath String Bridge Road, and below the sidewalk that leads to the main office of the Exeter Mills Apartments. A wooden trash rack exists at the head works to keep debris from entering the penstock. The penstock gates are not actively operated and are left in the open position.

Approximately 30 feet to the northwest of String Bridge Road, a vertical concrete wall was constructed inside the penstock (probably prior to the conversion of the Mills to apartments) to seal off the downstream end of the penstock. The penstock is full of water between the cut-off wall and the Exeter River at Great Dam. The penstock is dry between the concrete wall and the Exeter Mills Apartments complex. Manholes to access the penstock are located on and adjacent to the sidewalk on either side of the cut-off wall. Equipment that pumps water from inside the penstock to irrigate Exeter Mill Apartment lawns was observed in the upstream manhole.

Access to the dry end of the penstock was gained through the basement of the building that houses the heating and cooling equipment for the apartment complex. Two PVC water mains (approximately 8 inches diameter) run along the floor of penstock between the cut-off wall and the basement of the apartment building. The apartment complex uses water from one of the mains for fire suppression and water from the other main for air conditioning. Water used for air conditioning is discharged to a drainage manhole and eventually flows into the Squamscott River. According to the Exeter Mills Apartments' representative, the cooling system can draw up to 680 gallons per minute (approximately one million gallons per day) of water from the penstock.

The penstock currently functions as an extension of the Great Dam impoundment and supplies irrigation, fire suppression and cooling water to the Exeter Mills Apartments complex. The Exeter Public Library also has two dry hydrants that draw water from the penstock. Because of the cut-off wall constructed in the penstock and the removal of outlet works from the Exeter Mills Apartments complex, the penstock cannot be used to manage impoundment levels upstream of the Great Dam.

Based on conditions observed inside the penstock, we recommend representatives from the Town of Exeter and Exeter Mills Apartments meet to clarify issues concerning penstock ownership boundaries, water rights, liability and regulatory compliance. Additional work related to the penstock will be recommended to be part of the 2006 Phase I scope of work.

Wright-Pierce

Civil and Environmental Engineering Services