Periodic Inspection Report No. 6
Ottauquechee River
North Hartland, Vermont

North Hartland Lake

June 1999

US Army Corps
of Engineers

New England District

REPORT DOCUMENTATION PAGE

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North Hartland, Vermont

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This inspection has been conducted under the authority in ER 1110-2-100, which provides for the "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures." The purpose of the inspection is to examine the physical condition of North Hartland Lake project as part of a continuing program to insure its structural stability, safety, and operational adequacy. The field examination includes soils and geologic aspects of embankments, channels, and other components, as well as structural, concrete, mechanical, electrical, and hydrologic and hydraulic features of the project.

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CENAE-EP-MC

20 March 2000
Mr. Forbes/bd/78885

MEMORANDUM FOR Chief, Geotechnical and Water Management Branch

SUBJECT: Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures – Franklin Falls Dam, Ball Mountain Lake, Union Village Dam and North Hartland Lake

1. References:

a. CENAE-EP-GW memorandum dated 21 January 2000, Periodic Inspection and Continuing Evaluation of Completed Civil works Structures – Franklin Falls Dam, New Hampshire.

b. CENAE-EP-GW memorandum dated 14 February 2000, Periodic Inspection and Continuing Evaluation of Completed Civil works Structures – North Hartland Lake, Union Village Dam and Ball Mountain Lake, Vermont.

2. Periodic Inspection Report Technical Review Board met on 14 March 2000. Based upon this meeting, subject reports are approved subject to resolution of enclosed comments.

3. The next inspection of subject projects will be scheduled for FY2004.

4. Request that a memorandum be prepared concurring with enclosed comments and stating that they have been incorporated into the final reports. If your office does not concur with any of the comments, a meeting with the technical evaluation board will be held to resolve these.

5. Also, request that a tabulation of recommended dam safety, budgetary and normal maintenance repairs be prepared and submitted to Mr. Forbes, of this office. The tabulation should include a brief description of recommendation and E&D and construction cost estimates.

Encl

For H. Farrell McMillan
KENNETH E. HITCH, P.E.
Chief, Engineering/Planning Division

CF (w/encl)
Mr. Carlson – Con/Ops
Mr. Mackos – Design
Mr. Forbes – Eng. Mgmt
Eng/Plan Div. Files
(Disk 6 – FFD & UCRB dams.doc)

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

JUNE 1999

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS 01742-2751

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

TABLE OF CONTENTS

Paragraph	Subject	Page
1.	Executive Summary	1
2.	General Statement of Inspection Program	3
3.	Project Description	3
4.	Brief Project Summary	
	a. Project Characteristics	3
	b. Annual Peak Pool Levels Since the Last Inspection	5
	c. History of Major Remedial Measures	6
	d. Deficiencies Corrected Since Last Inspection	6
	e. Past Deficiencies Not Yet Corrected	6
5.	Inspection Results	
	a. Inspection Team	7
	b. Embankment	7
	c. Spillway	8
	d. Outlet Works	9
	e. Electrical Systems	12
	f. Project Instrumentation	13
6.	Dam Safety Recommendations	14

APPENDICES

Appendix I - History of Major Remedial Measures
Appendix II - Photographs
Appendix III - Figures
Appendix IV - Inspection Checklists
Appendix V - Summary of Inspection Notes
Appendix VI - Intermediate Trip Reports
Appendix VII - Instrumentation Data and/or Plots
Appendix VIII - Results of Crack Surveys
Appendix IX - Status of Project Documentation
Appendix X - Status of Dam Operations Management Policy (DOMP) Training

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

1. EXECUTIVE SUMMARY

a. The sixth periodic inspection of North Hartland Lake and appurtenant structures was performed on 15 June 1999. The inspection was conducted by a team of specialists representing various disciplines from Design and Geotechnical and Water Management Branches of the Engineering/Planning Division, and Construction/Operations Division, New England District, Corps of Engineers.

b. The purpose of the periodic inspection was to examine the physical condition of the North Hartland project as part of a continuing program to insure the structural stability, safety and operating adequacy. The field examination included soils and geologic aspects of embankments, channels and other components, as well as the structural, concrete, mechanical, electrical and hydrologic/hydraulic features of the project.

c. Based on visual inspection, project features of North Hartland Lake are generally in good condition. No deficiencies, which could jeopardize the operation of the project or integrity of the dam during flood events, were identified.

d. The next periodic inspection should be performed during FY 2004.

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2. GENERAL STATEMENT OF INSPECTION PROGRAM

a. Authority for periodic inspections is contained in ER 1110-2-100, which provides for the "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures." This program requires a detailed, systematic, technical inspection of each Corps-owned facility whose failure or partial failure would endanger the lives of the public or result in substantial property damage.

b. Failure at North Hartland Lake has the potential to result in loss of life and cause serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. Based on the hazard potential criteria adopted by the U.S. Army Corps of Engineers and presented in Appendix D of ER 1110-2-106 "Recommended Guidelines for Safety Inspection of Dams," North Hartland Lake is a high hazard dam.

c. Approval authority for periodic inspection reports has been delegated by HQUSACE to the Division Commander, U.S. Army Corps of Engineers, North Atlantic Division, who has further delegated this responsibility to the Chief, Engineering/Planning Division of the New England District. The New England District conducts an in-depth review by Engineering and Operations disciplines prior to submittal to the division.

3. PROJECT DESCRIPTION

a. North Hartland Lake is a flood control project situated on the Ottauquechee River in the town of Hartland, Vermont. The project has a drainage area of 220 square miles. It is operated to reduce flooding of the downstream communities along the Ottauquechee River, and in conjunction with other Corps flood control reservoirs to reduce flood stages along the main stem of the Connecticut River. A vicinity and reservoir map of North Hartland Lake are shown in Appendix III.

4. BRIEF PROJECT SUMMARY

a. Project Characteristics

Purpose	Flood control
Date of Construction	Jun 1958 – Jun 1961
Construction Cost	$7,312,200

a. Project Characteristics (continued)

Location of Structures

State	Vermont
County	Windsor
Town	Hartland and Hartford

Reservoir

Drainage Area	220 square miles

Operating Levels

Pool	Elevation (feet NGVD)	Area (acres)	Cumulative Capacity (acre-feet)
Recreation	425.0	215	3,050
Flood Control	546.5	1,100	74,150

Dam

Type	Rolled earth and rockfill
Maximum Height	185 feet
Length	1,640 feet
Top Elevation	572.0 feet NGVD

Dike

Type	Rolled earth and rockfill
Maximum Height	52 feet
Length	2,110 feet
Top Elevation	572.0-574.0 feet NGVD

Spillway

Location	Left bank
Type	L-shaped side channel with Uncontrolled ogee weir
Crest Length	465 feet
Crest Elevation	546.5 feet NGVD
Maximum Discharge Capacity	160,900 cfs

a. Project Characteristics (continued)

Outlet Works

	Dam	Dike
Type	Horseshoe conduit	Circular
Size	14'-4" diameter	36" diameter
Length	743 feet	476 feet
Gates	(3) service 5'-8" x 10'-0" vertical slide	(1) 3' x 3' sluice
Discharge at Spillway Crest	7,000 cfs	
Stilling Basin	None	

Note: Conduit is lined with a 12-foot diameter steel pipe for use as the hydropower inlet.

b. Annual Peak Pool Levels Since the Last Inspection. Table 1 lists annual peak pool levels at North Hartland Lake since the last periodic inspection. Annual water years are from October 1 to September 30.

TABLE 1

PEAK POOL LEVELS AT NORTH HARTLAND LAKE
SINCE LAST PERIODIC INSPECTION

Date	Maximum Stage Feet	Maximum Elevation Ft, NGVD	Storage Utilized		
			Inches	Acre-Feet	Percent
Jan 1995	51.0	441.0	0.4	4205	6
Jan 1996	78.4	468.4	1.2	14599	21
Oct 1996	56.7	446.7	0.5	6099	9
Apr 1998	105.9	495.9	2.4	28452	40

One inch of runoff = 11,733 acre-feet
Drainage Area = 220 square miles
Zero stage = 390.0 feet NGVD

c. History of Major Remedial Measures. There have been no major remedial measures at this project.

d. Deficiencies Corrected Since Last Inspection.

(1) This periodic inspection of North Hartland Lake was the sixth conducted since initiation of the dam safety inspection program. Listed below are the dates of prior inspections:

Periodic Inspection No. 5	Jun 1994
Periodic Inspection No. 4	Oct 1988
Periodic Inspection No. 3	Nov 1983
Periodic Inspection No. 2	Oct 1979
Periodic Inspection No. 1	July 1974

(2) There have been no intermediate inspections or site visits since the last periodic inspection at this dam.

(3) Deficiencies at the project, which have been corrected as a result of findings presented in the last periodic inspection, are listed below.

(a) Repaired broken hand rail posts, secured hand rail base plate and replaced missing emergency stop log slot grating on the inlet platform.

(b) Repaired the deteriorating electrical conduit in the north wall of the Control Tower, Operating Room Level. The openings were sealed to prevent the leakage.

e. Past Deficiencies Not Yet Corrected.

(1) Schedule a construction contract to perform general rehabilitation of the hydraulic system to stop fluid leaks, install isolation valves, replace main system fluid filter and repack the leaking telltale rods on service gates 1 and 3.

(2) Remove blockage of the intake tower sump drain.

(3) Execute a contract to resurface and repair portions of the Access and Dike Crest roads which. Portions of the Access and Dike Crest roads are scheduled to be resurfaced in FY01.

5. INSPECTION RESULTS

a. Inspection Team. This inspection was performed by the following team members from Engineering/Planning and Construction/Operations Divisions.

Steve Simmer	Hydrology/Hydraulics (Team Captain)	CENAE-EP-GW
Jennifer Lee	Concrete/Structural	CENAE-EP-DG
Deborah Gabrielson	Mechanical	CENAE-EP-DG
Thomas Ayau	Electrical	CENAE-EP-DG
Paul Young	Geology	CENAE-EP-GE
Philip Hollis	Geotechnical	CENAE-EP-GG
Jim Law	Operations	CENAE-CO-TS-OT

Other personnel at the inspection were as follows.

Mark Rosenthal	North Hartland Lake Project Manager	CENAE-CO-UCRB
Gary Wheeler	North Hartland Lake Park Ranger	CENAE-CO-UCRB
Roxanne Barbeau	North Hartland Lake Park Ranger	CENAE-CO-UCRB
Christie Baker	North Hartland Lake Park Ranger	CENAE-CO-UCRB
Mike Curran	Upper Conn. River Basin Manager	CENAE-CO-UCRB
Arthur Silvester	C.R.V.F.C.C.	
Matthew Jamieson	Mechanical	CENAE-EP-DG
Heather Rausch	Hydrology/Hydraulics	CENAE-EP-GW
John Kedzierski	Concrete/Structural	CENAE-EP-DG
Laura Fraser	Geotechnical	CENAE-EP-GG

b. Embankment.

(1) Main Dam

(a) Upstream Slope. The slope is in good condition and appears to be stable.

(b) Downstream Slope. The downstream slope is in good condition and appears to be stable.

(c) Crest Road. The crest remains in good condition.

(d) Seepage Conditions. No abnormal seepage, such as piping, boils, or sinkholes, was observed by the inspection team or reported by the Project Manager.

(e) Toe Drains. The toe drains are in good condition; however, medium-sized woody vegetation at the downstream slope toe should be removed as soon as possible.

(f) Rock Protection. The rocks on the slope protection are mostly phyllite. Overall, the slope protection is in good condition.

(g) Safety Fences. Fencing appears to be in good condition and well anchored.

(2) Dike. The embankment was in good condition and appeared to be stable. There was no indication of movement or sloughing of slopes. There was no evidence of settlement or subsidence cracks. The access and dike crest roads are in fair to good condition. The pavement in front of the office was resurfaced in 1990 and the recreation area road was resurfaced in 1998. The remaining portions of the access road that are in poor condition are budgeted to be resurfaced in FY01.

c. Spillway

(1) Approach. The overall condition of the approach area is excellent, but there is some vegetation along the spillway weir. There is no obstruction to flow, but vegetation should continue to be cleared periodically (see photo D-1).

(2) Control. The concrete spillway weir is located at the left (north) abutment of the dam. It is an uncontrolled L-shaped ogee weir. Overall, the concrete of the spillway weir and walls is in good condition with no major cracks or spalls that would significantly affect its hydraulic capacity. In general, the majority of weep holes appear to be functioning properly. The majority of the crack repairs done in FY92 is still in very good condition with no signs of deterioration. However, approximately 30% of the spall repairs performed in FY92 have failed (photo A-10). Deficiencies such as cracks with efflorescence and vegetation growing in joints were noted on the downstream face of weir and at the bottom of the spillway channel (photo A-11). Mapcracking with slight efflorescence was noted at the crest of the spillway.

(3) Exit. The spillway discharge channel is in good condition with no major outgrowth of trees or vegetation, or significant amount of debris, which would obstruct flow. There are minor amounts of vegetation in the exit channel that would not affect the hydraulic capacity of the spillway and are not considered a problem. The slopes and floor of the channel are stable and in good condition. The exit channel is shown in photo D-2.

d. Outlet Works

(1) Inlet Channel. Overall, the inlet is in good condition and clear of obstructions with only a minor amount of debris at the gate intake area. At the time of the inspection, the reservoir pool was 35.43 feet (425.43 feet NGVD).

(2) Log Boom. The log boom is in excellent condition and appears to be functioning well (photo D-3). The anchorages at the north and south ends, the log boom cable, and the majority of the logs are in good sound condition. All logs in the reservoir were floating and project personnel report that logs are replaced as needed. A clear, straight, 30-foot wide path has been maintained for the log boom, on the left (north) side of the reservoir to prevent it from getting caught up on trees/vegetation and should continue to be maintained in the future.

(3) Intake Inlet. The concrete walls show no evidence of movement. Only the upper portion of the inlet structure was visible at the time of the inspection. All concrete was in sound condition with all joints properly aligned and tightly bonded. The right three sections of handrails of the platform are askew and not properly secured (only tied to each other with rope) due to the broken connecting sleeve between the handrail post and the support bracket (photo A-7). The connecting sleeve is broken in three locations and requires repairs to ensure the safety of project personnel. The base plate for the interior post of the handrail section at the northeast corner is not anchored to the concrete curb and should be securely fastened to the curb.

This project was retrofitted with metal trash racks in front of the existing intake structure for hydropower purposes. Due to the closeness of the bars, the hydropower operators are required to maintain and remove debris from the trash racks regularly, however, the hydropower facility is no longer in service. Therefore, project personnel contracted to remove the trash racks. All but the lower trash racks in front of each gate have been removed. If another hydropower company takes over the operation, they should be required to clean the debris from the lower trash racks initially and also should be required to regularly clean the debris from the trash racks under their agreement/contract with the Corps. If there no longer is hydropower in service, these lower trash racks should be removed.

(4) Control Tower Exterior. The overall condition of the exterior concrete surface is good. All joints are properly aligned and tightly bonded. The membrane and ballast roof system has recently been replaced with a new one and is in excellent condition, with no leakage or deficiencies noted.

(5) Control Tower Interior. The overall condition of the control tower interior is good from roof level down to the base of the tower.

(a) Hydraulic Gate Operating System The hydraulic controls were inspected from the operating room as the Project Manager performed open and close cycles on all three service gates. The system generally appears to be in good condition. However, for environmental reasons, the gates were not raised above 2 ft. The gate position indicator for gate 2 was out of order. The indicating rod has separated from the gate. Dam project personnel determine its position by using a stopwatch during operation. The indicators for gates 1 and 3 were in good working order. In order to close the gates completely, the operator must watch the pressure gauge. The gauge makes a significant jump when the gate is closed. Just below the controllers, minor leakage of hydraulic fluid at the connections of ½ in. pipe was observed.

(b) Emergency Generator. The emergency generator is located in the utility building. The generator started and operated smoothly without incident. Lights and hydraulic pumps were operated on emergency power. The emergency generator appears to be in good condition, and operation was satisfactory.

(c) Heating and Ventilation Systems. Following the previous Periodic Inspection, a recommendation was made to replace the oil-fired warm-air furnace. A new furnace has since been purchased and installed, and it appears to be in good working order. The ventilation system consists of a fan and ductwork that runs the length of the intake tower. The ventilation system fan made loud irregular noises before failing. The system was thus inoperative at the time of the inspection because of a broken belt within the fan. The fan belt had loosened and entangled itself during routine testing procedures. (The fan belt and motor have been repaired in the time since the inspection took place.)

(d) Float Well. The float well operates satisfactorily. Project personnel use a heat lamp to take care of occasional freezing problems.

(e) Gate Chamber Floor Drainage System. The drainage system consists of three drains within the floor of the gate chamber. The drains feed a drainage pipe which empties into the conduit approximately 640 ft. downstream. The drainage pipe is completely blocked so that water leakage from the telltale rod builds up on the

floor. As a temporary fix, project personnel have drilled a hole in the access manhole cover over gate passage No. 3 and have installed a ball valve to allow them to manually drain the leakage.

(6) Service Gates.

(a) Service gate 1 was in good condition. Minor leakage was visible along the upper half of its seal. The steel body of the gate displayed minor surface corrosion, which is considered insignificant. No cracks or bulges were observed (see photo B-3).

(b) Service gate 2 was in very good condition. Virtually no leaks were visible. The gate's surface steel was in good condition with only minor surface corrosion. The gate body showed no cracks or bulges (see photo B-4).

(c) Service gate 3 was in good condition. The gate surface showed no cracks or bulges. There appeared to be some debris caught underneath the gate, which increased the volume of flow into the downstream conduit. Minor water leakage was observed along the gate perimeter, at its seal (see photo B-5).

(d) The embedded steel and the air vents for the three gates all appeared to be in good condition. The embedded steel was covered in an algae film, but this is considered insignificant. The air vents were clear. Their intake to the downstream conduit ceiling showed minor corrosion.

(7) Emergency Closure. This project is equipped with emergency stop log slots in front of each gate in which stop logs can be installed only during low flow conditions. Project personnel report the emergency stop logs are stored on site and are in good condition.

(8) Conduit. The outlet conduit and hydropower penstock were observed to be in good condition with no evidence of hydraulic cavitation. The overall condition of the steel penstock and the concrete transition remains good. During the conduit inspection, the gates were closed for a total of 45 minutes, during which the minimum outflow was 17 cfs due to gate leakage. This shutdown was coordinated with the State.

(9) Conduit Outlet and Exit Channel. The concrete in the outlet structure, built as part of the hydroelectric retrofit, is in very good condition with only isolated areas of minor hairline cracks and efflorescence noted. The original outlet structure, no longer in use, remains in good condition with only isolated areas of minor cracks and efflorescence noted. Water is flowing out of the 4" diameter drain steadily. The outlet channel is generally in good condition with no major obstructions to flow. The minor

shoal located downstream of the outlet, as noted in the last Periodic Inspection, remains unchanged and is not considered to obstruct discharge. No features of concern are evident on the slopes. The outlet channel is shown on photo D-4.

(10) Service Bridge. The service bridge at North Hartland Lake is no longer inspected as part of the Periodic Inspection Program, but instead is covered by the Bridge Inspection Program. The service bridge to the control tower is a four span structure with a total length of 363'-0". The last inspection of the bridge was conducted on 19 and 20 October 1994 and was found in overall good condition, with some deficiencies noted.

e. Electrical Systems.

(1) Service. The secondary utility service comes from across the access road. In 1978, the utility company replaced the original overhead primary and secondary service from the pole mounted transformers off the east corner of the Utility Building with an underground secondary service and a pad mounted transformer across the access road. A meter pedestal is adjacent to the transformer. Although the service conductor run is only a hundred feet, its advancing age will raise concern about its insulation resistance. A disconnect switch will be needed at the meter so that the conductors can be checked.

(2) Distribution System. The main distribution point is a switchboard, "Control Center" (CQ1), in the Work Shop of the Utility Building. The standby emergency diesel generator, replaced in 1984 and relocated from the Work Shop to a shed adjacent to the Work Shop, provides alternate service to this switchboard.

(3) Hydraulic Pump System, Pump Motor Controllers. The controllers, in "Control Center" CQ2, are of the reduced voltage, autotransformer type. Initially a starting contactor applies reduced voltage derived from an autotransformer to the motor. After a five to ten second delay controlled by a timing device, the starting contactor disengages and the main contactor engages to apply full voltage to the motor. This helps reduce the starting current and the attendant voltage drop. Noted is an unusual aspect of their operation. Usually the "ON" button need only be depressed momentarily then immediately released. Here, the "ON" button must be held until the main contactor engages. The record as-built drawing confirms this operation. The previous inspection reported the lack of delay for the main contactor of Pump No. 1 to engage, but the contactors worked properly during the inspection. The contactors and controllers appearance and test performances were satisfactory. The controllers consistently transitioned to full voltage after a seven second delay, albeit the "ON" button must be held depressed.

(4) Lightning Protection. The connections, wiring, and equipment on the roof of the Intake Tower were checked and found complete. The down conductors from the roof were satisfactory down to elevation 450. The conductors below this point, the connections to earth were not discernable from the Service Bridge and not inspected. Many ground fields, conductors, and connects were initially installed for the construction of the dam then added to by the 1993 Lightning Protection System project. This system should be scrutinized to confirm its integrity. Concerns about lightning and TVSS (Transient Voltage Surge Suppressor) make this imperative. Without adequate grounding, the best TVSS is not effective.

f. Project Instrumentation.

(1) Rain Gage. The project is equipped with a heated tipping bucket precipitation gage. It is located on the roof of the control tower, which is connected to NAE's GOES water control data collection system. There is also a non-recording "catch-type" precipitation gage at the Project Managers Office.

(2) Pool Stage Recorder. The project is equipped with a Sutron shaft encoder which measures pool stage and is hooked up to a Sutron 8210 data collection platform, located in the control tower. This unit logs rainfall and pool stage every 15 minutes and transmits on a 4-hour interval to the GOES Satellite. The unit is also capable of telephone modem communications. Pool stage on the day of the inspection was 35.43 feet (425.43 feet NGVD). This system works well.

(3) Staff Gages. There are tile staff gages located on the exterior of the control tower wall as well as on the intake structure. Both of the gages are in good condition.

(4) Tailwater Gage. A USGS gaging station is located 0.3 miles downstream from the dam and provides a continuous record of releases from the project. This gage is equipped with a Sutron 8210 data collection platform capable of both GOES satellite and telephone modem communications. The reading at the time of the inspection was 2.38 feet, indicating a flow of 132 cfs.

(5) Crest Monuments. Seven crest monuments and two control points are in place along the downstream crest of the dam. The crest monuments are in good condition.

(6) Piezometers. The thirteen piezometers are all operational.

(7) Strong Motion Accelerographs. Two strong motion accelerographs are operational and in good condition.

6. DAM SAFETY RECOMMENDATIONS

The inspection team members and project personnel held an exit meeting at the dam where the findings and recommendations were jointly discussed. Resulting dam safety recommendations are presented below. Needs and actions of the "normal maintenance" and "budgetary" categories are presented within the inspection reports in Appendix V.

a. Structural. A previous recommendation from the last inspection that was not implemented, needs to be addressed and completed:

Design and implement a repair procedure to alleviate the blocked drain condition, which continually backs up water into the tower base. This is scheduled to be done by the end of FY01, unless funds become available sooner.

b. Mechanical. None

c. Electrical. None.

d. Hydrology. Downstream Hydropower Facility (previously operated by Vermont Electric Cooperative, Inc.). It is recommended that the facility be fully inspected by NAE, FERC, and the new owner prior to it being placed into operation again. Based upon the 15 June 1999 periodic inspection, the following are additional recommendations on the hydropower facility:

(1) Bypass Control Gate: The bypass control gate at the hydropower facility is in the full open position while the facility is not in operation. In the event that the hydropower facility is going to be operated in the future, this bypass control gate and wiring should be fully inspected and operational prior to allowing the start of any hydropower operations.

(2) Intake Trash Racks: In the event that the hydropower facility is going to be operated in the future, the operators should be required to clean the debris from the lower trash racks initially and also should be required to regularly clean the debris from the trash racks under their agreement with the Corps. If there no longer is hydropower in service, these lower trash racks should be removed.

e. Geotechnical. None.

APPENDIX I

HISTORY OF MAJOR REMEDIAL MEASURES

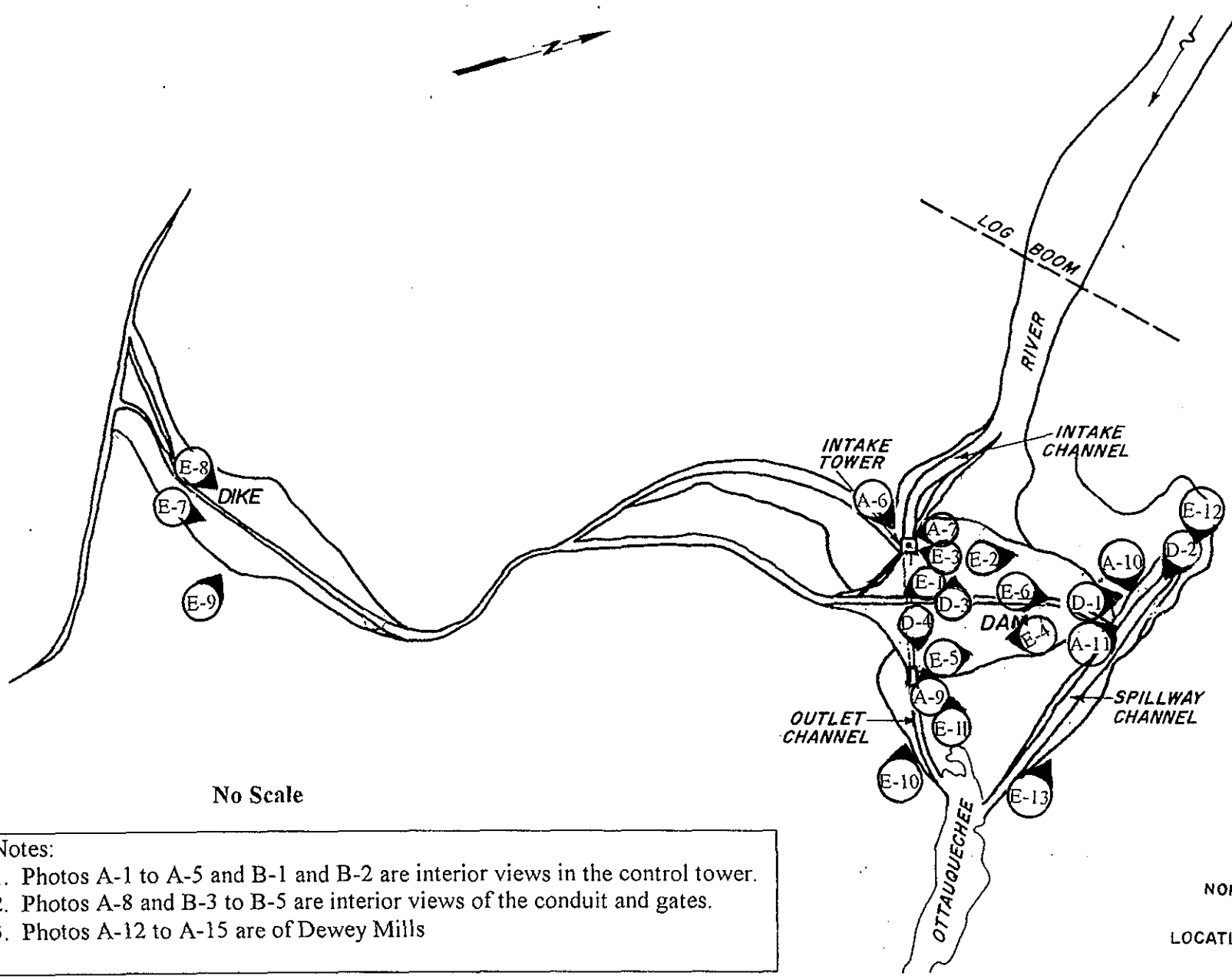
PERIODIC INSPECTION REPORT
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

HISTORY OF MAJOR REMEDIAL MEASURES

There have been no major remedial measures at this project.

APPENDIX II

PHOTOGRAPHS



No Scale

Notes:
1. Photos A-1 to A-5 and B-1 and B-2 are interior views in the control tower.
2. Photos A-8 and B-3 to B-5 are interior views of the conduit and gates.
3. Photos A-12 to A-15 are of Dewey Mills

NORTH HARTLAND DAM
VERMONT
LOCATION OF PHOTOGRAPHS
15 June 1999

NORTH HARTLAND LAKE
PERIODIC INSPECTION NO. 6

Photo A-1: Hairline cracks on the underside of the roof slab. Note: the water damage and the peeling paint

Photo A-2: A 2′ x 2′ spall, located 3′ above the floor at the center of the north wall of the control tower.

Photo A-3: Efflorescence leaching through the joint of the control tower. Note: the small spall at the joint.

Photo A-4: Water draining out of the 4" diameter drain at the original outlet structure.

NORTH HARTLAND LAKE
PERIODIC INSPECTION NO. 6

Photo A-5: 2″ to 3″ of water on the floor of the tower base.

Photo A-6: Debris on the steel grating over the center emergency stop log slot. Note: the rusting of the handrail

Photo A-7: Right 3 sections of handrail not properly secured due to the broken sleeve between the post and the bracket

Photo A-8: Minor areas of pitting and surface rusting of the interior of the conduit.

Photo A-9: Minor blistering of the coating of the exterior surface of the conduit.

Photo A-10: An area of unsound spall repair on the upstream face of the spillway weir.

Photo A-11: Mapcracking of the crest of the spillway. Note: the vegetation growing in the joints at the bottom of the channel.

Photo A-12: Overview of the Dewey Mills Dam. Note: the severely abraded spillway weir.

Photo A-13: Numerous areas of concrete deterioration and spalls, up to 6" deep, on the downstream face of the intake of Dewey Mills.

Photo A-14: Water leaking through the joint between the upper and lower portion of the non-overflow section of Dewey Mills.

Photo A-15: Numerous cracks with efflorescence and deteriorated and unsound concrete repair patches at the upper portion of the non-overflow section of Dewey Mills.

NORTH HARLAND LAKE
PERIODIC INSPECTION NO. 6

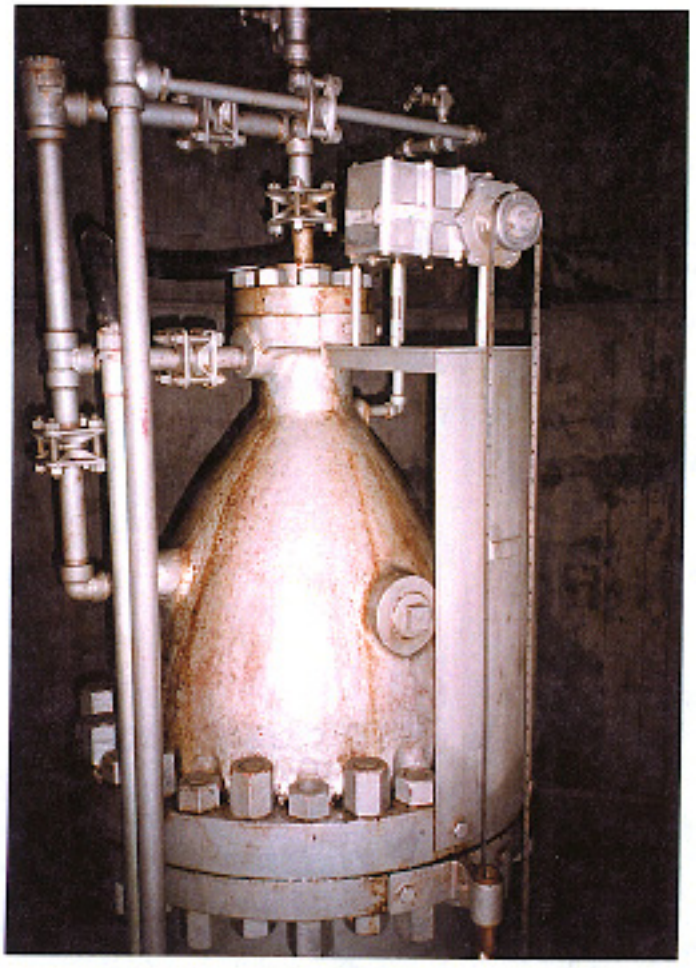
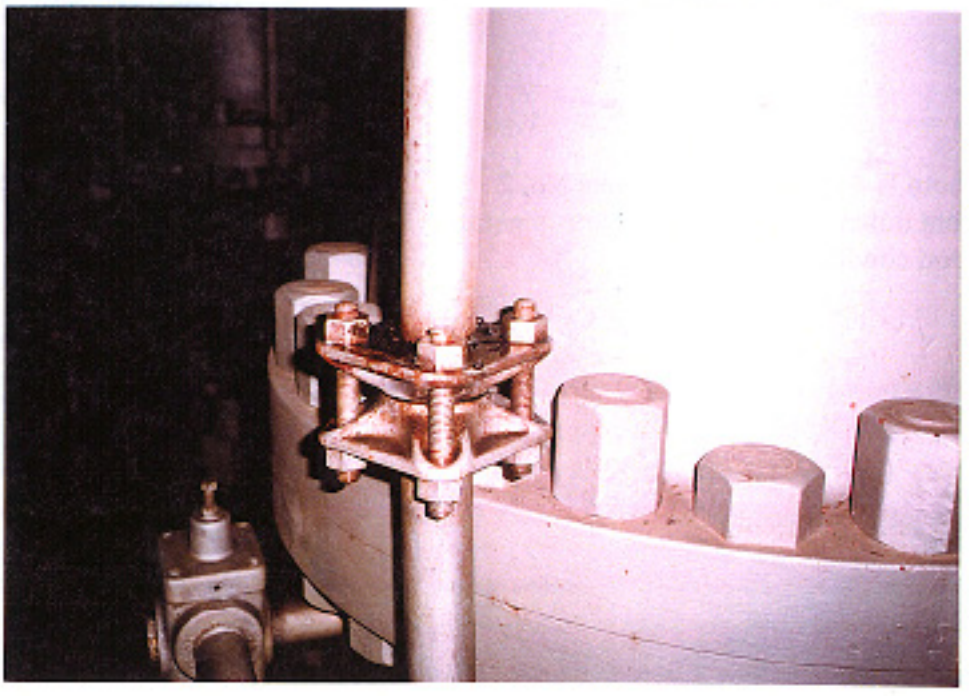


Photo B-1: Top of hydraulic cylinder for gate 1. Note evidence of hydraulic fluid leaks.

Photo B-2. Hydraulic return line of gate cylinder 3. Note hydraulic fluid leak at flange connection.



NORTH HARLAND LAKE
PERIODIC INSPECTION NO. 6

Photo B-3 (left). Service gate No. 1 from downstream conduit. Note minor leakage.

Photo B-4 (right). Service gate No. 2 from downstream conduit. Note generally good condition.

Photo B-5. Service gate No. 3 from downstream conduit. Note minor leakage.

PHOTO D-1: Spillway and spillway approach.

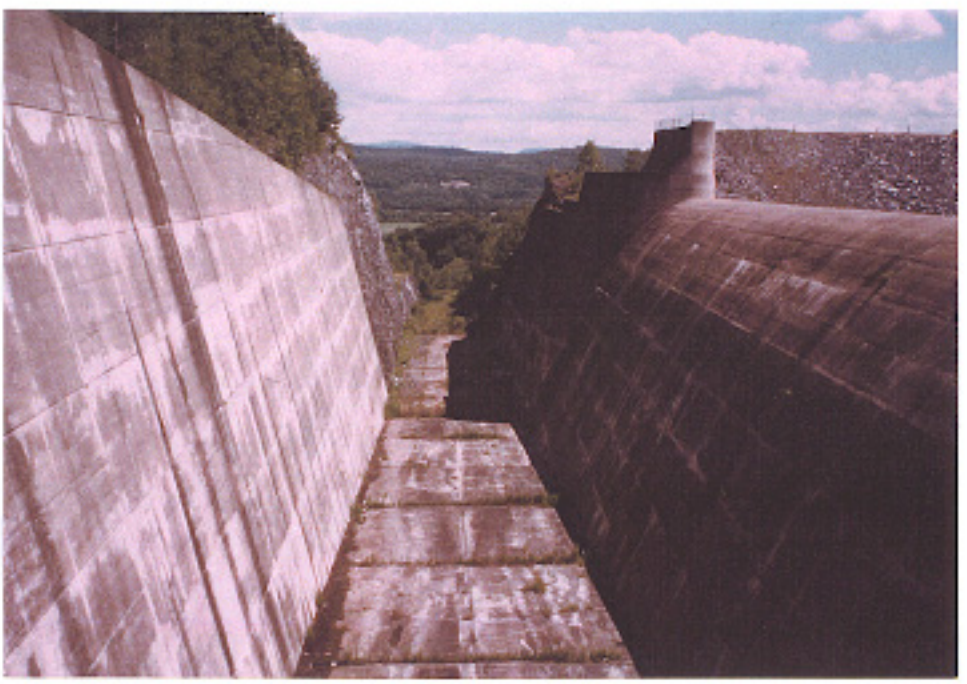


PHOTO D-2: View of spillway exit chute looking downstream.

PHOTO D-3: View of log boom from top of dam.

PHOTO D-4: View of the outlet works and discharge channel looking downstream.

Photograph E-1: Dam embankment- upstream slope

Photograph E-2: Weathered phyllite stone protection

Photograph E-3: Vegetation on lower one-third of upstream slope

Photograph E-4: Downstream slope. Note vegetation

Photograph E-5: Stone protection on downstream slope

Photograph E-6: Crest Road

Photograph E-7: Dike embankment downstream slope

Photograph E-8: Dike embankment upstream slope

Photograph E-9: Conduit through dike embankment-outlet

Photograph E-10: Flood Control Outlet works-outlet channel

Photograph E-11: Outlet Channel-12 foot diameter steel penstock

Photograph E-12: Vegetated rockfall at weir structure

Photograph E-13: Spillway discharge channel

Photograph E-14: Dewey Mills Dam

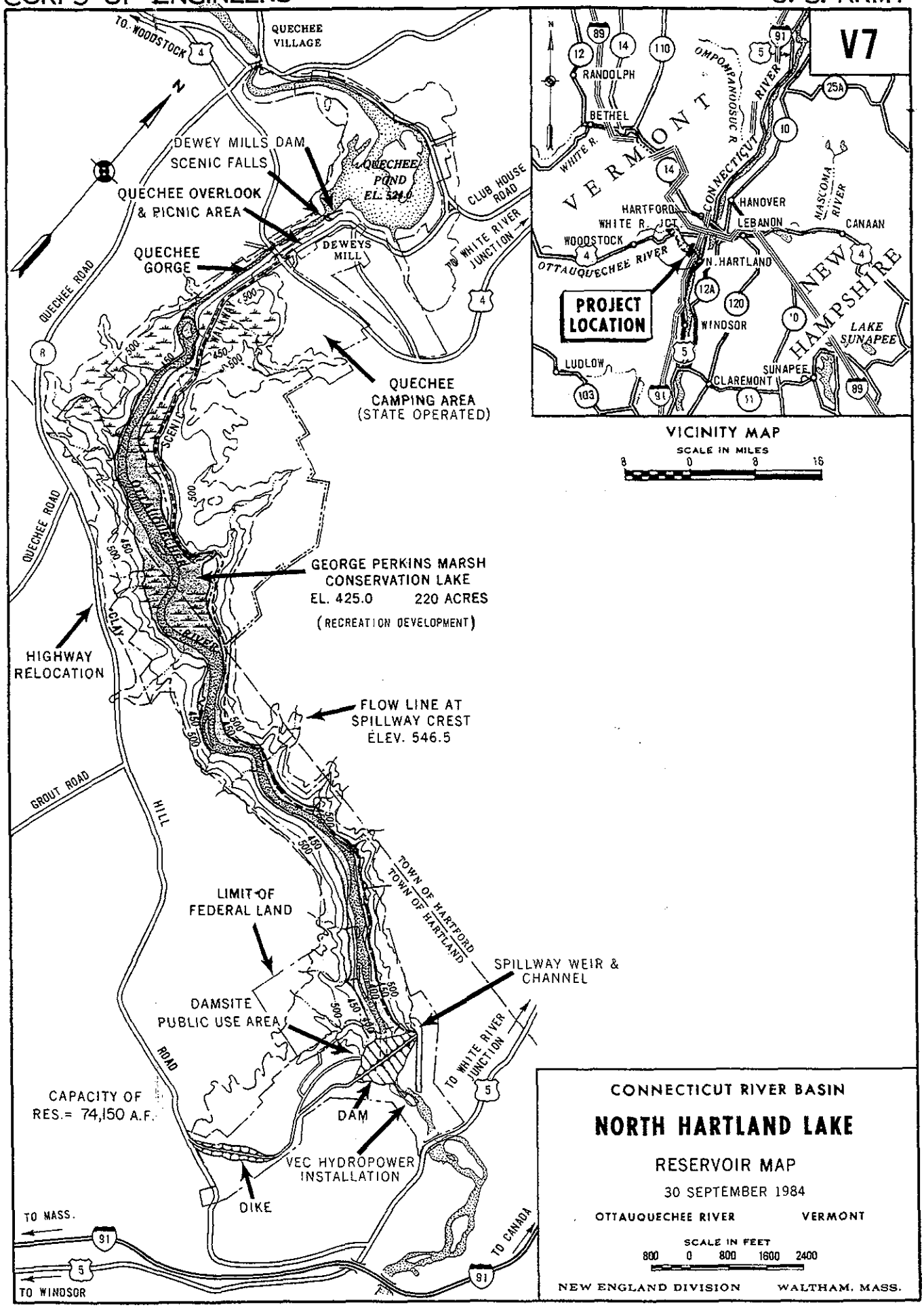
NORTH HARTLAND DAM
PERIODIC INSPECTION NO. 6

Photograph E-15: Vegetation growing through rockfill on the left bank upstream of the Dewey Mills Dam

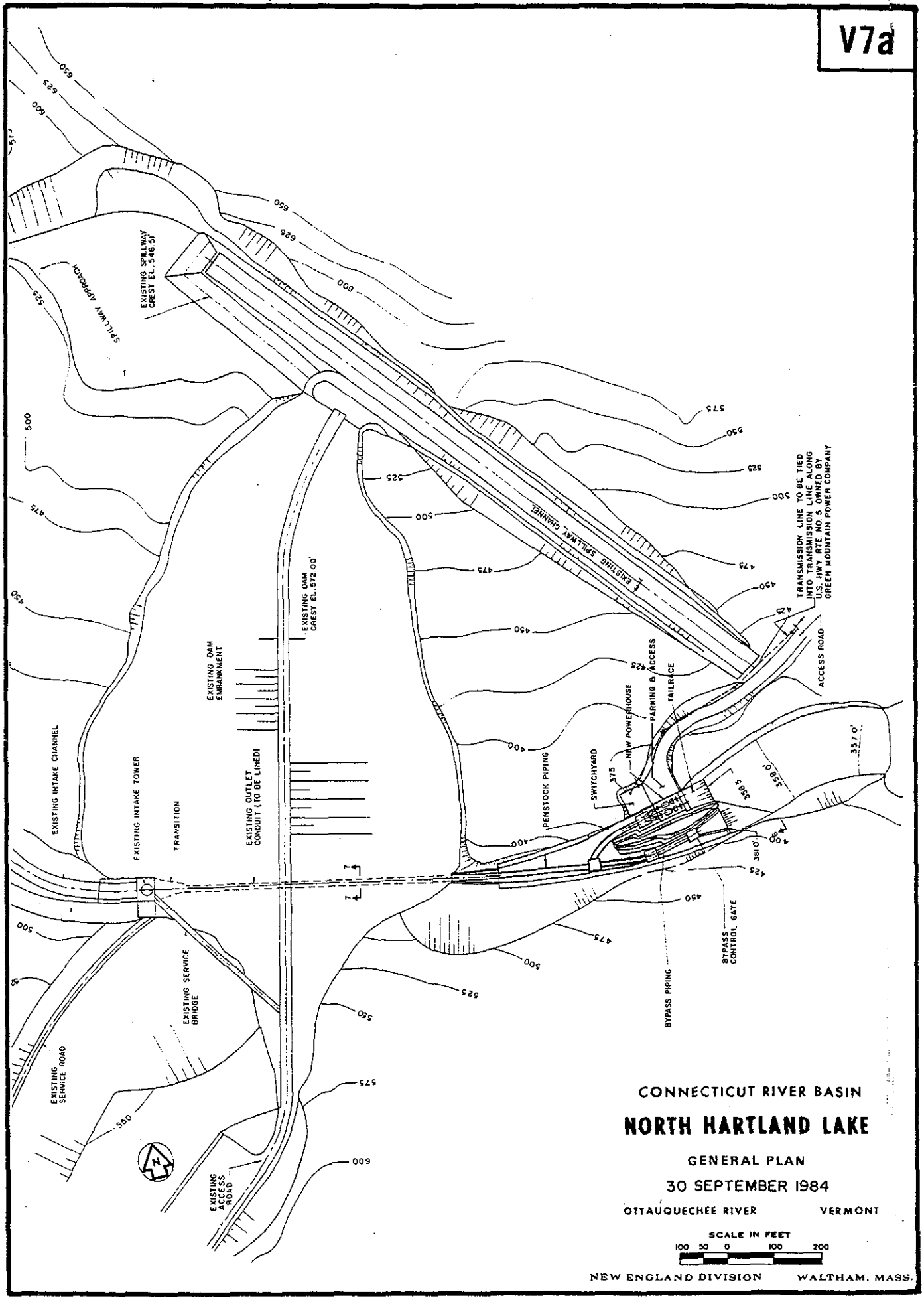
APPENDIX III

FIGURES

CORPS OF ENGINEERS U. S. ARMY



V7a


EXISTING SPILLWAY CREST EL. 546.51'
SPILLWAY APPROACH
EXISTING SPILLWAY CHANNEL
EXISTING DAM CREST EL. 572.00'
EXISTING DAM EMBANKMENT
EXISTING INTAKE CHANNEL
EXISTING INTAKE TOWER
TRANSITION
EXISTING OUTLET CONDUIT (TO BE LINED)
PENSTOCK PIPING
SWITCHYARD
NEW POWERHOUSE
PARKING & ACCESS
TAILRACE
TRANSMISSION LINE TO BE TIED INTO TRANSMISSION LINE ALONG U.S. HWY. RTE. NO. 5 OWNED BY GREEN MOUNTAIN POWER COMPANY
ACCESS ROAD
BYPASS CONTROL GATE
BYPASS PIPING
EXISTING SERVICE BRIDGE
EXISTING SERVICE ROAD
EXISTING ACCESS ROAD
CONNECTICUT RIVER BASIN
NORTH HARTLAND LAKE
GENERAL PLAN
30 SEPTEMBER 1984
OTTAUQUECHEE RIVER VERMONT
SCALE IN FEET
100 50 0 100 200
NEW ENGLAND DIVISION WALTHAM, MASS.

APPENDIX IV

INSPECTION CHECKLISTS

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
CONTROL TOWER		
a. Exterior		
General Condition of Concrete		Good
Condition of Joints		Good
Spalls		The concrete protecting the electrical conduit is spalling off at the base
Visible Reinforcement		None
Seepage or Efflorescence		None
Rusting or Staining		Rust stains beneath drains
Cracks		None
Roof		New & in excellent condition
b. Interior		
General Condition of Concrete		Good, from roof level to the base of tower
Condition of Joints		Good
Spalls		2′ x 2′ spall at the center of the north wall; 2 minor spalls in the lower level of control tower
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
CONTROL TOWER (cont'd)		
Visible Reinforcement		None
Seepage or Efflorescence		Efflorescence leaching through many cracks and joints in the lower levels of the tower
Rusting or Staining		None
Cracks		Hairline cracks on the underside of the roof slab and in the lower levels of the tower
Access Stairs		Good
General Condition		Paint system on the underside of the roof slab is peeling; 2" to 3" of water present on the floor of the tower base
INLET STRUCTURE		
General Condition of Concrete		Good; debris build-up at the access grating for stop log slot
Condition of Joints		Good
Spalls		None
Visible Reinforcement		None
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
INLET STRUCTURE (cont'd)		
Seepage or Efflorescence		None
Rusting or Staining		None
Cracks		None
Handrails		Rust spots scattered along the handrail; right 3 sections of railing not secured due to broken connections (3)
Trashracks		All have been removed except for 3 stuck in slots
CONDUIT AND TRANSITION		
a. Conduit/Penstock		
Steel Penstock		Good with very minor areas of pitting and surface rusting on the interior
Condition of Joints		Good
Welds		Good
Coating Condition		Minor blistering of the coating on the exterior
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	JL	
CONDUIT AND TRANSITION (cont'd)		
b. Transition		
General Condition of Concrete		Good with moderate surface abrasion, up to $1^1/_2$" deep, of the transition floor
Spalls		Minor roof spalls in the gate barrels
Visible Reinforcement		None
Seepage or Efflorescence		No seepage noted; minor efflorescence through joints and cracks
Cracks		Some longitudinal hairline cracks in all three gate barrels
OUTLET STRUCTURE		
General Condition of Concrete		Good
Condition of Joints		Good
Spalls		None
Visible Reinforcement		None
Rusting or Staining		Minor rusting of drain
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
OUTLET STRUCTURE (cont'd)		
Seepage or Efflorescence		Minor efflorescence in hairline cracks
Cracks		Several hairline cracks with efflorescence at both outlet structures
4" diameter drain		Water flowing out of drain - source is unknown
SPILLWAY WEIR AND WALLS		
General Condition of Concrete		Good with mapcracking with efflorescence at the crest of the spillway; weep holes functioning properly
Condition of Joints		Good; some vegetative growth in joints of the downstream face of weir and at the bottom of the spillway channel
Spalls		30% of spall repairs are unsound and some spalling of spillway walls
Visible Reinforcement		None
Seepage & efflorescence		Efflorescence through cracks and some joints
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY WEIR AND WALLS (cont'd)		
Rusting or Staining		None
Cracks		Some minor hairline cracks; previous crack repairs in good condition
LOG BOOM		
Logs		Majority are sound but some weathered logs were found at the north side of the project
Anchorage		Good
Cable		Good
DIKE GATE STRUCTURE		
General Condition of Concrete		Good
Rusting or Staining		None
Spalls		None
Visible Reinforcement		None
Seepage or Efflorescence		None
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
DIKE GATE STRUCTURE (cont'd)		
Condition of Joints		Good
Cracks		None
Anchor Bolts		Rust with some deterioration
RCP Inlet and Outlet		Good
DEWEY MILLS DAM		
a. Non-overflow Section		
General Condition of Concrete		Poor with extensive deterioration and unsound concrete repair patches
Rusting or Staining		None
Spalls		Numerous areas of concrete deterioration and spalls, up to 6" deep, at the upper portion of the downstream face of the intake
Visible Reinforcement		None
Seepage or Efflorescence	JL	Water is leaking through the joint between the upper and lower portion of the non-overflow section

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
DEWEY MILLS DAM (cont'd)		
Condition of Joints		Good
Cracks		Numerous cracks with efflorescence at the upper portion of the non-overflow section
b. Spillway Weir and Abutment		
General Condition of Concrete		Fair to good; downstream face of the spillway weir is severely abraded
Rusting or Staining		None
Spalls		Minor spalls and deterioration
Visible Reinforcement		None
Seepage or Efflorescence		Minor seepage through the joints of the flashboards
Condition of Joints		Good
Cracks		None
Flashboards		Good
	JL	

TEAM MEMBER'S CHECKLIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
DEWEY MILLS DAM (cont'd)		
c. Log Boom		
Overall Condition		Good
d. Control House		
Overall Condition		Interior and exterior concrete in good condition; isolated damp areas with slight efflorescence
	JL	

TEAM MEMBER CHECK LIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
MECHANICAL		
AIR VENTS AND EMBEDDED STEEL	DG & MJ	No obstructions. Minor corrosion of air vent intake. Algae film on all embedded steel.
SERVICE GATES (3)		All three gates in good condition. Gates 1 and 3 showed minor leakage along seal.
GATE POSITION INDICATORS		Indicator for gate 2 out of order. Personnel determine its position using a stopwatch during operation.
HYDRAULIC OPERATING SYSTEM		
a. Pumps & Tanks		Good condition.
b. Hydraulic Cylinders		Generally in good working condition. However, water and hydraulic fluid leaks were observed at the gate cylinders (see piping).
c. Piping		Moderate water and minor hydraulic leaks were observed in piping at the gate cylinders. Minor hydraulic leakage was observed just below the gate controllers.
d. Fluid		No data. Fluid has not been tested since 1991.
EMERGENCY GENERATOR		192.22 hours. Operation is satisfactory.
WARM AIR FURNACE		Good condition. Operation is satisfactory.
FRESH AIR FAN		Broken fan belt.
FLOAT WELL	DG & MJ	Heating tape wrapped around float well to thaw frozen water. Heat lamp is also used to prevent freezing.

TEAM MEMBERS CHECK LIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	BY	CONDITION
ELECTRICAL	TA	
Service		See report.
Equipment		Needs disconnect switch
Wiring		Needs review
Distribution System		Utility Bldg | Intake Tower
Wiring		Needs further review
Switchboard (Control Center)		New | Serviceable
Circuit Breakers		New | Serviceable
Meters		New | None
Documentation		Needs updating | Original condition
Appurtenances		Test TVSS, Reconnect GFM
Grounding		Needs review, more inspection
Emergency Power System		OK
Generator		OK, good regulation
Battery		OK, starts immediately
Charger		OK, keeps battery properly charged
Wiring		OK
Hydraulic Pump System		OK, serviceable for next five years
Motors		OK, insulation resistance high
Controllers		OK, clean & operates consistently
Wiring		OK, insulation resistance high
Lighting, Intake Tower		See report.
Exterior		OK, serviceable
Interior		Needs supplementation & maintenance
Branch Circuit		Inadequate
Devices		Need new receptacles and switches
Wiring		Needs addition & documentation
Lightning Protection		Needs further inspection
Roof connections		OK on Intake Tower
Earth connections		Need to be checked.
Wiring		Needs inspection
Equipment		Needs inspection

TEAM MEMBER CHECK LIST FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
HYDROLOGY/HYDRAULICS		
a. Spillway	SS	
Approach		Good, some minor vegetation.
Control		Excellent.
Exit		Good, generally clear.
b. Outlet Works		
Inlet:		
Channel		Good, clear.
Trash Bars		Good, minor amount of debris.
Log Boom		Good.
Emergency Closure		Good, stoplogs onsite.
Air Vents		Clear, good.
Gates		Good. All gates operated satisfactorily.
Outlet:		
Outlet Tunnel		Good condition.
Exit Channel		Good, minor shoal and vegetation.
c. Instrumentation		
Rain Gages		Good operating condition.
Pool Stage Recorder		Good operating condition.
Staff Gages		Good condition.
Tailwater Gage (USGS)	SS	Good operating condition.

NORTH HARTLAND LAKE

TEAM MEMBERS FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
GEOTECHNICAL **MAIN DAM EMBANKMENT**	LF PY PH	
Surface Cracks		None observed.
Crest		Good. Crushed stone surface
Movement or Settlement of Crest		None observed.
Lateral Movement		None observed.
Vertical Alignment		Good.
Horizontal Alignment		Good.
Condition at Abutments and Concrete Structures		Good.
Indications of Movement of Structural Items on Slope		None observed.
Trespassing on Slopes		Minor. Small paths on abutment ends, but these could be attributed to wildlife.
Sloughing or Erosion of Slopes or Abutments		None observed.
Rock Slope Protection		Good. Rock is undersized in places and there are some areas of minimal larger rock coverage. Downstream slope minor erosion gully and dip in stone protection
Unusual Movement or Cracking at or near Toes	LF PY PH	None observed.
Unusual Embankment or Downstream Seepage		None observed.

NORTH HARTLAND LAKE

TEAM MEMBERS CHECK LISTS FOR PERIODIC INSPECTION N0. 6		
AREA EVALUATED	**BY**	**CONDITION**
GEOTECHNICAL MAIN DAM EMBANKMENT (Continued)	LF PY PH	
Piping or Boils		None observed or reported.
Foundation Drainage Features		No problems observed.
Toe Drains		No problems observed.
Instrumentation System		
7 Crest Monuments		Good.
13 Piezometers		Good.
2 Accelerographs		Good. Replace plastic cover at shelter A and remove wasp nests in shelter B.
Vegetation and/or Debris		
Upstream Slope		Moderate. Warrants removal effort.
Downstream Slope		Moderate. Warrants removal effort.
Crest		Clear.
Toes	LF PY PH	Some woody vegetation at left side which needs removal as soon as possible. Trees roughly 4 ¼ in. dbh (diameter breast height) and 25 ft. in height require removal.

NORTH HARTLAND LAKE

TEAM MEMBERS CHECK LISTS FOR PERIODIC INSPECTION N0. 6		
AREA EVALUATED	**BY**	**CONDITION**
GEOTECHNICAL **OUTLET WORKS – INTAKE AND OUTLET CHANNEL**	LF PY PH	
Intake Channel		
Slope Conditions		Good overall.
Bottom Conditions		Under water. Not observed.
Rock Slides or Falls		No significant failures evident.
Debris		Minor.
Log Boom		Good.
Drains or Weep Holes		Not visible.
Outlet Channel		
Approach Area General Condition		Good. Clear
Wall Movement		None observed
Loose Rock or Trees Overhanging Channel		Some rock overhanging on right side. Significant failures not evident.
Floor of Approach Channel Weepholes		Under water. Not visible.
OUTLET WORKS – SPILLWAY WEIR, APPROACH AREA AND DISCHARGE CHANNELS	LF PY PH	
Approach Area General Condition		Clear of obstacles. Minor rockfall now vegetated over, needs removal

NORTH HARTLAND LAKE

TEAM MEMBERS CHECK LISTS FOR PERIODIC INSPECTION N0. 6		
AREA EVALUATED	**BY**	**CONDITION**
Loose Rock Overhanging Channel	LF PY PH	Minor rockfalls
Floor of Approach Channel		Needs to be cleared of brushy/woody vegetation.
Discharge Channel		
General Condition		Good.
Loose Rock Overhanging Channel		Minor.
Trees overhanging channel		Minor
Floor of Discharge		Clear
Channel		
Miscellaneous Features		Good.
Culverts under Access Road		Good.
Safety Fences		Good.
Dewey Mills Dam		
Dam		Fair to Good
Weir		Minor spalls, see structural narrative
Approach Channel		Mostly clear
Discharge Channel		Rock slopes steep, but satisfactory condition
	LF PY PH	

NORTH HARTLAND LAKE

TEAM MEMBERS CHECK LISTS FOR PERIODIC INSPECTION NO. 6		
AREA EVALUATED	**BY**	**CONDITION**
GEOTECHNICAL		
DIKE EMBANKMENT	LF	
Surface Cracks	PY	None observed.
Pavement Condition	PH	Fair to good.
Movement or Settlement of Crest		None observed.
Lateral Movement		None observed.
Vertical Alignment		Good.
Horizontal Alignment		Good.
Condition at Abutment and Concrete Structures		N/A. There are no concrete structures.
Indications of Movement of Structural Items on Slopes		None observed.
Trespassing on Slopes		No evidence.
Sloughing or Erosion of Slopes or Abutments		None observed.
Rock Slope Protection		Good.
Unusual Movement or Cracking at or Near Toes		None observed.
Unusual Embankment or Downstream Seepage		None.
Piping or Boils		None.
Foundation Drainage Features		None.
Toe Drains		None.
Vegetation and/or Debris		
Upstream slope		Minor to med. On most of slope
Crest		Minor
Downstream slope		Grass slope
Toe	LF	Minor
	PY	
	PH	

APPENDIX V

SUMMARY OF INSPECTION NOTES

APPENDIX V-A

CONCRETE/STRUCTURAL

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
CONCRETE/STRUCTURAL FEATURES

1. FIELD INSPECTION

The concrete/structural portion of Periodic Inspection No. 6 of North Hartland Lake at North Hartland, Vermont was conducted on 15 June 1999 by Jennifer Lee from Design Branch, Engineering/Planning Division of New England District. Major features inspected are as follows:

- Control Tower
- Inlet Structure
- Conduit and Transition
- Outlet Structure
- Spillway Weir and Walls
- Log Boom
- Dike Gate Structure
- Dewey Mills Dam

The service bridge at North Hartland Lake is no longer inspected as part of the Periodic Inspection Program, but instead is covered by the Bridge Inspection Program. The service bridge to the control tower is a four span structure with a total length of 363'-0". The last inspection of the bridge was conducted on 19 and 20 October 1994 and was found in overall good condition, with some deficiencies noted.

2. CONTROL TOWER

a. Exterior: The overall condition of the exterior concrete surface is good. All joints are properly aligned and tightly bonded. Rust staining is noted on the concrete surfaces beneath the drains. The tile gage remains in good condition. The concrete protecting the electrical conduit is cracked and spalling off at the base of the tower. The membrane and ballast roof system has recently been replaced with a new one and is in excellent condition, with no leakage and deficiencies noted.

b. Interior: The overall condition of the control tower interior is good from roof level down to the base of the tower.

(1) Upper Level: In general, the operating room is in good structural condition, with minor deficiencies noted. Hairline cracks located on the underside of the roof slab remain unchanged from that noted in the 1994 inspection. However, the roof slab is water damaged and stained, and the paint system has failed in many areas on the underside as well as along the top edge of the walls (photo A-1). The 2' x 2' spall, located 3' above the floor at the center of the north wall has not further deteriorated and the concrete is generally sound around the exposed conduit (photo A-2). The project manager informed the inspection team that a contractor will be brought in by the end of FY99 to seal the cracks on the underside of the slab, repaint the entire slab, and repair the spall on the north wall.

(2) Lower Level: The stairs and handrails leading down to the tower bases are in good condition with minimal signs of distress. The spalls in the concrete walls noted in the previous inspection report show no further deterioration. Efflorescence continues to leach through the joints and most hairline cracks in the lower levels of the control tower (photo A-3). As previously stated, the efflorescence is not a structural problem but should be cleaned from electrical conduits and lighting to prevent electrical-related problems.

Prior to the inspection of the control tower, the original outlet structure was inspected for any deficiencies. Water was draining out of the 4" drain (which exits the floor of the tower and extends 700' $^{+}/_{-}$ downstream through the wall of the original outlet structure) at this outlet structure, therefore, it was believed that the water ponding at the base of the control tower was draining properly (photo A-4). However, two to three inches of water was present on the floor of the tower base during the inspection (photo A-5). The project manager believes that the drain continues to be blocked and the water coming out of the drain is from a source other than the base of the control tower. A contractor is scheduled to clear the line and investigate the source of the current flow out of the drain.

3. INLET STRUCTURE: Only the upper portion of the inlet structure was visible at the time of the inspection. All concrete was in sound condition with all joints properly aligned and tightly bonded. All but the lower row of trash racks have been removed from service due to the non-operational status of the hydropower plant and have been placed on the upstream face of the dam. The 3 trash racks at the bottom level are stuck in their slots. The steel grating access panel over the emergency stop log slot for the center gate has been replaced, and it is covered with debris (photo A-6). Rust spots are scattered along the platform's handrail. The right three sections of handrails are askew and not properly secured (only tied to each other with rope) due to the broken connecting sleeve between the handrail post and the support bracket (photo A-7). The connecting sleeve is broken in three locations and requires repairs to ensure the safety of project personnel.

The base plate for the interior post of the handrail section at the northeast corner is not anchored to the concrete curb and should be securely fastened to the curb. The drainage slots at the platform are filled with debris and should be cleaned out.

4. CONDUIT AND TRANSITION: The overall condition of the steel penstock and the concrete transition remains good. The 12'-0" diameter penstock start at Sta. 8+03.50 and extend to Sta. 15+03.83, where there is a 12'-0" long steel transition to the concrete outlet channel. The concrete transition area between the gates and the penstock start at Sta. 7+12.00 and extend to Sta. 8+03.50 and consists of three gate barrels (numbered 1 to 3, starting from left, looking downstream) and one transition monolith starting from Sta. 7+74.0 extending to Sta. 8+03.50.

a. Conduit/Penstock: Steel surfaces and welds in the interior of the penstock are in good condition with no areas showing signs of distress. There are some very minor areas of pitting and surface rusting of the conduit (photo A-8). The exterior surface of the conduit was in overall good condition, with minor blistering of the coating (photo A-9). The concrete anchor blocks around the conduit show minor hairline mapcracking with efflorescence.

b. Transition: The joint between the steel penstock and the one concrete transitional monolith is tight with no signs of separation or leakage. The concrete transition exhibits minor deterioration at most joint locations, and the transition floor shows moderate surface abrasion throughout to a maximum depth of $1^1/_2$". The three gate barrels are in overall good condition. At the first gate barrel, there is a hairline crack with efflorescence at the air vent. At the second gate barrel, there are minor roof spalls and there is a longitudinal hairline crack in the roof at the first monolith from the gate thimble. At the third gate barrel, a longitudinal crack with efflorescence is present in the roof. In general, both splitter nosings are in good condition with minor deterioration. None of these deteriorations have worsened since the previous inspection and do not affect the overall structural integrity of the conduit.

5. OUTLET STRUCTURE: The concrete in the outlet structure, built as part of the hydroelectric retrofit, is in very good condition with only isolated areas of minor hairline cracks and efflorescence noted. The original outlet structure, no longer in use, remains in good condition with only isolated areas of minor cracks and efflorescence noted. As noted above under '2. CONTROL TOWER', water is flowing out of the 4" diameter drain steadily. Minor rusting of the drain is noted at the end of the pipe and at the intersection with the concrete wall.

6. SPILLWAY WEIR AND WALLS: Overall, the concrete of the spillway weir and walls is in good condition. In general, the majority of weep holes appear to be

functioning properly. The majority of the crack repairs done in FY92 is still in very good condition with no signs of deterioration. However, approximately 30% of the spall repairs performed in FY92 have failed (photo A-10). Deficiencies such as cracks with efflorescence and vegetation growing in joints were noted on the downstream face of weir and at the bottom of the spillway channel (photo A-11). Mapcracking with slight efflorescence was noted at the crest of the spillway.

7. LOG BOOM: The overall condition of the log boom is good. The anchorages at the north and south ends, the log boom cable, and the majority of the logs are in good sound condition. Some weathered logs were found at the north side of the project.

8. DIKE GATE STRUCTURE: The concrete of the dike gate structure and the reinforced outlet and inlet pipes is in good condition with no visible signs of distress.

9. DEWEY MILLS DAM: The concrete/structural features of Dewey Mills Dam consist of a non-overflow section, spillway weir and abutment, a log boom, and the control house. The overall condition of the dam is poor. There is extensive deterioration of the concrete at the dam (photo A-12).

a. Non-overflow Section: The concrete of the non-overflow section of the dam is in poor condition. The upstream base of the intake is in good condition. The upper portion of the downstream face of the intake has numerous areas of concrete deterioration and spalls, measuring up to 6" deep (photo A-13). The 3 "splitter walls" are all unsound and deteriorating. Water is leaking through the joint between the upper and lower portion of the non-overflow section between the intake and the weir (photo A-14). The upper portion of the non-overflow has numerous cracks with efflorescence and deteriorated and unsound concrete repair patches (photo A-15).

b. Spillway Weir and Abutment: The downstream surface of the spillway weir is severely abraded with minor spalls and deterioration, however, all underlying concrete is structurally sound. Water flows over the middle section of the spillway and minor debris is caught at that area. The flashboards at the crest of the weir are in overall good condition, with minor seepage through the joints. The spillway abutment, at the far end of the weir, is in good condition with no deficiencies noted.

c. Log Boom: The log boom is in good condition with no deficiencies noted.

d. Control House: The interior and exterior concrete of the control house is in good condition with only isolated damp areas with slight efflorescence.

10. STATUS OF PREVIOUS RECOMMENDATIONS

a. Develop a procedure to repair the deteriorating electrical conduit in the north wall of the operating room of the control tower. The openings should be sealed to prevent further moisture penetration and the interior spall repaired.

Repair done by the end of FY99.

b. Design and implement a repair procedure to alleviate the blocked drain condition, which continually backs up water into the tower base.

Not implemented.
Scheduled to be done by the end of FY01.

c. Repair the broken handrail posts and secure the handrail base plate. Replace the missing grating over the emergency stop log slot on the inlet structure.

Grating replaced; Repairs to handrail not done.
Project Manager will purchase new handrails.

d. The following items were cited for monitoring to determine if progressive deterioration has occurred, resulting in significant problems that require repairs:

(1) The two spalled areas in the lower levels of the control tower.

(2) Areas of efflorescence near electrical conduits and lighting in lower levels of control tower – clean as required.

(3) Indicated areas of minor deterioration in the transition area.

(4) The areas receiving concrete repairs in the spillway channel walls during 1992.

(5) The logs in the log boom; continue to replace on an as-needed basis.

(6) The upper portion of the downstream face of the non-overflow section, and the spillway weir at Dewey Mills Dam – eventually repairs will be required.

(7) Flashboards at Dewey Mills Dam – continue to replace on an as-needed basis.

Monitoring/Inspection performed as part of Periodic Inspection. Findings are cited in the body of appendix.

11. RECOMMENDATIONS

a. Dam Safety Items: The aforementioned, incomplete recommendations need to be addressed and completed.

b. Normal Maintenance Items

(1) The deteriorated concrete and unsound patches at the non-overflow section of Dewey Mills Dam should be removed to sound concrete and new concrete placed and built up to existing finish surfaces. Hydro Energies Corporation (HEC) should investigate the leakage through the horizontal joint of the non-overflow section and implement a procedure to stop the leakage. This recommendation should be forwarded by Construction/Operations Directorate to HEC for action.

(2) Clean, as required, the areas of efflorescence near the electrical conduits and lighting in the lower levels of the control tower to prevent electrical-related problems.

(3) Continue to replace on an as-needed basis the logs in the log boom.

APPENDIX V-B

MECHANICAL

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
MECHANICAL FEATURES

1. FIELD INSPECTION

The mechanical portion of Periodic Inspection No. 6 at North Hartland Lake was performed on 15 June 1999 by Ms. Deborah Gabrielson and Mr. Matthew Jamieson of Design Branch, Engineering Division. A complete inspection was made of the mechanical features, including the three service gates. Service gates 1, 2, and 3 were operated through a closing cycle, and the conduit was accessed from the downstream outlet. Flow had slowed considerably but then surged again for some unknown reason. The gates were then lifted slightly and closed again to clear debris and again impede the flow. Loud banging and rumbling was heard within the conduit. The noises were thought to result from expansion of the steel conduit, which was exposed to the heat of the sun.

Once conduit flow decreased, a thorough inspection of the three service gates was conducted. The downstream sides of all three gates and their associated embedded steel were inspected. A visual inspection of the upstream side of the service gates was not conducted because the pool water level was too high. The remainder of the mechanical inspection was conducted within the intake tower.

2. OUTLET WORKS

a. Operating House

(1) Interior

(a) Hydraulic Gate Operating System The hydraulic controls were inspected from the operating room as the Project Manager performed open and close cycles on all three service gates. Separately and in succession, the three gates were raised from ½ ft. to approximately 2 ft. and then back down again to ½ ft. The system generally appears to be in good condition. However, for environmental reasons, the gates were not raised above 2 ft. The gate position indicator for gate 2 was out of order. The indicating rod has separated from the gate. Dam project personnel determine its position by using a stopwatch during operation. The indicators for gates 1 and 3 were in good working order. In order to close the gates completely, the operator must watch the pressure gauge. The gauge makes a significant jump when the gate is closed. Just below the controllers, minor leakage of hydraulic fluid at the connections of ½ in. pipe was observed.

Both pumps 1 and 2 were run through the above described gate cycles. The pumps and their respective tanks were in good condition. No leaks or unusual vibrations were observed. The hydraulic fluid has not been tested since 1991.

The hydraulic cylinders were inspected from the base of the intake tower. Moderate leakage of hydraulic fluid at top of gate cylinder 1 was observed. The leak appears to originate at

the flanged connections of the hydraulic supply line just above cylinder. The fluid then drips along the outside of the hanger body and appears to collect within the groove of the large bolted flange at the top of the cylinder (see photo B-1). On gate cylinders 1 and 3, moderate leakage of water was observed in the packing where the telltale indicator rod passes through the bonnet. The puddles of water present on the room floor are caused by this leak. In addition, the flanged connection on the hydraulic return line of gate cylinder 3 showed moderate leakage of hydraulic fluid (see photo B-2).

(b) Emergency Generator The emergency generator is located in the utility building. The generator started and operated smoothly without incident. Lights and hydraulic pumps were operated on emergency power. The emergency generator appears to be in good condition, and operation was satisfactory.

(c) Heating and Ventilation System Following the previous Periodic Inspection, a recommendation was made to replace the oil-fired warm-air furnace. A new furnace has since been purchased and installed, and it appears to be in good working order. The ventilation system consists of a fan and ductwork that runs the length of the intake tower. The fan blows fresh air from the top of the tower to its bottom. The ventilation system fan made loud irregular noises before failing. The system was thus inoperative at the time of the inspection because of a broken belt within the fan. The fan belt had loosened and entangled itself during routine testing procedures. (The fan belt and motor have been repaired in the time since the inspection took place.)

(d) Float Well The float well operates satisfactorily. Project personnel use a heat lamp to take care of occasional freezing problems.

(e) Gate Chamber Floor Drainage System The drainage system consists of three drains within the floor of the gate chamber. The drains feed a drainage pipe which empties into the conduit approximately 640 ft. downstream. The drainage pipe is completely blocked so that water leakage from the telltale rod builds up on the floor. As a temporary fix, project personnel have drilled a hole in the access manhole cover over gate passage No. 3 and have installed a ball valve to allow them to manually drain the leakage.

b. Service Gates

(1) Service gate 1 was in good condition. Minor leakage was visible along the upper half of its seal. The steel body of the gate displayed minor surface corrosion, which is considered insignificant. No cracks or bulges were observed (see photo B-3).

(2) Service gate 2 was in very good condition. Virtually no leaks were visible. The gate's surface steel was in good condition with only minor surface corrosion. The gate body showed no cracks or bulges (see photo B-4).

(3) Service gate 3 was in good condition. The gate surface showed no cracks or bulges. There appeared to be some debris caught underneath the gate, which increased the volume of flow into the downstream conduit. Minor water leakage was observed along the gate perimeter, at its seal (see photo B-5).

(4) The embedded steel and the air vents for the three gates all appeared to be in good condition. The embedded steel was covered in an algae film, but this is considered insignificant. The air vents were clear. Their intake to the downstream conduit ceiling showed minor corrosion.

3. RECOMMENDATIONS

a. Dam Safety Items

None.

b. Budgetary Items

(1) Schedule a construction contract to perform general rehabilitation of the hydraulic system. The goal of the project should be to stop both water and hydraulic fluid leaks within the system in order to ensure reliable future performance. The work should include, but not be limited to, installing isolation valves, installing new gaskets or replacing parts for the above- described leaking joints (part of the hydraulic supply and return piping), and re-packing the leaking telltale rods on service gate 1 and 3. Note: This project will consist of draining, storing, and refilling approximately 1400 gallons of hydraulic fluid from the hydraulic gate operating system. Work should be completed before the next scheduled Periodic Inspection. Estimated construction cost is $15,000 and estimated engineering and design cost is $3,000.

(2) Proceed with plans to clear blockage from tower sump drainage system as noted in Appendix A, Structural Features.

c. Normal Maintenance

(1) Project personnel should attempt to reattach existing (or attach new) telltale rod to gate No. 2. This work must be done when the pool is below the top of the gate. If it is not possible to attach the rod with the gate in place, the possibility of using alternative means to indicate gate position should be investigated.

(2) The hydraulic fluid should be tested as soon as possible.

APPENDIX V-C

ELECTRICAL

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
ELECTRICAL

1. FIELD INSPECTION

The electrical features of North Hartland Lake were inspected by Thomas Ayau of the General Engineering Section (GES), Engineering/Planning Division. The major feature inspected was the Outlet Works.

2. OUTLET WORKS

a. Service. The secondary utility service comes from across the access road when in 1978, the utility company replaced the original overhead primary and secondary service from the pole mounted transformers off the east corner of the Utility Building with an underground secondary service and pad mounted transformer across the access road. A meter pedestal is adjacent to the transformer. No disconnect at the meter is shown in the drawings. Although the service conductor run is only a hundred feet, its advancing age will raise concern about its insulation resistance. A disconnect switch will be needed at the meter so that the conductors can be checked.

b. Distribution System. The main distribution point is a switchboard, "Control Center" (CQ1), in the Work Shop of the Utility Building. The standby emergency diesel generator, replaced in 1984 and relocated from the Work Shop to a shed adjacent to the Work Shop, provides alternate service to this switchboard. From CQ1, power is fed to the hydraulic pump motors in the Intake Tower through another control center, CQ2. Because these motors are essential to operate the slide regulating gates, two feeders (CQ1-q1-CQ2 and CQ2-q2-CQ2[1]) provide redundant circuits to CQ2.

(1) Switchboard, Breakers, and Meters. In 1994, Cole Electric, Inc. replaced the switchboard and circuit breakers with an assembly primarily supplied by the Square D Company. The hinged doors and small removable panel sections provide easy access for inspection and maintenance[2].

(a) Meters. The multifunction meter, a Square D "Power Logic™ Circuit Monitor" shows a multitude of data and pertinent readings are listed in the data sheet. These values should be reset so future extremes may be captured but directions for this meter were not found. Comparing the readouts with other meters show this is reporting, and therefore connected, correctly. Its capabilities should be utilized more because it can

[1] This notation used to identify equipment and wiring is explained in EM 1110-2-3006 Hydroelectric Power Plants Electrical Design.
[2] Some of the components, such as the potential transformers, seem to be much over-designed.

monitor data that may be useful in diagnosing and predicting problems. The maximum voltage readings may help explain events such as the TVSS failures cited below. Prior to the next periodic inspection or field visit by the Engineering/Planning electrical engineer, the project manager should forward a copy of the instructions for the multifunction meter to the engineer. During the visit, the engineer should demonstrate the operation to project personnel and document the procedures and data in a report to the project manager. Then project personnel should record the data and reset the meter monthly in conjunction with testing the generator.

(b) Orientation. The new switchboard was installed with the front toward the aisle to the generator shed permitting full utilization of the storage area, now behind the switchboard, and convenient access to the switches and meters.

(2) Wiring. These feeders have been of concern since 1979 when Periodic Inspection No. 2 reported, "A short was found in one phase of feeder #2 which runs from the switchgear in the utility building to the control tower." Periodic Inspection No. 3 said, "The two feeder circuits ... have high leakage currents ... will be replaced ...." Replacement feeders were included with the generator replacement in 1984 but measurements taken at inspections No. 4, No. 5, and (this) No. 6 show phase C of feeder no. 2 to have significantly lower insulation resistance than the others.

(a) Data. These were the insulation resistance in megohms:

Date	Inspection No.	Feeder No. 2 Phase C	Feeder No. 2 Average of Ph. A&B	Feeder No. 1 Average of 3 Phases
Jun '99	6	0.8	150-200	1000
Jun '94	5	5	2000	2000
Oct '88	4	18	800	200
Nov '83	3	Both feeders reported low, no data.		
Oct '79	2	Unspecified phase low, no data.		OK

Insulation resistance will vary depending on temperature and moisture. The significant reduction in resistance, both absolute and comparative, seems to warrant marked concern.

(b) Handhole Inspection. Inspection of the wiring in the handhole has increased importance since insulation resistance measurement identified a concern. Only one handhole cover was removable due to the lack of handles and the snug fit. When the generator and feeders were replaced in 1984, a handhole was added between Handhole No. 2 (HH-2, in front the Utility Building, Sta. A-28+27) and HH-3, Sta. A-26+18. Its location was shown as Sta. 27+63, 31'-9" northeast of the northeast wall of the Utility Building and was designated HH #3. To minimize confusion, this will be referred to as

HH-2A[3]. This was the only handhole inspected but the observations raise additional concerns. 1) Although not confirmed (by the use of definitive cable tracing methods), a small (1/4") black cable in the handhole appears to be telephone. For communication lines to share a handhole with power is prohibited due to the hazard to telephone users and equipment.[4] 2) The grounding conductor that should also have been intercepted by the handhole is not evident.[5] 3) One conductor has an epoxy resin cast splice where no splices were allowed. 4) Saddles (usually of porcelain) for placement on the brackets to support the cables were instead strewn on the floor. 5) The PVC ducts stubbed into the handholes have no end bells to minimize damage to cable insulation. 6) Pulling irons are not properly located or unavailable. (None could be seen in the photos.) 7) Mud is beginning to enter the ducts. 8) Expansion urethane foam was used to seal the ends of some ducts (perhaps to keep the mud out).[6] 9) No drain was evident, the bottom was

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[3] The record drawings show these four initial handholes (with concomitant ducts) installed in 1957-58 during the construction of the dam, whose sequence ascends northeast along the access road:

HH-1, Sta. A-30+31 in front Comfort Station,
HH-2, Sta. A-28+27 in front Utility Building,
HH-3, Sta. A-26+18 after bend in Access Road, and
HH-4, Sta. A-24+56 prior to Service Bridge.

The installation of strong motion accelerograph shelters in 1978 provided HH-5, HH-6, and concrete encased ducts to connect Shelter "A" (~Sta. 28) with Shelter "B" (Sta. 20+00), independent of those initial ducts and handholes (other than going through HH-2 for grounding and to connect to CQ1 for power). Other projects: 1960 Operator's Quarters, 1978-1980 Restroom, 1978 Relocate Electric Services used those initial ducts and handholes but added none.

[4] The Generator/Feeder Replacement project did not require a new telephone handhole attendant with the new electric handhole. The telephone duct should have bypassed the electric handhole leaving only three ducts to go through HH-2A instead of the four found. The record drawing of the duct sections and handhole plans confirms the observations except somehow the telephone duct and the spare duct seem reversed. The telephone duct should be closest to the road, inline with the telephone handhole. The reason for this handhole is not fathomed. The fact that this handhole had the only remaining handle is consistent with its more recent installation.

[5] The possibility of a telephone line co-located with power is appropriately alarming. This concern can be compounded by the absence of a similarly co-located grounding conductor. (The grounding conductor (hopefully) provides a favorable receiver for stray currents to ground.) On the other hand, properly installed telephone systems are provided with arresters to shunt dangerous voltages (and currents) to ground. Although primarily designed for lightning strikes, these arresters are also supposed to protect users when telephone lines contact power lines too.

[6] Although not prohibited, sealing the duct is poor practice. Ducts should be free to drain. If possible, duct systems are designed so that the low points are the handholes. Holes are provided with drains or sumps for drainage. Some seepage into the duct is expected. Sealing may inhibit water from entering the duct but it also prevents water from exiting.

damp, water stains indicate water rises above bottom ducts. 10) The diameter of the duct should be measured to confirm that the required size was installed.[7]

(3) Documentation. The modifications by the many various projects (listed in the footnote cited above) need to be shown on one combined drawing to comprehensively describe the present distribution system adequately.

(4) Appurtenances.

(a) TVSS.

- Previous Repairs. A transient voltage surge suppressor (TVSS)[8] was provided with the replacement of the switchboard in 1994. In 1997, the Park Manager expressed concern about its viability after printed circuit cards (PCC) were repeatedly destroyed, apparently by lightning strikes. The PCC provides the diagnostic interface, cost three to five hundred dollars each, and were requiring replacement once or twice a year. Replacing the TVSS had been suggested but not implemented. Since then, a spare PCC is kept available. This TVSS may not be sufficiently rated and may need replacement with one of higher rating.[9]
- Testing. Colebrook River Lake has the test set for this *Current Technology*™ TVSS and it should be borrowed to check this one. The TVSS should be tested by the electrical engineer to establish benchmarks and then Park personnel should do it annually or more frequently[10] and at periodic inspections. The test set is simple to operate with instructions inside the cover of the case, requiring connection of a single connector to the outside of the TVSS, and connection of the power plug. Frequent checks by Park personnel will provide data to evaluate the value and practicality of this $1,400 test set.
- Shorten Leads. As commonly found the leads to the TVSS are too long and reduce its effectiveness. The leads should be cut as short as possible to allow optimum

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[7] The drawings show that three-inch duct was required but estimating from the photos they seem smaller.
[8] The TVSS has the following nameplate data: DPA Series - Power Siftor, *Current Technology*™, Model No. DPA480-3UD-FCC, Part No. 900-0024-110-0001, Serial No. T3Q396341094, Operating voltage 480, Configuration 3PH, DELTA, UL1449 Suppression Voltage Rating, L-N N/A L-G N/A N-G N/A L-L 1500 volts. The GSA price is about $1,900.
[9] The DPA series has a surge current exposure class of 150,000 amperes, which the manufacturer describes as medium-low exposure. A high-medium exposure model (DP) rated for 250,000 amperes costs about $3,900 and a high exposure model (MP) rated for 350,000 amperes costs about $6,000.
[10] The manufacturer recommends testing twice a year. Analysis of the test data, similar to insulation resistance readings, can warn of incipient failure so those critical components can be replaced before failure occurs.

effectiveness of the TVSS. This could be done by the Engineering/Planning Division electrical engineer during the next visit or instructions (design) could be provided for an electrician.

(b) Ground Fault Monitor. The ground fault monitor can provide more comprehensive diagnosis of the ground fault potential of the system but needs reconnection of the wiring. The monitor may be able to provide detailed and frequent evaluations of insulation integrity comparable to insulation resistance measurements now taken only every five years during periodic inspections. During a site visit for an inspection or project, the Engineering/Planning electrical engineer should reconnect or design the reconnection of the monitor.

(5) Grounding. The record drawings show extensive grounding provisions. Many features should be tested and inspected to confirm the continued functioning of the original grounding system. Some of these features are the connections to the several ground fields installed originally and in subsequent projects. So-called Ground Inserts located in several places in the Intake Tower and handholes should also be checked.[11]

c. Hydraulic Pump System, Pump Motor Controllers. The controllers, in "Control Center" CQ2, are of the reduced voltage, autotransformer type. Initially a starting contactor applies reduced voltage derived from an autotransformer to the motor. After a five to ten second delay controlled by a timing device, the starting contactor disengages and the main contactor engages to apply full voltage to the motor. This helps reduce the starting current and the attendant voltage drop. Noted is an unusual aspect of their operation. Usually the "ON" button need only be depressed momentarily then immediately released. Here, the "ON" button must be held until the main contactor engages. The record as-built drawing confirms this operation. The previous inspection reported the lack of delay for the main contactor of Pump No. 1 to engage but the

[11] These points were provided for convenient access for testing the grounding system but the field effort to uncover and test these points would itself require at least a day or two. In addition, a test plan and procedure would be required. A list of all the possible test points should be made. From this, a list of the possible pairs of test points. A simple schematic diagram of the grounding system must be made to allow analysis and selection of the critical links. At each test point, the ground links should be opened and each branch from that point individually tested to measure and record their connectivity/conductivity. Study of the proposed procedures and the resultant data must be studied to ensure that inadvertent short-circuits or sufficient measurements are not overlooked. The test method for each point must be chosen. The test method could be either the two-point or three-point ground resistance test. Test points and procedures must be chosen carefully to insure accurate and meaningful data. The test equipment must be prepared: the Vibroground™ resistance meter has the following requirements: batteries must be bought or charged, instructions must be reviewed, and calibration must be checked; and test leads must be inventoried, inspected, and sufficient lengths determined.

contactors worked properly during this inspection. The contactors and controllers appearance and test performances were satisfactory. The controllers consistently transitioned to full voltage after a seven second delay, albeit the "ON" button must be held depressed..

d. Lighting. Although only mentioned in passing in the previous periodic inspection report as needing some attention, this and Inspection No. 4 indicate the overall lighting system requires serious consideration. Two aspects need to be addressed.

(1)Original System. The original system is in various states of disrepair ranging from lamps (bulbs) being out to possibly the raceway system being unusable. Besides one of the two fixtures on the Furnace Room floor being out, the following were also lacking:

(a) Wall mounted vapor-tight fixtures were unlit on the following landings below: #4 (elevation 530.62), #5 (lamp broken), #8, #14, #16, and #19 (fixture missing[12]). On the Gate Chamber floor, three of the four wall mounted fixtures were out (one was missing the glass globe). Of the twenty-five fixtures below the Operating Room Floor, ten (forty percent) were out. (If the Gate Chamber floor is not counted (see reason below), thirty-three percent were out.) Besides insufficient illumination, the exposure left by the missing fixture and glass globe allows moisture into the raceway enclosure system, furthering its deterioration. Review of the record drawing support the abandonment of the outlet boxes below landing #18 (elevation 423.12). Permeation of moisture into the raceways has been problematic since Periodic Inspection Report No. 1 cited that "main gate chamber ... switch and receptacle plates have deteriorated and should be replaced." The outlet at landing #19, the fixture and receptacle outlets on the downstream[13] and right (facing downstream) are at the bottom of the raceway system. They probably have the most corrosion. The only operating fixture on the Gate Chamber floor (left end, facing the upstream wall), is fed from the functioning outlet on the level above, landing #17 (elevation 438.62). The fixture and receptacle outlets directly below landing #18, although fed from the working outlet at landing #18, the stains on the wall below the outlet appear to be from corrosion within.

(b) In addition, the Gate Chamber has a pair of ceiling fixtures provided by the original design but long since abandoned. The record drawing calls these type "H"

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[12] Landing #19 is at the corner before the Gate Chamber floor. The ends of the circuit conductors had been insulated with tape and wire nuts.

[13] The three Air Vents corresponding to the three Slide Gates on the upstream side of the Chamber distinguish the downstream side of the Gate Chamber.

and shows these 750-watt incandescent fixtures as mounted from a "*Disconnecting and lowering type hanger*" to permit their maintenance despite their mounts 30-feet above the Gate Chamber floor. These must have been inoperative before Periodic Inspection No. 4. This supplemental lighting as discussed below had been criticized in that report as making it difficult to recognize and avoid hazards. This probably had been installed due to the failure of the original ceiling fixtures. Also, the "*Disconnecting and lowering type hanger*" mechanism can become inoperative from the corrosive effects of the high humidity.

(2) Supplemental System. As reported by Periodic Inspection No. 4, two outlets with three lampholders for 150-watt parabolic reflector flood lamps (150PAR-38) were installed to supplement or replace the original fixtures. They are mounted on the edge of the landing on landing #18. Switching a circuit breaker in panelboard CR2 in control center CQ2 operates them. A sign needs to be posted at the top of the stairway saying that these lights must be turned on here, in the switchboard, before proceeding to the Gate Chamber floor but also, the circuit breaker is not made for the repeated on-off operation required of a light switch. A special breaker rated for "Switching Duty" is required or a snap switch needs to be provided in the circuit.

(3) Additional System. As noted in report No. 4, the PAR lamp system is inadequate and a safety hazard due to the pervasive shadows hiding hazards and hindering inspection, maintenance, and repair. A new lighting system needs to be added to the existing system to fill in the shadows. A recommendation is an exterior type floodlight[14] with a 400-watt metal-halide lamp. Mount one on the wall at each end of the Gate Chamber, about eight feet above the floor. They would be pointed at about 45-degrees above horizontal at the air vents. The reflected light should provide sufficient diffused illumination on the floor for safe passage among the various obstacles (water, piping, cover plates, cords, and debris).

e. Branch Circuits.

(1) Receptacle Outlets. As mentioned in the previous inspection, the present system of duplex receptacle outlets should be supplemented or replaced. That recommendation is still applicable. Provisions in the budget should be made to provide

[14] The Tri-Service CADD/GIS detail no. is D502310E described with the following features: die cast aluminum housing, anodized aluminum reflector, hinged aluminum door with gasket and captive screws, stainless steel or noncorrosive hardware, and UL "Wet Label" listing.

conductors in electrical metallic tubing[15] to power surface mounted receptacles in cast metal boxes with device plates having individual weatherproof hinged covers.

(a) Operating Room. The receptacle outlets were cited in Periodic Inspection Nos. 3 and 5. With the roof repaired, hopefully water will no longer infiltrate the raceways but they must be abandoned due to the previous corrosion. Surface raceways must be provided to replace the failed receptacles where needed such as next to the Forebay Recorder (Gage Well float) metal cabinet and the Gate Control Panel.

(b) Gate Chamber. Although the receptacles feeding the heat tape appear acceptable, the proliferation of extension cords and heat tape intended to keep the water in the gage well from freezing should be removed. They are no longer required since the Project personnel use a heat lamp lowered into the gage well to keep the float free.

(c) Utility Building Work Shop. The portable "trouble" light reel and extension cord cited in the previous report is no longer attendant with the switchboard although a receptacle was installed for them.

(2) Lighting Outlets. The abandoned fixtures should be removed (already gone at landing #19) and the outlets covered with a blank outlet plate to allay future questions about their serviceability.

(3) Wiring. The exposed conductors condition reported in the previous inspection, that "exposed conductors hanging from an apparently abandoned conduit located at the head of the stairs leading down from the Operating Room Floor", has been corrected. The conduit remains but no conductors hang from it.

f. Lightning Protection. The connections, wiring, and equipment on the roof of the Intake Tower were checked and found complete. The down conductors from the roof were satisfactory down to elevation 450. The conductors below this point, the connections to earth were not discernable from the Service Bridge and not inspected. Many ground fields, conductors, and connects were initially installed for the construction of the dam then added to by the 1993 Lightning Protection System project. This system should be scrutinized to confirm its integrity. Concerns about lightning and TVSS

[15] Although PVC could be the proper choice for wiring in the Gate Chamber (as has been installed) due to the corrosive environment, EMT should be used in the upper floors. It is recognized for its use in electrical circuits. Seals and drains are still required in the plastic raceways in the Gate Chamber to prevent the entry of condensate into the outlet boxes and lighting fixtures.

mentioned earlier make this imperative. Without adequate grounding, the best TVSS is not effective.

3. RECOMMENDATIONS

a. Dam Safety Items. None.

b. Budgetary Items.

(1) Distribution System Wiring and Documentation. Replace the feeder with the faulty phase from the Utility Building to the Intake Tower. This consists of three #4/0 AWG conductors, each 900 to 1000 feet long, (say 2800 linear feet total). The insulation should be ethylene propylene rubber (type EPR). At $400 per hundred linear feet, this costs around $12,000 total. The manholes and drains should be cleaned, saddles attached to the brackets, and cables supported with these saddles for an additional $1,000. Design cost, $3,000 to include updating the as-builts.

(2) Branch Circuit Receptacle Outlets. Replace receptacles, provide new receptacle outlets, and cover abandoned outlets for an estimated design cost of $1,000 and contract cost of $2,000.

(3) Lighting and Branch Circuit Lighting Outlets. Provide additional Gate Chamber lighting at landing #18, metal halide, area floodlight fixtures, 400-watt, two each, at $600 each, approximately $1500. Provide additional switching outlets and circuits, and cover abandoned light fixture outlets for a total estimated design cost of $2,000 and total contract cost of $4,000.

(4) Distribution System TVSS and Ground Fault Monitor. Electrical engineer from Engineering/Planning Division to initially test the TVSS, borrowing test equipment from Colebrook River Lake project personnel. Engineer will provide hands-on, over-the-shoulder training. Also, engineer will shorten the leads to the TVSS and provide design for reconnecting the Ground Fault Monitor to fully utilize its capabilities to monitor for an estimated engineering cost of $2,000 and contract cost of $800 (if required).

(5) Lightning Protection. In conjunction with the next periodic inspection, the electrical engineer should confirm the integrity and inspect the connections and status of the various grounding provisions. Add $1200 to the inspection budget allowing an extra day for the inspection and another day for writing additional report. (This is required due to the extensive grounding provisions at this site which are not present at other projects.)

c. Normal Maintenance Items.

(1) Lighting, Supplemental System. Provide a sign at the head of the stairway to the Gate Chamber explaining the location of the light switch in the panelboard.

(2) Distribution System Grounding. Annually, visually inspect the grounding conductors and connections around the base of the Intake Tower and Utility Building to confirm their integrity.

(3) Distribution System TVSS Testing. Annually, borrow the test set from project personnel at Colebrook River Lake and test the TVSS in the Utility Building and report the measurements to the Engineering/Planning electrical engineer. Engineer advises Park personnel about the operation of the test set and reviews data with overall evaluation in subsequent periodic inspection reports.

PERIODIC INSPECTION NO. 6
ELECTRICAL DATA SHEET
NORTH HARTLAND LAKE

A. Hydraulic Pump Motor Currents, Power, & Voltage

The following data is taken with the VIP System 3 Energy Analyzer. "STATUS" gives time of recording and when noted, the hydraulic fluid pressure read on the gage in pounds per square inch (indicated by "#"), the identity of the gate (G) being moved, the direction of gate movement (↑=up, ↓=down), and the height of the gate in feet ('). Besides the motor readings, this also gives other instrumentation data. "Σ(3φ)" indicates average of 3 phases. The basic reading is the "OVERALL" type reading and the second line shows the individual phase powers in watts, Σ(3φ) of the line-to-line voltages, and the line-to-ground voltages. Other smaller "Page" type readings are taken to save time and tape are described as required. The 20 HP pump motors have a nameplate rating of 26 amperes @ 440 volts (calculated maximum input requirement is 16 kW @ 0.8 power factor (p.f.)).

	CURRENT (Amperes) Line				REAL POWER (Watts)	VOLTAGE (Volts) Lines		
STATUS	L1	L2	L3	Σ(3φ)		12	23	31
13:39:45 No load. Trial setup, 3W with ground connected.						432	474	509
				Σ(3φ) = 472V		270	228	317
13:42:46 No load. Trial setup, 4W with ground connected.						433	473	509
				Σ(3φ) = 472V		271	228	316
13:43:46 No load. Trial setup, 4W, ground disconnected.						464	469	467
				Σ(3φ) = 467V		267	269	273
13:45:24 No load. Trial setup, 3W, ground disconnected.						464	470	467
				Σ(3φ) = 467V		267	269	273
Pump #1								
14:07:52 starting	6.2	6.2	6.4	6.3	2455	462	469	467
48%	764	845	846	Σ(3φ) = 466		265	268	274
The above was an attempt to record the reduced voltage start but the voltage leads were still connected to the line side of the contactor instead of the load side toward the motor terminals.								
14:09:23 idle 0#	10.1	9.8	10.7	10.2	2062	463	469	467
25%	536	757	769	Σ(3φ) = 466		266	268	273
14:17:54 idle	3.4	3.4	3.3	3.4	519	280	276	275
32%, reduced voltage	536	757	769	Σ(3φ) = 466		161	162	156
Another attempt to record the reduced voltage start but apparently caught a very transient condition.								
14:30:23 300#		62%		12.9	6400		Σ(3φ) = 466	

	CURRENT (Amperes)			REAL POWER		VOLTAGE (Volts)		

The 2nd line shows frequency (Hz) (if other than 60Hz), Σ(3φ) power factor (%), individual phase powers in watts, the Σ(3φ) of the line-to-line voltage, and the line-to-ground voltages.

STATUS	Line L1	L2	L3	Σ(3φ)	(Watts)	Lines 12	23	31
14:30:39 400# G1 ↑	13.6	13.9	14.1	13.9	7460	462	468	466
67%	2380	2540	2540	Σ(3φ) = 465		266	268	272
14:32:55 200# G1↑ 1.5'	11.2	11.5	11.7	11.5	4672	462	467	466
51%	1484	1614	1574	Σ(3φ) = 465		266	267	272
14:34:19 350# G1 ↓ 2'	11.5	11.8	12.1	11.8	5027	461	466	465
53%	1567	1758	1702	Σ(3φ) = 464		265	267	272
14:36:48 250# G2↑ 0.5'	12.0	11.9	12.4	12.1	5349	465	471	470
55%	1681	1799	1869	Σ(3φ) = 469		268	269	275
14:39:09 350# G2 ↓	13.7	13.2	14.2	13.7	7070	473	479	478
63%	2210	2320	2540	Σ(3φ) = 477		273	273	280
Pump #2								
14:43:17 250# G3↑	12.4	12.4	13.2	12.7	5600	474	480	479
53%	1690	1930	1980	Σ(3φ) = 477		273	274	280
14:44:38 0# idle	10.8	10.7	11.5	11.0	2119	474	481	479
23%	556	795	768	Σ(3φ) = 478		273	274	281
14:46:06 370#		61%		13.8	6960		Σ(3φ) = 478	
14:46:21 350#	13.3	13.5	14.7	13.7	6900	473	480	479
61%	2100	2370	2430	Σ(3φ) = 478		273	274	281
14:47:55 400#		63%		14.1	7340		Σ(3φ) = 477	
14:50:03 seating	13.6	13.8	14.6	14.0	7220	472	479	478
63%, (~800#, 12kW)	2210	2470	2540	Σ(3φ) = 476		272	273	280
14:52:14 reduced voltage start		45%		6.5	1571		Σ(3φ) = 310	
14:53:23 starting	6.6	6.6	6.5	6.6	1570	311	311	312
44%, reduced voltage	530	521	519	Σ(3φ) = 311		180	179	179

Data taken at the switchboard in the Utility Building from the multifunction meter, a Square D Power Logic™ "circuit monitor". The following was taken at about 16:00

Instantaneous:	13	18	15	5	3000	470	469	468
Maximum:	139	143	141	136	46000	555	569	566
Instantaneous Demand	12	17	14	5				
Maximum Demand	27	31	33	22	-10000			

B. Insulation Resistance Tests (θ-G in megohms @ 500 volts DC)

PHASE:	WINDINGS (All the same.)	FEEDER A	B	C
Pump #1:	100	100	100	500
Pump #2:	50	300	300	400
Feeder from Utility Building to Intake Tower				
Feeder #1	1000	1000	1000	
Feeder #2	150	150-200	0.8	

C. Generator.

Battery.

Before cranking	12.94 V
Lowest during cranking	11.88 V
Time to start	immediate
Immediately after starting	13.44 V
Generator charging current	7 A
After 15 minutes of operation	13.96 V
Generator charging current	2 A

Meters and Gages.
Running elapsed time meter showed the following before testing = 192.2 hours.
The generator was operated for 20 minutes, elapsed time meter = 192.5 hours.
Initially, gages & meters read: 0 degrees F, 65 psi., 1800 RPM, 59.6 Hz.
After 15 minutes, they read: 170 degrees F, 60 psi, 1700 RPM, 59.4 Hz.
Voltmeter read 485 volts AC.

APPENDIX V-D

HYDROLOGY/HYDRAULICS

PERIODIC INSPECTION NO. 6
NORTH HARTLAND LAKE
HYDROLOGIC AND HYDRAULIC FEATURES

1. FIELD INSPECTION

The hydrology and hydraulic features of North Hartland Lake were inspected by Steve Simmer of Water Management Section, Geotechnical and Water Management Branch, Engineering/Planning Division. Major features inspected include the spillway, outlet and inlet works, and hydrologic monitoring equipment. Past operating experiences were also reviewed.

2. SPILLWAY

a. Approach. The overall condition of the approach area is excellent, but had some vegetation along the spillway weir. There would be no obstruction to flow, but vegetation should continue to be cleared periodically (see photo D-1).

b. Control. The concrete spillway weir is located at the left (north) abutment of the dam. It is an uncontrolled L-shaped ogee weir. It is in good condition with no major cracks or spalls that would significantly affect its hydraulic capacity.

c. Exit. The spillway discharge channel is in good condition with no major outgrowth of trees or vegetation, or significant amount of debris, which would obstruct flow. There are minor amounts of vegetation in the exit channel that would not affect the hydraulic capacity of the spillway and are not considered a problem. The exit channel is shown in photo D-2.

3. OUTLET WORKS

a. Approach.

(1) Inlet Channel. Overall, the inlet is in good condition and clear of obstructions with only a minor amount of debris at the gate intake area. There was also debris on the steel grating cover for the emergency stop log slots which should be cleaned under normal maintenance. This project was retrofitted with metal trash racks in front of the existing intake structure for hydropower purposes. Due to the closeness of the bars, the hydropower operators are required to maintain and remove debris from the trash racks regularly, however, the hydropower facility is no longer in service. Therefore, project personnel contracted to remove the trash racks. All but the lower trash racks in front of

each gate have been removed. If another hydropower company takes over the operation, they should be required to clean the debris from the lower trash racks initially and also should be required to regularly clean the debris from the trash racks under their agreement/contract with the Corps. If there no longer is hydropower in service, these lower trash racks should be removed.

(2) Log Boom. The log boom is in excellent condition and appears to be functioning well (photo D-3). All logs in the reservoir were floating and project personnel report that logs are replaced as needed. A clear, straight, 30-foot wide path has been maintained for the log boom, on the left (north) side of the reservoir to prevent it from getting caught up on trees/vegetation and should continue to be maintained in the future. The right (south) side of the log boom is open with no vegetation.

(3) Gates and Gate Passage. The project is equipped with three hydraulic service gates. A visual inspection of the downstream side of the gates was performed. Only minor leakage was observed from the gates and all gates and embedded steel are in good condition. The gates were operated and performed satisfactorily. The gate setting indicator rod on gate #2 (middle gate) is broken and needs to be repaired. Project personnel set the gate by timing its movement and regularly shut the gate to reset the opening timing. The indicator rod is scheduled to be replaced this fall. If the gate setting indicator rod can not be repaired in the fall a supplemental system needs to be developed and put in place so the gate settings are known. For further discussion see Appendix V-B, Mechanical Features.

(4) Emergency Closure. This project is equipped with emergency stop log slots in front of each gate in which stop logs can be installed only during low flow conditions. Project personnel report the emergency stop logs are stored on site and are in good condition.

(5) Air Vents. The air vents were clear and in good condition. Some rust was visible inside the vents.

b. Conduit. The outlet conduit and hydropower penstock were observed to be in good condition with no evidence of hydraulic cavitation. During the conduit inspection, the gates were closed for a total of 45 minutes, during which the minimum outflow was 17 cfs due to gate leakage. This shutdown was coordinated with the State.

c. Exit Channel. The outlet channel is generally in good condition with no major obstructions to flow. The minor shoal located downstream of the outlet, as noted in the last Periodic Inspection, remains unchanged and is not considered to obstruct discharge. The outlet channel is shown on photo D-4.

d. Dike. The dike is in good condition. The downstream outlet of the 36" conduit has some sediment buildup which should be evaluated during the next inspection.

4. PROJECT INSTRUMENTATION

a. Rain Gage. The project is equipped with a heated tipping bucket precipitation gage. It is located on the roof of the control tower, which is connected to NAE's GOES water control data collection system. There is also a non-recording "catch-type" precipitation gage at the Project Managers Office.

b. Reservoir Pool Stage Recorder. The project is equipped with a Sutron shaft encoder which measures pool stage and is hooked up to a Sutron 8210 data collection platform, located in the control tower. This unit logs rainfall and pool stage every 15 minutes and transmits on a 4-hour interval to the GOES Satellite. The unit is also capable of telephone modem communications. Pool stage on the day of the inspection was 35.43 feet (425.43 feet NGVD). This system works well.

c. Staff Gage. There are tile staff gages located on the exterior of the control tower wall as well as on the intake structure. Both of the gages are in good condition.

d. Tailwater Gage. A USGS gaging station is located 0.3 miles downstream from the dam and provides a continuous record of releases from the project. This gage is equipped with a Sutron 8210 data collection platform capable of both GOES satellite and telephone modem communications. The reading at the time of the inspection was 2.38 feet, indicating a flow of 132 cfs.

e. Comment. At the time of this inspection, each of the above instruments was in good operating condition.

5. HYDROELECTRIC FACILITIES

a. Downstream Hydroelectric Facility. The hydroelectic facility that is located immediately downstream from North Hartland Dam on the Ottauquechee River was previously operated by Vermont Electric Cooperative (VEC), Inc. However, VEC is no longer in business and the facility is not in use at this time. Below is a description of the facility and how it was operated in the past. There are ongoing negotiations with a new potential operator of the facility, therefore, the recommendations will be made for two scenarios; if the facility begins operation again under a new operator, and, if the facility remains out of service.

(1) Project Description. This hydroelectric facility is located immediately downstream from North Hartland Dam on the Ottauquechee River. The project utilizes the original flood control outlet at the dam, and consists of: (a) the original outlet lined with a 12-foot diameter steel pipe for use as the hydropower inlet, (b) a 12-foot diameter penstock installed above ground for a distance of 470 feet from the toe of the dam to the powerhouse, (c) a powerhouse containing two 2,000 kW generating units, (d) a tailrace approximately 400-feet long, which extends from the powerhouse to the river, (e) a bypass conduit, 12-feet in diameter, which branches off from the penstock about 100-feet before the powerhouse, discharging water through a control gate into a concrete-lined channel extending 60-feet east to the tailrace, (f) a 4.16/ 12.5-kV switchyard, (g) a 12.5-kV transmission line, and (h) appurtenant works.

(2) Operation. Construction began in April 1983, with the facility placed on line during July 1985. The power facilities were a daily peaking operation. Consequently, the reservoir storage would go through a daily peaking and ponding cycle. This period begins at a time associated with the priority peak demand of the electrical system and ends 24 hours later with the start of the next cycle. Depending on the available water resource, the turbine discharge would range from about 200 to 810 cfs during the generation cycle. Consistent with the limitations imposed in the operating license, the pool fluctuation would be confined to a maximum of 3 feet between elevations 422 and 425 feet NVGD.

During the daily peak demand period, the plant would generate, drawing down the reservoir whenever powerhouse flow exceeded reservoir inflow. When generation ceased, the outflow would be reduced to the minimum allowable discharge so that the pool storage would be replenished. The minimum discharge varied from 23 cfs for July through October to 4 cfs for November through June.

(3) Responsibilities. Vermont Electric Cooperative (VEC) was responsible for the maintenance of all new structures and equipment associated with the hydroelectric installation, bypass facilities and the access road. The modified intake piers and the trash racks were VEC's responsibility. The prospective new operators should have the same responsibilities.

An annual joint inspection of the facility was carried out by representatives of New England District, Vermont Electric Cooperative, and the Federal Energy Regulatory Commission when the facility was operational. The inspection consisted of, at least, the trash rack, penstock, bypass control gate, the access road, and the reservoir area. VEC was responsible for any maintenance required to these items as a result of the inspection. Since the facility is no longer in operation it has not been annually inspected. This annual joint inspection should resume if a new operator takes over the facility.

(4) Observations and Recommendations. The annual inspection of the North Hartland hydropower project was not conducted as the VEC is no longer in business and the facility is not in service. However, it is recommended that the facility be fully inspected prior to it being placed in operation again. Based upon the 15 June 1999 periodic inspection the additional recommendations are as follows:

(a) Bypass Control Gate: The bypass control (tainter) gate at the hydropower facility is in the full open position while the facility is not in operation. When the facility is in operation, flood releases from North Hartland Lake are normally made through this bypass gate. The electrical conduit, which houses the wiring that operates the gate, is cracked in a few places. In the event that the hydropower facility is going to be operated in the future, this bypass control gate and wiring should be fully inspected and made operational prior to allowing the start of any hydropower operations.

(b) Intake Trash Racks: This Corps flood control project was retrofitted with metal trash racks in front of the existing intake structure for hydropower purposes. Due to the closeness of the bars, the hydropower operators were required to maintain and remove debris from the trash racks regularly, however, the hydropower facility is no longer in service. Therefore, project personnel contracted to remove the trash racks. All but the lower trash racks in front of each gate have been removed. If another hydropower company takes over the operation, they should be required to clean the debris from the lower trash racks initially and also should be required to regularly clean the debris from the trash racks under their agreement/contract with the Corps. If there no longer is hydropower in service, these lower trash racks should be removed.

b. Hydro Energies Corporation

(1) Project Description. This hydroelectric facility is located at the headwaters of North Hartland Reservoir at Dewey's Mills Dam. The project consists of: (a) three concrete gravity overflow-type dam sections approximately 7 feet high, having an aggregate length of 215 feet spanning the river and joining two islands, (b) a reservoir with a surface area of 22 acres, (c) a headrace, (d) a 40-foot long retaining wall, (e) a powerhouse containing two turbines rated at 680 and 1,395 hp, and two generators rated at 600 and 1,250 kW, (f) a tailrace, (g) a 200-foot long transmission line, (h) a substation containing one step-up transformer, and (i) appurtenant facilities.

(2) Operation. Operation of the hydroelectric facility is on a run-of-river basis. River flows upstream of the project equal flows downstream of the tailrace during normal operation.

Three-foot high crest gates and conventional flashboards are used on the dam crest. During normal operation, the turbines and the crest gates are modulated so that the headwater level is maintained within six inches of El. 526.2 feet NGVD. The Corps of Engineers owns in fee to El. 527.0 feet NGVD within the project area and holds flowage easements above El. 527.0 feet NGVD for the purpose of flood control only. At such time as water is impounded behind North Hartland Dam to El. 490.0 feet NGVD, operation of the power generation equipment is terminated and an alarm is sent to the operator. The operator then closes a watertight door sealing the powerhouse. A compressor is started and air is fed to the powerhouse to pressurize the interior of the building against the intrusion of floodwaters. When the water in the impoundment subsides to below El. 490.0 feet NGVD, normal operation will resume.

(3) Responsibilities. Hydro Energies corporation (HEC) is responsible for the maintenance of all new structures and appurtenances including, but not limited to, headworks, penstocks, powerhouse, switchgear building, and flashboards. HEC is also responsible for the maintenance of the existing Dewey's Mills Dam.

(4) Observations and Recommendations. The last annual inspection of the Dewey's Mills Dam hydropower project was conducted on 17 October 1995 by representatives of New England Division and HEC. Based upon the recommendations of the 17 October 1995 hydropower inspection and the 15 June 1999 periodic inspection, the hydropower facility is in good working condition. HEC should continue to replace flashboards and clean log boom debris as needed.

6. RECOMMENDATIONS

a. Dam Safety. Downstream Hydropower Facility (previously operated by Vermont Electric Cooperative, Inc.). It is recommended that the facility be fully inspected by NAE, FERC, and the new owner prior to it being placed into operation again. Based upon the 15 June 1999 periodic inspection, the following are additional recommendations on the hydropower facility:

(1) Bypass Control Gate: The bypass control gate at the hydropower facility is in the full open position while the facility is not in operation. In the event that hydropower facility is going to be operated in the future, this bypass control gate and wiring should be fully inspected and operational prior to allowing the start of any hydropower operations.

(2) Intake Trash Racks: In the event that the hydropower facility is going to be operated in the future, the operators should be required to clean the debris from the lower trash racks initially and also should be required to regularly clean the debris from the trash racks under their agreement with the Corps. If there no longer is hydropower in service, these lower trash racks should be removed.

b. Budgetary Items. Schedule the next inspection for FY04. Due to State Fisheries concerns, the next inspection should be scheduled for the fall, if feasible.

c. Normal Maintenance Items.

(1) The gate setting indicator rod on gate #2 (middle gate) is broken and is scheduled to be replaced in the fall of 1999. If the gate setting indicator rod can not be repaired in the fall, a supplemental system needs to be developed and put in place so the gate settings are known.

(2) Continue to periodically clear the vegetation from the spillway areas and the log boom paths.

APPENDIX V-E

GEOTECHNICAL

PERIODIC INSPECTION NO.6

NORTH HARTLAND DAM

GEOTECHNICAL FEATURES

1. FIELD INSPECTION

Based on a visual inspection performed on 15 June 1999, the geotechnical features for the North Hartland Dam appear to be in good condition. There are thirteen piezometers available to measure pore water pressure in the embankment and foundation. The geotechnical features were inspected by:

Laura Fraser, CENAE-EP-GG
Paul Young, CENAE-EP-GE
Philip Hollis, CENAE-EP-GG

At the time of the inspection, the pool was impounded at elevation 425.4 feet National Geodetic Vertical Datum (NGVD), 35.43 foot stage, and the tailwater elevation was 392.38 feet NGVD, 2.38 foot stage. The discharge was 132 cubic feet per second.

2. EMBANKMENT

a. Main Dam. The dam crest and slopes were examined by walking the entire length of the crest and toes of the embankment. There was no apparent vertical or horizontal misalignment. There was no evidence of settlement, lateral movement, sloughing of slopes, significant irregularities or instability that would affect the performance of the dam. There was no evidence of piping or boils at the downstream toe of the dam.

(1) Upstream Slope. The upstream slope was generally in good condition and appeared to be stable (photo E-1). It was designed to have a 2-foot thick layer of phyllite stone protection over a large phyllite rock fill zone. During construction, a large area of the upstream slope's phyllite stone protection layer was replaced with gneiss stone protection (a more durable material). The gneiss stone protection was in good condition while the phyllite stone protection was in fair condition because most of the stones have weathered into much smaller sizes (photo E-2). However, there was no evidence of wave cut benches, movement or sloughing of the slopes caused by previous high impoundments. The team discovered several areas, which measured a few feet in diameter, where large rock coverage was minimal. These areas were mostly located about halfway up the slope and should be examined during future inspections for signs of erosion.

A substantial amount of vegetation was growing along the lower one-third of the slope and the right abutment (photo E-3). This condition was noted during the 1994 inspection. The project manager stated that woody stems are cut or pulled yearly.

(2) Downstream Slope. The downstream slope was generally in good condition and appeared to be stable (photo E-4). It was designed to have a 2-foot thick riprap layer underlain by a 1-foot thick gravel bedding layer and impervious fill zone. The stone protection surface is composed entirely of phyllite rock, which is in fair condition (photo E-5). Many of the smaller pieces of rock on the slope were very friable; however, there was no evidence of erosion of fines. The team discovered several areas, which measured a few feet in diameter, where the thickness of the larger rock coverage was much less than 2 feet. These areas were mostly located about halfway up the slope and should be examined during future periodic inspections for signs of erosion. About 60 feet upslope and on the right side, a drainage gully was identified. This gully showed no signs of erosion of fines but should be examined for signs of erosion during future inspections. A minor depression was also noticed about one-third of the way upslope and located near piezometer No. 8 on the right abutment. The depression is not a concern but should be examined during future inspections.

The slope had small-sized vegetation on a large part of its area. The project manager stated that this vegetation is removed annually.

Drainage at the downstream toe is provided by a rock fill toe, which extends from approximately station 17+80 to station 21+90. The top of this rockfill zone is at elevation 422 feet NGVD. There were no signs of sinkholes or piping in this area. On the left side of the downstream toe, medium-sized vegetation and small trees were noted that should be removed as soon as possible because of its potential for interference with monitoring for piping and boils during high water events. A fifteen-foot swath along the toe should be cleared.

(3) Crest Road. The crest road has a crushed stone surface from the spillway to the service bridge. This section of the crest road was in good condition. From the service bridge to the right abutment, the crest road has a bituminous concrete surface, which was in good condition (photo E-6).

As previously noted, there were no cables attached to the guard posts on this dam, which poses a safety hazard. However, unauthorized vehicles are not allowed on the dam.

(4) Abutments. The abutments appear to be in good condition. Vegetation is encroaching along the embankment/abutment interface and should continue to be removed as part of normal maintenance.

(5) Seepage. A small seep, which is located approximately 75 feet south of the intake tower and immediately above the service road drainage ditch, was previously reported in the 1994 inspection. During the 1994 inspection, the seep covered a circular area that was approximately one and one-half feet in diameter. No evidence was found of the reported seep during this inspection.

No unusual seepage conditions were observed during the inspection or reported by project personnel since the last periodic inspection.

(6) Service Bridge to Intake Tower. The service bridge is supported by a concrete abutment on the east end, three concrete piers along the east one-half, and a concrete intake tower on the west end. The abutment and piers are founded on in-situ glacial till while the intake tower is founded on rock. The piers and intake tower showed no signs of distress and appeared to be stable. The distances from the west side of the abutment parapet wall and the east end of the west girders were measured. Record drawing CT-1-5251 shows a 3-inch distance. A record of the distances measured to date is shown below. These distances should be checked and recorded during future periodic inspections (see sketch 1 at the end of this section).

DATE	TEMPERATURE (Degrees F.)	NORTH GIRDER (Inches)	SOUTH GIRDER (Inches)
19 Oct 1988	NA	3 top 3 bottom	2 ¾ top 2 ¾ bottom
2 Jun 1994	70	3 top 3 bottom	2 ¾ top 2 ¾ bottom
15 Jun 1999	75	2 5/8 bottom	2 5/8 bottom

b. DIKE EMBANKMENT AND ABUTMENTS

The embankment was in good condition and appeared to be stable (photo E-7). There was no indication of movement or sloughing of slopes. There was no evidence of settlement or subsidence cracks. The concrete guardrails along the crest were all well aligned, and its cables were in good condition.

(1) Upstream Slope. The upstream slope was generally in good condition and appeared to be stable (photo E-8). It was designed to have a 1-foot (lower portion) or 2-foot thick layer of stone protection layer underlain by 1-foot thick gravel layer and a miscellaneous fill core. The stone protection is in fair condition. Most of the stones have weathered into much smaller sizes. However, there is no evidence of wave cut benches, movement or sloughing of the slopes caused by previous high impoundments.

A small amount of herbaceous vegetation was found on the lower portion of the rock slope. This vegetation is only a minor concern.

(2) Downstream Slope. The grass cover on the downstream slope was in excellent condition. There was no evidence of sloughing or seepage on the downstream slope.

(3) Abutments. The abutments appeared to be in good condition. It was evident that project personnel had made a conscientious effort to clear the vegetation from the abutments.

(4) Stone Protection. The stone protection material types and condition are discussed in the upstream slope section above. Its gradation appears finer than originally specified due to weathering. However, it has performed well to date and appeared to be adequate at this time.

(5) Seepage Conditions. The team did not observe any unusual seepage conditions during the inspection. Project personnel have not reported any seepage problems since the last periodic inspection.

(6) Bituminous Concrete Pavement. An 18-foot wide paved access road extends from Clay Hill Road to the south abutment of the dam. The road was in fair to good condition. Cable-type guardrails have been installed at the edges of the road where it crosses the dike. The cables appeared to be in good condition.

(7) Conduit Through Dike Embankment. A 36-inch diameter reinforced concrete pipe was jacked through the dike embankment during construction as part of a job change. A gate tower with a hand-operated gate is located about midway on the upstream slope. The intake and outlet channels were clear of debris and vegetation (photo E-9). There is a pvc pipe through the 36-inch conduit which helps to drain the upstream pond through the beaver dam.

3. FLOOD CONTROL OUTLET WORKS

a. Inlet channel. The channel was clear and in satisfactory condition. Soil movements along the east slope above the service road (service road stations 10+00 to 17+00) sometimes choke the open cut drainage ditch at roadside in several places. The problem is minor but requires occasional excavation to keep the drainage ditch open.

b. Outlet Channel. The channel was in good condition (photo E-10). The rock slopes in phyllite around the hydroelectric project appeared stable, and there were no signs of significant failures developing. The soil banks were in satisfactory condition, and no major erosion was evident. A 12-foot diameter steel penstock was inserted inside the existing 14 foot - 4-inch concrete conduit during construction of the hydroelectric facility discussed above in the dam embankment and abutments section (photo E-11). Three drainpipes were placed through a concrete cradle at the end where the conduit emerges into the stilling basin. These drains consist of 8-inch half pipe sections that must be kept clear. At the time of inspection, these were clear and no water was observed flowing from them. Any evidence of water would indicate that the joints in the concrete conduit or steel penstock were leaking. Surface drains and ditches in the inspected area appeared to be functioning adequately.

c. Hydroelectric Project. A 4,000 kilowatt hydroelectric plant was put into service by Vermont Electric Cooperative (VEC) at North Hartland dam in July 1985. It includes a 1,275-foot long, 12-foot diameter steel penstock and downstream powerhouse and by-pass gatehouse structures. The power plant is a peaking facility that depends upon the

availability of water. However, VEC no longer operates the facility. Therefore, the bypass piping remains open. The inspected areas appeared neat and clear from obstructions at the time of inspection. No geotechnical related concerns were observed in the area.

4. SPILLWAY

a. Approach Channel. The approach area was clear of obstructions. However, brush and vegetation should be removed on a regular basis. The project manager states that the approach channel area is burned every other year to control vegetation. Some minor rockfalls from the phyllite slope have occurred and more rockfalls are likely. No significant failures appeared imminent at the time of inspection. The team found that the minor rockfalls (approximately 10 cubic yards), which were reported during the 1994 inspection, at the toe of the weir near the rock wall still remain. This area is now heavily vegetated (photo E-12). The vegetation and rock should be removed from this area because its presence could allow trespassers easy access to the top of the weir.

b. Discharge channel. The channel was mostly clear but there were areas with a small amount of standing water and grass in the lower reach (photo E-13). The concrete to rock interface appeared to be in good condition. The phyllite sidewalls of the channel were fractured in some places, but there were no signs of significant failures developing. Minor vegetation was observed in some of the weepholes while the rest appeared clear and functioning as intended.

c. Safety Fences. The safety fences along the spillway were in place and are in good condition.

5. PROJECT INSTRUMENTATION

Existing instrumentation consists of seven crest monuments, two strong motion accelerographs, and thirteen Casagrande-type piezometers.

All piezometers were sounded and appeared to be functioning normally.

The doors to the strong motion shelters are in good condition. Inspection of the interiors of the shelters showed no damage to instrumentation or electrical wiring. However, the plastic cover in shelter "A" has deteriorated and should be replaced. Shelter "B" contained wasp nests that should be removed. No repairs are currently needed.

A complete discussion of the instrumentation and an interpretation and evaluation of data is contained in the Instrumentation Appendix attached to this report.

6. RECOMMENDATIONS

a. Dam Safety Items. There are no dam safety items.

b. Normal Maintenance.

(1) The vegetation on both the upstream and downstream slopes and the small trees along the downstream toe should be removed by project personnel to avoid problems associated with seepage and access.

(2) The rockfalls adjacent to the spillway weir at the approach channel should be removed to prevent access to the top of the weir.

(3) The drainage ditch along the upstream service road near the tower should be kept clear of soil and vegetation.

(4) The plastic cover for the instrument in accelerograph shelter "A" should be replaced.

c. Contract Item. No contract items were identified.

SUPPLEMENT TO INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
MISCELLANEOUS GEOTECHNICAL FEATURES
DEWEY MILLS DAM

1. General. Based on visual inspection, the geotechnical portions of Dewey Mills Dam were in good condition. The dam is located at the headwaters of North Hartland Lake. The dam's purpose is to provide a storage pond for the Dewey Mills hydropower facility. The hydropower conversion project by Hydro Energies Corporation was completed in 1985.

The geotechnical portion of the inspection was performed by the following on 15 June 1999:

Laura Fraser, CENAE-EP-GG
Paul Young, CENAE-EP-GE
Philip Hollis, CENAE-EP-GG

2. Observations and Evaluations. The original dam is a masonry wall dam with a 10-foot concrete section on top of it. A concrete ogee weir is adjacent (photo E-14). The dam and weir are founded on bedrock. The condition of the dam was described as poor in the previous inspection reports.

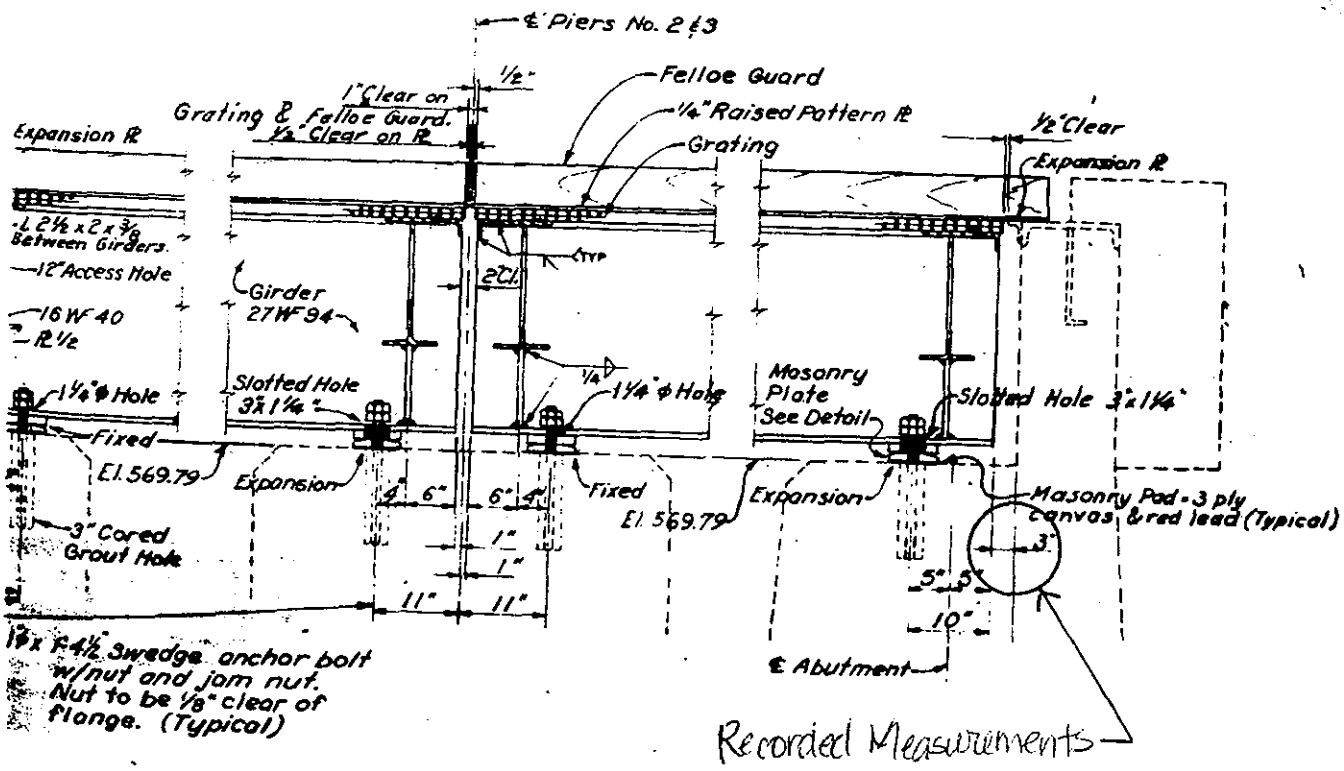
As part of the hydropower conversion, the dam was reinforced by a concrete anchored buttress. The gate structures have been converted to feed the penstocks. A powerhouse and tailrace were constructed downstream in the gorge. The transformer is located at the top of the gorge.

During the flood of April 1987, it was reported that the dam was considerably overtopped. There was 20 feet of water over the power house, which was submerged for 10 days. No damage to the structures was visible. Rock slopes appeared stable. However, these slopes are steep and overhang slightly in places and are generally overgrown. Rock/concrete contacts were in good condition. This is not detrimental to the integrity of the structure, but does obscure views of the surface structural condition. Vegetation was growing through the rockfill on the left bank just upstream of the dam (photo E-15). Root systems could eventually disrupt this layer.

3. Conclusions and Recommendations.

a. General. Based upon visual observation, all geotechnical features of the dam and hydropower structures appeared to be in good condition. No items of an urgent nature were found.

b. Maintenance Items. Hydro Energies Corporation should periodically remove plant growth from the dam and powerhouse vicinity to keep the concrete structure visible so that developing problems can be detected. Plant growth on rockfill should be periodically cleared to prevent root damage to the rockfill layer.



PIERS NO. 2 AND 3

ABUTMENT

GIRDER END DETAILS

Scale: 1" = 1'-0"

Elevation of the Girder / Abutment End

(NTS)

Note:
Measurements taken during the Periodic Inspection are shown in Appendix V-E of the report.

NORTH HARTLAND LAKE DAM

SERVICE BRIDGE MEASUREMENTS

JUNE 1999 SKETCH 1

APPENDIX VI

INTERMEDIATE TRIP REPORTS

PERIODIC INSPECTION REPORT
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

INTERMEDIATE TRIP REPORTS

There have been no intermediate trip reports since Periodic Inspection No. 5.

APPENDIX VII

INSTRUMENTATION DATA AND/OR PLOTS

INSTRUMENTATION APPENDIX TO PERIODIC INSPECTION REPORT NO. 6 NORTH HARTLAND DAM, VERMONT

by

Haley & Aldrich, Inc.
Boston, Massachusetts

for

Department of the Army
New England District

File No. 12126-009
February 2000

HALEY & ALDRICH

INSTRUMENTATION APPENDIX

TO PERIODIC INSPECTION REPORT NO. 6

NORTH HARTLAND LAKE DAM, VERMONT

Table of Contents

Paragraph	Subject	Page No.
1	Project Performance	1
2	General Project Description	1
	a. General	1
	b. Geology and Foundations	2
	(1) General	2
	(2) Topography	2
	(3) Geology	2
	(4) Dam and Outlet Works	2
	(5) Dike	2
	(6) Seismicity	3
	d. Dam and Appurtenant Structures	3
	(1) Dam	3
	(2) Outlet Works	3
	(3) Spillway	4
	(4) Dike	4
3	Instrumentation	5
	a. General	5
	b. Crest Monuments	5
	c. Piezometers	5
	d. Strong Motion Accelerographs	5
4	Data Collection, Interpretation and Evaluation	6
	a. Crest Monuments	6
	(1) Data Collection	6
	(2) Interpretation and Evaluation	6
	b. Piezometers	7
	(1) Data Collection	7
	(2) Interpretation and Evaluation	7

	c. Strong Motion Accelerographs	16
	(1) Data Collection	16
	(2) Interpretation and Evaluation	16
5	Conclusions and Recommendations	16
	a. General	16
	b. Crest Monuments	16
	(1) Schedule	16
	(2) Evaluation of Adequacy	17
	c. Piezometers	17
	(1) Reading Schedule	17
	(2) Evaluation of Adequacy	17
	d. Strong Motion Accelerographs	17
	(1) General	17
	(2) Reading Schedule	17
	(3) Evaluation of Adequacy	17

INSTRUMENTATION APPENDIX

TO PERIODIC INSPECTION REPORT NO. 6

NORTH HARTLAND DAM, VERMONT

List of Tables

Table No.	Description
1	Piezometer Summary
2	Piezometer Water Elevations

List of Figures

Figure No.	Title
1	Project Locus
2	Record Drawing, General Plan
3	Record Drawing, Dam Embankment, Spillway and Outlet Works – Plan
4	Record Drawing, Dam Embankment – Typical Sections
5	Record Drawing, Dike and Access Road
6	Instrumentation Plan
7	General Legend and Notes
8	Engineering Logs, Piezometer Explorations
9	Engineering Logs, Piezometer Explorations
10	Engineering Log Section, Station 19+50
11	Engineering Log Section, Station 21+00
12	Crest Survey Monuments - General Layout, Location and Survey
13	Crest Survey Monuments – Horizontal & Vertical Movement
14	Settlement vs. Time, Crest Monuments
15	Time History Plots, Sta. 19+50, PZ 1A, 1B, and 2A

List of Figures (con't)

16	Time History Plots, Sta. 19+50, PZ 3, 4 and 9
17	Time History Plots, Sta. 21+00, PZ 5A, 5B, and 6A
18	Time History Plots, Sta. 21+00, PZ 7 and 8
19	April 1994 Event, Sta. 19+50, PZ 1A, 1B, 2A, 3, 4, and 9
20	April 1994 Event, Sta. 21+00, PZ 5A, 5B, 6A, 7, and 8
21	April 1998 Event, Sta. 19+50, PZ 1A, 1B, 2A, 3, 4, and 9
22	April 1998 Event, Sta. 21+00, PZ 5A, 5B, 6A, 7, and 8
23	Piezometer Elevation vs. Pool Elevation, PZ-1A
24	Piezometer Elevation vs. Pool Elevation, PZ-1B
25	Piezometer Elevation vs. Pool Elevation, PZ-2A
26	Piezometer Elevation vs. Pool Elevation, PZ-3
27	Piezometer Elevation vs. Pool Elevation, PZ-4
28	Piezometer Elevation vs. Pool Elevation, PZ-5A
29	Piezometer Elevation vs. Pool Elevation, PZ-5B
30	Piezometer Elevation vs. Pool Elevation, PZ-6A
31	Piezometer Elevation vs. Pool Elevation, PZ-7
32	Piezometer Elevation vs. Pool Elevation, PZ-8
33	Piezometer Elevation vs. Pool Elevation, PZ-9
34	Piezometer Levels, Station 19+50, PZ 1A, 1B, 2A, 2B, 3 and 4
35	Piezometer Levels, Sta. 21+00, PZ 5A, 5B, 6A, 6B, 7, and 8
36	Phreatic Surface Plan

List of Appendices

Appendix	Title
A	Monitoring Schedules

INSTRUMENTATION APPENDIX

TO PERODIC INSPECTION REPORT NO. 6

NORTH HARTLAND DAM, VERMONT

1. PROJECT PERFORMANCE

Based on visual observation and instrumentation data compiled to date, the dam performance is rated as good. The computed crest monument data shows vertical movements between 0.84 in. of heave to 0.5 in. of settlement from 1984 to 1998. Horizontal movement of the crest of the dam ranged from 0.9 to 2.2 in. between 1987 to 1998.

Based on the data collected to date, all of the piezometers appear to be functioning correctly. They respond to fluctuations in pool level and seem representative of the ground water in their area. At normal pool level the head loss is 34 feet, while during the flood of 1998, the head loss was approximately 104 feet. For both events the piezometric levels decrease from the upstream side of the dam towards the downstream toe, with most of the head loss occurring at the internal chimney drain. The instrumentation evaluation is based on the piezometric readings from January 3, 1994 through December 1, 1998.

Since their installation in 1978, the strong motion accelerographs at North Hartland Dam have experienced five significant earthquakes and were activated once in 1982 by the Gaza, NH earthquake. The records from this event showed a maximum acceleration of 0.06g. The present schedule for reading all strong motion accelerographs at North Hartland Dam is once per month and should be maintained.

2. GENERAL PROJECT DESCRIPTION

a. General

North Hartland Lake is one of a system of seven dams and reservoirs which have been constructed in the Upper Connecticut River Basin for flood control. The operation of the seven dams is coordinated to reduce flood stages in the densely populated downstream areas of Vermont, Massachusetts, and Connecticut. The project location is shown on Figure 1. The dam is located approximately 1.2 miles northwest of North Hartland, Vermont. It is on the westerly flowing Ottaquechee River, approximately 1.3 miles from its confluence with the southerly flowing Connecticut River.

Construction of the project began in June 1958 and was completed by June 1961. Pertinent construction drawings are shown on Figures 2 through 5. The dam is 1,640 feet long and has a maximum height of 185 feet. The top of the dam, normal pool and inlet elevations are 572, 425, and 390 feet, respectively. The reservoir has a total drainage area of 222 square miles.

All elevations provided are referenced to the National Geodetic Vertical Datum (1929).

b. Geology and Foundations

(1) General

Geology information for the site prior to construction of the dam and appurtenances can be found in previous instrumentation reports. Geologic information collected after construction is provided on Figures 7 and 11.

(2) Topography

The regional topography is maturely dissected. It is characterized by wooded, steep-sided hills and irregularly crested ridges that rise abruptly from relatively narrow valleys. The maximum relief in the vicinity of the dam site is approximately 1,000 feet. Numerous bedrock outcrops project through thin layers of glacial till and residual soil on the tops and upper slopes of the hills. The remnants of terraces produced during downcutting by the rivers are found along the valley walls. Thick deposits of glacial till usually overlain by sand and gravel outwash or by lake silts and clays are found in the valleys. Most of the rivers, including the Connecticut, are still in the process of downcutting and presently flow in beds above the bottoms of the preglacial valleys. A few of the rivers, of which the Ottauquechee is one, have cut through the thin layers of glacial material and have cut substantial gorges in the underlying bedrock.

(3) Geology

North Hartland Lake is part of the New England Upland, a geologic province in which the rock is composed of highly metamorphosed sediments and post-folding igneous intrusives varying in age from Ordovician to Mississippian. The underlying bedrock is a finely laminated interbedded phyllite and sericitic schist of probable Devonian age. It is part of a thick accumulation of feldspathic sandstone and calcereous shale that was deposited in a broad geosynclinal basin and metamorphosed during a vigorous post-depositional disturbance into the present phyllite and schist. Erosive forces and continental glaciation that produced the existing physiographic features have altered the region. Faults of major proportion transect the area approximately one mile downstream from the dam site.

(4) Dam and Outlet Works

The overburden at the left abutment below El. 575 is primarily outwash deposits consisting of sands and silts. The outwash deposits are stratified and vary in depth from 5 to 60 feet. Previous instrumentation reports indicate that some of the silt and fine sand strata/lenses are wet, concluding that that the water table is high along the left abutment. The material is moderately compact. Glacial till lenses exist in isolated areas under the sands and silts. Above El. 575, the bedrock is covered with one to five feet of slope wash.

The overburden at the right abutment is glacial till. It varies in depth from 7 to 65 feet near the dam axis and increases in depth significantly upstream of the dam. A 5 to 10 foot thick layer of fine sand overlies the glacial till in the vicinity of the dam axis.

(5) Dike

The dike is on the edge of an ancient river channel, which is now filled with glac sediments. The upper portion of the sediments is soft cohesionless silt that varies in depth

from 33 feet to 92 feet. The silt is underlain with glacial till which extended to 122 feet of depth in the deepest hole drilled in the area.

(6) Seismicity

North Hartland Lake is located in seismic zone 2 that has a seismic coefficient of 0.10g. Seismic activity has taken place in adjacent regions of New England but no records of earthquakes occurring in the dam site area have been found.

c. Dam and Appurtenant Structures

(1) Dam

The embankment of North Hartland Dam is comprised of rolled earth and dumped rockfill, having a total length of 1,640 feet and a maximum height of 185 feet above the streambed. Record drawings of the dam are shown on Figures 3 and 4. The embankment section is primarily impervious fill, but contains an inclined pervious chimney drain in the upstream portion of the impervious fill. Three pervious drainage layers in the downstream portion of the impervious fill also exist, of which two are positioned within the embankment. The third, a blanket drain, is 3 ft. thick and located on the foundation, intersecting the chimney drain and the downstream toe. There is an upstream rockfill zone varying in thickness from 8 to 60 feet and a two foot thick stone protection layer on the downstream slope. The outer upstream slope varies from 1V on 2H to 1V on 2.5H. The downstream slope is 1V on 2H.

The embankment is founded partially on bedrock and partially on a thin layer of overburden. The soil portion of the foundation is in the right abutment and consists of a glacial till deposit. The glacial till deposit varies in thickness from 5 to 65 feet and is composed of gravelly silty sand. The surface of the bedrock against which embankment fill was placed was generally rolling and smooth but with deep depressions. Some areas contained highly irregular and jagged rock.

Materials for the dam embankment were obtained from the required rock excavations for the spillway, government designated borrow areas, and from contractor-furnished sources. The impervious fill was obtained from a borrow area located on the right abutment immediately upstream of the dam site, and consisted of a micaceous gravelly silty sand (glacial till). Pervious-fill material and gravel bedding were obtained from a source about one-half mile downstream from the dam site, and consisted of non-plastic sand, gravelly sand, and sandy gravel containing less than five percent fines. Rock from the required excavations was generally flat and elongated, and tended to break down during handling and stockpiling. A better quality rock for use on an area of the upstream slope in the vicinity of the intake tower was obtained from a quarry located about 1.5 miles south of the dam site.

(2) Outlet Works

The outlet works consist of an intake channel and structure, a conduit, an outlet structure and an outlet channel. They are shown in plan and section on Figures 3 and 4 before they were modified to produce hydroelectric power. The reinforced concrete intake structure, conduit and outlet structure are founded on bedrock. A grout curtain or seepage control was not provided for the outlet works. Previous instrumentation reports indicate that designers considered a prevailing strike of the rock structure normal to the outlet works as being an effective seepage control.

The intake channel is an unlined rock and earth cut that is about 610 feet long, 37 feet wide and has an invert elevation of 390. Two rock lined slopes at the downstream end of the inlet channel guide water into the intake structure.

The concrete intake structure consists of a U-shaped concrete intake apron, an intake tower and an outlet conduit transition. It is 191 feet long. The intake tower houses the necessary equipment to operate three 5.7 by 10-foot slide gates with hydraulic hoists. The gates regulate the discharge through the outlet conduit.

The outlet conduit is 551.5 feet long having a diameter of 14.3 feet. It has an entrance invert elevation of 390 and an exit invert elevation of 348.48. The conduit directs flow to a U-shaped concrete apron, which functions as the dam's outlet structure. The outlet structure is 100 feet long and varies in width from 14.3 to 25 feet. The outlet channel is an unlined rock cut that is about 600 feet long and 25 feet. Its bottom slopes downstream approximately 0.5 percent to junction with the original river channel.

Hydropower was added to North Hartland Dam by Vermont Electric Generator and Transmission Cooperative. A 12-foot diameter circular steel penstock was constructed inside the existing 14.3 foot outlet conduit. The steel penstock passes both hydropower flow and flood discharge. A branch in the conduit divides flows between hydropower station and flood control discharges. The flood control conduit has a bypass valve at the end, which is normally closed. The hydropower pool averages about El. 425.

(3) Spillway

The spillway is located on the left abutment of the dam. It is an L-shaped channel that was cut into rock and lined with concrete for approximately 550 feet. The approach channel floor is unexcavated and is at El. 536. The ogee-shaped crest is 465 feet long and is at El. 546.5. The unlined discharge channel is 50 feet wide and approximately 1,400 feet long. It's bottom slopes vary from 0.5 to 8 percent as it descends to the original river channel. A single line grout curtain runs along the toe of the spillway weir and extends to the centerline of the dam. All concrete linings and spillway weir sections are anchored and drained.

(4) Dike

The dike is a low, homogeneous, rolled earthfill structure. Its proximity to the dam can be seen on Figure 2. One foot of gravel bedding and two feet of riprap protect the upstream face. A seeded topsoil blanket protects the downstream face. The upstream and downstream slopes vary from 1H on 6V to 1H on 3V. The embankment is founded upon a thick, soft silt deposit overlying a thin layer of glacial till. The silt is moderately stratified with thin layers of fine sand and clay.

Materials for the dike embankment were obtained from the required earth excavations for the spillway and dam. The earthfill materials included sandy silts, silty sands, and gravelly silty sands. Rock was obtained from the required rock excavation for the spillway, and gravel bedding was obtained from a source about 0.5 miles downstream from the dam site.

3. INSTRUMENTATION

a. General

During construction of the North Hartland facility, instrumentation was installed to monitor movements and water levels within the dam and dike. Instrumentation consisted of 24 slope monuments, 3 settlement gages and 20 piezometers. The slope monuments and settlement gages have not been read since construction of the facility and are not addressed in this instrumentation report. The piezometers are no longer operable; however, locations for 12 of the piezometers are shown on Figure 6. Additional information about the construction phase instrumentation program is available in the original contract drawings and from previous instrumentation reports for North Hartland Dam.

Instrumentation to monitor embankment performance since construction of the North Hartland Dam consists of seven crest survey monuments, thirteen piezometers (four double and five single), and two strong motion accelerographs. The location plan of the instrumentation is shown on Figure 6.

b. Crest Monuments

Seven crest monuments (Mon 1 to Mon 7) and two control points (B and C) were installed at North Hartland Dam in 1984 at the locations shown on Figure 6. The crest monuments are located along the downstream crest of the dam. The control points were installed in the overburden to the east of the downstream end of the spillway channel. The crest monuments and control points consist of a 4-inch sonotube that has been filled with concrete. A standard brass disk has been set in the top of each control point and crest monument. The seven crest monuments were installed to measure vertical and horizontal movement of the dam's crest.

Four surveys of the crest monuments have been performed, most recently in March 1998. Surveys were performed with an electronic distance meter (EDM), based on angles and distances, and tied to the state coordinate system. The results of the surveys are presented on Figures 12 through 14. For reference, the current standards and procedures employed by the Corps of Engineers surveyors for crest monument surveys at North Hartland Dam are contained in Appendix A.

c. Piezometers

A total of thirteen piezometers were installed in 1989 and 1992 at North Hartland Dam at the locations shown on Figure 6. The piezometers were installed using drive and wash drilling methods. They have Casagrande type tips and ¾-inch diameter PVC riser pipes. Water levels in the piezometers are measured with an electronic water level indicator.

The test boring and piezometer logs for the piezometers installed in 1989 and 1992 are presented on Figures 8 and 9. Table 1 presents a summary of these piezometers, including elevations for the riser pipes and piezometer tips.

d. Strong Motion Accelerographs

Two SMA-1 strong motion accelerographs were installed at North Hartland Dam in 1978. The SMA-1 accelerograph is a compact, portable, self-contained unit with an accelerometer for measuring accelerations in three orthogonal directions. The units are activated

automatically by a trigger sensitive to vertical accelerations of 0.01g. They are housed in concrete shelters located on the left abutment (Shelter A) and at the downstream crest of the embankment just outside the guardrail at Station 20+00 (Shelter B) as shown on Figu They were installed to monitor earthquake ground motions at the dam.

4. DATA COLLECTION, INTERPRETATION and EVALUATION

a. Crest Monuments

(1) Data Collection

Survey data, including coordinates and elevations of the crest monuments for the four surveys completed between 1984 and 1998, are tabulated on Figure 12. The surveys were performed by New England Division (NED) surveyors in October 1984, August 1987, January 1992 and most recently in March 1998. Horizontal measurements were only made in 1987, 1992 and 1998. For reference, distances between control points and crest monuments for the survey performed in 1998 are also shown on Figure 12 along with the locations and elevations of the control points.

The work was done using electronic distance measuring equipment (EDM) and in accordance with the procedures outlined in Appendix A. The crest monument coordinates were calculated using a combination of trilateration and triangulation. The accuracy of the surveys is considered to be third order, class I (1:10000) for vertical measurements and third order, class II (1:5000) for horizontal measurements. For the range of distances surveyed and considering propagation of error through the computations, this level of accuracy translates to a tolerance of ± 0.20 to ± 0.37 ft. in the computed movement of the crest monuments.

(2) Interpretation and Evaluation

The elevation surveys indicate that the total settlement of all monuments was limited to less than 0.04 ft (0.5 in.) over this fourteen-year period. A crest settlement profile is shown on Figure 13. The observed cumulative vertical movements of the crest monuments from 1984 to 1998 varied between 0.84 inches of heave to 0.5 inches of settlement. As indicated in the previous instrumentation report (Report No. 5), from 1984 to 1987 there was an upward trend in the movements and now, from 1987 to 1998, there is a general downward trend in the movements. That is, with the exception of Monument 1, all of the monuments have settled since 1987. This pattern may reflect the thickness of the embankment fill. The monuments located above the areas with the largest amount of fill, monuments 2 through 5, show the most settlement. Monuments on or near the abutments, monuments 1 and 6, show less settlement, with Monument 1 actually showing heave. The maximum differential settlement between the center of the embankment and the abutment is approximately 1.3 in.

A representative plot of settlement versus time shows a general linear time-settlement behavior for the data from 1987 to 1998, as shown in Figure 14. A comparison to the readings collected in 1992 indicates that in general the rate of settlement has decreased. With the exception of Monument 1, the monuments have settled less than 0.25 in. since 1992. Monument 1 shows 0.5 in. of upward movement since 1992, possibly due to local disturbance of the monument.

The observed horizontal movements of the crest monuments from 1987 to 1998 varied between 0.9 and 2.2 inches, with movements as shown on Figure 13. Since the 1992 survey, the crest monuments have moved horizontally between 0.2 and 0.8 in. Similar to the previous instrumentation report (Report No. 5), the horizontal movements tend to be in a north to northeast direction and fairly consistent in magnitude. Monuments 1 through 3 generally show movements in the northern direction, with slightly greater magnitudes than Monuments 4 through 7. Since the loads on the dam during high pools occur near the center of the embankment, Sta. 19 +00 to Sta. 21 +00, and in a southwest direction, it appears that most of the observed movements may be due to survey error.

The data that have been acquired to date indicate that there has been little vertical and horizontal movement within the embankment. A settlement pattern reflecting the amount of fill placed along the embankment centerline has developed and the rate of settlement appears to be linear with time. Horizontal movements appear to be consistent with those previously reported. In addition, both the cumulative vertical and horizontal movements are within the accuracy range of the survey. Therefore, the magnitudes of the movements are considered negligible.

b. Piezometers

(1) Data Collection

(a) General

The water levels in the operable piezometers are measured manually by project personnel using an electronic water-measuring device.

(b) Schedule

Project personnel measure the water levels in the active piezometers once a month during normal dam operation (pool level between El. 424 and 426). When access to the instruments is hazardous due to snow or ice, the measurements are deferred until safe access is possible. During rising and falling reservoir levels greater than El. 435, the measurements are made once a day. After a pool has receded to El. 426, the measurements are continued for five additional days. Project personnel contact Geotechnical Engineering Division when unusual water level measurements occur or a piezometer becomes inoperable.

Readings obtained from the piezometers are presented in Table II. Pertinent information includes the date of reading, pool stage and elevation, and piezometer water elevations.

(2) Interpretation and Evaluation

(a) Data Presentation

Numerous plots have been developed to present the piezometric data. The piezometer plots fall into three categories: time-history, event and "x-y" plots.

Time-history plots were developed for years 19940-1998 and are presented on Figures 15 through 18. Event plots were produced for the rising pools of both April 1994 and April 1998 and are shown on Figures 19 through 22. A series of x-y plots of piezometer water level elevation vs. pool elevation were developed for each piezometer and are shown on

Figures 23 through 33. These plots incorporate piezometric data from January 3, 1994 through December 1, 1998 and include a projection of the piezometer level corresponding to a pool elevation at the spillway crest. This projection was calculated by linearly regressing the piezometer data provided and plotting the best-fit line.

The "average" water level in each piezometer was calculated using water levels obtained when the pool was close to the normal pool level. For example, for the normal pool of El. 425, piezometric water levels corresponding to a pool level range of El. 424 to El. 426 were used to calculate the average water level for each piezometer. All piezometric data, including static, rising and falling readings obtained when the pool was between El. 424 and El. 426 were used to calculate the "average" piezometric water level. It should be noted that in some cases these "average" piezometric water levels were calculated based on a very limited set of data and were used to create a basis for a comparison to the high pool data of April 1994 and/or April 1998.

(b) Individual Piezometers

(1) PZ-1A

Piezometer 1A is the deeper of the two piezometers installed in borehole FD-92-3. The top of the riser pipe (El. 518.2) for piezometer 1A is located at Station 19+50, on the upstream slope of the dam. The tip of the piezometer is located beneath the impervious fill section of the dam in bedrock at El. 390.8.

The water levels in piezometer 1A have varied between El. 417.6 and 429.8 during normal dam operation (pool El. 424 to 426), averaging El. 421.8 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 15. The measured water levels in PZ-1A appear to respond in a linear manner to changes in pool elevation as shown in Figure 23. Based on a linear projection, the water level in the piezometer should rise to El. 473.2 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood event of April 1998, daily readings were taken when access to the piezometer was possible. Due to the limited data collected during the April 1998 flood event for this piezometer, the April 1994 event is included in the following discussion. The data from both events is presented on Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. PZ-1A shows a response time of 1 to 3 days to a rising pool. During the 1994 event, the water level in the piezometer rose nearly 17 ft from its average level to a maximum level of El. 438.8 on 18 April. For the 1998 event, it appears that the water level rose approximately 27 ft. to El. 448.75. However, several days of data are missing during this event due to inaccessibility. A higher water level and a quicker response to the 1998 event may have been recorded had the piezometer been accessible.

Previous instrumentation reports for North Hartland Dam stated that water levels for piezometers 1A and 1B were sometimes inadvertently reversed. A review of the current data (1994 to 1998) indicates that the piezometers appear to be operating appropriately and measurements from each have been collected properly by Project personnel. Under certain events, such as the 1994 and 1998 flood events, piezometer 1A recorded higher piezometric levels than its upper counterpart, PZ-1B. This pattern is deemed acceptable considering that

PZ-1A is located within the bedrock and PZ-1B is within the impervious core. A piezometer positioned in the upper surface of the typically weathered or jointed bedrock foundation may experience higher piezometric levels than an upper piezometer located within the impervious fill of the embankment. In this case, it appears that the water levels in the upper piezometer are controlled by the seepage pattern caused by the internal chimney drain.

(2) PZ-1B

Piezometer 1B is the shallower of two piezometers installed in borehole FD-92-3. The top of the riser pipe (El. 518.3) for piezometer 1B is located at Station 19+50, on the upstream slope of the dam. The tip of the piezometer is located in the impervious fill section of the dam at El. 423.8. The boring log indicates that the impervious core material at PZ-1B consists of silty sand with gravel.

The water levels in PZ-1B have varied between El. 424.7 and 430.8 during normal dam operation (pool El. 424 to 426), averaging El. 426.4 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 15. The measured water levels in PZ-1B appear to respond in a linear manner to changes in pool elevation as shown in Figure 24. Based on a linear projection, the water level in the piezometer should rise about 11 ft from its average height to El. 437.1 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood event of April 1998, daily readings were taken when access to the piezometer was possible. Due to the limited data collected during the April 1998 flood event for this piezometer, the April 1994 event is included in the following discussion. The data from both events is presented on Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. Piezometer 1B shows a response time of 1 to 3 days to a rising pool. During the 1994 event, the water level in the piezometer rose nearly 4 ft from its average level to a maximum level of El. 429.6 on 18 April. For the 1998 event, it appears that the water level rose approximately 8 ft. to El. 434.6. As with PZ-1A, several days of data are missing during this event due to inaccessibility. A higher water level and a quicker response to the 1998 event may have been recorded had the piezometer been accessible.

A review of the water levels recorded for PZ-1B indicates that it is functioning properly. The measured water levels in PZ-1B are typically higher than other piezometers because it is furthest upstream. The chimney drain near the center of the embankment appears to be lowering the phreatic surface, as seen from PZ-1B and subsequent downstream piezometers.

(3) PZ-2A

Piezometer 2A is the deeper of two piezometer installed in borehole FD-89-4. The top of the riser pipe (El. 574.2) for piezometer 2A is located at Station 19+50, at the downstream edge of the crest of the dam. The tip of the piezometer is located in the bedrock foundation of the dam at El. 387.8.

The water levels in PZ-2A have varied between El. 406.3 and 416.7 during normal dam operation (pool El. 424 to 426), averaging El. 411.4 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 15. The measured water levels in PZ-2A appear

to respond in a linear manner to changes in pool elevation as shown in Figure 25. Based on a linear projection, the water level in the piezometer should rise about 6 ft from its average height to El. 417.6 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood events of April 1994 and April 1998, daily readings of PZ-2A were taken. The data from both events is presented on Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Review of Figures 19 and 21, indicates that PZ-2A showed very little response to a raising and lowering pool level during both events. When compared to average pool levels, the following performance was noted. During the 1994 event, the water level in the piezometer rose approximately 3 ft from its average level to a maximum level of El. 414.6 on 19 April. For the 1998 event, it appears that the water level rose approximately 7 ft. to El. 418.2 on 9 April. Note that the recorded 1998 event level (El. 418.2) slightly exceeds the projected flood level (El. 417.6) for this piezometer. This difference may have resulted from an error in the field measurement or the effects of data scatter on the accuracy of the projected levels during the flood stage.

The water levels in PZ-2A are much lower than piezometer 1A and 5A, which are also in bedrock but approximately 150 feet upstream. Although placed in rock, the piezometric levels in PZ-2A are controlled by the horizontal drain. As expected, the pressure head beneath the embankment is dropping in the downstream direction.

(4) PZ-2B

Piezometer 2B is the shallower of two piezometer installed in borehole FD-89-4. The top of the riser pipe (El. 574.1) for piezometer 2B is located at Station 19+50, at the downstream edge of the crest of the dam. The tip of the piezometer is located in the impervious section of the dam at El. 414.8. The boring log indicates that the impervious core consists of silty sand with gravel.

Piezometer 2B has been dry since it was installed. A falling head test was performed immediately after piezometer installation and shows the piezometer to be working properly. It is apparent that the internal chimney and horizontal drains significantly lower than the phreatic surface though the embankment.

(5) PZ-3

Piezometer 3 was the only piezometer installed in borehole FD-92-4. The top of the riser pipe (El. 485.7) for piezometer 3 is located at Station 19+50, on the downstream slope of the dam. The tip of the piezometer is located within the foundation bedrock at El. 386.5.

The water levels measured in PZ-3 were typically a few feet above the original ground surface. The water levels in PZ-3 have varied between El. 397.6 and 401.1 during normal dam operation (pool El. 424 to 426), averaging El. 399.4 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 16. The measured water levels in PZ-3 appear to respond in a linear manner to changes in pool elevation as shown in Figure 26. Based on a linear projection, the water level in the piezometer should rise about 3 ft from its average height to El. 403 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood event of April 1998, daily readings were taken when access to the piezometer was possible. Due to the limited data collected during the April 1998 flood event for this piezometer, the April 1994 event is included in the following discussion. The data from both events is presented on Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. During the 1994 event, the water level in the piezometer rose nearly 1 ft from its average level to a maximum level of El. 400.6 on 19 April. For the 1998 event, it appears that the water level rose approximately 2 ft. to El. 401.2. As with PZ-1A, several days of data are missing during this event due to inaccessibility. A higher water level and a quicker response to the 1998 event may have been recorded had the piezometer been accessible.

Although located in bedrock, the piezometric level PZ-3 is controlled by the horizontal drainage layer. Thus, PZ-3 does not seem to be significantly affected by rising and falling pools, showing little response during both flood events. The water levels in PZ-3 are generally lower than upstream piezometers, confirming that the piezometric head beneath the embankment is dropping in response to the drainage layer.

(6) PZ-4

Piezometer 4 was the only piezometer installed in borehole FD-89-2. The top of the riser pipe (El. 400.8) for piezometer 4 is located at Station 19+50, slightly beyond the downstream toe of the dam. The tip of the piezometer is located in weathered shale at El. 383.8.

Similar to the previous instrumentation report (Report No. 5), the water levels measured in PZ-4 are slightly above the original ground surface. The water levels in PZ-4 have varied between El. 390.8 and 391.4 during normal dam operation (pool El. 424 to 426), averaging El. 391 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 16. The measured water levels in PZ-4 appear to respond in a linear manner to changes in pool elevation as shown in Figure 27. Based on a linear projection, the water level in the piezometer should rise about 1 ft from its average height to El. 392.1 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood events of April 1994 and April 1998, daily readings of PZ-4 were taken. The data from both events is presented on Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. During the 1994 event, the water level in the piezometer rose approximately 0.6 ft from its average level to a maximum level of El. 391.6 on 17 April. For the 1998 event, it appears that the water level rose only 0.3 ft. to El. 391.3 on 9 April.

Piezometer 4 does not seem to be significantly affected by rising and falling pools, showing very little response during both flood events. The piezometric level in PZ-4 is controlled by the downstream rock fill toe drain.

(7) PZ-5A

Piezometer 5A is the deeper of two piezometers installed in borehole FD-92-1. The top of the riser pipe (El. 516.8) for piezometer 5A is located at Station 21+00, on the upstream

slope of the dam. The tip of the piezometer is located beneath the impervious fill section c the dam in rock at El. 383.6.

The water levels in piezometer 5A have varied between El. 412.9 and 420.4 during norm.. dam operation (pool El. 424 to 426), averaging El. 415.3 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 17. The measured water levels in PZ-5A appea: to respond in a linear manner to changes in pool elevation as shown in Figure 28. Based on : linear projection, the water level in the piezometer should rise to El. 463.6 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood event of April 1998, daily readings wer taken when access to the piezometer was possible. Due to the limited data collected during the April 1998 flood event for this piezometer, the April 1994 event is included in the following discussion. The data from both events is presented on Figures 20 and 22. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. PZ-5A shows a response time of 1 to 3 days to a rising pool. Durin the 1994 event, the water level in the piezometer rose nearly 17 ft from its average level to a maximum level of El. 432.1 on 17 April, coincident with the date of maximum pool. For th 1998 event, it appears that the water level rose approximately 23 ft. to El. 438.3. However, several days of data are missing during this event due to inaccessibility. A higher water leve and a quicker response to the 1998 event may have been recorded had the piezometer been accessible.

Under certain events, PZ-5A recorded higher piezometric levels than its upper counterpar PZ-5B. This pattern is deemed acceptable considering that PZ-5A is located within th bedrock and PZ-5B is within the impervious core. A piezometer positioned in the uppe surface of the typically weathered or jointed bedrock foundation may experience highe piezometric levels than an upper piezometer located within the impervious fill of th embankment. In this case, it appears that the water levels in the upper piezometer ar controlled by the seepage pattern caused by the internal chimney drain.

(8) PZ-5B

Piezometer 5B is the shallower of two piezometers installed in borehole FD-92-1. The top c the riser pipe (El. 516.8) for piezometer 5B is located at Station 21+00, on the upstrear slope of the dam. The tip of the piezometer is located in the impervious fill section of th dam at El. 422.6. The boring log indicates that the impervious core material at piezometer 5 consists of silty sand.

Piezometer 5B provided very few readings during this monitoring period. Only five actual water levels were recorded over the recent 4-year monitoring period. These levels were recorded in May 1994, May 1996 and in both April and June of 1998. Field measurements during the remaining months indicated that the piezometer was either dry or inaccessible. A falling head test was performed immediately after piezometer installation and shows the piezometer to be working properly.

Utilizing the limited data, the average water level is approximately El. 424.2 for normal po levels ranging from El. 424 to 426. Based on a linear projection of the five readings, the water level in the piezometer should rise to only El. 424.5 when the pool reaches the spillwa

crest, as shown on Figure 29. The piezometer was dry or inaccessible during the flood events of 1994 and 1998.

A review of data collected from PZ-5B indicates that the dam's chimney drain significantly lowers water levels through the embankment.

(9) PZ-6A

Piezometer 6A is the deeper of two piezometer installed in borehole FD-89-5. The top of the riser pipe (El. 573.7) for piezometer 6A is located at station 21+00, at the downstream edge of the crest of the dam. The tip of the piezometer is located in the bedrock foundation of the dam at El. 389.9.

The water levels in PZ-6A have varied between El. 404.9 and 413.9 during normal dam operation (pool El. 424 to 426), averaging El. 409.2 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 17. The measured water levels in PZ-6A appear to respond in a linear manner to changes in pool elevation as shown in Figure 30. Based on a linear projection, the water level in the piezometer should rise about 7 ft from its average height to El. 416.1 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood events of April 1994 and April 1998, daily readings of PZ-6A were taken. The data from both events is presented on Figures 20 and 22. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Review of Figures 20 and 22, indicates that PZ-6A showed very little response to a raising and lowering pool level during both events. When compared to average pool levels, the following performance was noted. During the 1994 event, the water level in the piezometer rose approximately 4 ft from its average level to a maximum level of El. 413.2 on 19 April. For the 1998 event, it appears that the water level rose approximately 6 ft. to El. 414.8 on 9 April.

The water levels during normal pools and flood events for PZ-6A are very similar to those gathered for PZ-2A. As with PZ-2A, the water levels in PZ-6A are controlled by the horizontal drainage layer. Thus, as expected, the pressure head beneath the embankment is dropping in the downstream direction.

(10) PZ-6B

Piezometer 6B is the shallower of two piezometers installed in borehole FD-89-5. The top of the riser pipe (El. 573.7) for piezometer 6B is located at Station 21+00, at the downstream edge of the crest of the dam. The tip of the piezometer is located in the impervious section of the dam at El. 416.4. The boring log indicates that the impervious core consists of silty sand with gravel near piezometer 6B.

Piezometer 6B has been dry since it was installed. A falling head test was performed immediately after piezometer installation and shows the piezometer to be working properly. It is apparent that the internal chimney and horizontal drains significantly lowers the phreatic surface though the dam.

(11) PZ-7

Piezometer 7 was the only piezometer installed in borehole FD-92-2. The top of the pipe (El. 485.9) for piezometer 7 is located at Station 21+00, on the downstream slope of the dam. The tip of the piezometer is located in rock at El. 390.7.

The water levels measured in PZ-7 are typically a few feet above the original ground surface. The water levels in PZ-7 have varied between El. 399.6 and 406.8 during normal dam operation (pool El. 424 to 426), averaging El. 403.1 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 18. The measured water levels in PZ-7 appear to respond in a linear manner to changes in pool elevation as shown in Figure 31. Based on a linear projection, the water level in the piezometer should rise about 11 ft from its average height to El. 414.1 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood event of April 1998, daily readings were taken when access to the piezometer was possible. Data collected during both the April 1994 and the April 1998 flood events, as shown in Figures 20 and 22, is included in the following discussion. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Review of Figures 20 and 22, indicates that PZ-7 showed very little response to a raising and lowering pool level during both events. When compared to average pool levels, the following performance was noted. During the 1994 event the water level in the piezometer rose approximately 4.5 ft from its average level to a maximum level of El. 407.5 on 19 April. For the 1998 event, it appears that the water level also rose approximately 4.5 ft. to El. 407.4. As with other piezometers, several days of data are missing during this event due to inaccessibility. A higher water level and a quicker response to the 19[illegible] event may have been recorded had the piezometer been accessible.

Although located in bedrock, the piezometric level PZ-7 is controlled by the horizontal drainage layer. Thus, PZ-7 does not seem to be significantly affected by rising and falling pools, showing little response during both flood events. The water levels in PZ-7 are generally lower than upstream piezometers, confirming that the piezometric head beneath the embankment is dropping in response to the drainage layer.

(12) PZ-8

Piezometer 8 was the only piezometer installed in borehole FD-89-1. The top of the riser pipe (El. 402.1) for piezometer 8 is located at Station 21+00, on the downstream toe of the dam. The tip of the piezometer is located in shale bedrock at El. 386.9.

The water levels in PZ-8 have varied between El. 390.2 and 391.7 during normal dam operation (pool El. 424 to 426), averaging El. 391 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 18. The measured water levels in PZ-8 appear to respond in a linear manner to changes in pool elevation as shown in Figure 32. Based on a linear projection, the water level in the piezometer should rise about 1.5 ft from its average height to El. 392.5 when the pool reaches the spillway crest, El. 546.5.

During large changes in pool level, such as the flood events of April 1994 and April 1998, daily readings of PZ-8 were taken. The data from both events is presented on Figures 20 and 22. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool

level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. During the 1994 event, the water level in the piezometer rose approximately 0.8 ft from its average level to a maximum level of El. 391.8 on 17 April. For the 1998 event, it appears that the water level rose only 0.6 ft. to El. 391.6 on 9 April. Piezometer 8 does not seem to be significantly affected by rising and falling pools, showing very little response during both flood events. As with nearby PZ-4, the water levels in PZ-8 are controlled by the rock fill toe drain.

(13) PZ-9

Piezometer 9 was the only piezometer installed in borehole FD-89-3. The top of the riser pipe (El. 400.8) for piezometer 9 is located at Station 20+25, on the downstream toe of the dam. The tip of the piezometer is located in shale bedrock at El. 384.6.

The water levels in PZ-9 have varied between El. 390.7 and 391.5 during normal dam operation (pool El. 424 to 426), averaging El. 391 over the entire monitoring period. Based on the available data during this monitoring period, the piezometer responded to changes in pool elevation as shown in Figure 16. The measured water levels in PZ-9 appear to respond in a linear manner to changes in pool elevation as shown in Figure 33. Based on a linear projection, the water level in the piezometer should rise about 1.5 ft from its average height to El. 392.4 when the pool reaches the spillway crest, El. 546.5.

Daily readings of PZ-9 were taken during large changes in pool level, such as the flood events of April 1994 and April 1998, as shown in Figures 19 and 21. A pool level of El. 468.8 was recorded on 17 April 1994, while a higher maximum pool level of El. 495.8 occurred on 4 April 1998. Based on the flood events shown, the following performance was noted. During the 1994 event, the water level in the piezometer rose approximately 0.6 ft from its average level to a maximum level of El. 391.6 on 17 April. For the 1998 event, it appears that the water level rose only 0.3 ft. to El. 391.3 on 4 April.

Piezometer 9 does not seem to be significantly affected by rising and falling pools, showing very little response during both flood events. As with other downstream toe piezometers, the water levels in PZ-9 are controlled by the rock fill toe drain.

(c) Cross Section Evaluation

Representative water level data for piezometers located at Sta. 19+50 and 21+00 are shown in Figures 34 and 35, respectively. At Sta. 21 +00, the head loss for the normal pool level is 34 feet and the head loss for the flood of 1998 level is 104.2 feet. At Sta. 19+50, the head loss for the normal pool level is 34 feet and the head loss for the flood of 1998 level is 104.6 feet. For both events the piezometric levels decrease from the upstream side of the dam towards the downstream toe, with most of the head loss occurring at the internal chimney drain. The decrease in piezometric levels illustrates the effectiveness of the dam's internal drainage system.

(d) Phreatic Surface Elevation Plan

Figure 36 presents a plot of phreatic surface elevations under normal pool conditions. Upstream, the pool level is at El. 425, the average pool level. The water level contours indicate that there is a 34 foot head differential across the dam. Similar trends in dissipation

of head occurred for the event of April 1998 with the total head loss across the dam increasing to approximately 105 feet.

c. Strong Motion Accelerographs

(1) Data Collection

The U.S. Army Corps of Engineers Waterways Experiment Station (WES) maintains all of the New England Division's strong motion instruments. Personnel from WES inspect each site twice per year as part of a maintenance and repair program. North Hartland Lake personnel perform a mandatory monthly inspection to check the AC power inside each shelter and record the electromechanical counter reading at each instrument. Their findings are recorded on a standard form and mailed to Geotechnical Engineering Division (GED).

In the event of an earthquake, and in accordance with ER-1110-2-1802, GED directs Nor Hartland Lake personnel to read the counters and perform a visual inspection of the projec Based on this inspection and the intensity of the event, an engineering team may be dispatche to perform a visual inspection, and the Office of the Chief of Engineers may be advised. WE is also notified so that they can retrieve the earthquake record from any activate accelerographs. GED is required to provide an Earthquake Incident Report of the event.

(2) Interpretation and Evaluation

In their twenty year history, the accelerographs at North Hartland Dam have experienced five significant seismic events but have only been activated once. The accelerographs were tripped by the Gaza, NH event and the maximum acceleration was 0.06g. The results of the Gaza, NH earthquake event and information regarding other regional seismic events has been included in the previous instrumentation report (Report No. 5) for North Hartland Dam.

5. CONCLUSIONS AND RECOMMENDATIONS

a. General

Geotechnical instrumentation at North Hartland Dam consists of crest monuments, piezometer and strong motion accelerographs. All the instrumentation appears to be functioning. Thirtee Casagrande type piezometers were installed in 1989 and 1992 to monitor pore pressures in the dam during high water events to replace the inoperable closed-type piezometers.

b. Crest Monuments

(1) Schedule

Crest monument surveys at North Hartland Dam are scheduled once every five years, which coincides with the periodic inspection schedule. If unusual readings are obtained during the next survey, or if field evidence of embankment movement manifests itself, the monitoring schedule should be adjusted as required.

(2) Evaluation of Adequacy

Maximum vertical and horizontal movements of 0.42 and 2.86 inches have been observed at North Hartland Dam. Although small, the settlement appears to be developing linearly with time and is considered tolerable.

The number of crest monuments and current standards of surveying at North Hartland Dam is adequate. Third order accuracy is presently the standard utilized to perform all crest monument surveys.

c. Piezometers

(1) Reading Schedule

The current reading schedule outlined in paragraph four of this report should continued to be implemented by project personnel. The schedule will be adjusted if field evidence of embankment distress occurs or unusual results are obtained from a set of readings.

(2) Evaluation of Adequacy

The piezometer data analysis and plots show the seepage patterns within the embankment and foundation of North Hartland Dam. The phreatic surface gradually slopes downward in the downstream direction due to an effective internal drainage system. Based on the data collected to date, all 13 operating piezometers appear to be functioning properly. The number of operating piezometers is considered adequate to monitor the embankment's performance and additional piezometers are not recommended at this time.

d. Strong Motion Accelerographs

(1) General

Since their installation in 1978, the two strong motion accelerographs at North Hartland Dam have experienced five significant seismic events and were activated once, in 1982, by the Gaza, New Hampshire earthquake. The records from this event showed a maximum acceleration of 0.06g at the dam's crest.

(2) Reading Schedule

The strong motion accelerographs at North Hartland Dam are read once per month. The schedule has been maintained very well and there is a good data base of information for the accelerographs. The present schedule is adequate and should be maintained.

(3) Evaluation of Adequacy

The two strong motion accelerographs at North Hartland Dam are adequate to monitor the motion of the embankment and foundation of the dam during an earthquake. Continued maintenance of the current equipment is recommended. No additional accelerographs are recommended at this time.

TABLE I

PIEZOMETER SUMMARY
NORTH HARTLAND DAM

PIEZOMETER NUMBER	APPROXIMATE STATION	APPROXIMATE CENTERLINE OFFSET	RISER PIPE TOP ELEVATION	PIEZOMETER TIP ELEVATION	ZONE LOCATED	MATERIAL AT TIP ELEVATION
PZ-1A	19+50	100 U/S	518.2	390.8	FOUNDATION	Bedrock
PZ-1B	19+50	100 U/S	518.3	423.8	IMPERVIOUS FILL	Olive gray silty (37.4) SAND with gravel (10.9) (SM)
PZ-2A	19+50	20 D/S	574.2	387.8	FOUNDATION	Bedrock
PZ-2B	19+50	20 D/S	574.1	414.8	IMPERVIOUS FILL	Dark brown silty SAND with gravel (17.3) (SM)
PZ-3	19+50	190 D/S	485.7	386.5	FOUNDATION	Bedrock
PZ-4	19+50	390 D/S	400.8	383.8	FOUNDATION	Bedrock
PZ-5A	21+00	100 U/S	516.5	383.6	FOUNDATION	Bedrock
PZ-5B	21+00	100 U/S	516.8	422.6	IMPERVIOUS FILL	Olive gray silty (36.1) SAND (SM)
PZ-6A	21+00	20 D/S	573.7	389.9	FOUNDATION	Bedrock
PZ-6B	21+00	20 D/S	573.7	416.4	IMPERVIOUS FILL	Green silty (15-25) SAND with gravel (10-20) (SM)
PZ-7	21+00	190 D/S	485.9	390.7	FOUNDATION	Bedrock
PZ-8	21+00	400 D/S	402.1	386.9	FOUNDATION	Bedrock
PZ-9	20+25	390 D/S	400.8	384.6	FOUNDATION	Bedrock

Notes:
1. All elevations in feet and referenced to National Geodetic Vertical Datum (NGVD).

TABLE II
PIEZOMETER WATER ELEVATIONS
NORTH HARTLAND DAM

			PIEZOMETRIC WATER ELEVATIONS (FT - NGVD)												
DATE	STAGE	POOL EL.	PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3	PZ-4	PZ-5A	PZ-5B	PZ-6A	PZ-6B	PZ-7	PZ-8	PZ-9
1/3/1994	35.03	425.03	NA	NA	410.61	PD	NA	390.96	NA	NA	407.82	PD	NA	390.58	390.96
2/4/1994	34.13	424.13	NA	NA	409.29	PD	NA	390.83	NA	NA	407.10	PD	NA	390.49	390.89
3/1/1994	34.20	424.20	NA	NA	408.18	PD	NA	390.92	NA	NA	406.28	PD	NA	390.71	390.92
4/4/1994	36.54	426.54	NA	NA	409.98	PD	NA	391.88	NA	NA	408.41	PD	NA	391.93	391.88
4/8/1994	42.27	432.27	423.58	PD	410.77	PD	399.56	391.88	418.04	PD	409.75	PD	406.28	391.93	391.94
4/9/1994	36.10	426.10	NA	NA	411.26	PD	NA	391.71	NA	NA	409.95	PD	NA	391.73	391.71
4/10/1994	32.53	422.53	NA	NA	411.79	PD	NA	391.45	NA	NA	410.64	PD	NA	391.54	391.45
4/11/1994	38.70	428.70	422.11	PD	411.56	PD	399.83	391.32	416.96	PD	410.34	PD	406.70	391.44	391.32
4/12/1994	33.50	423.50	421.78	PD	411.92	PD	399.96	391.15	416.24	PD	410.64	PD	406.64	391.40	391.32
4/13/1994	34.90	424.90	NA	NA	412.54	PD	NA	391.22	NA	NA	411.10	PD	NA	391.44	391.32
4/14/1994	52.59	442.59	424.99	PD	412.61	PD	400.12	391.78	420.21	PD	411.13	PD	406.47	391.83	391.84
4/15/1994	71.09	461.09	431.26	424.75	412.77	PD	400.09	391.74	426.41	PD	411.43	PD	406.61	391.76	391.71
4/16/1994	74.37	464.37	NA	NA	415.63	PD	NA	391.48	NA	NA	412.28	PD	NA	391.57	391.48
4/17/1994	78.75	468.75	438.22	429.28	410.47	PD	400.38	391.61	432.12	PD	412.48	PD	407.36	391.76	391.61
4/18/1994	73.74	463.74	438.84	429.64	413.62	PD	400.35	391.48	431.89	PD	412.84	PD	407.39	391.60	391.48
4/19/1994	63.47	453.47	436.94	429.37	414.58	PD	400.58	391.32	429.59	PD	413.20	PD	407.49	391.54	391.35
4/20/1994	52.77	442.77	433.66	428.06	414.54	PD	400.52	391.29	426.80	PD	412.94	PD	407.36	391.50	391.29
4/21/1994	40.82	430.82	429.13	426.09	411.10	PD	400.38	391.19	422.01	PD	412.90	PD	405.23	391.44	391.22
4/22/1994	34.05	424.05	426.31	424.98	414.35	PD	400.32	391.19	419.09	PD	412.41	PD	406.80	391.47	391.19
4/23/1994	33.43	423.43	424.83	PD	414.41	PD	400.32	391.12	418.08	PD	412.28	PD	406.44	391.47	391.15
4/24/1994	34.09	424.09	424.50	PD	414.58	PD	400.42	391.12	418.04	PD	412.41	PD	406.38	391.44	391.06
4/25/1994	34.68	424.68	423.91	PD	414.18	PD	400.22	391.06	417.62	PD	411.95	PD	405.82	391.37	391.15
4/26/1994	34.88	424.88	423.62	PD	413.99	PD	400.12	391.12	417.52	PD	411.52	PD	405.62	391.44	391.15
5/3/1994	33.93	423.93	423.09	PD	413.20	PD	399.79	391.19	416.83	PD	410.74	PD	404.57	391.50	391.22
6/2/1994	35.10	425.10	422.11	PD	412.18	PD	399.30	390.99	415.58	424.18	409.46	PD	403.49	390.78	391.02
7/6/1994	35.32	425.32	421.65	PD	410.74	PD	398.94	390.92	415.09	PD	408.38	PD	402.37	390.55	390.96
8/1/1994	36.24	426.24	421.19	PD	410.61	PD	398.94	391.19	414.70	PD	408.11	PD	402.24	391.34	391.15
9/6/1994	35.25	425.25	NA	NA	411.62	PD	NA	390.89	NA	NA	408.87	PD	NA	390.52	390.89
10/4/1994	35.38	425.38	417.55	PD	410.31	PD	398.74	390.92	414.53	PD	407.88	PD	401.98	390.62	390.96
11/1/1994	39.00	429.00	NA	NA	410.64	PD	NA	390.83	NA	NA	408.18	PD	NA	390.35	390.86
12/2/1994	34.65	424.65	NA	NA	408.67	PD	NA	390.89	NA	NA	406.60	PD	NA	390.45	390.89
1/3/1995	34.63	424.63	NA	NA	409.06	PD	NA	390.89	NA	NA	407.06	PD	NA	390.62	390.92
1/17/1995	51.00	441.00	NA	NA	409.46	PD	NA	391.61	NA	NA	407.19	PD	NA	391.60	391.61
1/15/1995	42.29	432.29	NA	NA	409.56	PD	NA	391.45	NA	NA	408.31	PD	NA	391.44	391.45
1/19/1995	35.80	425.80	NA	NA	409.79	PD	NA	391.25	NA	NA	407.55	PD	NA	391.24	391.29
1/20/1995	33.69	423.69	NA	NA	410.28	PD	NA	391.15	NA	NA	407.82	PD	NA	391.11	391.15
1/21/1995	37.20	427.20	NA	NA	410.21	PD	NA	391.29	NA	NA	408.47	PD	NA	391.31	391.29
1/27/1995	34.40	424.40	NA	NA	409.92	PD	NA	391.35	NA	NA	407.69	PD	NA	391.31	391.38
1/24/1995	36.05	426.05	NA	NA	409.98	PD	NA	391.19	NA	NA	407.69	PD	NA	391.11	391.19
1/27/1995	34.97	424.97	NA	NA	410.02	PD	NA	391.42	NA	NA	407.75	PD	NA	391.34	391.42
2/1/1995	35.40	425.40	NA	NA	410.80	PD	NA	390.96	NA	NA	408.44	PD	NA	390.62	390.99
3/2/1995	35.48	425.48	NA	NA	409.62	PD	NA	390.86	NA	NA	407.42	PD	NA	390.62	390.96
4/3/1995	35.25	425.25	420.17	PD	410.21	PD	398.78	390.89	NA	NA	408.01	PD	402.80	390.65	391.02
5/2/1995	35.00	425.00	420.30	PD	411.46	PD	398.71	390.86	414.24	PD	408.01	PD	402.34	390.55	390.86
6/1/1995	34.68	424.68	419.74	PD	409.10	PD	398.32	390.89	413.45	PD	407.16	PD	401.62	390.35	390.92
7/6/1995	35.40	425.40	419.71	PD	406.31	PD	397.79	390.73	413.25	PD	408.31	PD	400.73	391.67	390.73
8/3/1995	34.97	424.97	419.25	PD	407.42	PD	397.63	390.96	412.93	PD	405.85	PD	400.90	390.85	391.02
9/6/1995	35.66	425.66	420.27	PD	409.56	PD	398.28	390.76	413.98	PD	407.33	PD	401.32	390.19	390.83
10/4/1995	34.74	424.74	NA	NA	408.31	PD	PI	390.79	PI	PI	404.93	PD	PI	390.12	390.79
10/23/1995	41.00	431.00	422.07	PD	408.11	PD	397.69	391.45	418.70	PD	404.37	PD	400.54	391.47	391.45
10/24/1995	34.25	424.25	420.37	PD	408.47	PD	397.92	391.22	413.62	PD	406.41	PD	400.86	391.27	391.22
10/25/1995	35.35	425.35	420.40	PD	408.44	PD	397.89	391.09	413.75	PD	406.31	PD	400.93	391.21	391.09
10/26/1995	33.59	423.59	NA	PD	408.54	PD	PI	391.02	PI	PI	406.44	PD	PI	390.98	391.02
11/1/1995	33.77	423.77	NA	PD	408.70	PD	PI	391.09	PI	PI	406.60	PD	PI	391.27	391.06
11/13/1995	53.58	443.58	NA	PD	410.21	PD	PI	391.29	PI	PI	407.95	PD	PI	391.31	391.29
11/14/1995	38.78	428.78	NA	PD	410.44	PD	PI	391.19	PI	PI	408.15	PD	PI	391.34	391.19
11/15/1995	40.02	430.02	NA	PD	411.23	PD	PI	391.25	PI	PI	408.83	PD	PI	391.37	391.22
11/16/1995	37.32	427.32	NA	PD	410.67	PD	PI	391.45	PI	PI	408.31	PD	PI	391.57	391.51
11/17/1995	36.83	426.83	NA	PD	410.67	PD	PI	391.29	PI	PI	408.31	PD	PI	391.37	391.29
12/4/1995	34.54	424.54	NA	PD	411.52	PD	PI	390.92	PI	PI	408.80	PD	PI	390.65	390.92
12/29/1995	35.50	425.50	NA	PD	409.88	PD	PI	390.79	PI	PI	407.55	PD	PI	390.39	390.89
1/22/1996	76.82	466.82	NA	PI	409.85	PD	PI	391.22	PI	PI	408.11	PD	PI	391.31	391.22
1/23/1996	71.87	461.87	NA	PI	410.28	PD	PI	391.09	PI	PI	408.57	PD	PI	391.08	393.29
1/24/1996	65.82	455.82	NA	PI	410.57	PD	PI	390.99	PI	PI	409.10	PD	PI	390.91	390.99
1/25/1996	71.95	461.95	NA	PI	410.31	PD	PI	391.71	PI	PI	408.70	PD	PI	391.80	391.71
1/26/1996	66.50	456.50	NA	PI	410.41	PD	PI	391.38	PI	PI	408.90	PD	PI	391.50	391.45
1/27/1996	60.50	450.50	NA	PI	411.20	PD	PI	391.19	PI	PI	409.56	PD	PI	391.24	391.19
1/28/1996	66.50	456.50	NA	PI	411.23	PD	PI	392.20	PI	PI	409.56	PD	PI	392.19	392.20
1/29/1996	64.00	454.00	NA	PI	411.52	PD	PI	391.55	PI	PI	409.85	PD	PI	391.63	391.61
1/30/1996	54.30	444.30	NA	PI	411.92	PD	PI	391.25	PI	PI	410.38	PD	PI	391.31	391.22
1/31/1996	40.00	430.00	NA	PI	411.95	PD	PI	391.15	PI	PI	410.25	PD	PI	391.17	391.12
2/1/1996	35.72	425.72	NA	PI	411.72	PD	PI	391.09	PI	PI	410.05	PD	PI	391.08	391.15
2/2/1996	35.71	425.71	NA	PI	411.43	PD	PI	391.02	PI	PI	410.02	PD	PI	391.04	390.99
2/3/1996	35.48	425.48	NA	PI	410.11	PD	PI	390.99	PI	PI	409.85	PD	PI	391.01	390.99
2/4/1996	33.99	423.99	NA	PI	411.66	PD	PI	390.92	PI	PI	409.79	PD	PI	390.94	390.92

TABLE II
PIEZOMETER WATER ELEVATIONS
NORTH HARTLAND DAM

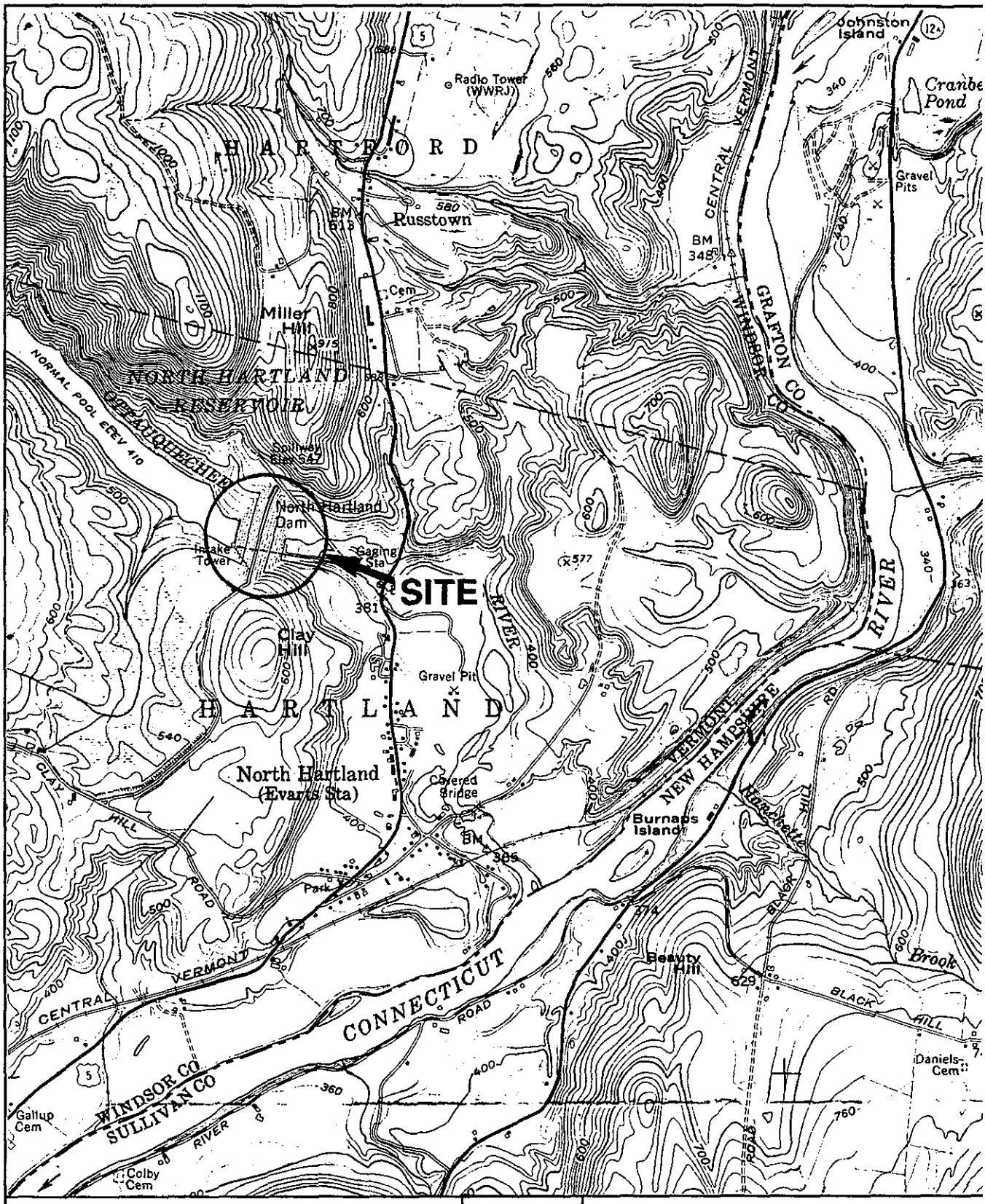
DATE	STAGE	POOL EL.	PIEZOMETRIC WATER ELEVATIONS (FT - NGVD)												
			PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3	PZ-4	PZ-5A	PZ-5B	PZ-6A	PZ-6B	PZ-7	PZ-8	PZ-9
2/5/1996	33.49	423.49	NA	PI	411.82	PD	PI	390.92	PI	PI	409.75	PD	PI	390.85	390.89
3/1/1996	33.76	423.76	NA	PI	411.10	PD	PI	391.12	PI	PI	408.83	PD	PI	391.08	391.09
4/2/1996	35.51	425.51	NA	PI	411.56	PD	PI	390.89	PI	PI	409.26	PD	PI	390.71	390.89
4/17/1996	49.37	439.37	NA	PI	411.85	PD	PI	392.43	PI	PI	409.62	PD	PI	392.39	392.43
4/18/1996	51.31	441.31	NA	PI	411.52	PD	PI	391.78	PI	PI	409.46	PD	PI	391.93	391.74
4/20/1996	39.47	429.47	NA	PI	411.66	PD	PI	391.55	PI	PI	410.16	PD	PI	391.47	391.12
4/19/1996	43.49	433.49	NA	PI	411.69	PD	PI	391.35	PI	PI	409.85	PD	PI	391.54	391.35
4/21/1996	10.07	400.07	NA	PI	412.08	PD	PI	391.15	PI	PI	410.21	PD	PI	394.75	391.15
4/22/1996	37.55	427.55	NA	PI	412.02	PD	PI	392.04	PI	PI	410.21	PD	PI	391.24	391.06
4/23/1996	38.66	428.66	NA	PI	412.54	PD	PI	391.02	PI	PI	410.57	PD	PI	391.44	390.99
4/24/1996	47.24	437.24	NA	PI	412.51	PD	PI	391.45	PI	PI	410.54	PD	PI	391.76	391.45
4/25/1996	40.80	430.80	NA	PI	412.67	PD	PI	391.45	PI	PI	410.57	PD	PI	391.57	391.45
4/26/1996	34.78	424.78	NA	PI	412.94	PD	PI	391.19	PI	PI	410.84	PD	PI	391.47	391.19
4/27/1996	40.66	430.66	NA	PI	412.54	PD	PI	391.19	PI	PI	410.51	PD	PI	391.73	391.22
4/28/1996	39.41	429.41	NA	PI	412.44	PD	PI	391.19	PI	PI	410.44	PD	PI	391.70	391.22
4/29/1996	34.37	424.37	NA	PI	412.61	PD	PI	391.12	PI	PI	410.57	PD	PI	391.24	391.12
5/1/1996	47.62	437.62	NA	PI	412.94	PD	PI	392.07	PI	PI	410.93	PD	PI	392.09	392.07
5/2/1996	51.50	441.50	NA	PI	413.17	PD	PI	391.68	PI	PI	411.13	PD	PI	391.93	391.68
5/3/1996	49.57	439.57	NA	PI	413.46	PD	PI	391.45	PI	PI	411.36	PD	PI	391.86	391.45
5/4/1996	39.23	429.23	NA	PI	413.53	PD	PI	391.32	PI	PI	411.39	PD	PI	391.80	391.32
5/6/1996	34.71	424.71	PI	PI	413.36	PD	PI	391.22	PI	PI	411.23	PD	PI	391.70	391.22
5/7/1996	34.37	424.37	PI	PI	413.33	PD	PI	391.22	PI	PI	411.23	PD	PI	391.44	391.19
5/8/1996	35.24	425.24	PI	PI	413.72	PD	PI	391.12	PI	PI	411.39	PD	PI	391.40	391.12
5/9/1996	33.74	423.74	PI	PI	411.20	PD	PI	391.06	PI	PI	413.49	PD	PI	391.37	NA
5/10/1996	35.33	425.33	PI	PI	413.72	PD	PI	391.09	PI	PI	411.52	PD	PI	391.37	NA
5/13/1996	53.29	443.29	PI	PI	413.89	PD	PI	391.91	PI	PI	411.56	PD	PI	392.13	391.97
5/14/1996	47.08	437.08	427.39	424.75	414.22	PD	400.38	391.06	420.80	424.14	411.85	PD	405.85	391.80	391.51
5/15/1996	40.58	430.58	422.63	PD	414.31	PD	400.38	391.35	419.16	424.11	412.05	PD	406.15	391.70	391.29
5/16/1996	34.04	424.04	PI	PI	414.51	PD	PI	391.29	PI	PI	412.18	PD	PI	389.01	391.29
5/17/1996	31.71	421.71	PI	PI	414.44	PD	PI	391.12	PI	PI	411.85	PD	PI	391.47	391.09
5/19/1996	30.92	420.92	PI	PI	414.67	PD	PI	391.09	PI	PI	412.05	PD	PI	391.27	391.02
5/25/1996	39.59	429.59	PI	PI	413.23	PD	PI	391.19	PI	PI	411.26	PD	PI	391.67	391.22
6/3/1996	34.90	424.90	PI	PI	413.69	PD	PI	390.89	PI	PI	410.84	PD	PI	390.71	390.86
7/2/1996	35.42	425.42	421.65	PD	411.95	PD	399.50	390.89	414.96	PD	409.33	PD	399.65	390.55	390.89
7/15/1996	42.54	432.54	NA	NA	412.08	PD	NA	391.88	NA	NA	NA	PD	NA	392.16	391.84
7/16/1996	38.82	428.82	425.22	PD	412.15	PD	399.63	391.88	416.37	PD	409.46	PD	403.26	392.09	391.81
7/17/1996	38.36	428.36	423.26	PD	412.15	PD	399.73	391.91	416.21	PD	406.34	PD	403.46	391.93	391.97
7/18/1996	34.46	424.46	NA	NA	412.25	PD	NA	391.35	NA	NA	409.52	PD	NA	391.60	391.29
7/19/1996	34.10	424.10	NA	NA	412.74	PD	NA	391.29	NA	NA	410.11	PD	NA	391.44	391.22
7/20/1996	35.28	425.28	NA	NA	412.71	PD	NA	391.02	NA	NA	411.75	PD	NA	391.47	391.15
7/21/1996	35.15	425.15	NA	NA	412.51	PD	NA	391.12	NA	NA	409.88	PD	NA	391.27	391.15
7/22/1996	35.09	425.09	421.78	PD	412.71	PD	399.99	391.15	415.06	PD	410.08	PD	404.14	391.31	391.12
7/23/1996	34.91	424.91	421.78	PD	412.71	PD	399.99	391.09	415.22	PD	410.15	PD	404.21	391.21	391.06
8/1/1996	37.43	427.43	PI	PI	413.20	PD	PI	390.99	PI	PI	410.38	PD	PI	391.08	391.02
9/2/1996	35.23	425.23	NA	NA	411.26	PD	NA	390.79	NA	NA	408.70	PD	NA	390.29	390.79
10/1/1996	35.56	425.56	419.91	PD	408.70	PD	398.25	390.96	413.19	PD	406.57	PD	400.83	390.68	390.92
10/21/1996	55.17	445.17	PI	PI	408.93	PD	PI	393.35	PI	PI	408.11	PD	PI	393.24	393.32
10/22/1996	52.23	442.23	426.01	PD	409.26	PD	398.65	391.97	418.80	PD	407.16	PD	401.52	392.16	392.01
10/23/1996	39.23	429.23	423.88	PD	409.26	PD	398.81	391.35	416.08	PD	407.29	PD	401.85	391.54	391.32
10/24/1996	37.09	427.09	422.70	PD	409.56	PD	398.91	391.15	415.09	PD	407.49	PD	402.18	391.37	391.19
10/25/1996	35.61	425.61	421.65	PD	409.43	PD	398.84	391.12	414.30	PD	407.39	PD	402.18	391.27	391.12
10/26/1996	35.75	425.75	PI	PI	409.26	PD	PI	390.92	PI	PI	407.19	PD	PI	391.17	390.96
10/27/1996	35.82	425.82	PI	PI	409.88	PD	PI	391.02	PI	PI	407.78	PD	PI	391.14	391.02
10/28/1996	35.09	425.09	421.16	PD	410.08	PD	399.30	390.92	414.27	PD	408.15	PD	402.77	391.04	390.96
10/29/1996	35.27	425.27	PI	PI	409.92	PD	PI	390.89	PI	PI	407.82	PD	PI	390.85	390.89
11/4/1996	35.55	425.55	420.53	PD	410.28	PD	399.10	390.92	413.94	PD	407.95	PD	402.50	390.68	390.92
11/10/1996	51.00	441.00	PI	PI	410.97	PD	PI	391.45	PI	PI	408.60	PD	PI	391.34	391.45
11/11/1996	46.83	436.83	PI	PI	410.97	PD	PI	391.25	PI	PI	408.60	PD	PI	391.21	391.19
11/12/1996	41.04	431.04	PI	PI	410.87	PD	PI	391.12	PI	PI	408.51	PD	PI	391.14	391.06
12/3/1996	44.25	434.25	423.75	PD	411.10	PD	399.33	392.01	416.90	PD	408.74	PD	402.77	391.96	391.94
1/3/1996	34.88	424.88	PI	PI	413.20	PD	PI	390.99	PI	PI	410.47	PD	PI	390.71	390.96
2/7/1997	34.88	424.88	PI	PI	411.13	PD	PI	390.96	PI	PI	408.70	PD	PI	PI	390.92
3/5/1997	34.65	424.65	420.43	PD	410.67	PD	399.47	391.09	414.04	PD	408.60	PD	403.29	391.14	391.09
4/1/1997	36.12	426.12	PI	PI	411.66	PD	PI	391.65	PI	PI	409.39	PD	PI	391.73	391.65
4/30/1997	34.53	424.53	421.78	PD	413.59	PD	400.48	391.15	415.65	PD	411.13	PD	405.13	391.34	391.15
6/4/1997	35.40	425.40	421.45	PD	412.67	PD	399.89	390.96	418.41	PD	413.33	PD	403.39	391.93	390.89
7/1/1997	35.55	425.55	420.89	PD	411.00	PD	399.33	390.89	414.34	PD	408.54	PD	402.34	390.35	390.89
8/2/1997	35.43	425.43	420.56	PD	407.82	PD	399.07	390.83	413.81	PD	410.25	PD	401.78	390.35	390.86
9/2/1997	35.40	425.40	420.20	PD	409.69	PD	399.07	390.96	413.68	PD	407.49	PD	401.78	390.75	390.96
10/1/1997	35.45	425.45	420.66	PD	410.70	PD	399.24	390.79	414.07	PD	408.11	PD	401.95	390.49	390.83
11/3/1997	35.39	425.39	420.50	PD	409.29	PD	398.58	391.25	413.62	PD	407.10	PD	401.22	391.24	391.22
12/1/1997	37.40	427.40	PI	PI	410.90	PD	PI	391.02	PI	PI	408.31	PD	PI	390.91	390.99
1/5/1998	36.65	426.65	PI	PI	410.11	PD	PI	390.89	PI	PI	407.65	PD	PI	390.32	390.96
1/9/1998	51.89	441.89	PI	PI	410.51	PD	PI	392.66	PI	PI	408.64	PD	PI	392.72	392.63
1/10/1998	43.26	433.26	PI	PI	410.28	PD	PI	391.88	PI	PI	408.05	PD	PI	392.22	391.88

TABLE II
PIEZOMETER WATER ELEVATIONS
NORTH HARTLAND DAM

DATE	STAGE	POOL EL.	PIEZOMETRIC WATER ELEVATIONS (FT - NGVD)												
			PZ-1A	PZ-1B	PZ-2A	PZ-2B	PZ-3	PZ-4	PZ-5A	PZ-5B	PZ-6A	PZ-6B	PZ-7	PZ-8	PZ-9
1/11/1998	39.18	429.18	PI	PI	410.41	PD	PI	391.48	PI	PI	408.24	PD	PI	391.80	391.45
1/12/1998	35.45	425.45	PI	PI	410.25	PD	PI	391.25	PI	PI	408.21	PD	PI	391.50	391.22
1/13/1998	34.79	424.79	PI	PI	410.74	PD	PI	391.15	PI	PI	408.74	PD	PI	391.34	391.15
1/14/1997	34.77	424.77	PI	PI	410.28	PD	PI	391.09	PI	PI	408.24	PD	PI	391.17	391.09
1/15/1998	35.31	425.31	PI	PI	410.57	PD	PI	391.02	PI	PI	408.54	PD	PI	391.04	391.02
1/16/1998	35.01	425.01	PI	PI	410.08	PD	PI	390.99	PI	PI	408.83	PD	PI	390.85	390.99
2/3/1998	35.24	425.24	PI	PI	411.26	PD	PI	390.86	PI	PI	408.80	PD	PI	390.62	390.86
3/30/1998	54.99	444.99	427.36	PD	413.33	PD	400.29	391.29	421.16	PD	410.87	PD	404.74	391.57	391.29
3/31/1998	63.72	453.72	430.21	425.08	413.49	PD	400.38	391.25	423.79	PD	411.13	PD	405.23	391.54	391.22
4/1/1998	80.50	470.50	435.46	427.34	413.72	PD	400.35	391.12	429.13	PD	411.49	PD	405.56	391.50	391.15
4/2/1998	96.12	486.12	PI	PI	414.35	PD	PI	391.02	PI	PI	412.41	PD	PI	391.60	391.19
4/3/1998	103.71	493.71	PI	PI	415.04	PD	PI	391.22	PI	PI	413.07	PD	PI	391.60	391.22
4/4/1998	105.84	495.84	PI	PI	415.46	PD	PI	391.25	PI	PI	412.97	PD	PI	391.60	391.25
4/5/1998	103.38	493.38	PI	PI	416.05	PD	PI	391.25	PI	PI	414.12	PD	PI	391.57	391.22
4/6/1998	94.01	484.01	PI	PI	416.58	PD	PI	391.15	PI	PI	414.48	PD	PI	391.54	391.19
4/7/1998	85.85	475.85	448.75	434.59	416.61	PD	401.04	391.19	438.29	PD	414.54	PD	407.33	391.54	391.15
4/8/1998	77.04	467.04	445.66	433.48	416.74	PD	401.14	391.09	435.43	PD	414.51	PD	407.36	391.50	391.09
4/9/1998	65.43	455.43	PI	PI	418.22	PD	PI	391.12	PI	PI	414.84	PD	PI	391.47	391.09
4/10/1998	57.03	447.03	438.38	430.98	417.23	PD	401.24	391.02	428.77	PD	414.67	PD	407.13	391.47	391.78
4/11/1998	51.15	441.15	PI	PI	416.74	PD	PI	391.09	PI	PI	PI	PI	PI	391.44	391.09
4/12/1998	44.45	434.45	PI	PI	416.54	PD	PI	391.02	PI	PI	413.82	PD	PI	391.34	391.06
4/13/1998	35.96	425.96	428.96	426.72	416.64	PD	401.04	391.06	420.37	PD	413.85	PD	406.44	391.31	391.06
4/14/1998	35.51	425.51	426.08	430.82	416.71	PD	401.07	391.06	419.49	PD	413.79	PD	406.31	391.31	391.02
4/15/1998	35.01	425.01	426.50	426.03	416.58	PD	401.07	390.99	418.80	PD	413.53	PD	406.01	391.24	390.99
4/16/1998	35.01	425.01	425.72	425.40	416.22	PD	400.88	390.99	418.27	PD	413.13	PD	405.79	391.14	390.99
4/30/1998	35.12	425.12	423.35	424.72	411.43	PD	400.45	390.99	416.70	424.41	411.79	PD	404.70	390.94	391.02
6/2/1998	34.89	424.89	422.37	PD	413.26	PD	400.02	390.92	415.58	424.21	410.51	PD	403.92	390.55	390.92
6/16/1998	58.29	448.29	PI	PI	412.74	PD	PI	394.11	PI	PI	410.21	PD	PI	393.96	394.07
6/17/1998	44.87	434.87	PI	PI	412.77	PD	PI	392.24	PI	PI	410.28	PD	PI	392.42	392.24
6/18/1998	41.12	431.12	PI	PI	412.64	PD	PI	391.88	PI	PI	410.25	PD	PI	392.22	391.84
6/21/1998	34.73	424.73	PI	PI	412.38	PD	PI	391.25	PI	PI	409.95	PD	PI	391.63	391.29
6/22/1998	34.56	424.56	PI	PI	412.57	PD	PI	391.25	PI	PI	410.18	PD	PI	391.60	391.25
6/22/1998	34.62	424.62	PI	PI	412.61	PD	PI	391.22	PI	PI	410.25	PD	PI	391.40	391.19
6/23/1998	34.37	424.37	PI	PI	412.84	PD	PI	391.15	PI	PI	410.28	PD	PI	391.31	391.12
9/2/1998	35.45	425.45	421.45	PD	411.72	PD	399.66	390.83	414.70	PD	408.97	PD	402.64	390.58	390.92
9/30/1998	35.04	425.04	420.83	PD	410.77	PD	399.24	390.83	414.14	PD	408.28	PD	402.11	390.42	390.89
11/2/1998	36.00	426.00	420.99	PD	410.64	PD	399.24	390.86	414.11	PD	408.11	PD	401.98	390.49	390.83
12/1/1998	35.51	425.51	420.83	PD	410.15	PD	399.14	391.02	413.94	PD	407.88	PD	402.14	391.01	391.02
AVG. LEVEL DURING NORMAL POOL			421.80	426.4	411.4	PD	399.4	391.0	415.3	424.3	409.2	PD	403.08	390.97	391.03

NOTES:

1. PD - PIEZOMETER DRY, PI - PIEZOMETER INACCESSIBLE, PF - PIEZOMETER FROZEN, NA - INFORMATION NOT GIVEN
2. AVERAGE POOL WATER LEVEL FOR PIEZOMETERS IS BASED ONLY ON READINGS WHEN THE POOL ELEVATION FALLS BETWEEN EL. 424 AND 426.



SITE COORDINATES: 43°36'17"N 72°21'40"W

U.S.G.S. QUADRANGLE: NORTH HARTLAND, NH–VT

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

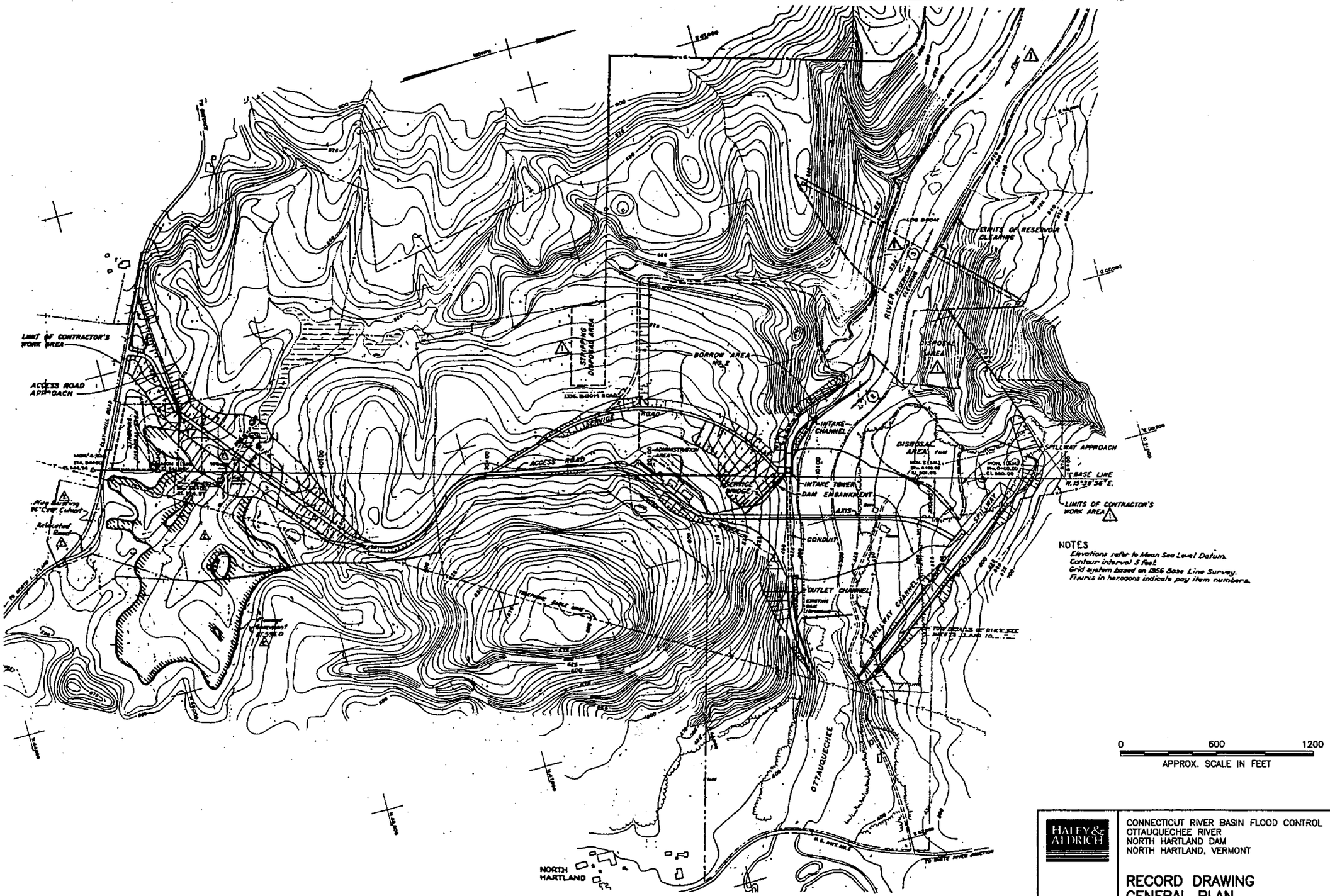
PROJECT LOCUS

APPROXIMATE SCALE: 1:24,000

OCTOBER 1999

12126–009 A20

FIGURE



NOTE:
DRAWING PROVIDED BY THE U.S. ARMY CORPS. OF ENGINEERS.

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

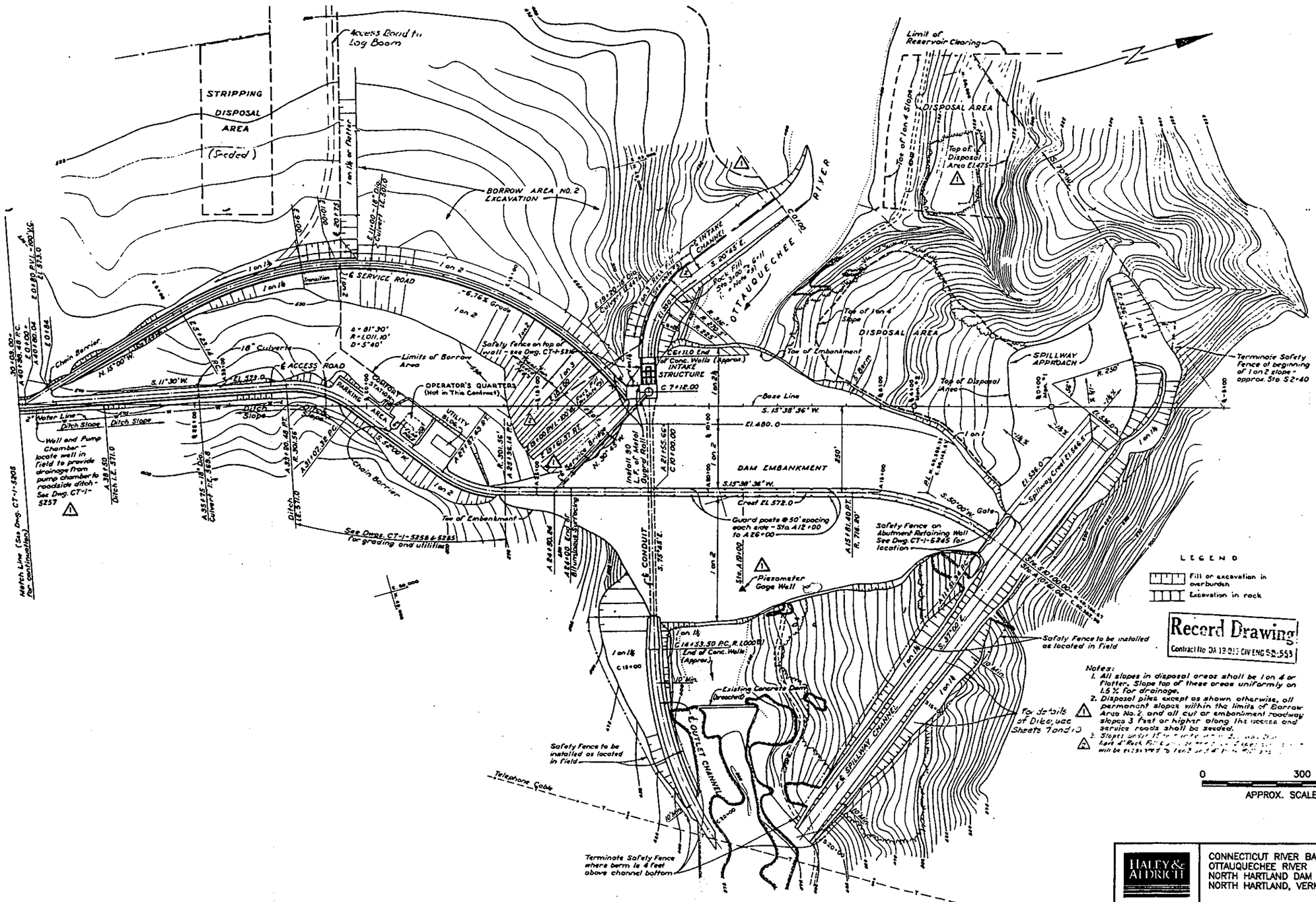
RECORD DRAWING
GENERAL PLAN

SCALE: AS SHOWN

OCTOBER 1999

12126-009 B21

FIGURE 2



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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

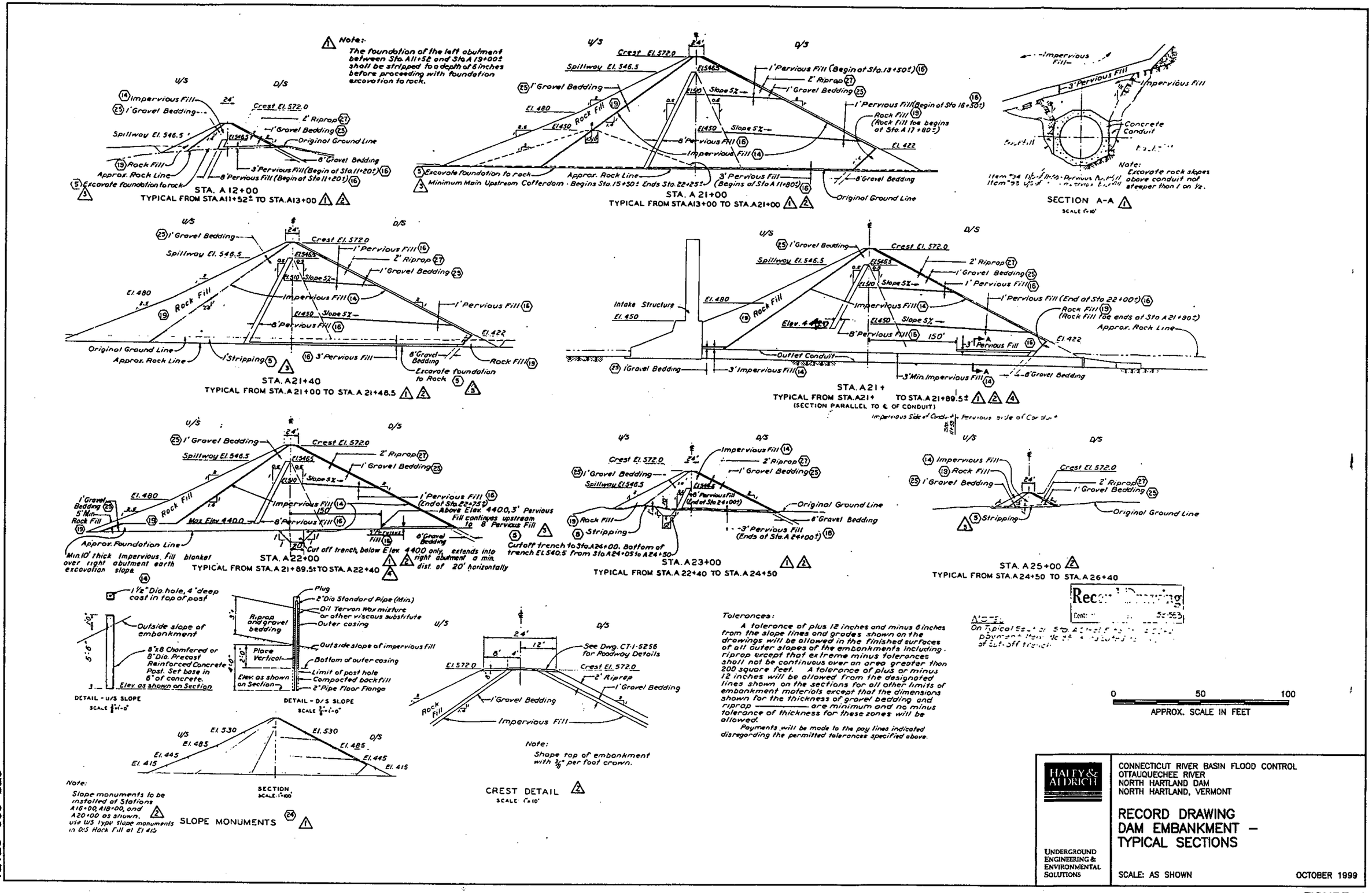
RECORD DRAWING
DAM EMBANKMENT, SPILLWAY AND OUTLET WORKS – PLAN

SCALE: AS SHOWN

OCTOBER 1999

12126-009 B22

FIGURE 3



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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

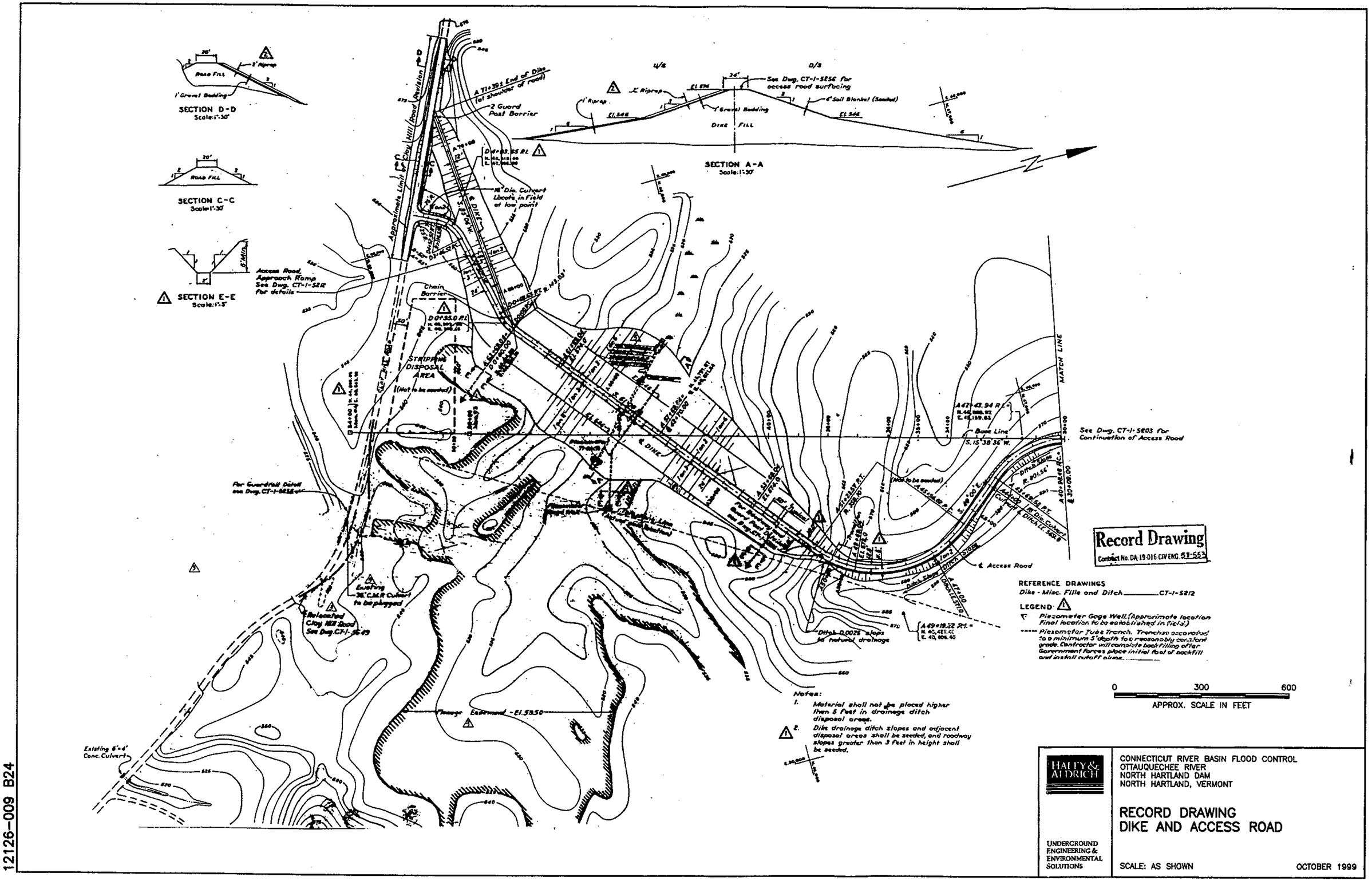
RECORD DRAWING
DAM EMBANKMENT –
TYPICAL SECTIONS

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 4

12126-009 B23


SECTION D-D
Scale: 1"=30'
SECTION C-C
Scale: 1"=30'
SECTION E-E
Scale: 1"=5'
SECTION A-A
Scale: 1"=30'
U/S
D/S
Dike Fill
Access Road, Approach Ramp See Dwg. CT-1-5212 for details
Chain Barrier
STRIPPING DISPOSAL AREA
(Not to be seeded)
Existing 36" C.M.P. Culvert to be plugged
Relocated Clay Hill Road See Dwg. CT-1-5219
Existing 6'x4' Conc. Culvert
Tailwater Elevation - El. 539.50
See Dwg. CT-1-5203 for Continuation of Access Road
Base Line
S.15°38'36"W.
Ditch 0.0025 slope for natural drainage
Access Road
MATCH LINE
Record Drawing
Contract No. DA-19-016 CIV ENG. 53-553
REFERENCE DRAWINGS
Dike - Misc. Fills and Ditch CT-1-5212
LEGEND
Piezometer Gage Well (Approximate location Final location to be established in field)
Piezometer Tube Trench. Trenches excavated to a minimum 5' depth to a reasonably constant grade. Contractor will complete backfilling after Government forces place initial foot of backfill and install cutoff plugs.
0 300 600
APPROX. SCALE IN FEET
Notes:
1. Material shall not be placed higher than 5 feet in drainage ditch disposal areas.
2. Dike drainage ditch slopes and adjacent disposal areas shall be seeded, and roadway slopes greater than 3 feet in height shall be seeded.
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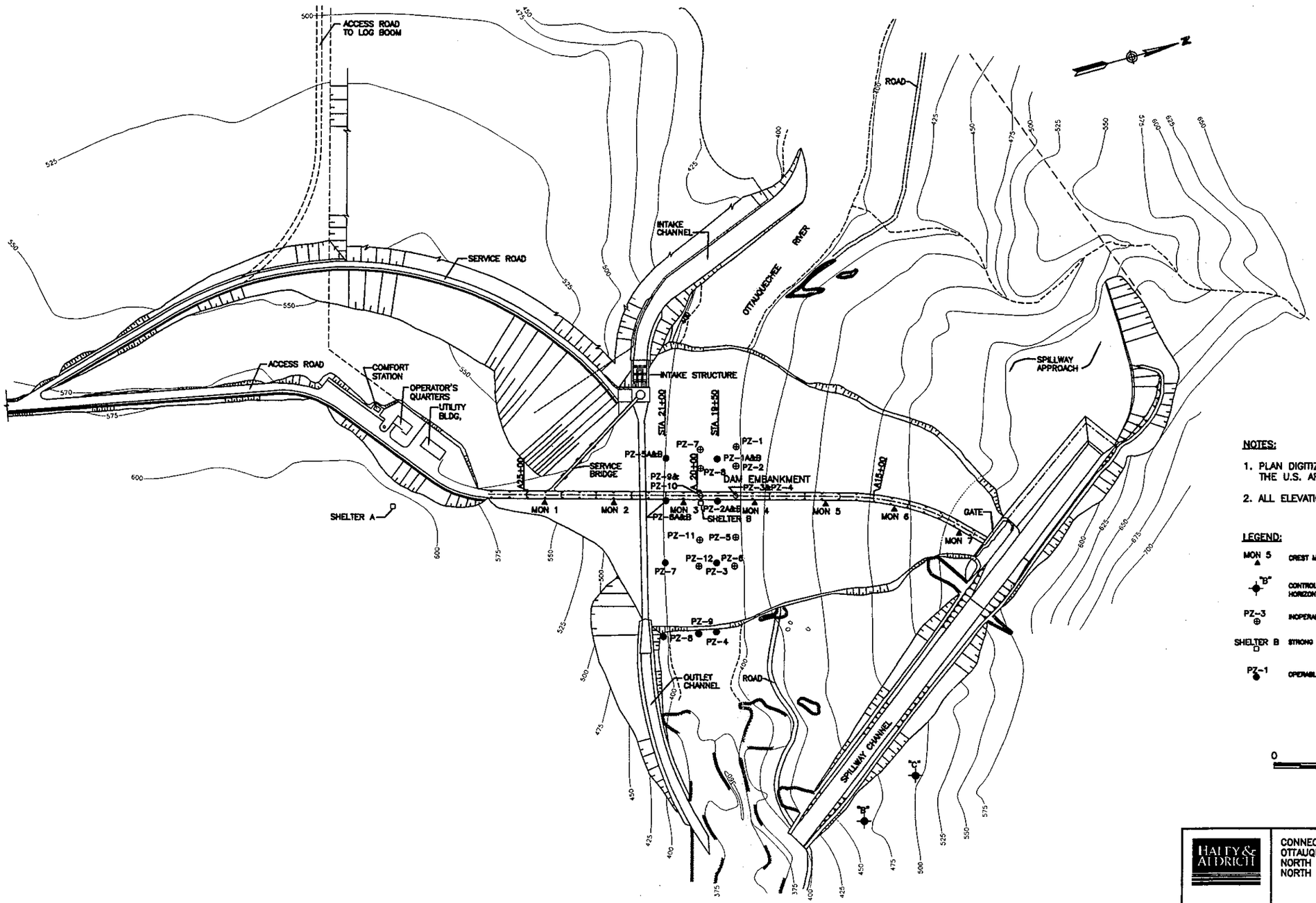
UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS
CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT
RECORD DRAWING
DIKE AND ACCESS ROAD
SCALE: AS SHOWN
OCTOBER 1999
12126-009 B24

FIGURE 5



NOTES:

1. PLAN DIGITIZED FROM BASE PLAN PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.

LEGEND:

MON 5 ▲	CREST MONUMENT
"B"	CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL
PZ-3 ⊕	INOPERABLE PIEZOMETER
SHELTER B □	STRONG MOTION ACCELEROGRAPH
PZ-1 ●	OPERABLE PIEZOMETER

0 300 600

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

INSTRUMENTATION PLAN

SCALE: AS SHOWN

OCTOBER 1999

12126-009 B31

FIGURE 6

LEGEND FOR GRAPHIC LOGS

FD90-2
1/30/90
EL. 515

Type, year and number of exploration.
Date exploration completed.
Elevation of ground surface at time of exploration.

Maximun artesian head.

Subsurface water level.

Artesian flow encountered.

Range of subsurface water level during period of observation.

SM — Group letter symbol according to ASTM D2487 AND ASTM D2488.

NR — No recovery or unsatisfactory soil samples recovered.

NS — Not sampled

25 — Number of blows per foot of penetration using a 140 lb. hammer falling freely an average drop of 30 inches to drive a sample spoon of 2" O.D – 1-3/8" I.D. in size equipped with bevelled and sharpened drive shoe.

* — Indicates sample taken with a 300 lb. hammer and a drop of 18 inches.

Cobbles or boulders.

Coarse gravel or nested cobbles and boulders.

El. 5.0 Elevation of bedrock surface.

Rock core recovery 0-25%.

Rock core recovery 25-50%

Rock core recovery 50-75%

Rock core recovery 75-90%

Rock core recovery 90- 100%

El. 9.0 Elevation at bottom of exploration.

LEGEND FOR PIEZOMETER

Granular Backfill

Bentonite Seal

Filter Material

Piezometer Tip El. 8.0

Cement Grout

Boring Number	Piezometer Number
FD-89-1	PZ-8
FD-89-2	PZ-4
FD-89-3	PZ-9
FD-89-4	PZ-2A
FD-89-4	PZ-2B
FD-89-5	PZ-6A
FD-89-5	PZ-6B
FD-92-1	PZ-5A
FD-92-1	PZ-5B
FD-92-2	PZ-7
FD-92-3	PZ-1A
FD-92-3	PZ-1B
FD-92-4	PZ-3

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

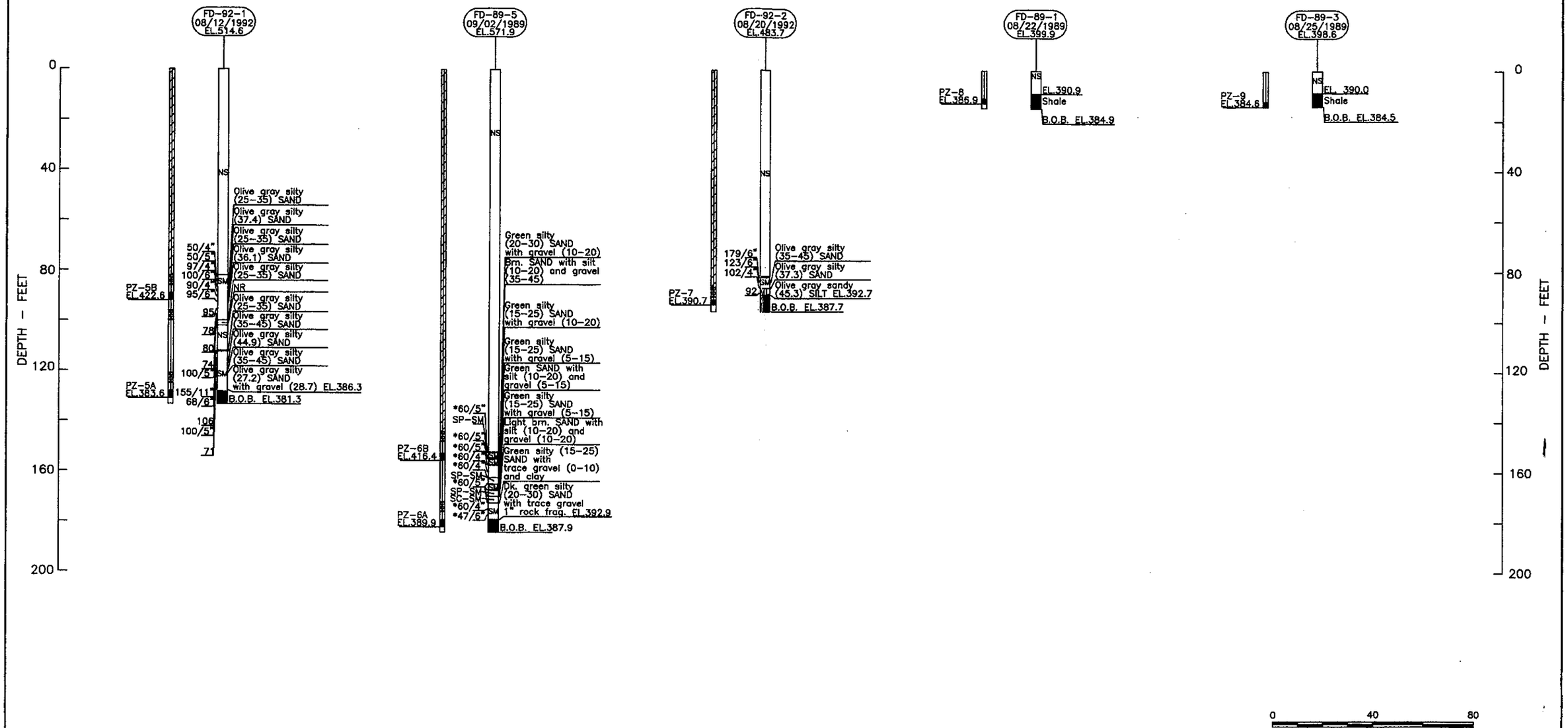
GENERAL LEGEND AND NOTES

SCALE: AS SHOWN

OCTOBER 1999

12126-009 B32

FIGURE 7



NOTES:

1. TEST BORINGS AND PIEZOMETER LOGS PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. REFER TO FIGURE 7 FOR GENERAL LEGEND AND NOTES.

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

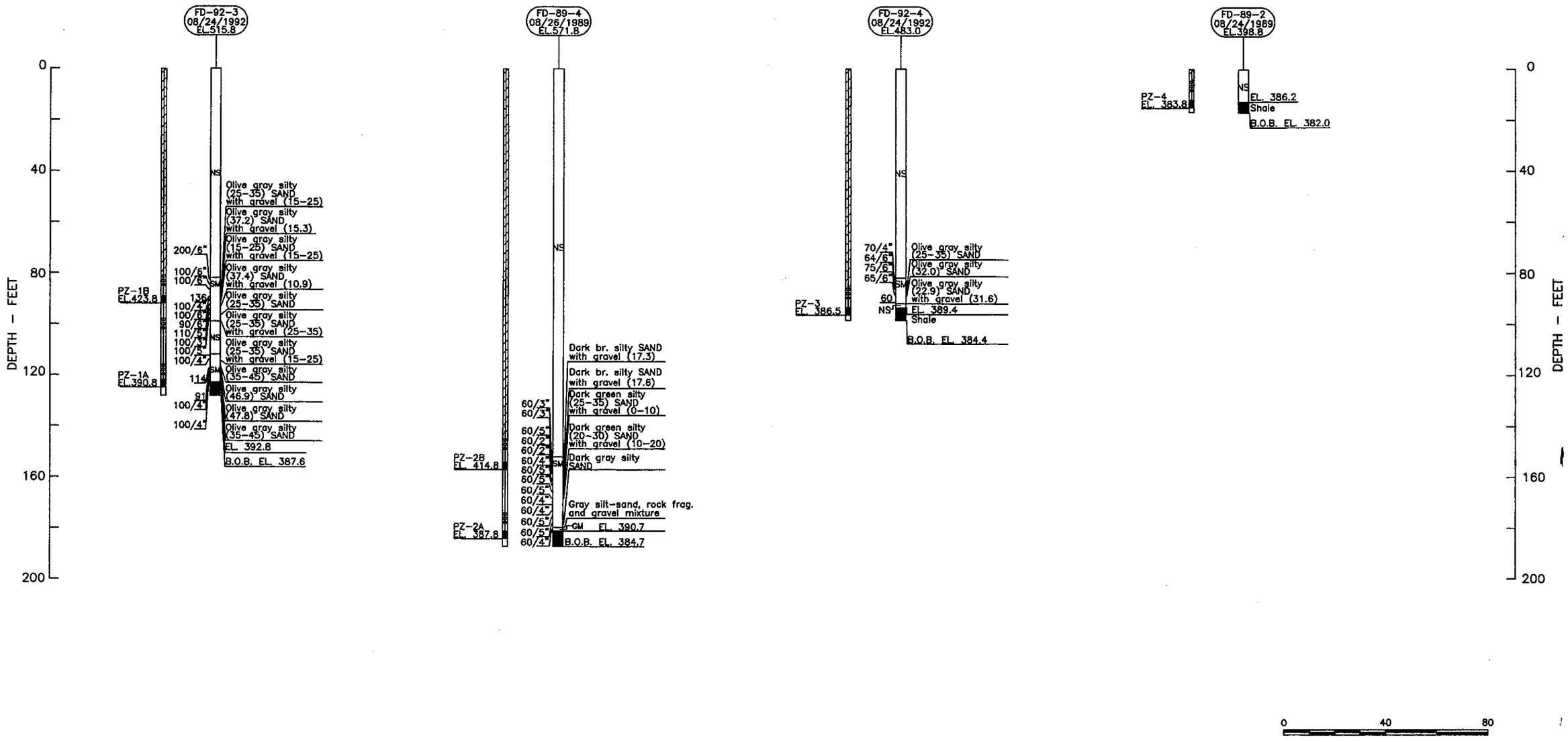
ENGINEERING LOGS
PIEZOMETER EXPLORATIONS

SCALE: AS SHOWN

NOVEMBER 1999

12126-009 B33

FIGURE 8



NOTES:

1. TEST BORINGS AND PIEZOMETER LOGS PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. REFER TO FIGURE 7 FOR GENERAL LEGEND AND NOTES.

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

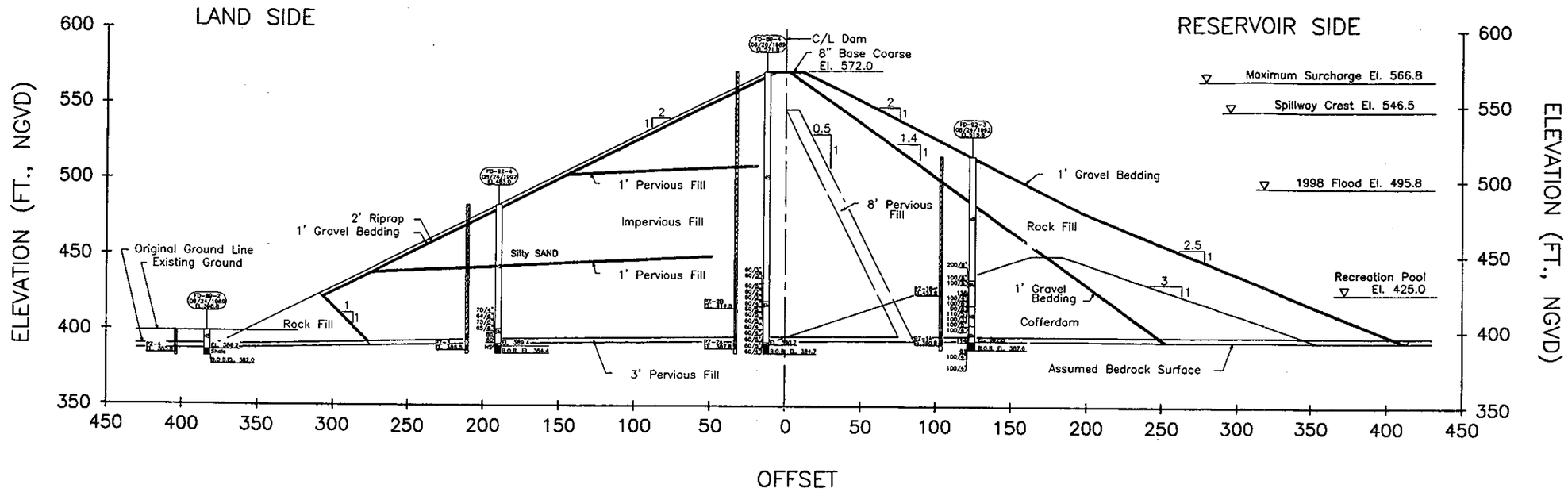
ENGINEERING LOGS
PIEZOMETER EXPLORATIONS

SCALE: AS SHOWN

NOVEMBER 1999

12126-009 B34

FIGURE 9



ENGINEERING LOG SECTION – STATION 19+50

NOTES:

1. CROSS SECTION PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 7 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURES 8 AND 9 FOR FULL DESCRIPTION OF ENGINEERING LOGS.

0 80 160

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

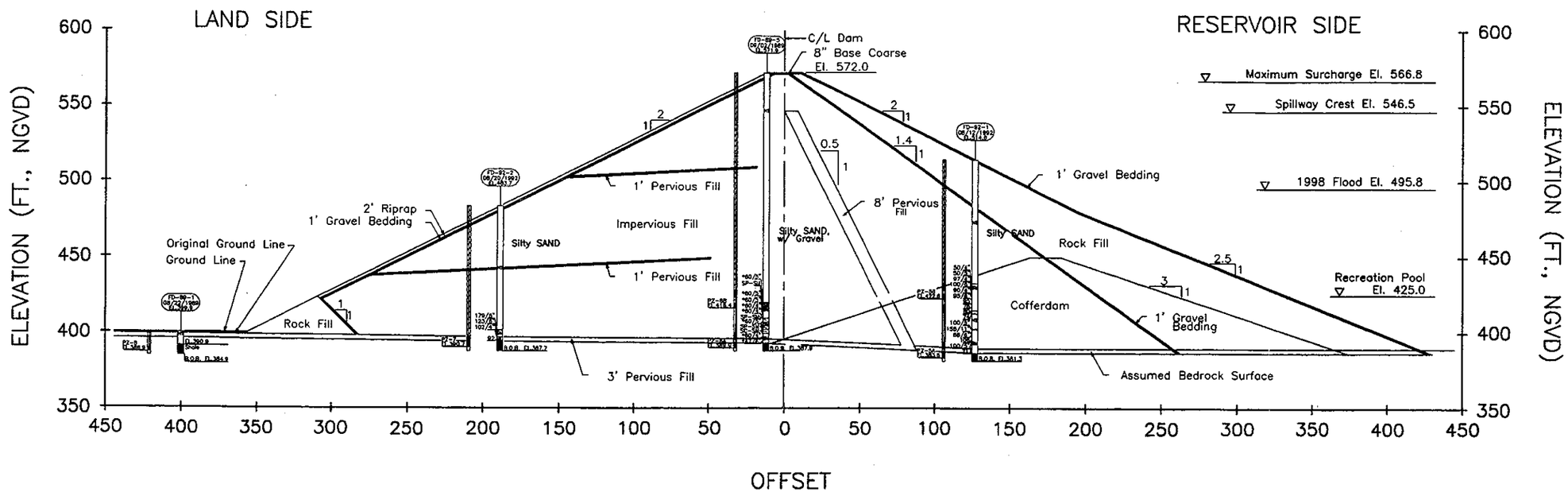
ENGINEERING LOG SECTION
STATION 19+50

SCALE: AS SHOWN

OCTOBER 1999

12126-009 B35

FIGURE 10



ENGINEERING LOG SECTION – STATION 21+00

NOTES:

1. CROSS SECTION PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
2. REFER TO FIGURE 7 FOR GENERAL LEGEND AND NOTES.
3. REFER TO FIGURES 8 AND 9 FOR FULL DESCRIPTION OF ENGINEERING LOGS.

0 80 160

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

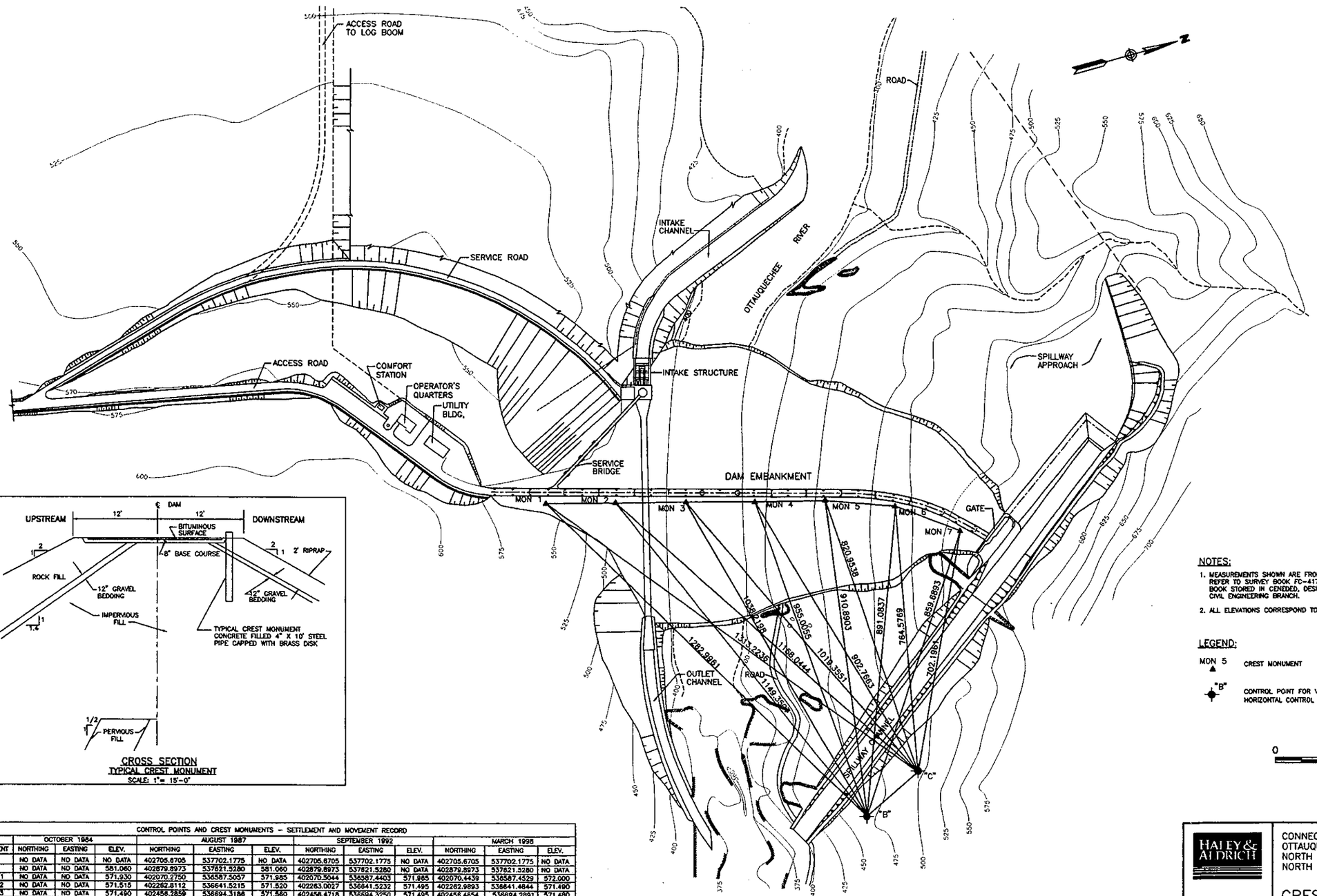
CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

ENGINEERING LOG SECTION
STATION 21+00

SCALE: AS SHOWN NOVEMBER 1999

12126-009 B36

FIGURE 11



CROSS SECTION
TYPICAL CREST MONUMENT
SCALE: 1" = 15'-0"

NOTES:

1. MEASUREMENTS SHOWN ARE FROM MARCH 1998 SURVEY. REFER TO SURVEY BOOK FC-417 AND PLAN SUR-426. BOOK STORED IN CENDEED, DESIGN DIVISION, CIVIL ENGINEERING BRANCH.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.

LEGEND:

MON 5 — CREST MONUMENT

"B" — CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

0 300 600

CONTROL POINTS AND CREST MONUMENTS – SETTLEMENT AND MOVEMENT RECORD

DATE	OCTOBER 1984			AUGUST 1987			SEPTEMBER 1992			MARCH 1998		
MONUMENT	NORTHING	EASTING	ELEV.	NORTHING	EASTING	ELEV.	NORTHING	EASTING	ELEV.	NORTHING	EASTING	ELEV.
B	NO DATA	NO DATA	NO DATA	402705.6705	537702.1775	NO DATA	402705.6705	537702.1775	NO DATA	402705.6705	537702.1775	NO DATA
C	NO DATA	NO DATA	581.060	402879.8973	537821.5280	581.060	402879.8973	537821.5280	NO DATA	402879.8973	537821.5280	NO DATA
MON. 1	NO DATA	NO DATA	571.930	402070.2750	536587.5057	571.985	402070.5044	536587.4403	571.985	402070.4439	536587.4529	572.000
MON. 2	NO DATA	NO DATA	571.515	402262.8112	536641.5215	571.520	402263.0027	536641.5232	571.495	402262.9893	536641.4844	571.490
MON. 3	NO DATA	NO DATA	571.490	402458.2859	536694.3188	571.560	402456.4718	536694.3250	571.495	402456.4854	536694.2891	571.480
MON. 4	NO DATA	NO DATA	571.445	402648.6655	536748.8441	571.455	402648.8232	536748.8862	571.430	402648.7812	536748.8581	571.410
MON. 5	NO DATA	NO DATA	571.560	402841.5407	536801.4324	571.595	402841.6458	536801.4860	571.575	402841.6321	536801.4770	571.580
MON. 6	NO DATA	NO DATA	571.775	403028.0327	536871.3989	571.785	403028.1518	536871.5079	571.770	403028.1518	536871.4813	571.760
MON. 7	NO DATA	NO DATA	571.710	403188.0631	536990.5424	571.750	403188.1247	536990.6499	571.740	403188.1116	536990.5982	571.730

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

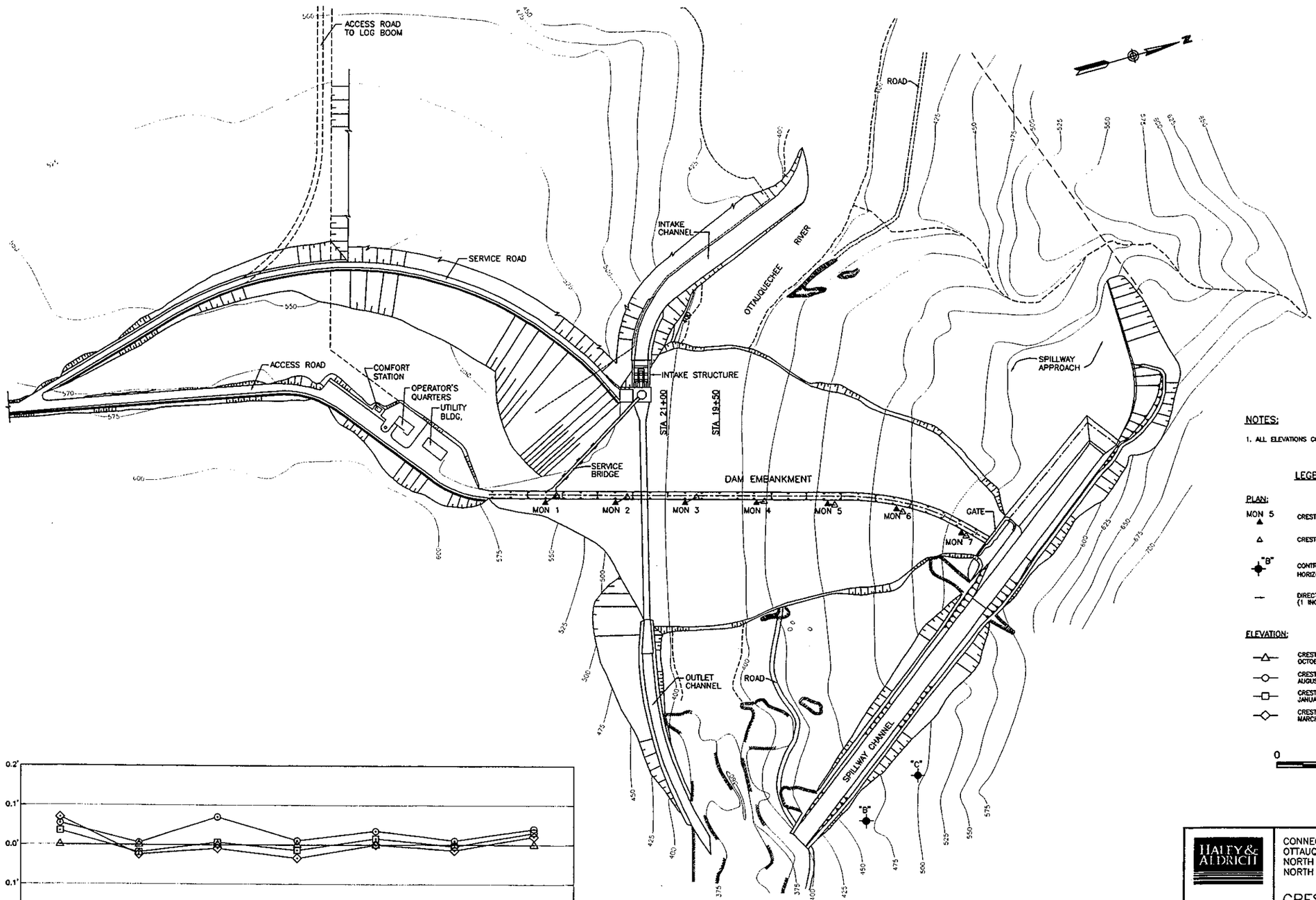
CREST SURVEY MONUMENT – GENERAL LAYOUT, LOCATION AND SURVEY DATA

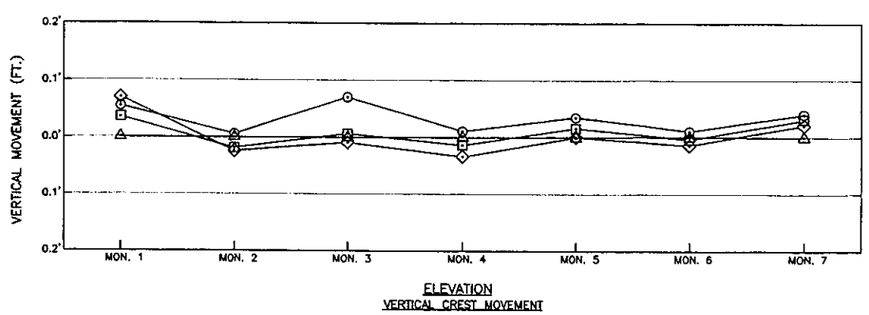
SCALE: AS SHOWN

NOVEMBER 1999

12126-009 B37

FIGURE 12





ELEVATION
VERTICAL CREST MOVEMENT

NOTES:

1. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.

LEGEND:

PLAN:

MON 5 — CREST MONUMENT 1987

CREST MONUMENT 1998

"B" — CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

DIRECTION OF HORIZONTAL MOVEMENT (1 INCH = 0.5 FEET)

ELEVATION:

CREST MONUMENT INITIAL ELEVATION OCTOBER 1984

CREST MONUMENT ELEVATION AS OF AUGUST 1987

CREST MONUMENT ELEVATION AS OF JANUARY 1992

CREST MONUMENT ELEVATION AS OF MARCH 1998

0 300 600

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

CREST SURVEY MONUMENTS – HORIZONTAL AND VERTICAL MOVEMENT

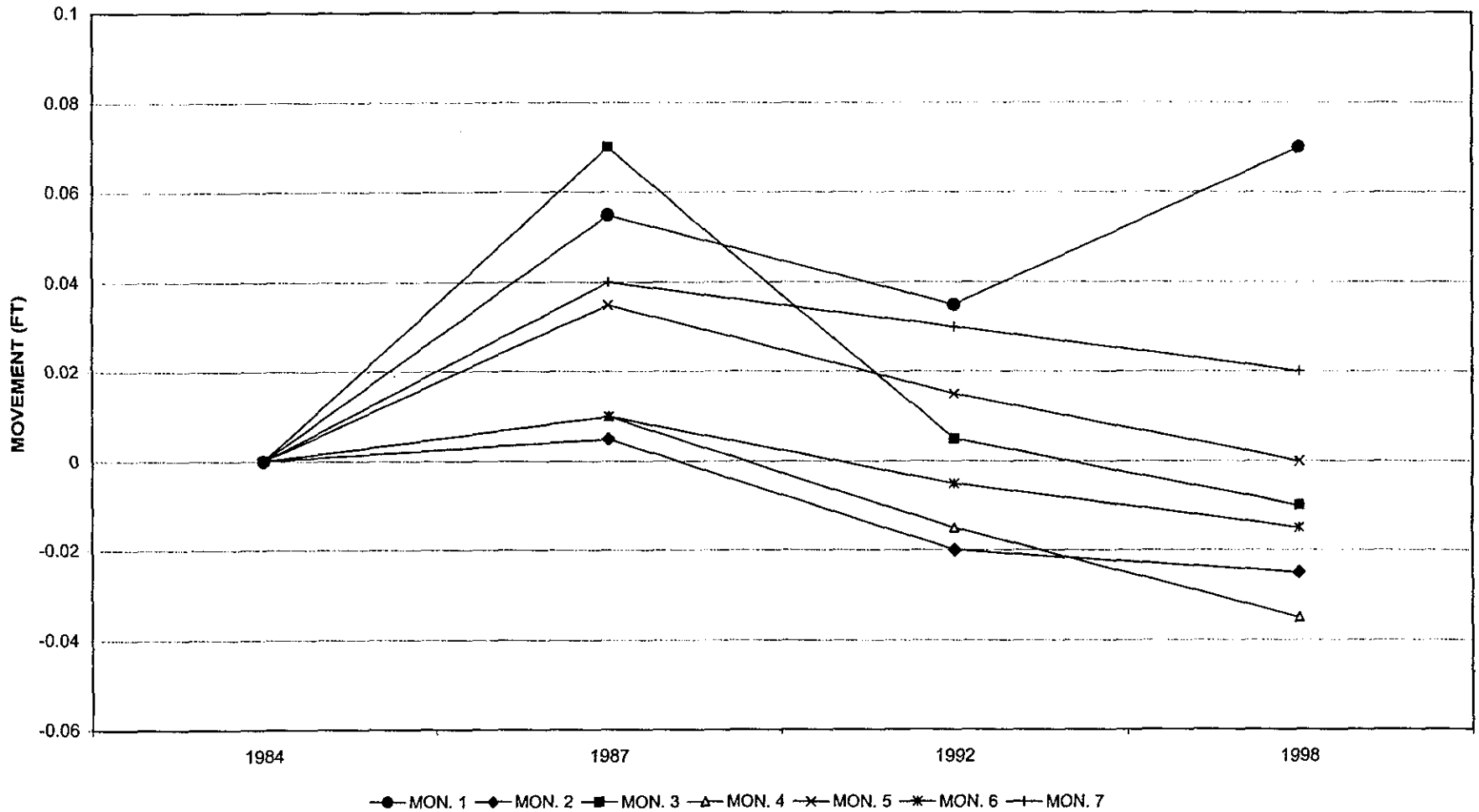
SCALE: AS SHOWN

JANUARY 2000

12126-009 B38

FIGURE 13

FILE NO. 12126-009



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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

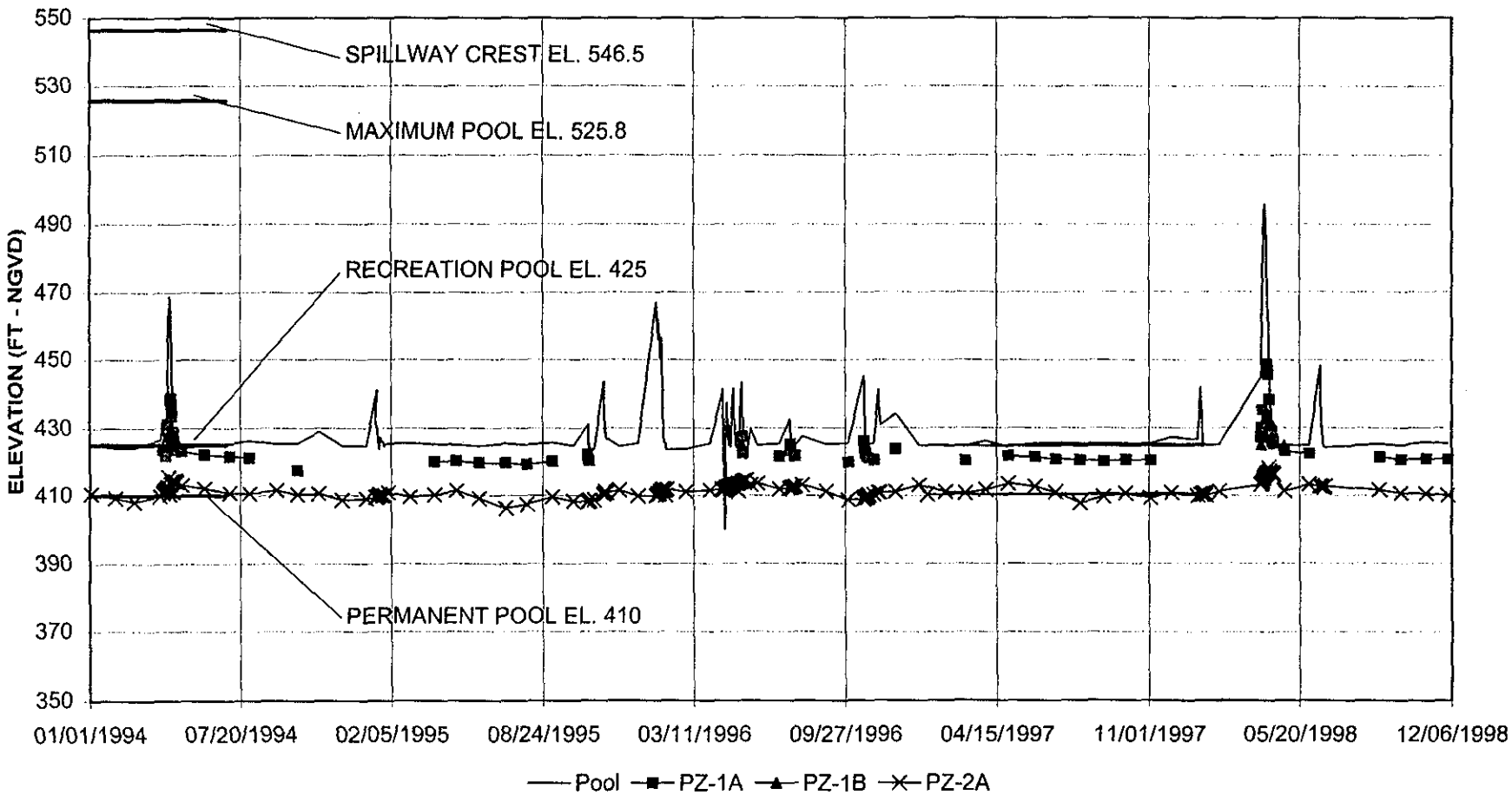
SETTLEMENT vs. TIME
CREST MONUMENTS

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 14

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-1A	390.8	518.2
PZ-1B	423.8	518.3
PZ-2A	387.8	574.2

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CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

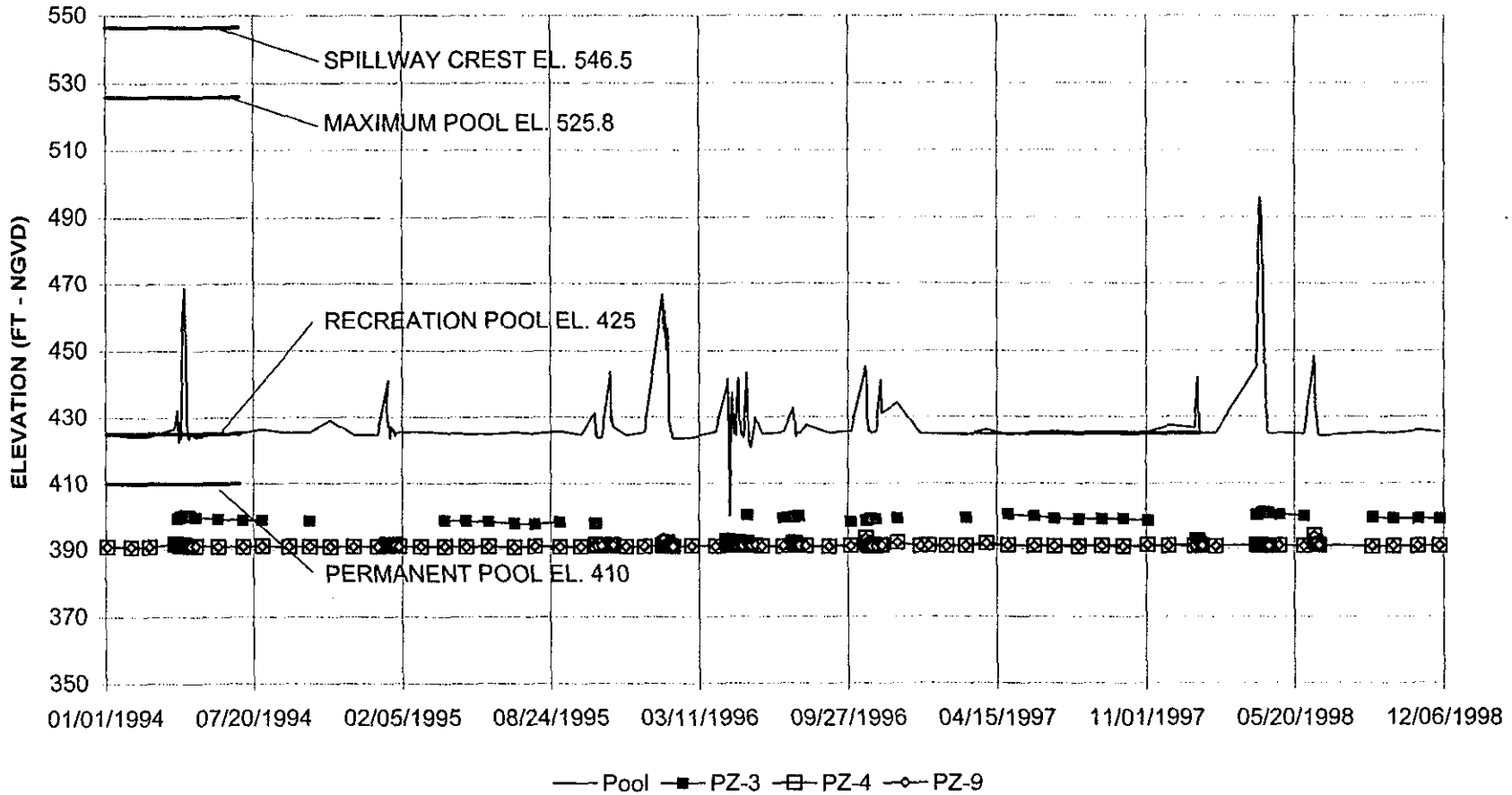
TIME HISTORY PLOTS
STATION 19+50
PZ-1A, 1B, and 2A

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 15

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-3	386.5	485.7
PZ-4	383.8	400.8
PZ-9	384.6	400.8

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

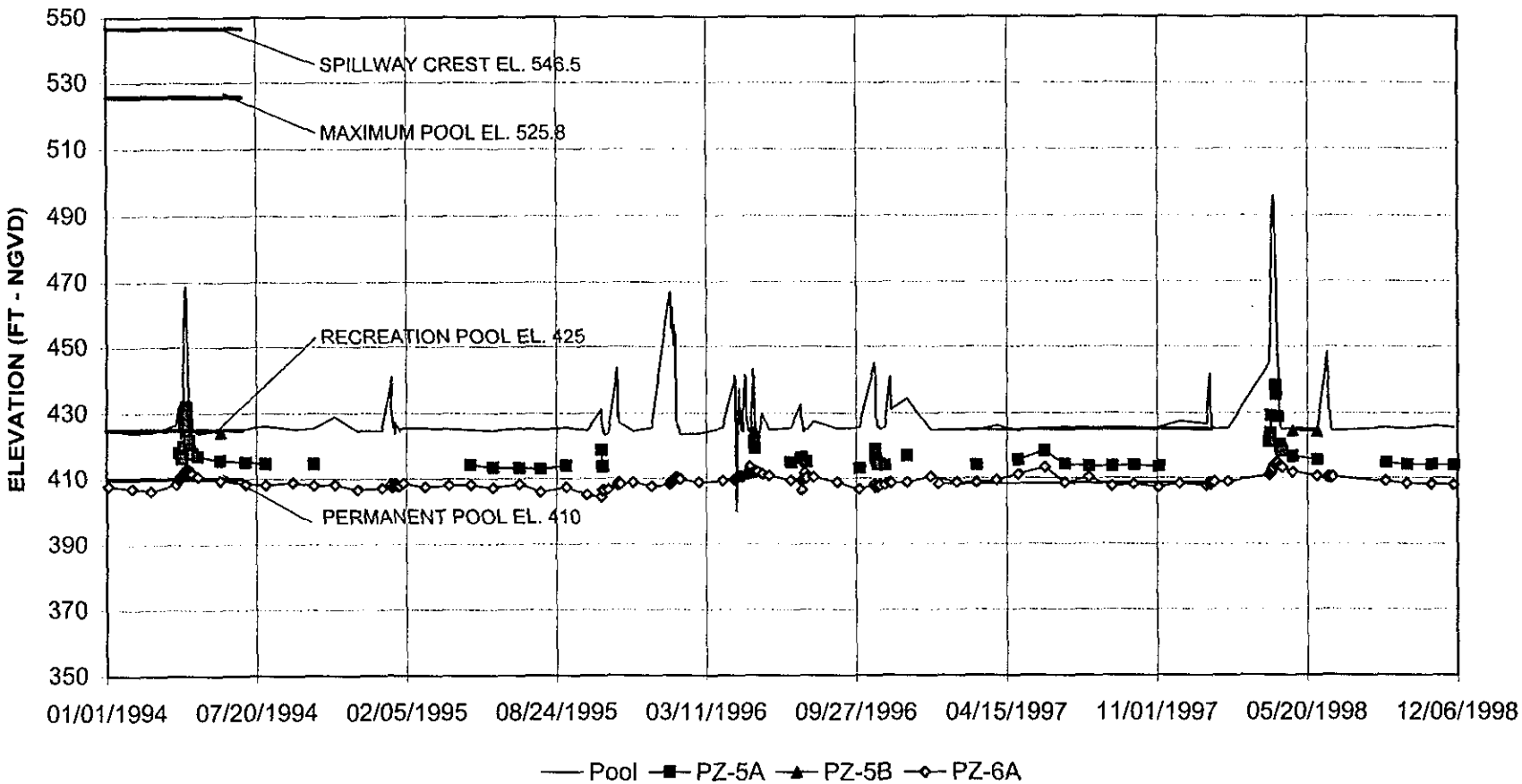
TIME HISTORY PLOTS
STATION 19+50
PZ-3, 4, and 9

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 16

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-5A	383.6	516.5
PZ-5B	422.6	516.8
PZ-6A	389.9	573.7

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

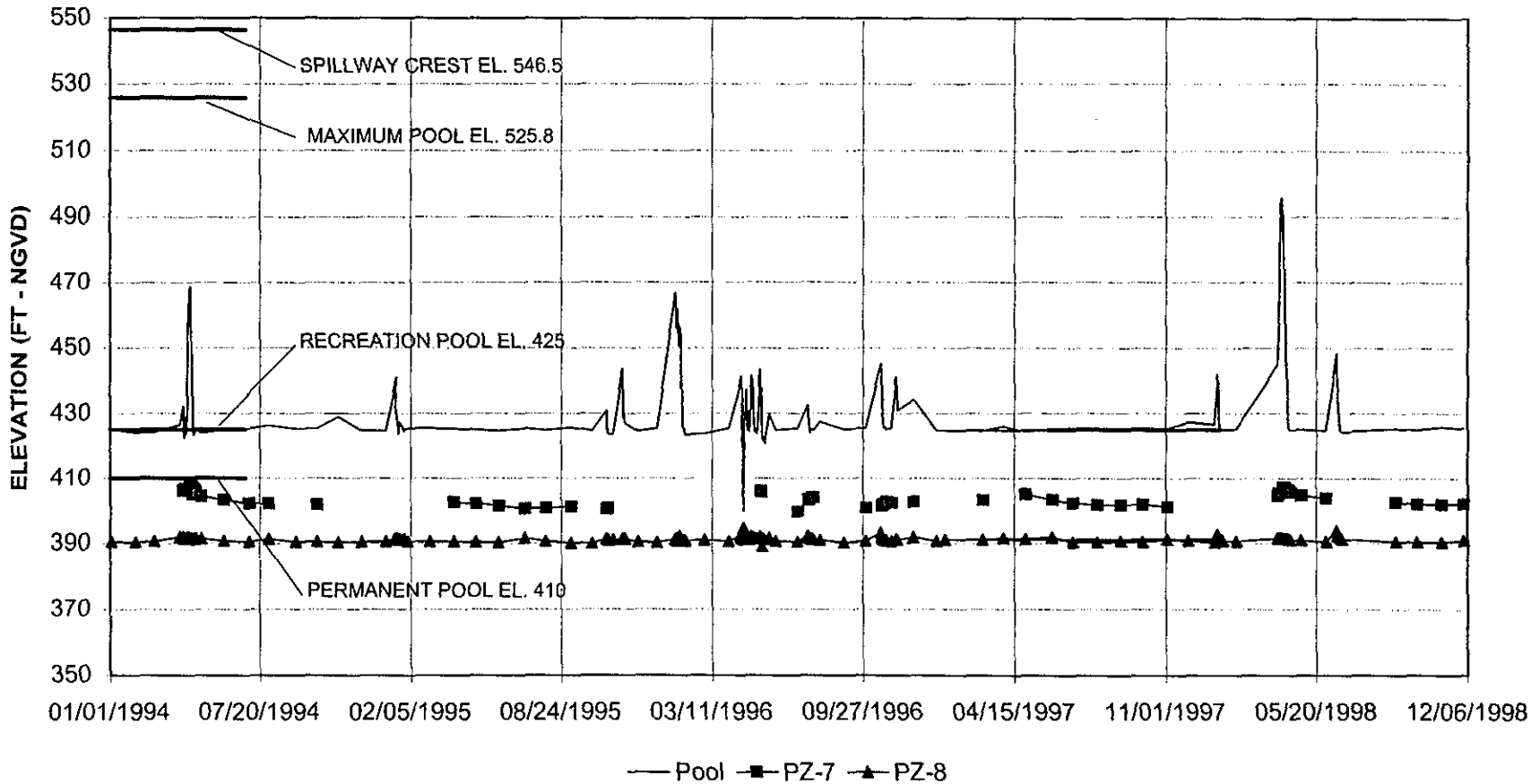
TIME HISTORY PLOTS
STATION 21+00
PZ-5A, 5B, and 6A

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 17

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-7	390.70	485.90
PZ-8	386.90	402.10

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

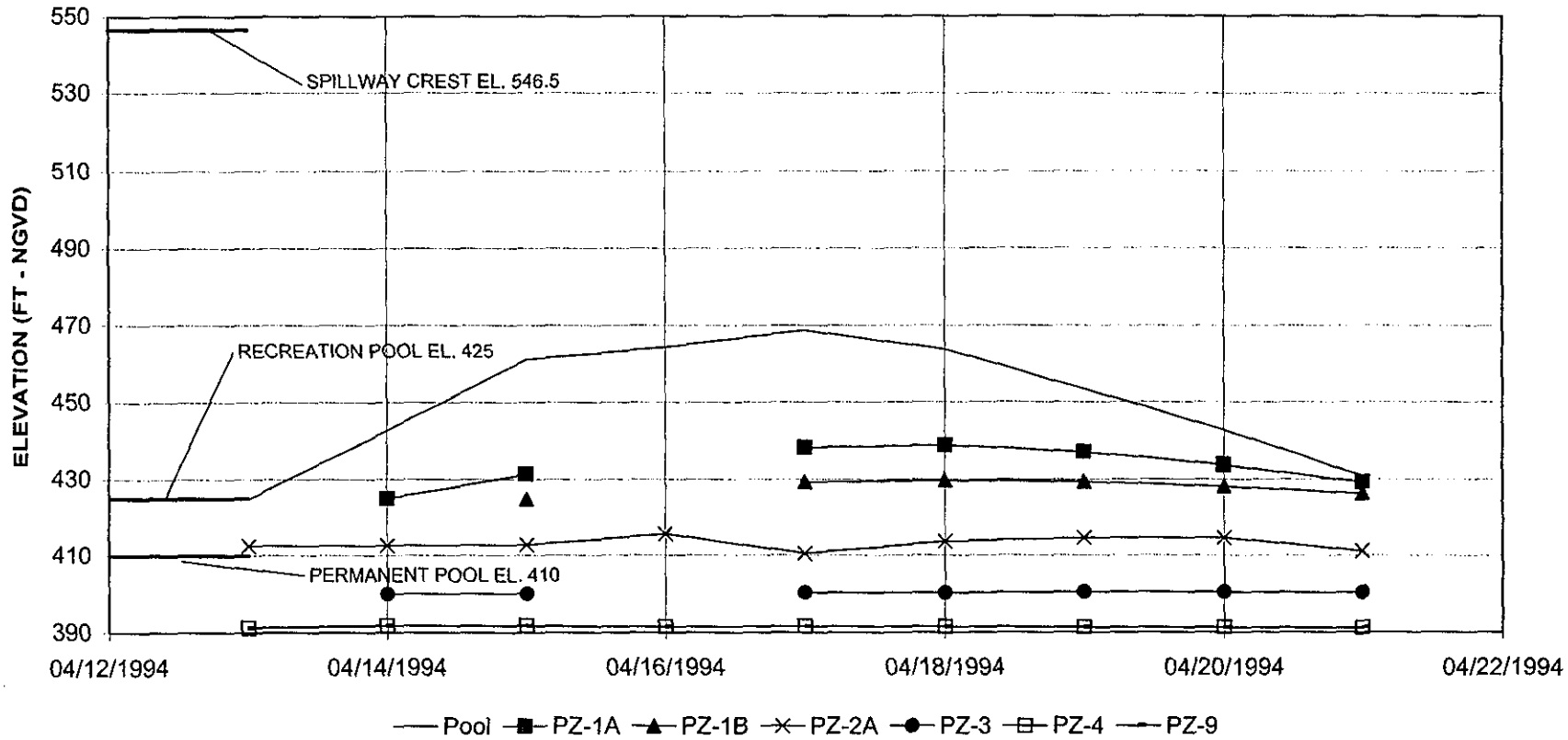
TIME HISTORY PLOTS
STATION 21+00
PZ-7 and 8

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 18

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-1A	390.8	518.2
PZ-1B	423.8	518.3
PZ-2A	387.8	574.2
PZ-3	386.5	485.7
PZ-4	383.8	400.8
PZ-9	384.6	400.8

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

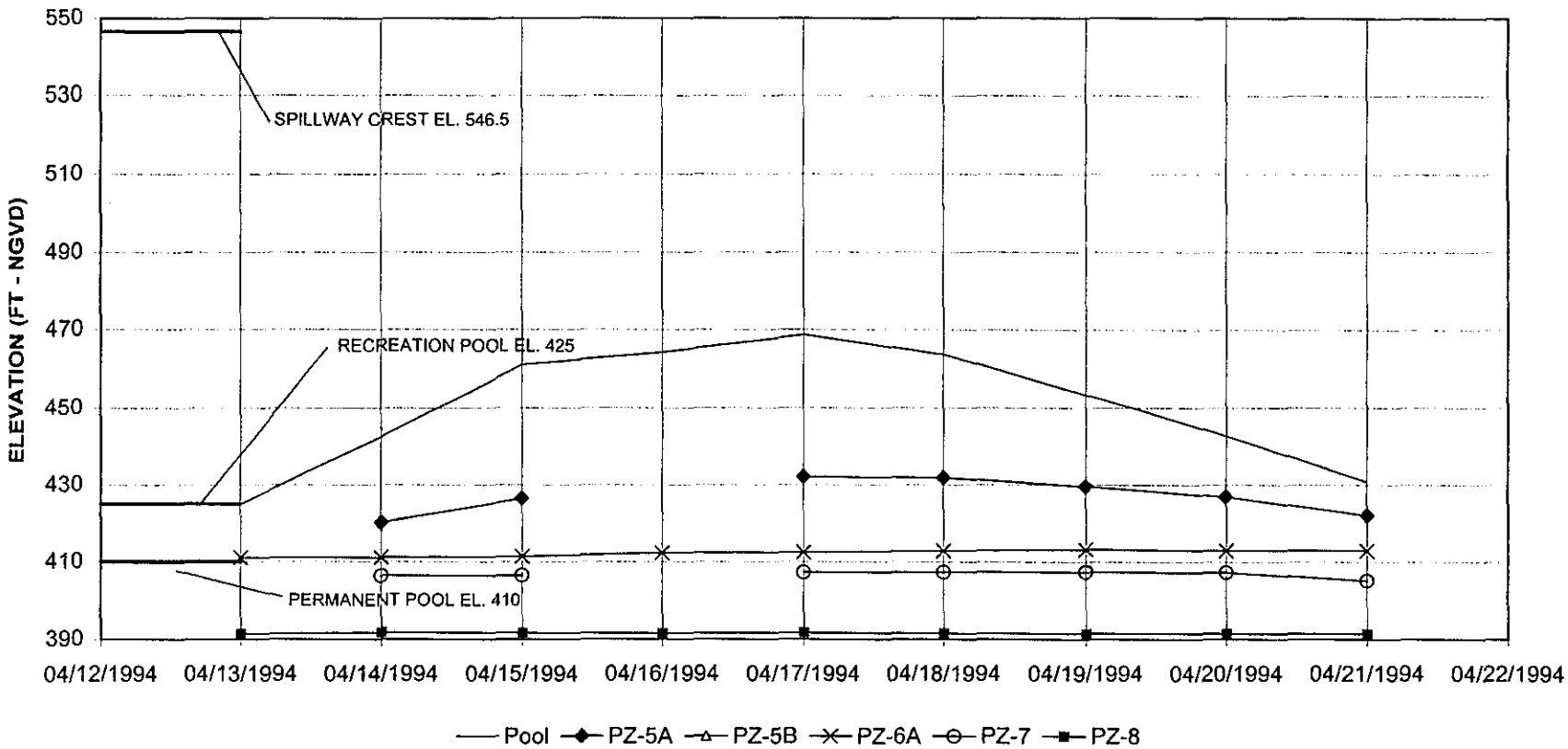
CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

APRIL 1994 EVENT
STATION 19+50
PZ-1A, 1B, 2A, 3, 4, and 9

SCALE: AS SHOWN OCTOBER 1999

FIGURE 19

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-5A	383.6	516.5
PZ-5B	422.6	516.8
PZ-6A	389.9	573.7
PZ-7	390.70	485.90
PZ-8	386.90	402.10

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

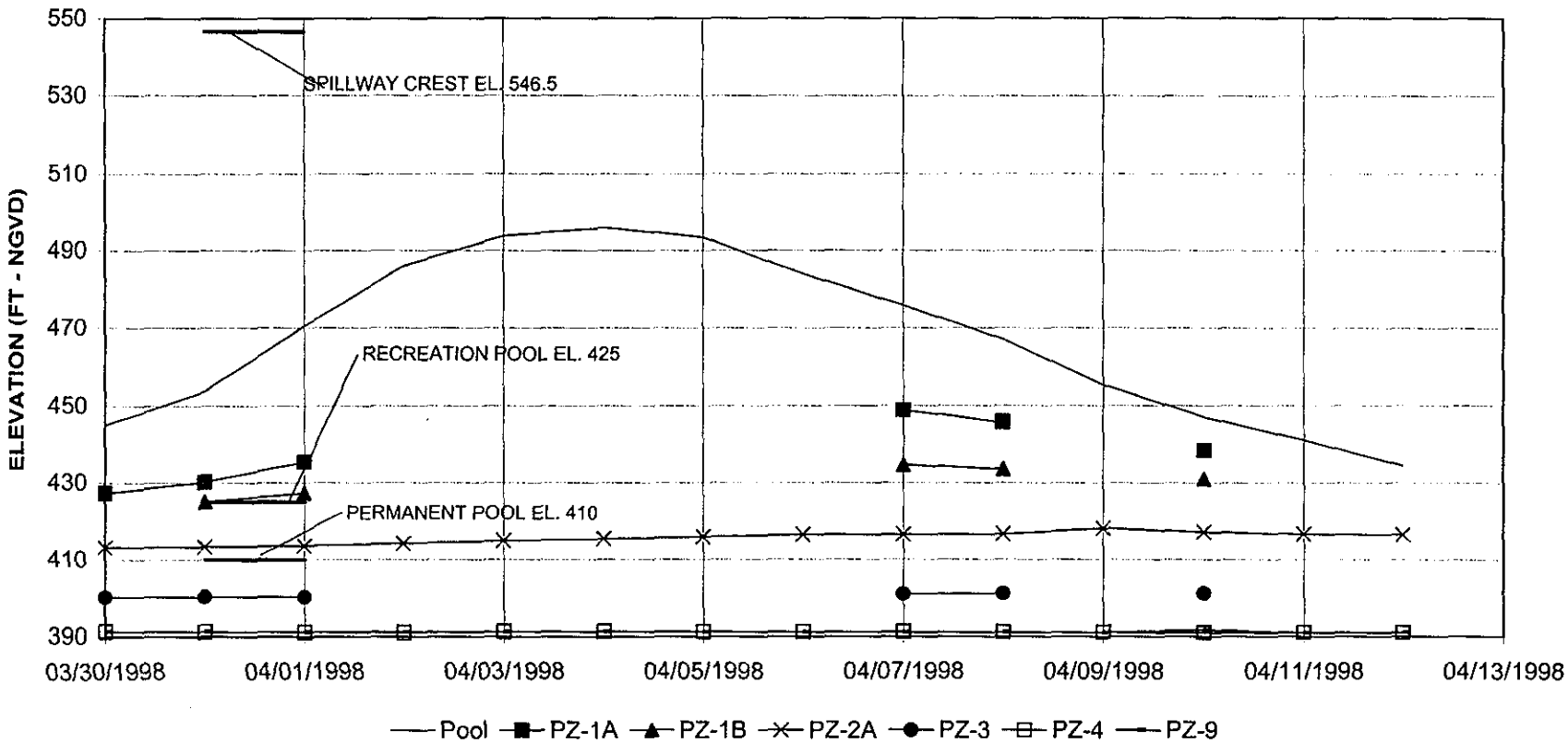
APRIL 1994 EVENT
STATION 21+00
PZ-5A, 5B, 6A, 7, and 8

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 20

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-1A	390.8	518.2
PZ-1B	423.8	518.3
PZ-2A	387.8	574.2
PZ-3	386.5	485.7
PZ-4	383.8	400.8
PZ-9	384.6	400.8

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

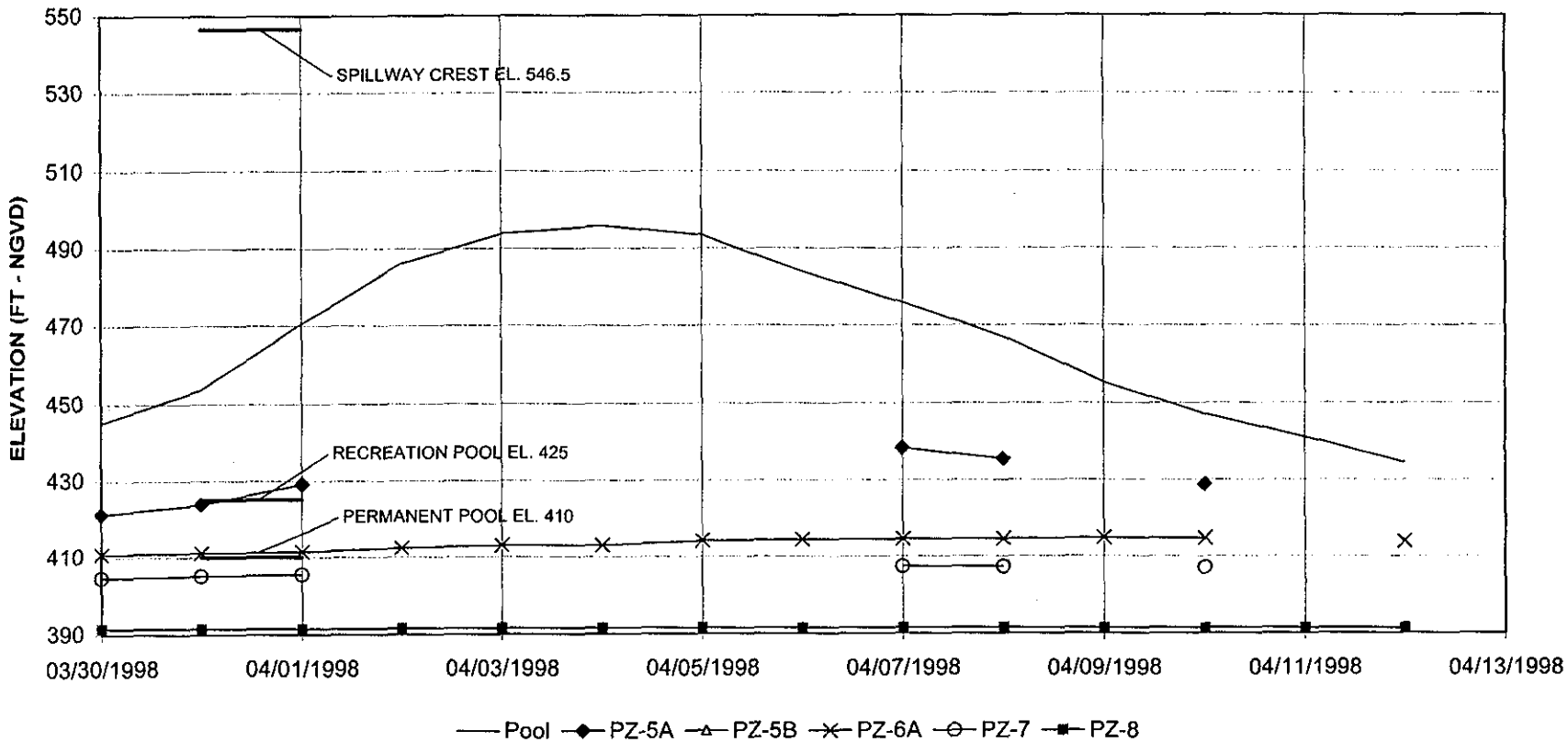
APRIL 1998 EVENT
STATION 19+50
PZ-1A, 1B, 2A, 3, 4, and 9

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 21

FILE NO. 12126-009



Piezometer No.	Tip Elevation (ft - NGVD)	Riser Pipe Elevation (ft - NGVD)
PZ-5A	383.6	516.5
PZ-5B	422.6	516.8
PZ-6A	389.9	573.7
PZ-7	390.70	485.90
PZ-8	386.90	402.10

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

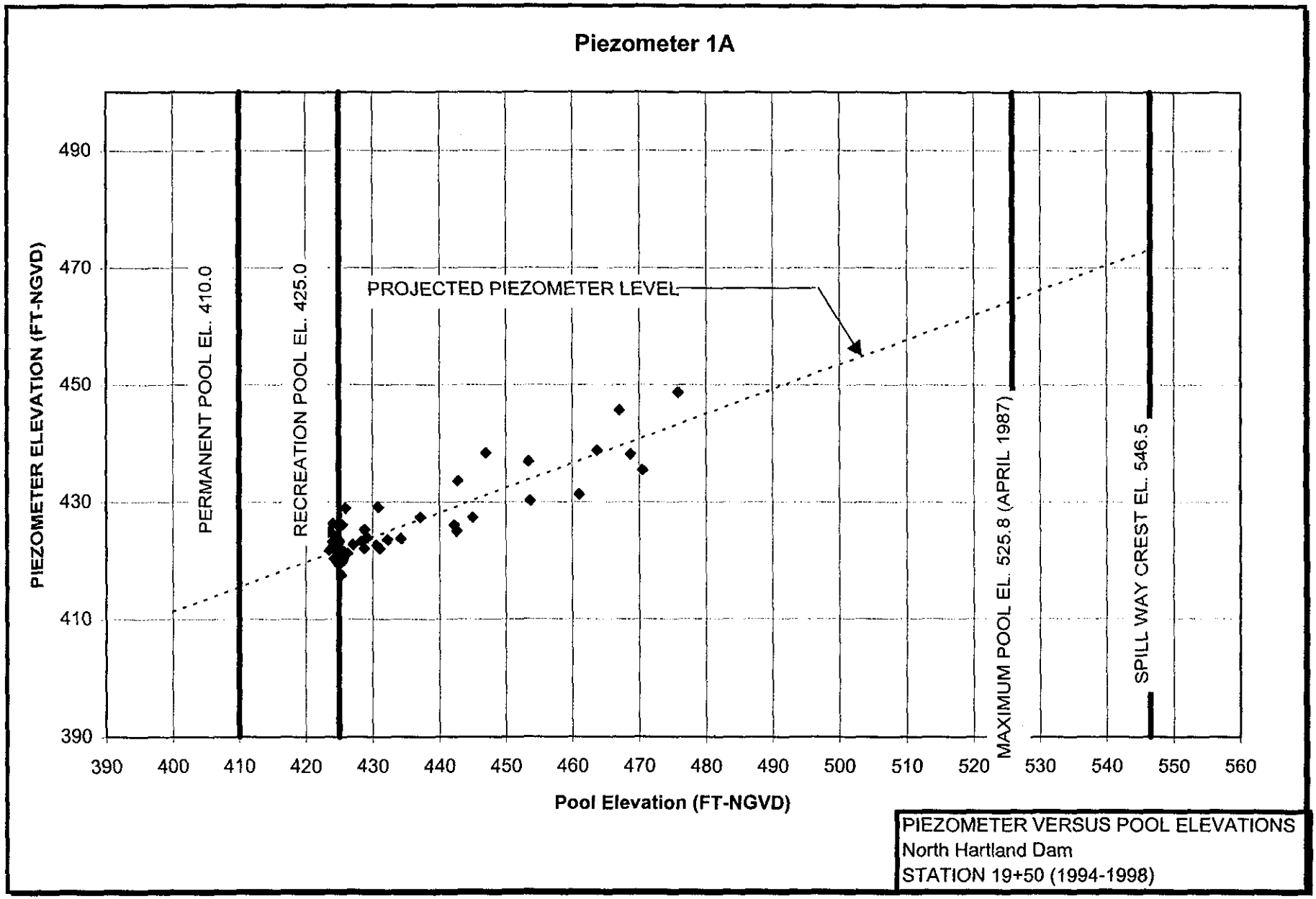
CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

APRIL 1998 EVENT
STATION 21+00
PZ-5A, 5B, 6A, 7, and 8

SCALE: AS SHOWN

OCTOBER 1999

FIGURE 22



PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)

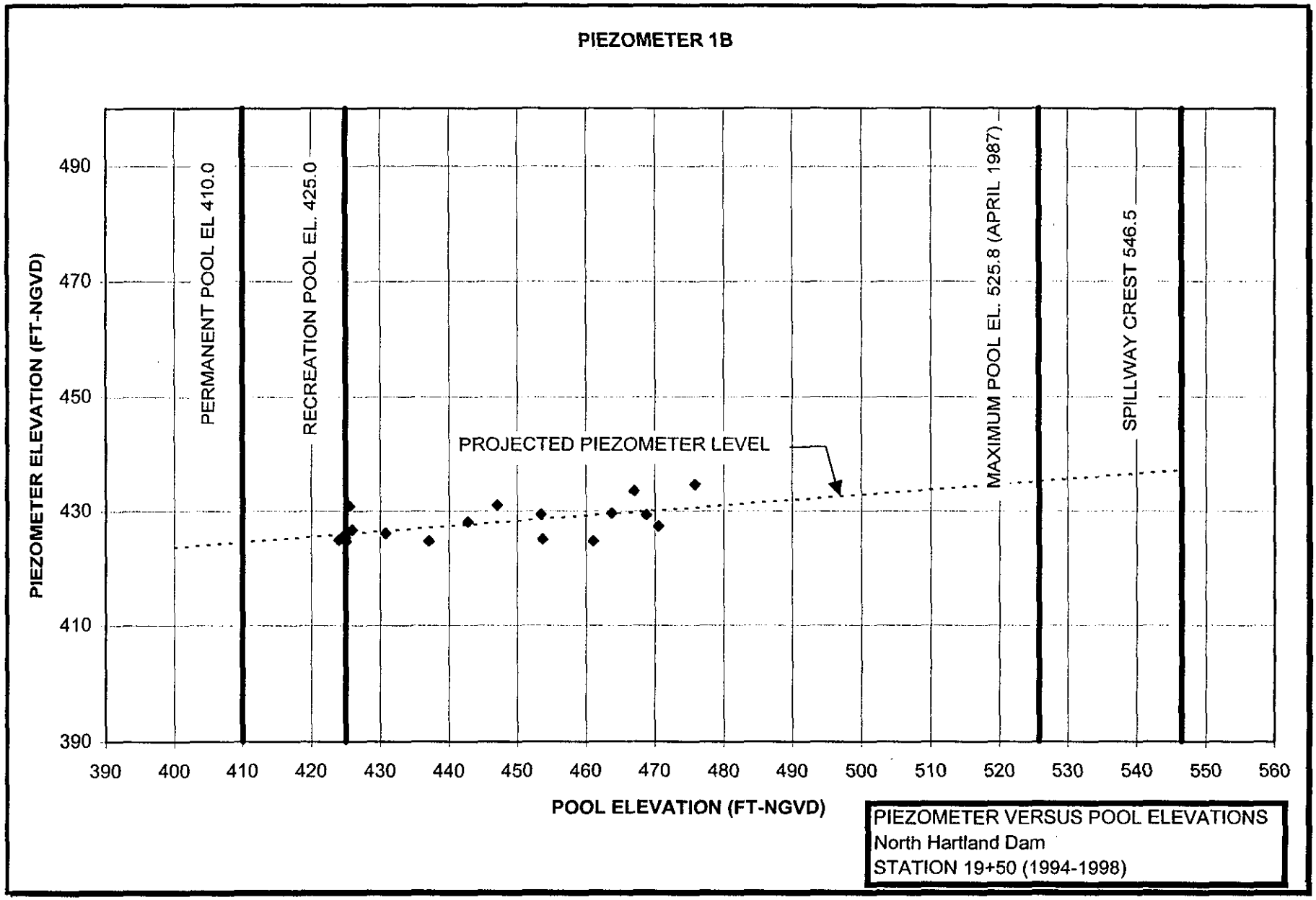
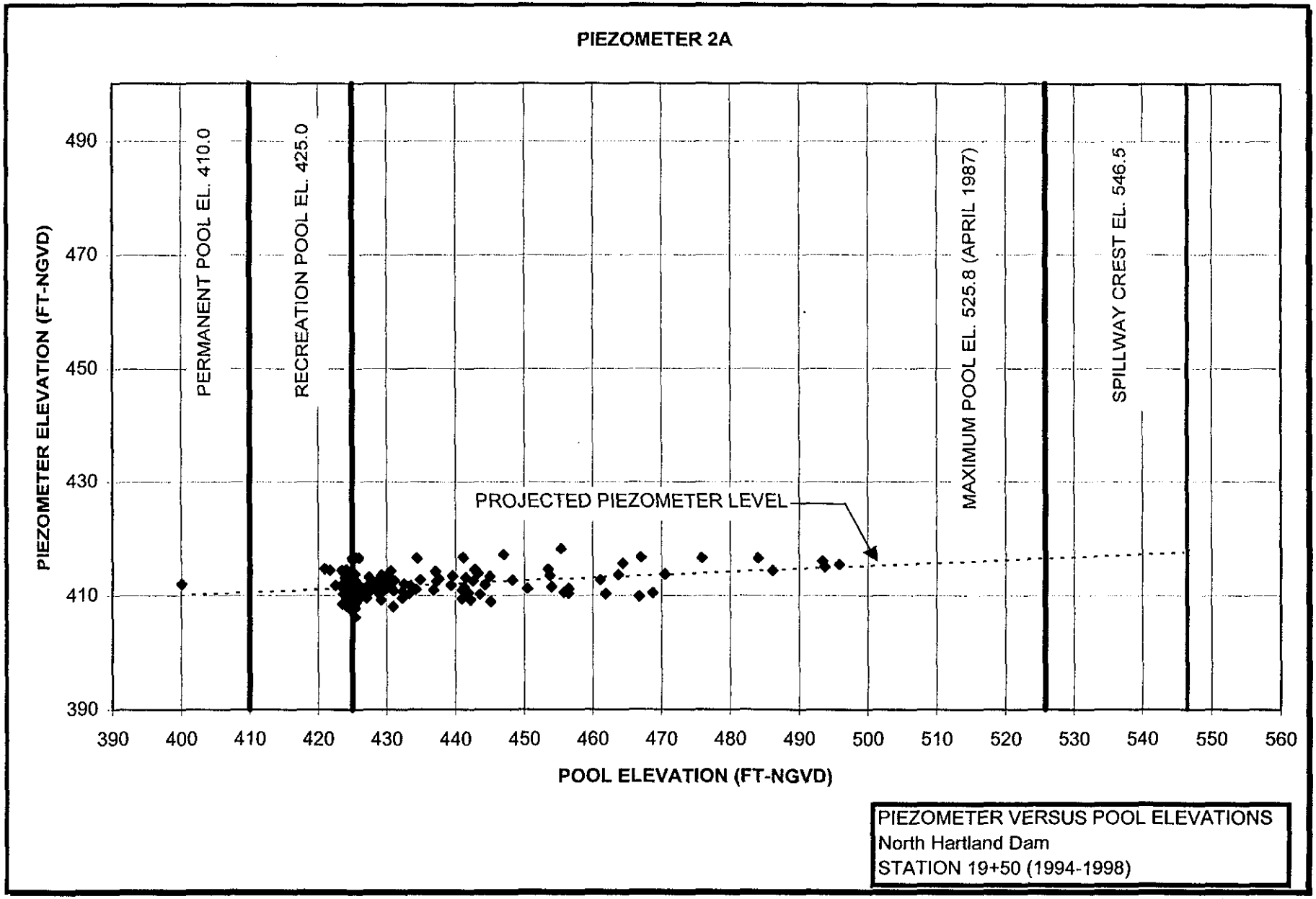

PIEZOMETER 1B
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL 410.0
RECREATION POOL EL. 425.0
PROJECTED PIEZOMETER LEVEL
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST 546.5
390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560
POOL ELEVATION (FT-NGVD)
PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)

FIGURE 24


PIEZOMETER 2A
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST EL. 546.5
PROJECTED PIEZOMETER LEVEL
390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560
POOL ELEVATION (FT-NGVD)
PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)

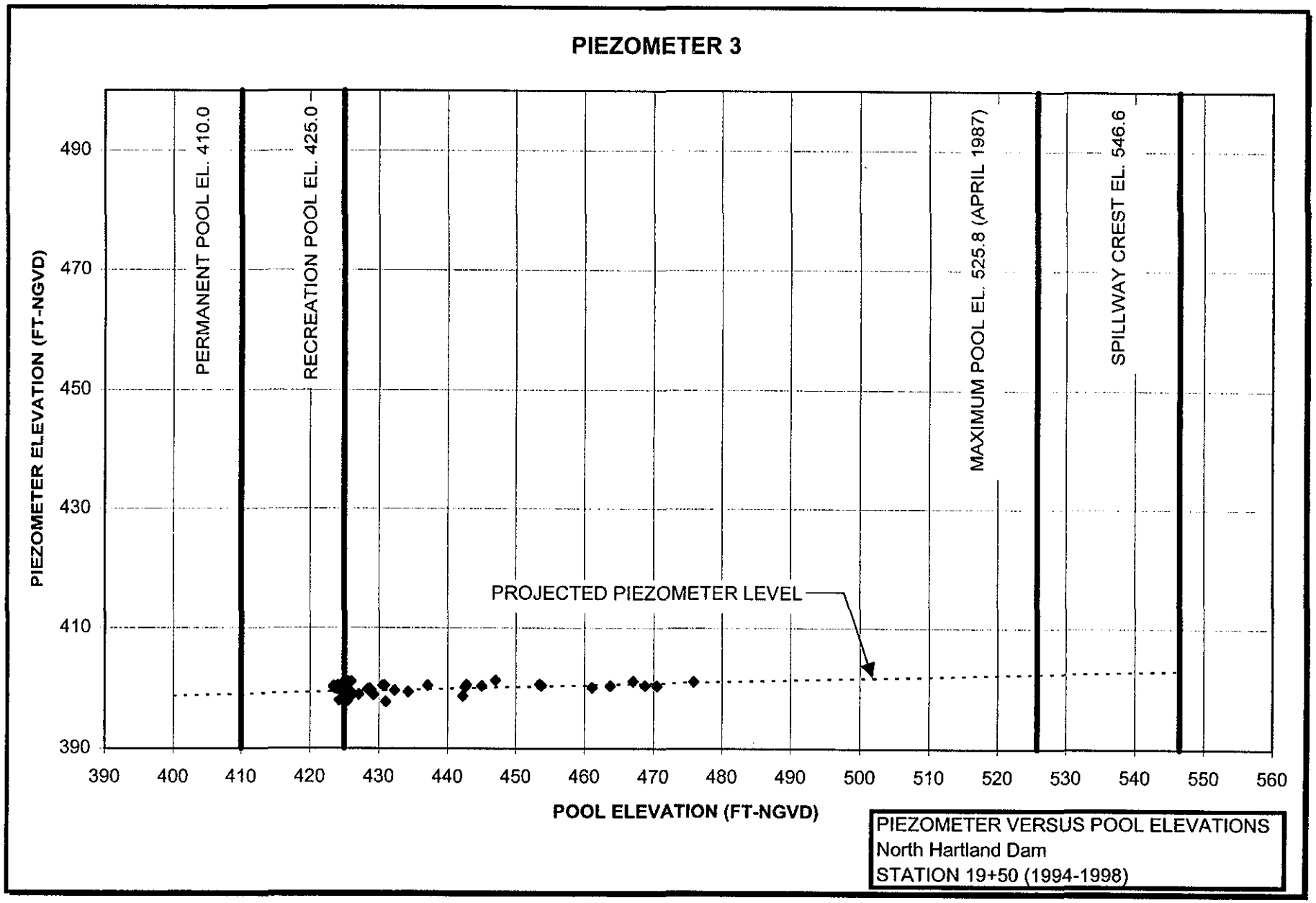
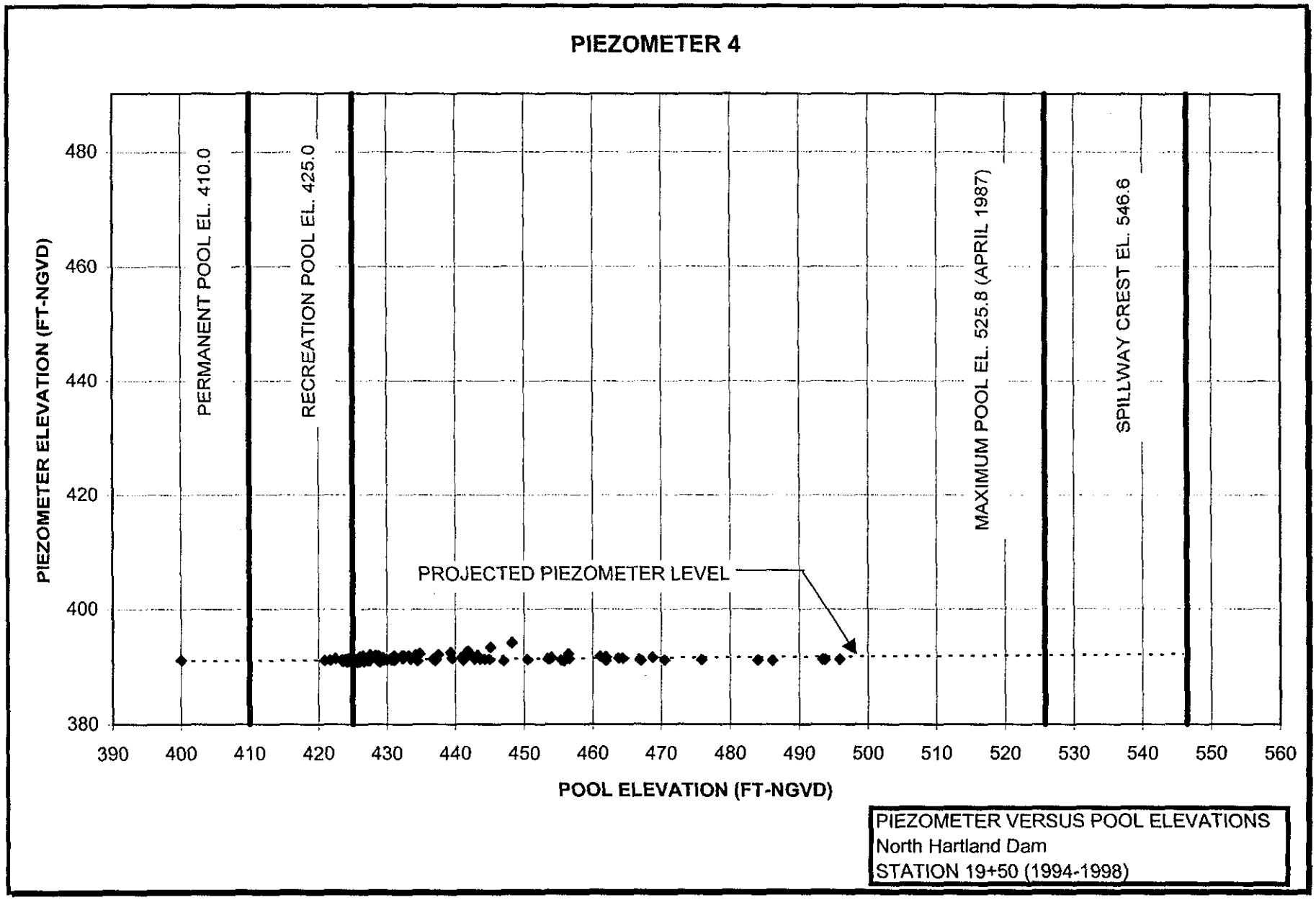

PIEZOMETER 3
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST EL. 546.6
PROJECTED PIEZOMETER LEVEL
390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560
POOL ELEVATION (FT-NGVD)
PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)

FIGURE 26



PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)

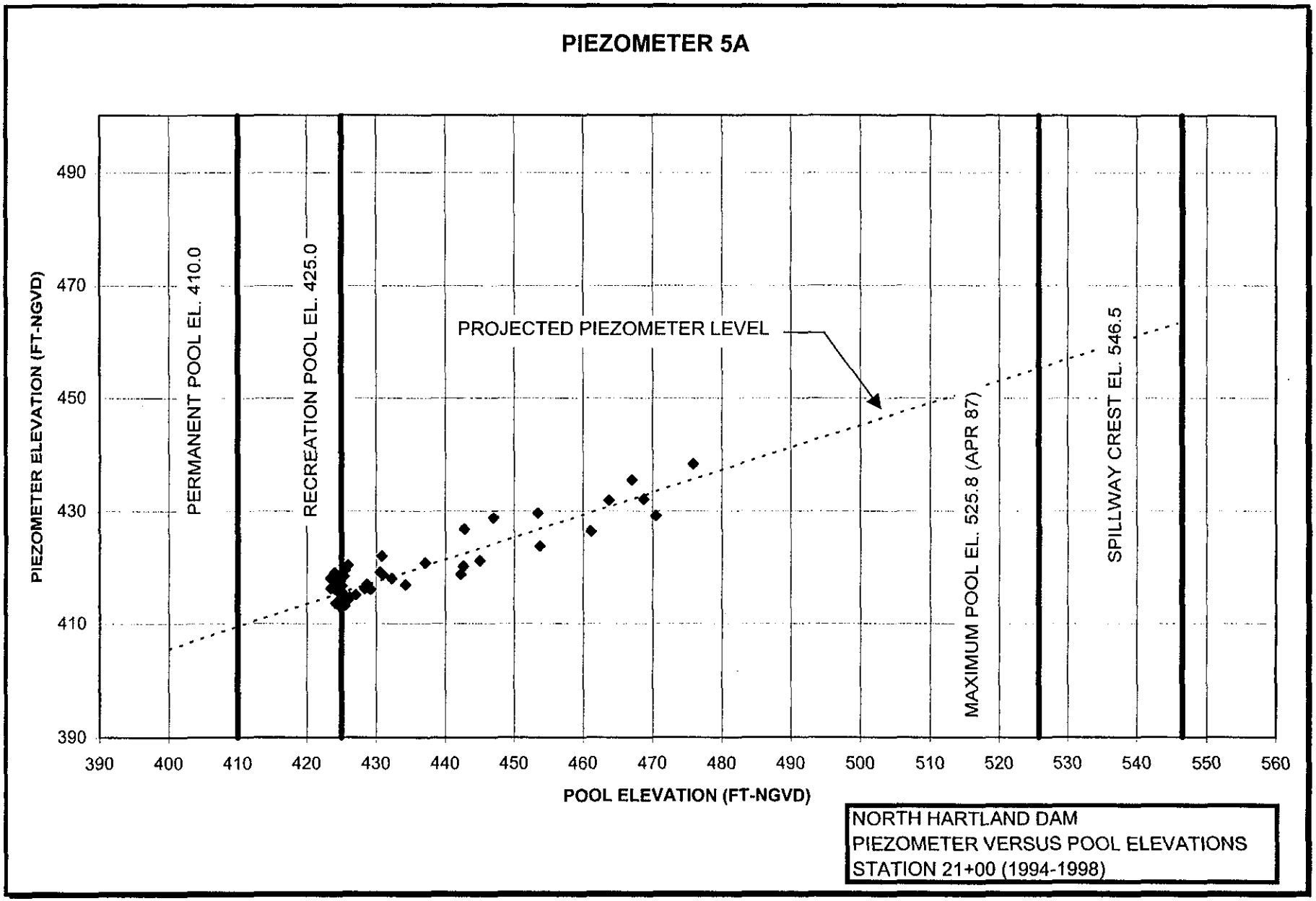
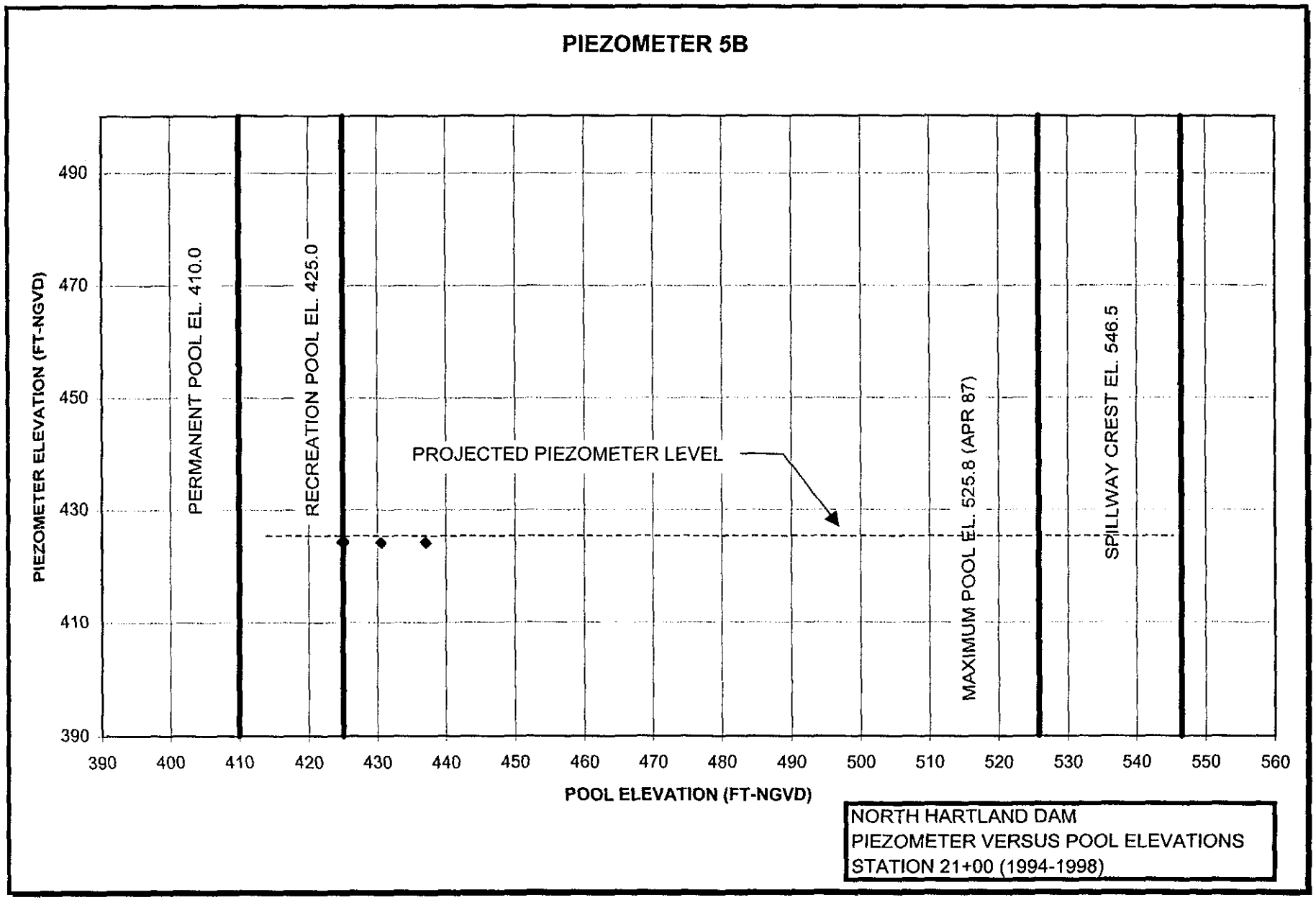

PIEZOMETER 5A
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
POOL ELEVATION (FT-NGVD)
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
PROJECTED PIEZOMETER LEVEL
MAXIMUM POOL EL. 525.8 (APR 87)
SPILLWAY CREST EL. 546.5
NORTH HARTLAND DAM
PIEZOMETER VERSUS POOL ELEVATIONS
STATION 21+00 (1994-1998)

FIGURE 28


PIEZOMETER 5B
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
PROJECTED PIEZOMETER LEVEL
MAXIMUM POOL EL. 525.8 (APR 87)
SPILLWAY CREST EL. 546.5
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
POOL ELEVATION (FT-NGVD)
NORTH HARTLAND DAM
PIEZOMETER VERSUS POOL ELEVATIONS
STATION 21+00 (1994-1998)

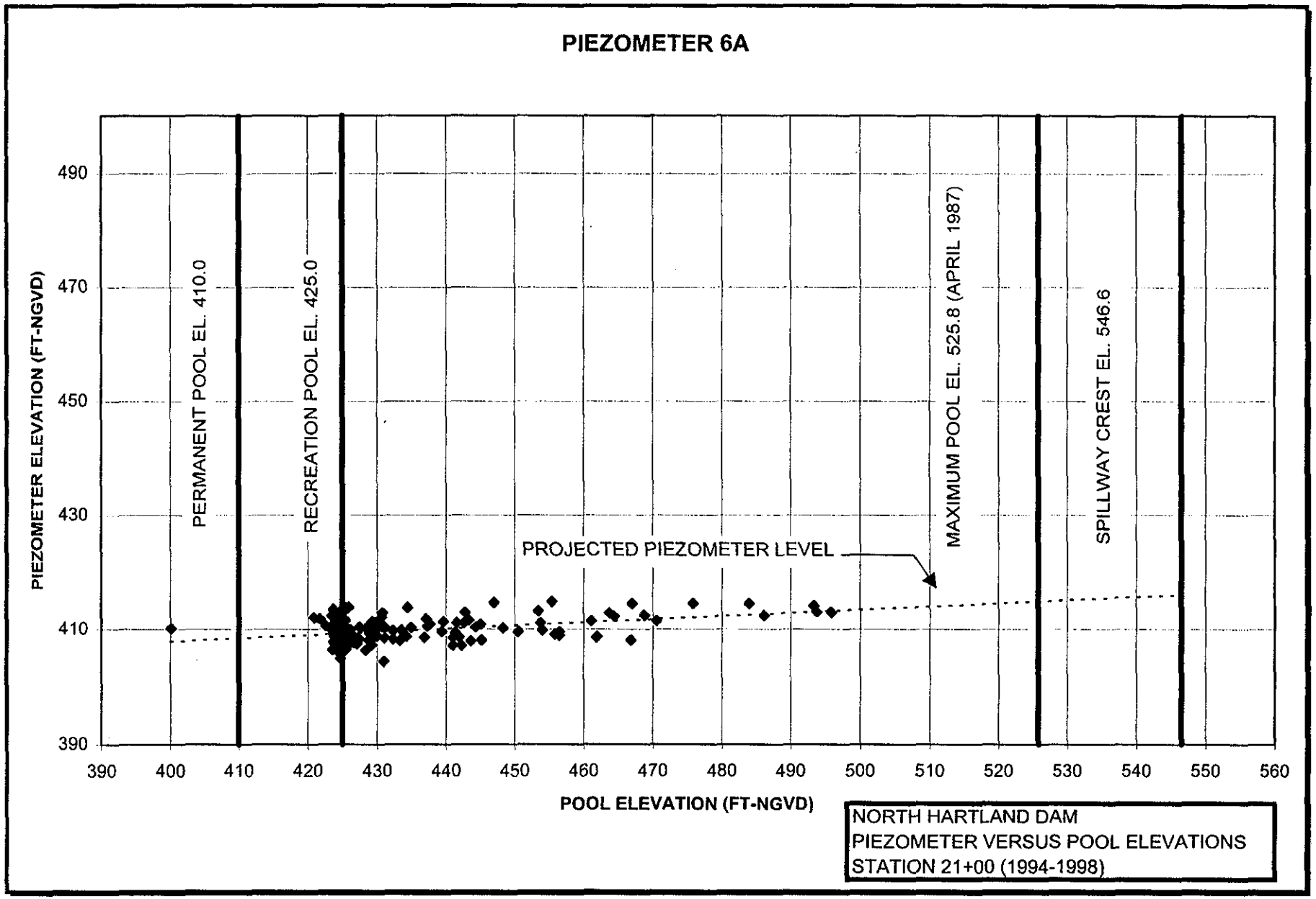
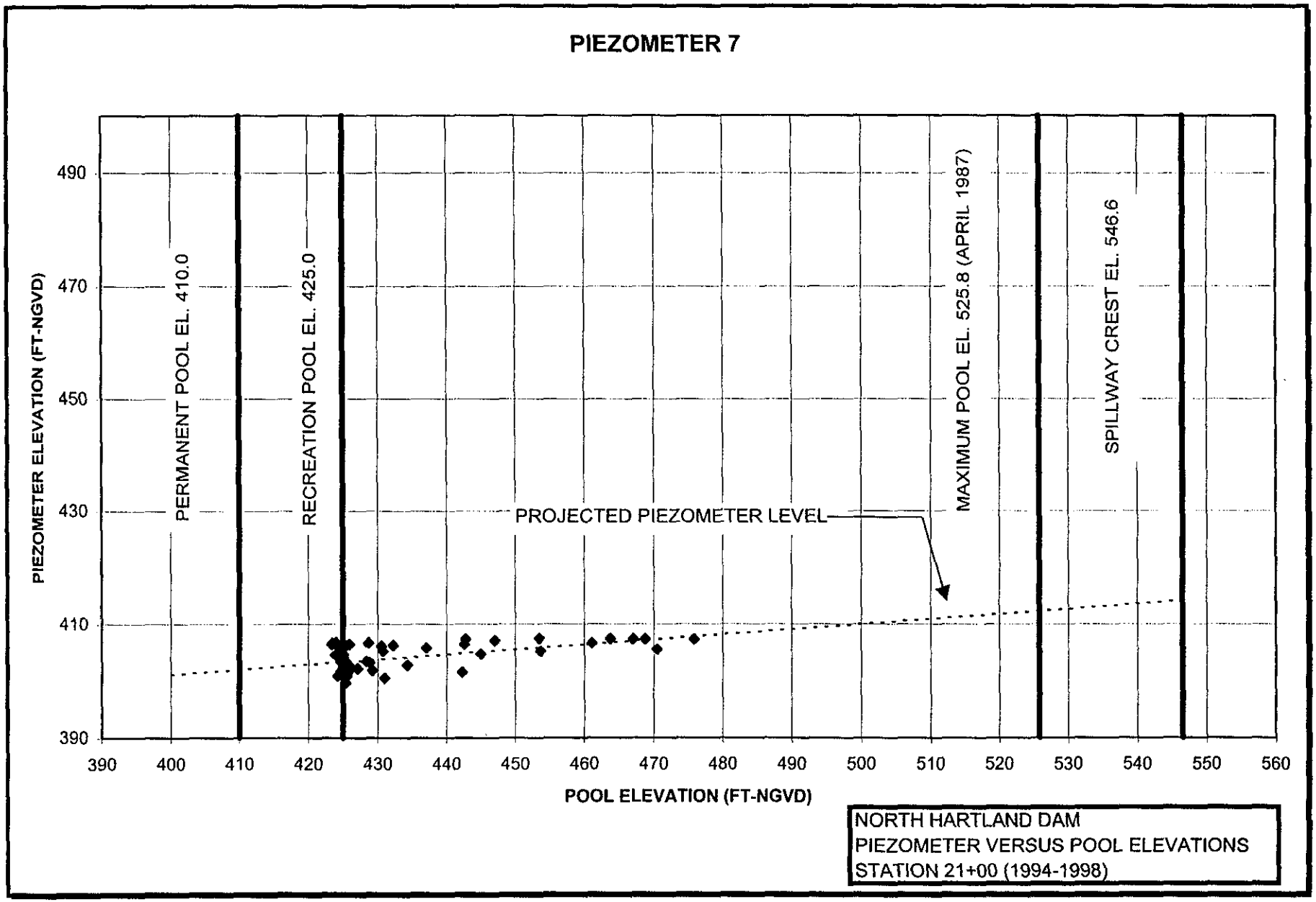

PIEZOMETER 6A
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST EL. 546.6
PROJECTED PIEZOMETER LEVEL
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
POOL ELEVATION (FT-NGVD)
NORTH HARTLAND DAM
PIEZOMETER VERSUS POOL ELEVATIONS
STATION 21+00 (1994-1998)

FIGURE 30


PIEZOMETER 7
PIEZOMETER ELEVATION (FT-NGVD)
490
470
450
430
410
390
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
PROJECTED PIEZOMETER LEVEL
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST EL. 546.6
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
POOL ELEVATION (FT-NGVD)
NORTH HARTLAND DAM
PIEZOMETER VERSUS POOL ELEVATIONS
STATION 21+00 (1994-1998)

F RE 31

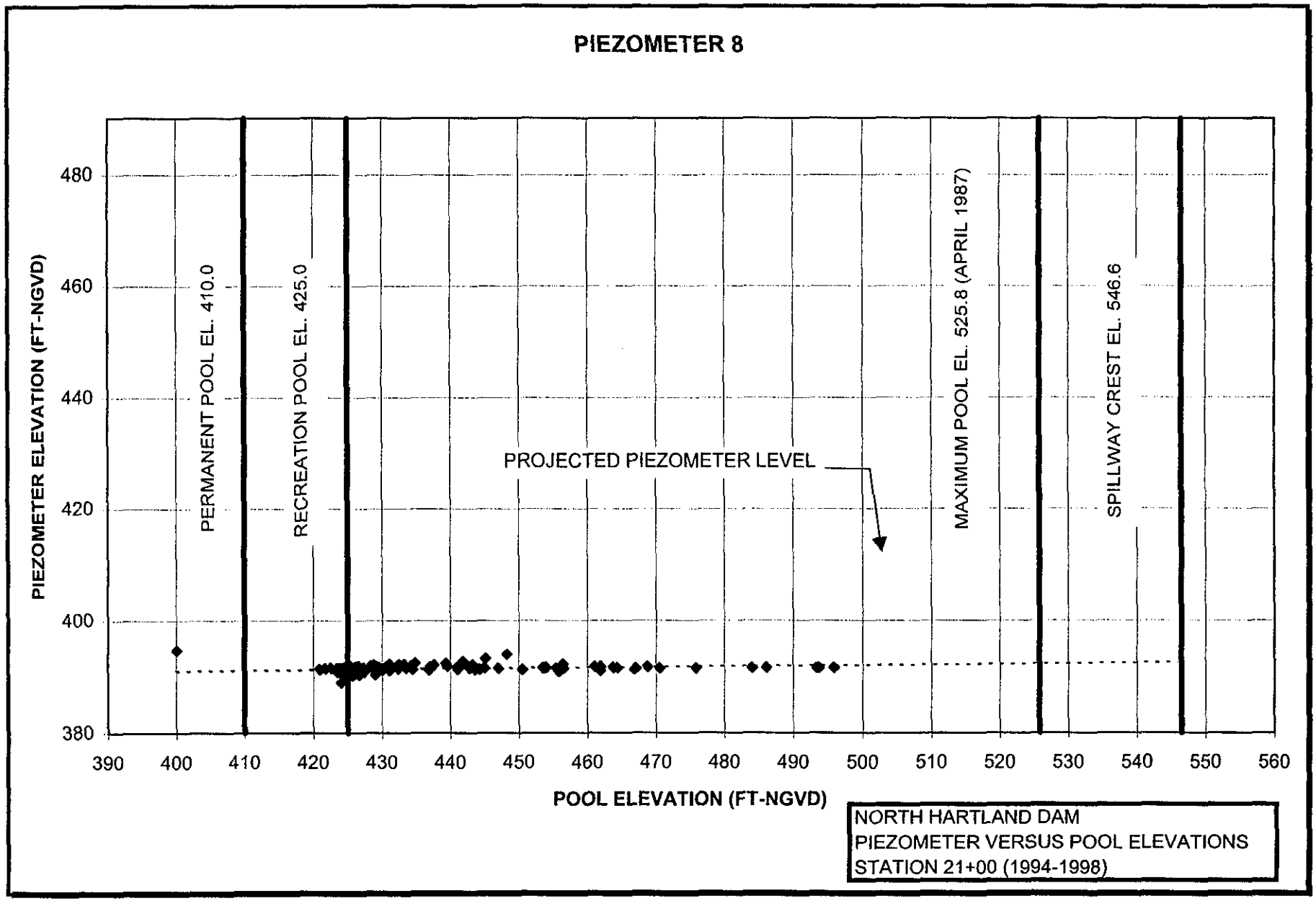
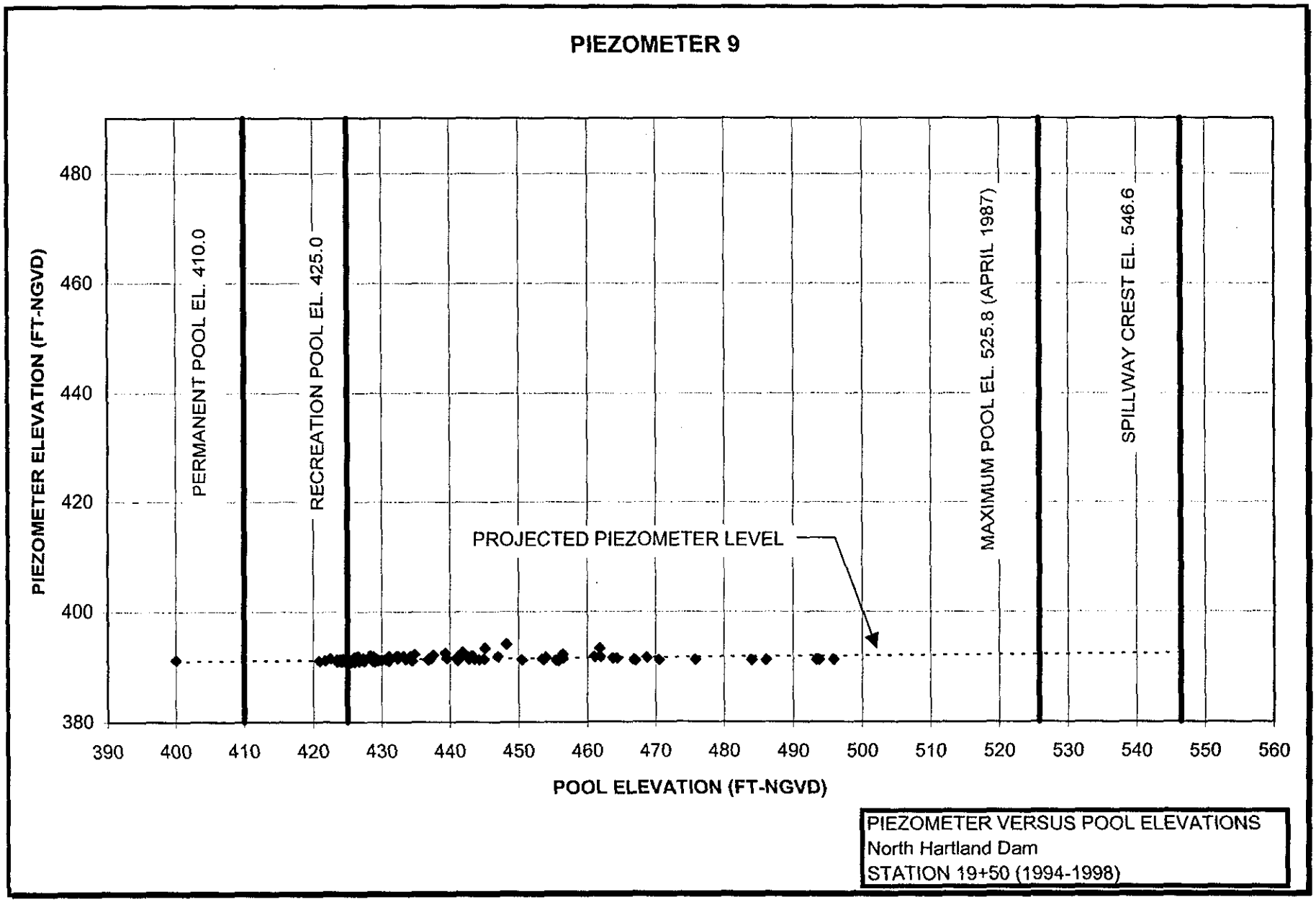
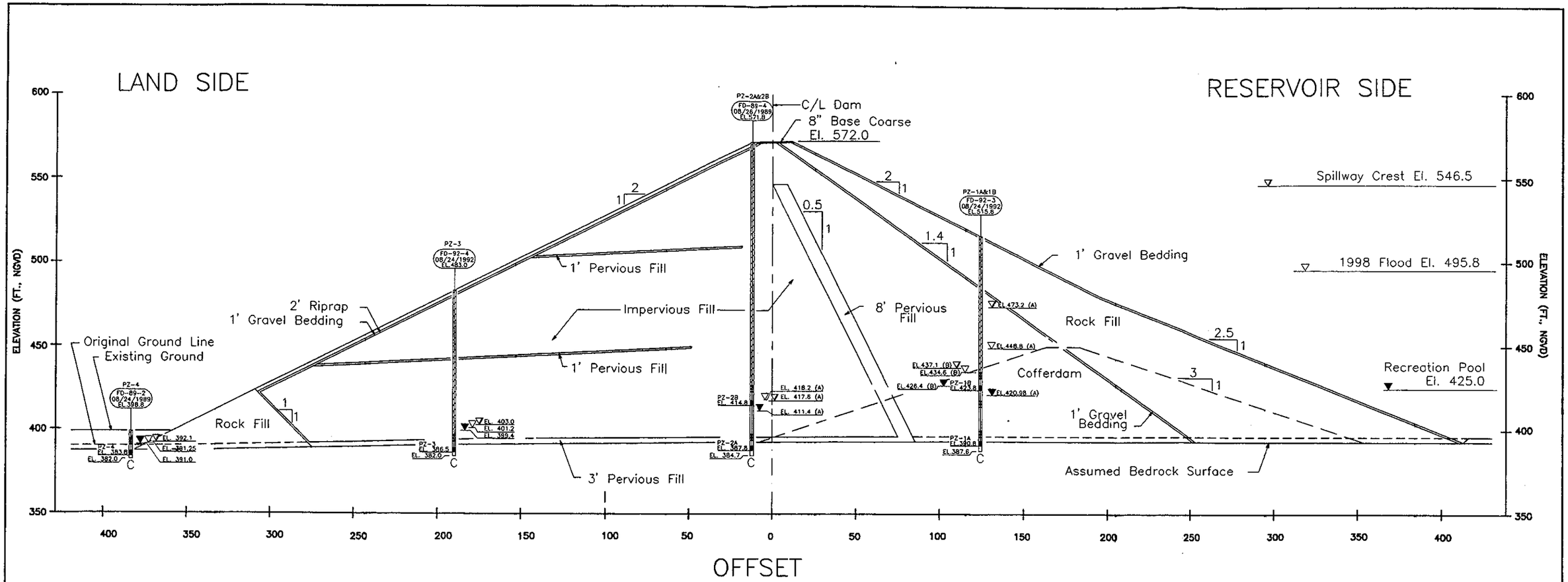

PIEZOMETER 8
PIEZOMETER ELEVATION (FT-NGVD)
480
460
440
420
400
380
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
POOL ELEVATION (FT-NGVD)
PERMANENT POOL EL. 410.0
RECREATION POOL EL. 425.0
PROJECTED PIEZOMETER LEVEL
MAXIMUM POOL EL. 525.8 (APRIL 1987)
SPILLWAY CREST EL. 546.6
NORTH HARTLAND DAM
PIEZOMETER VERSUS POOL ELEVATIONS
STATION 21+00 (1994-1998)

FIGURE 32



PIEZOMETER VERSUS POOL ELEVATIONS
North Hartland Dam
STATION 19+50 (1994-1998)



PIEZOMETER LEVELS – STATION 19+50

LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL POOL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1998

NOTES:

1. CROSS SECTION PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. PZ–2B HAS BEEN DRY SINCE IT WAS INSTALLED IN 1990.

0 60 120

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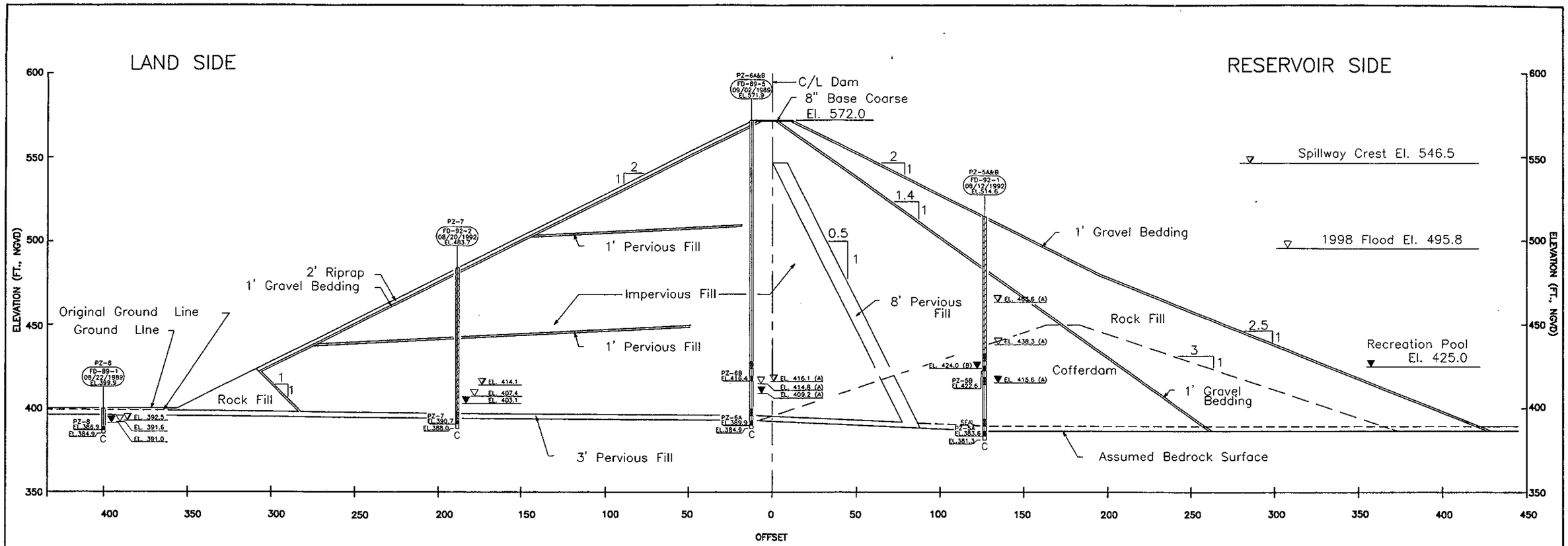
CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

PIEZOMETER LEVELS
STATION 19+50
PZ 1A, 1B, 2A, 2B, 3 AND 4

SCALE: AS SHOWN NOVEMBER 1999

12126–009 B56

FIGURE 34



PIEZOMETER LEVELS – STATION 21+00

LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL POOL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1998

NOTES:

1. CROSS SECTION PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. PZ-6B HAS BEEN DRY SINCE IT WAS INSTALLED IN 1990.

0 60 120

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

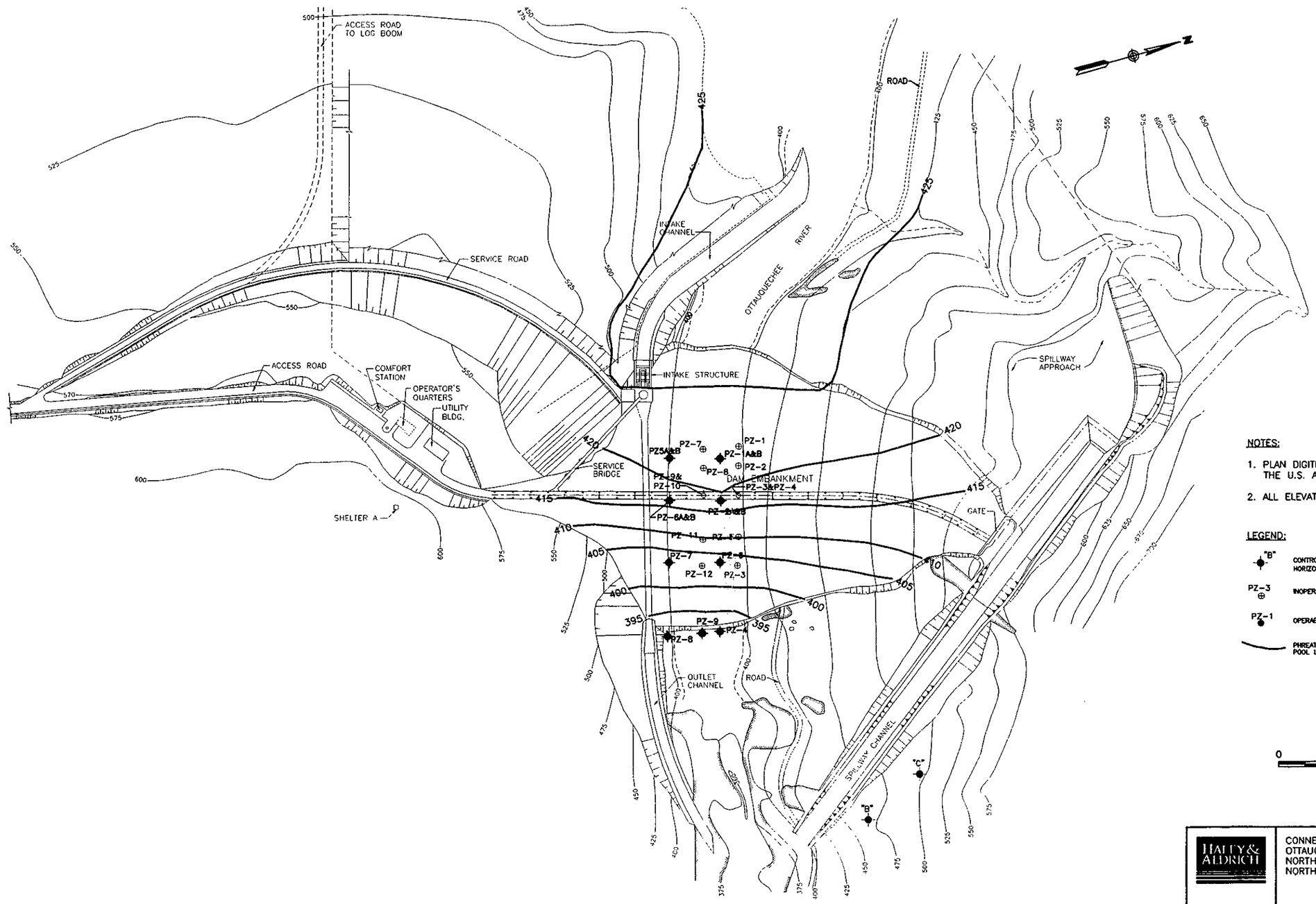
PIEZOMETER LEVELS
STATION 21+00
PZ 5A, 5B, 6A, 6B, 7 AND 8

SCALE: AS SHOWN

NOVEMBER 1999

12126-009 B57

FIGURE 35



NOTES:

1. PLAN DIGITIZED FROM BASE PLAN PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.

LEGEND:

"B" — CONTROL POINT FOR VERTICAL AND/OR HORIZONTAL CONTROL

PZ-3 — INOPERABLE PIEZOMETER

PZ-1 — OPERABLE PIEZOMETER

PHREATIC SURFACE FOR NORMAL POOL LEVEL

0 300 600

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

CONNECTICUT RIVER BASIN FLOOD CONTROL
OTTAUQUECHEE RIVER
NORTH HARTLAND DAM
NORTH HARTLAND, VERMONT

PHREATIC SURFACE PLAN

SCALE: AS SHOWN

NOVEMBER 1999

12126-009 B58

FIGURE 36

APPENDIX A

Monitoring Schedules

NORTH HARTLAND DAM
CONNETICUT RIVER BASIN

Reading Schedule for Piezometers

1. General. Piezometers are utilized to measure groundwater levels and pore pressures both in the foundation and embankments of earth and rockfill dams. Experience has shown that installation of piezometers in earth fills and their foundation provides significant data indicating the magnitude and distribution of pore pressures and their variations with time and also patterns of seepage, zones of potential piping, and the effectiveness of underseepage control measures.

2. Piezometer Readings. At the present time, files are maintained for dams which have operating piezometers and most of the data is put on the computer. Data is transmitted to GEB in writing by the project manager. Piezometer data should be reduced in the field and each reading compared with previous data; thus, if a piezometer has an unusual reading, the reading can be checked immediately. Pool elevations, tailwater elevations, measuring weir discharge quantities, and rainfall data should be recorded simultaneously with piezometer readings.

a. Reading Schedules.

(1) Routine. During periods when the reservoir is at or below the 45 foot stage (Elev 435) readings should be made by the project manager at least once a month. When access to instruments is made hazardous by snow or ice, the readings may be deferred until safe access is possible.

(2) High Pool. During periods when the reservoir level (includes rising and falling pools) is above the 45 foot stage (Elev. 435), readings should be made on a daily basis. Pool elevations and all the other information requested in paragraph 2, above, should be recorded simultaneously with piezometer readings. On a falling pool, piezometer readings should continue for approximately five days after the pool has returned to its normal elevation.

b. Data Collection.

(1) Location Maps. A general plan of the project showing the location of the active piezometers and the corresponding identification number for each piezometer is provided to eliminate identification and data recording inaccuracies.

(2) Data Collection Tables. A table listing the piezometer identification number, stationing and offset, as well as piezometer top and tip elevations is also provided for recording and submitting piezometer readings. It should be noted that when two piezometers are located in the same protective casing, each shall be designated with a number as well as an "A" or "B". The letter "A" will indicate the deeper piezometer riser and the letter "B" shall designate the more shallow riser for each such location. All piezometers shall be clearly labeled with the appropriate identification number and letter (if required). These labels will be installed inside of the protective casings and attached to each respective piezometer riser by the project manger.

(3) Destination. All data should be sent to the following address on the first of each month.

U.S. Army Corps of Engineers
New England Division
CENED-ED-GD
424 Trapello Road
Waltham, MA. 02254-9149
RE: PIEZOMETERS

(4) Special Conditions. If unusual changes in readings develop or if piezometers become inoperable, Geotechnical Engineering Branch should be contacted.

The following standards and procedures are employed for Crest Monument Surveys at North Hartland Dam.

STANDARDS FOR SETTLEMENT SURVEYS

1. Control points are stamped brass disks preferably set in a ledge area. Where no ledge is available, they are set in concrete bounds placed flush with the ground.

2. Control points are set in areas such that the maximum possible number of crest monuments on the dam are visible.

3. Control points are tied into four reference points by distance. This provides a check each time they are occupied for settlement surveys or allow them to be replaced if found to be destroyed.

4. Distances are read and recorded between settlement bounds. Both distance and angle are read and recorded from the control points that are being occupied to locate each settlement bound on the dam.

5. In locating each settlement bound, a control point will be occupied setting 0-00´-00" (referenced line of site) on a second control point, reading and recording both interior and exterior angle closure, along with distances through each settlement bound located on the dam. Each settlement bound is located from a minimum of two control points. These locations are third order, class II survey with relative accuracies of not less than 1 part in 5,000.

6. Levels are run from control points through each settlement bound on the dam with a return run back into the control points to check the elevation closure on the run. Closure tolerance should be no greater than 0.05´. These levels are third order, class I survey with relative accuracies not less than 1 part in 10,000.

7. Crest monument surveys are performed using Topcon EDM Total Stations and recording both horizontal angles and horizontal distances.

PROCEDURE FOLLOWED FOR SETTLEMENT SURVEYS

The horizontal and vertical monitoring plan for settlement bound movement points employed a combination of triangulation and trilateration angle and distance techniques to survey the control network. Control points, in the form of stamped brass disks, were placed off the dam structure in areas from which the entire length of the dam is visible. Settlement bounds themselves, with stamped brass disks, were placed on the dam structure in a location that is clearly visible from the control points. Horizontal coordinates of the control points are based on the State Plane Coordinate System. Elevations of the control points are based on the National Geodetic Vertical Datum (NGVD). Control points are occupied utilizing an EDM Total Station; observed distances and angles (interior and exterior angles), between control points and settlement bound establishing permanent bench marks. Standard leveling techniques are followed. Levels are double run and the means of the front and back runs were computed and recorded.

DATA ADJUSTMENT

A combination of triangulation and trilateration surveying techniques are applied. Each crest monument is located from two control points and two sets of coordinates are calculated using adjusted field angles and compliments and EDM distances. The two sets of coordinates are averaged to give a net result. The averaged coordinates are then established on each settlement bound for use in determining shifts in the dam surface structure over a period of years by comparing repetitive surveys.

APPENDIX VIII

RESULTS OF CRACK SURVEYS

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
RESULTS OF CRACK SURVEYS

1. PURPOSE

This crack survey is intended to identify the location and the size of cracks in concrete features at North Hartland Lake. It is important to monitor cracks to determine the cause of cracking, the severity of the crack in relation to the concrete feature, and the remedial measures that may be required to strengthen the feature. Two types of cracks are structural and non-structural cracks.

2. STRUCTURAL CRACKS

Structural cracks are developed due to over-stressing of a concrete member or differential movement or settlement within a member or monolith. Structural cracks will typically be located in tensile zones of members subject to bending (flexural cracks), in shear zones of beams or walls (shear cracks), and in walls or foundations due to differential movement or settlement (settlement cracks). No structural cracks were found at North Hartland Lake during Periodic Inspection No. 6.

3. NON-STRUCTURAL CRACKS

Non-structural cracks are developed typically due to improper placement and curing techniques during construction (shrinkage and pattern cracks) or inadequate spacing of expansion/contraction joints to allow for thermal movement of concrete members (temperature cracks). Because non-structural cracks are not caused by over-stressing of a concrete member, they are of lesser concern. Non-structural cracks were found inside the control tower, in the transition area of the conduit, at the outlet structure, the spillway weir and walls, and the Dewey Mills Dam. Refer to Appendix V-A for descriptions and locations of these cracks. Photos and crack maps for the transition area are provided at the end of this appendix.

4. RESULTS OF CRACK SURVEYS

There are currently no structural cracks at North Hartland Lake that would require monitoring. All of the cracks found during Periodic Inspection No. 6 are non-structural and do not affect the structural integrity of the project.

Photo 1: Efflorescence leaching through the joint at the right wall of the third gate barrel.

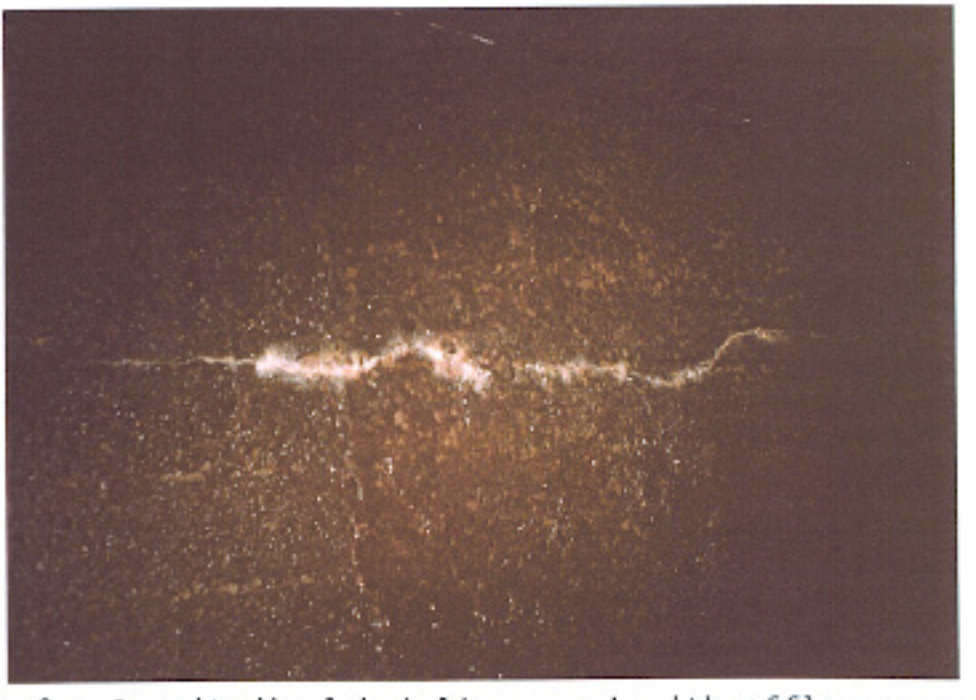
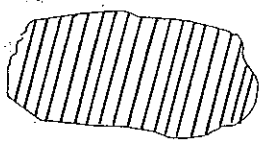
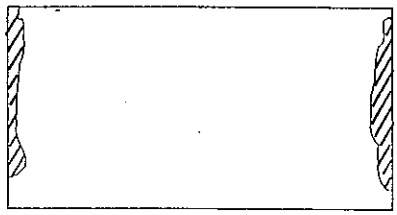
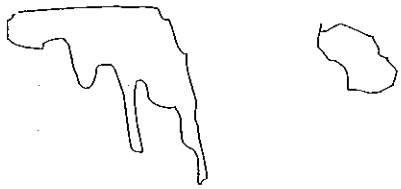
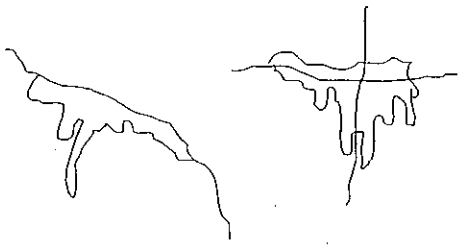
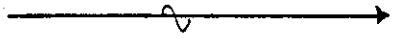
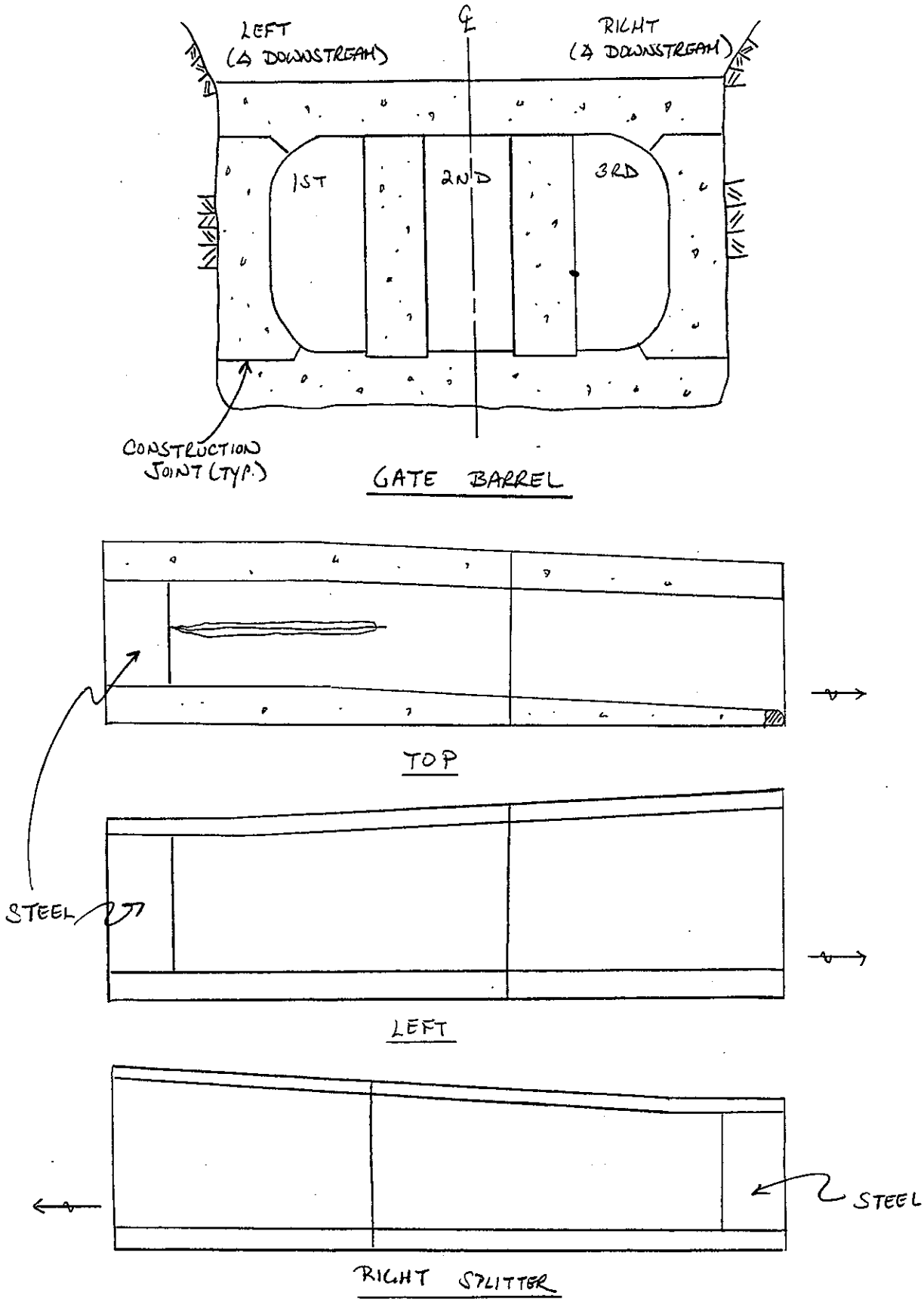


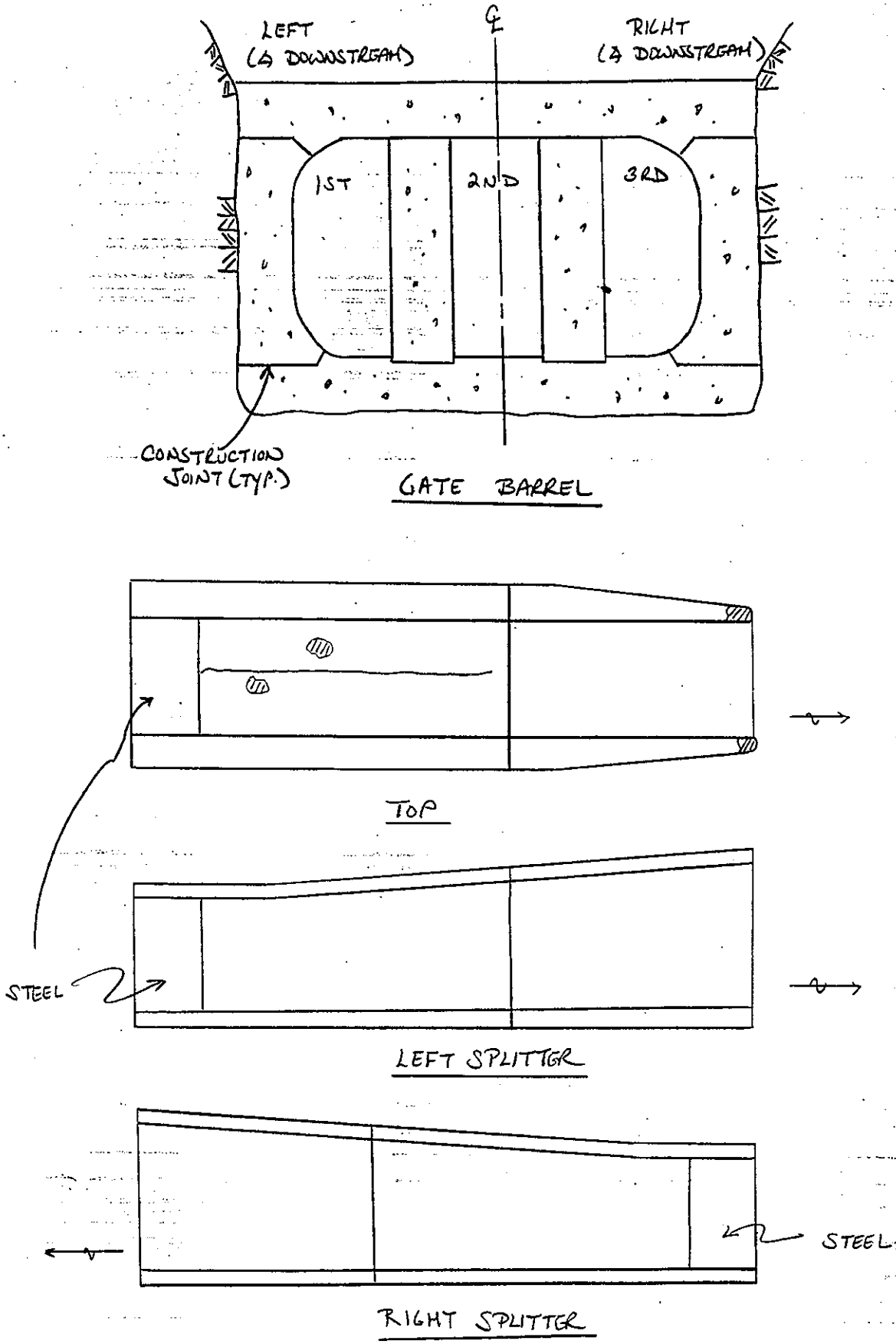
Photo 2: Longitudinal hairline crack with efflorescence at the roof of the first gate barrel.

PERIODIC INSPECTION REPORT NO. 6
NORTH HARTLAND LAKE
RESULTS OF CRACK SURVEYS

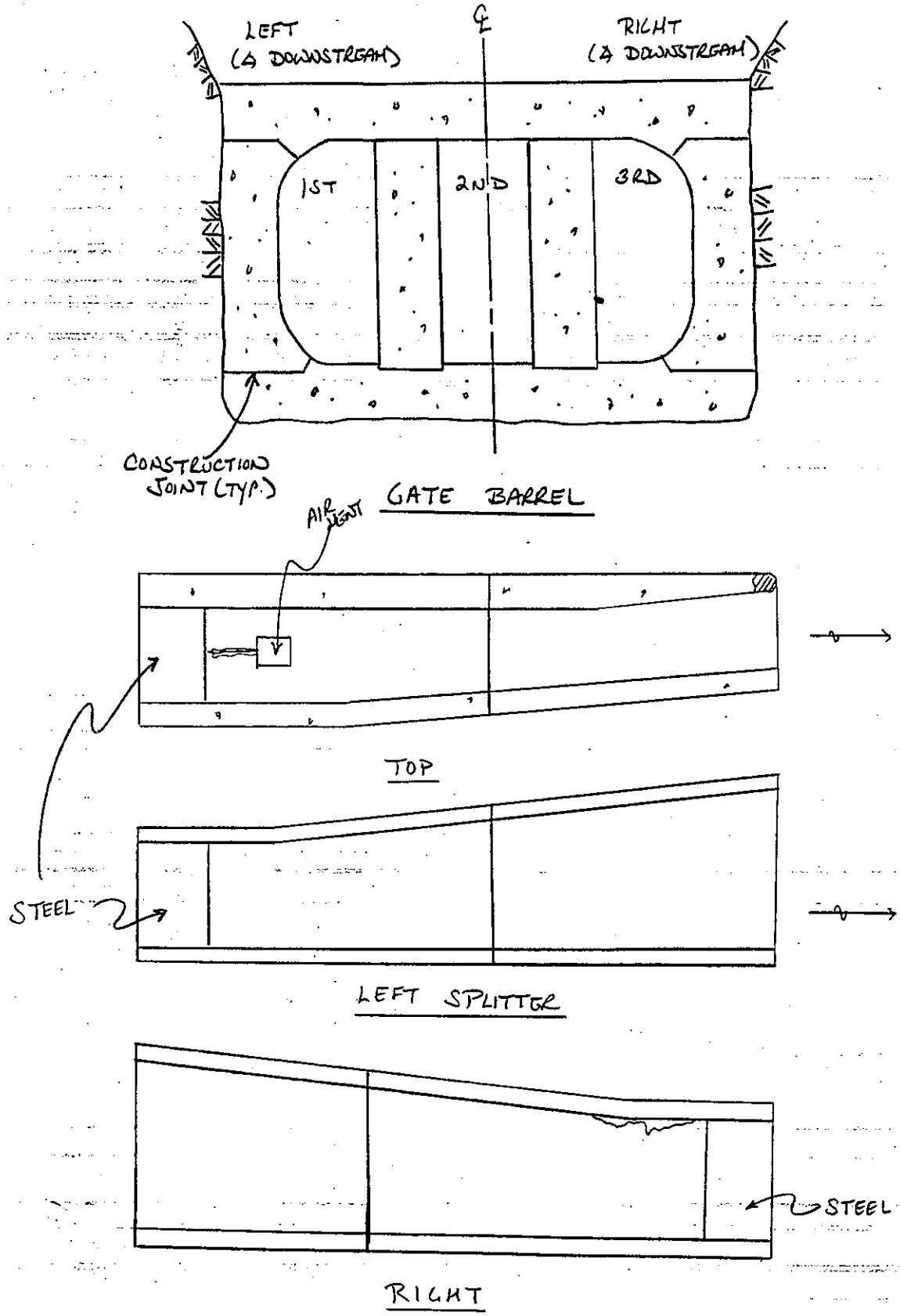
DESCRIPTION OF SYMBOLS	
DESCRIPTION	SYMBOL
SPALL OR DETERIORATION	
JOINT DETERIORATION	
HAIRLINE CRACKS	
EFFLORESCENCE	
CRACKS WITH EFFLORESCENCE	
DIRECTION OF FLOW	



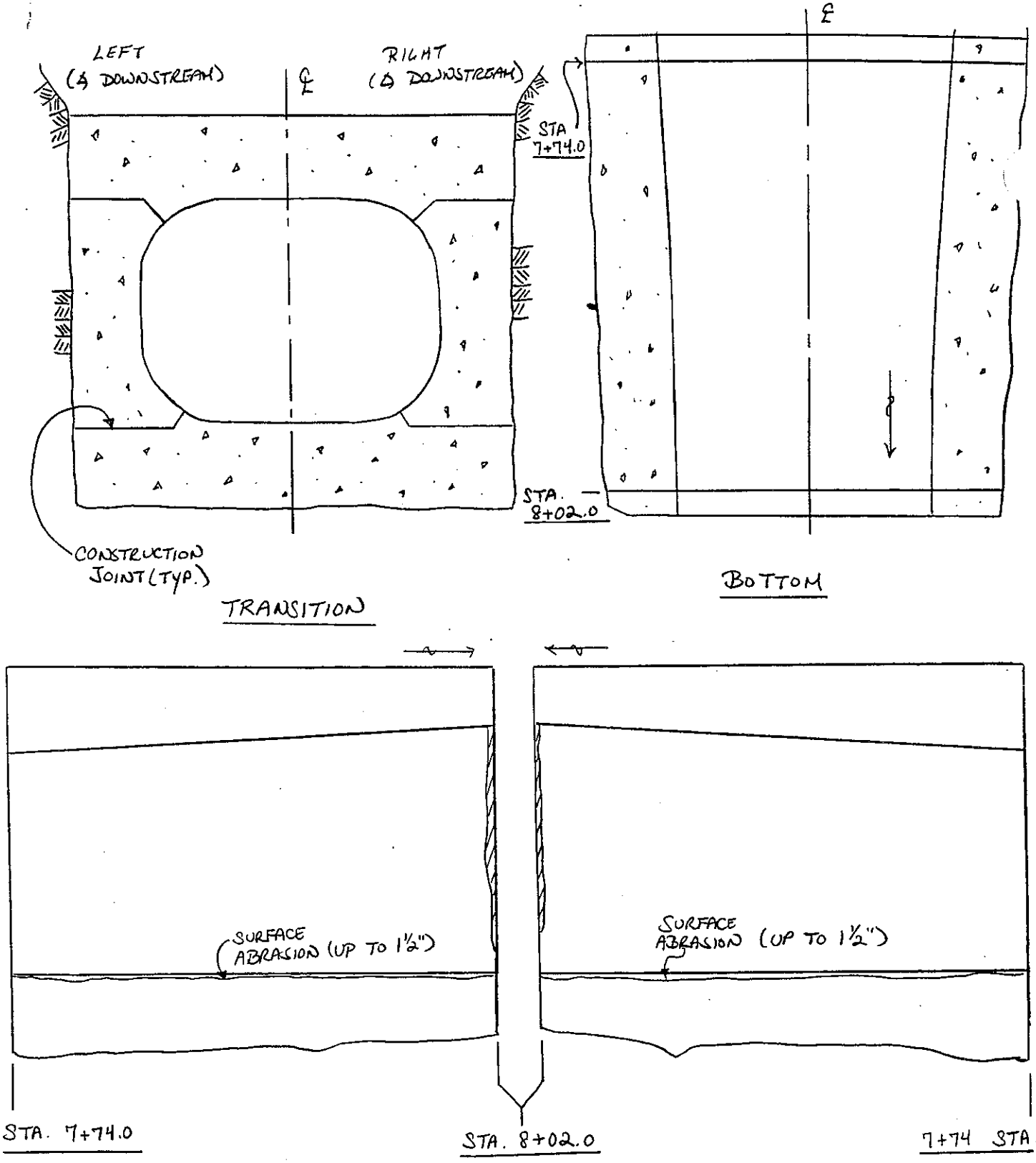
CRACK MAP
1ST GATE BARREL



CRACK MAP
2ND GATE BARREL



CRACK MAP
3RD GATE BARREL



CRACK MAP

TRANSITION MONOLITH

APPENDIX IX

STATUS OF PROJECT DOCUMENTATION

PERIODIC INSPECTION REPORT
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

STATUS OF PROJECT DOCUMENTATION

Engineering data related to project features is required to be collected and permanently retained in accessible, appropriate files at the project site. The data should consist of design memoranda, subsurface exploration results, as-built drawings and pertinent construction records including foundations and embankment criteria reports, contract specifications, emergency plans, etc. At this site, project data, listed in the attached table, are accessible in the files located at the project office.

NORTH HARTLAND LAKE		
DOCUMENT	**Y/N**	**COMMENTS**
Construction Plans	Y	
Post-Construction Repairs/Mods	Y	VEC Hydro Plant and Miscellaneous Repairs
O&M Manuals	Y	
Construction Photos	Y	
Water Control Manual	Y	
Dam-Break Flood Analysis	Y	September 1983
Flood Emergency Plan	Y	
Periodic Inspection Nos. 1 - 5	Y	
Natural Disaster Procedures	Y	
Emergency Communications Manual	Y	Supplement to ER 500-1-1 December 1977
Fed. Guidelines for Dam Safety	Y	June 1979
Analysis of Design	NA	
Aerial Photographs	Y	
Bridge Inspection Report	Y	
Static Analysis of Structure		
Dynamic Analysis of Structure		
Design Memorandum	Y	
Other:		
Review of Stuctural Stability	Y	Wright-Pierce July 1984

APPENDIX X

STATUS OF DAM OPERATION MANAGEMENT POLICY (DOMP) TRAINING

PERIODIC INSPECTION REPORT
NORTH HARTLAND LAKE
NORTH HARTLAND, VERMONT

STATUS OF DAM OPERATION MANAGEMENT POLICY (DOMP) TRAINING

a. New England District has implemented a dam safety training program for O&M personnel, with retraining every four years, which addresses the following:

(1) Discussion of basic typical design considerations for various types of construction, including hydraulic considerations, foundation factors, etc.

(2) Procedures for monitoring potential problem areas.

(3) Dam safety features in design and construction.

(4) Normal operation, surveillance, monitoring and reporting procedures.

(5) Emergency Operations, surveillance, monitoring and reporting procedures.

b. DOMP training for the Upper Connecticut River Basin, which includes North Hartland Lake personnel, was conducted on November 6, 1997. The next DOMP training for the basin is scheduled for FY02