Engineering Study and Evaluation

For the Rehabilitation of Curtis Pond Dam

Prepared for the

The Curtis Pond Dam Committee
Town of Calais, VT 05648

Prepared by:

DuBois & King inc.

STATE OF VERMONT
JEFFREY W. TUCKER
No. 5806
REGISTERED
PROFESSIONAL ENGINEER

January 30, 2004

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

I. INTRODUCTION

The purpose of this study is to identify and evaluate existing deficiencies at the Curtis Pond Dam. This study also includes the preparation of an Emergency Action Plan (EAP) and the evaluation of a new concrete wall, within the intended function of reinforcing the existing dam to retain the pond. The dam is currently privately owned, and there is currently ongoing discussions regarding the future owner status.

The Curtis Pond Dam Committee (Committee) was formed to advance the evaluation of the dam on behalf of the dam owner. The Committee retained the professional services of DuBois & King, Inc., (D&K) a consulting engineering firm in Randolph, Vermont, to assist with the development of this evaluation and prepare the engineering report.

DuBois & King's primary role is to lead the investigation into the condition of the dam, to develop the EAP and to develop a conceptual design of a new concrete wall. Jeffrey W. Tucker, P.E., Vice President, is the Senior Dam Engineer and primary author of this report on behalf of DuBois & King. The Vermont Department of Environmental Conservation, Dam Safety Section (Dam Safety) is providing technical oversight to this project.

The primary goals and objectives for this project are summarized below:

1. **Identify and quantify the existing condition of the dam, including deficiencies.**

2. **Evaluate the feasibility of a New Concrete Wall to correct the deficiencies**

3. **Prepare an Emergency Action Plan for use in the event of a dam failure.**

<u>Background</u>

Curtis Pond is located in the Town of Calais, Washington County, Vermont. Historically, there were 2 smaller, separate ponds prior to the dam being constructed. When the dam was constructed circa 1900, the water level in the brook was raised approximately 10-feet. This additional depth inundated both ponds, creating the 72-acre body of water that exists today.

The volume of water impounded by the dam is approximately 724-acre-feet, at the normal water level, and increases to approximately 1,000 acre-feet at the top of the dam. Because the dam impounds more than 11.5 acre-feet, it falls under the regulatory jurisdiction of the Vermont Department of Environmental Conservation, Dam Safety Section (Department), under the provisions of 10 VSA, Chapter 43 Dams.

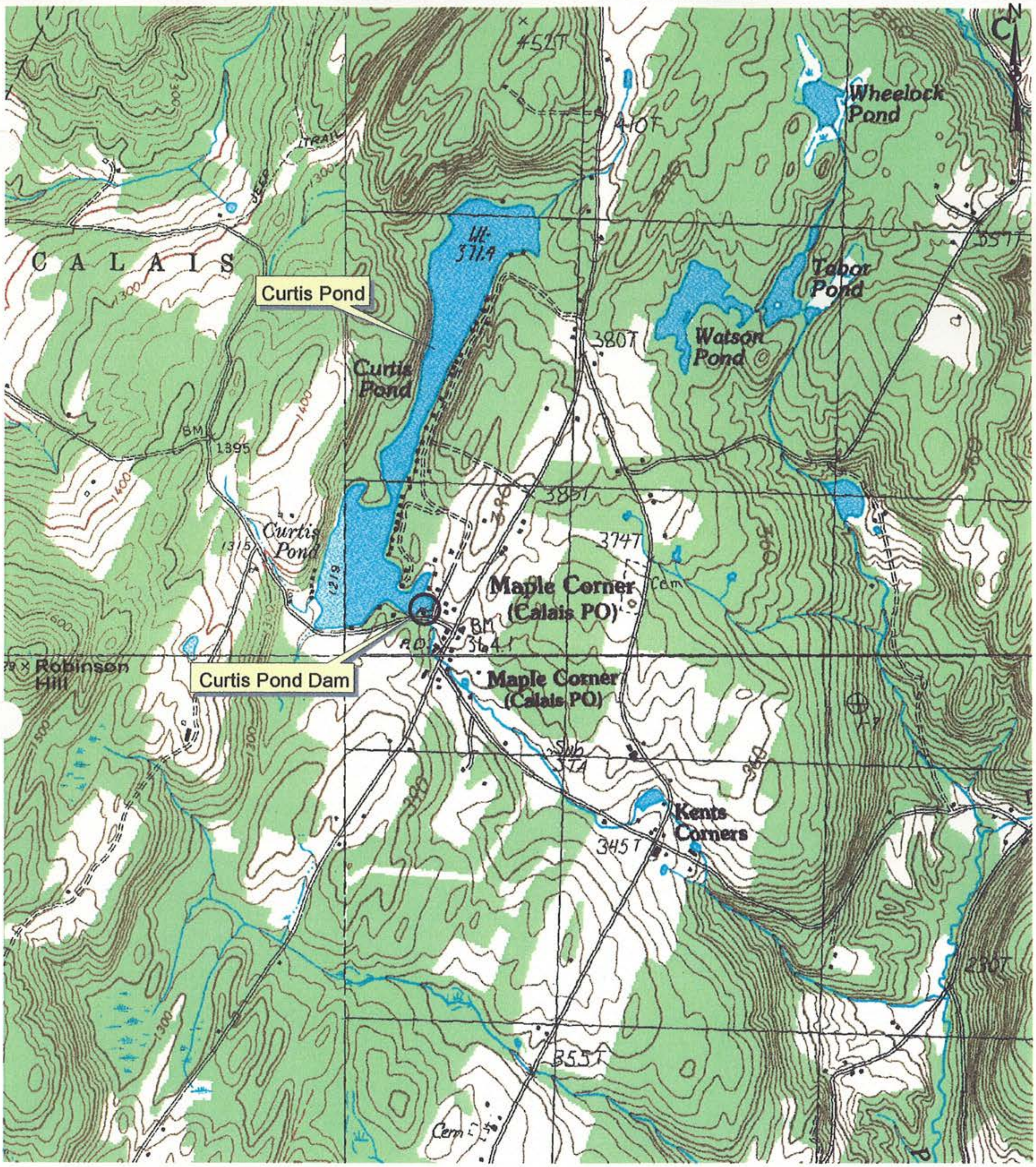
The dam was originally constructed around 1900, and is located near the southeastern corner of the pond. The structure consists of a laid up masonry stone on the downstream face, which supports a sand and gravel embankment. The maximum height is approximately 11-feet and its length is approximately 120-feet. The Hazard Classification of this dam is currently Significant, as defined by Department Guidelines.

Recent Dam Safety Reports prepared by the Department, state that the dam is considered to be in poor condition. This condition is defined by a number of parameters, including inadequate hydraulic spillway capacity, active piping of backfill through the stonewall, uncontrolled seepage through the dam, an inoperable low-level drain and movement of the stones.

Description of Dam and Watershed

The Curtis Pond drainage area is approximately 884 acres (1.38 square miles) in size and is part of the Pekin Brook Watershed, which is a tributary of the Kingsbury Branch of the Winooski River. The drainage area is predominately rural and undeveloped, with a majority of the current land use consisting of pasture and woodland. Topographic relief is relatively mild in the lower portions of the watershed and very steep in the upper reaches. A detailed hydrologic analysis of the watershed was conducted as part of this project and the results are presented later in this report.

The Department's Agency Facilities Division conducted a topographic survey of Curtis Pond Dam in May 2003 and provided it to DuBois & King for use with this study. Horizontal control was based on ground control points established at the time of the survey. Vertical control was an assumed local datum. An existing condition base map of the dam and adjacent area was prepared following the topographic survey. A copy of the base map is appended to this report.



DuBois & King inc.

engineering planning management development

CURTIS POND DAM
CALAIS, VERMONT

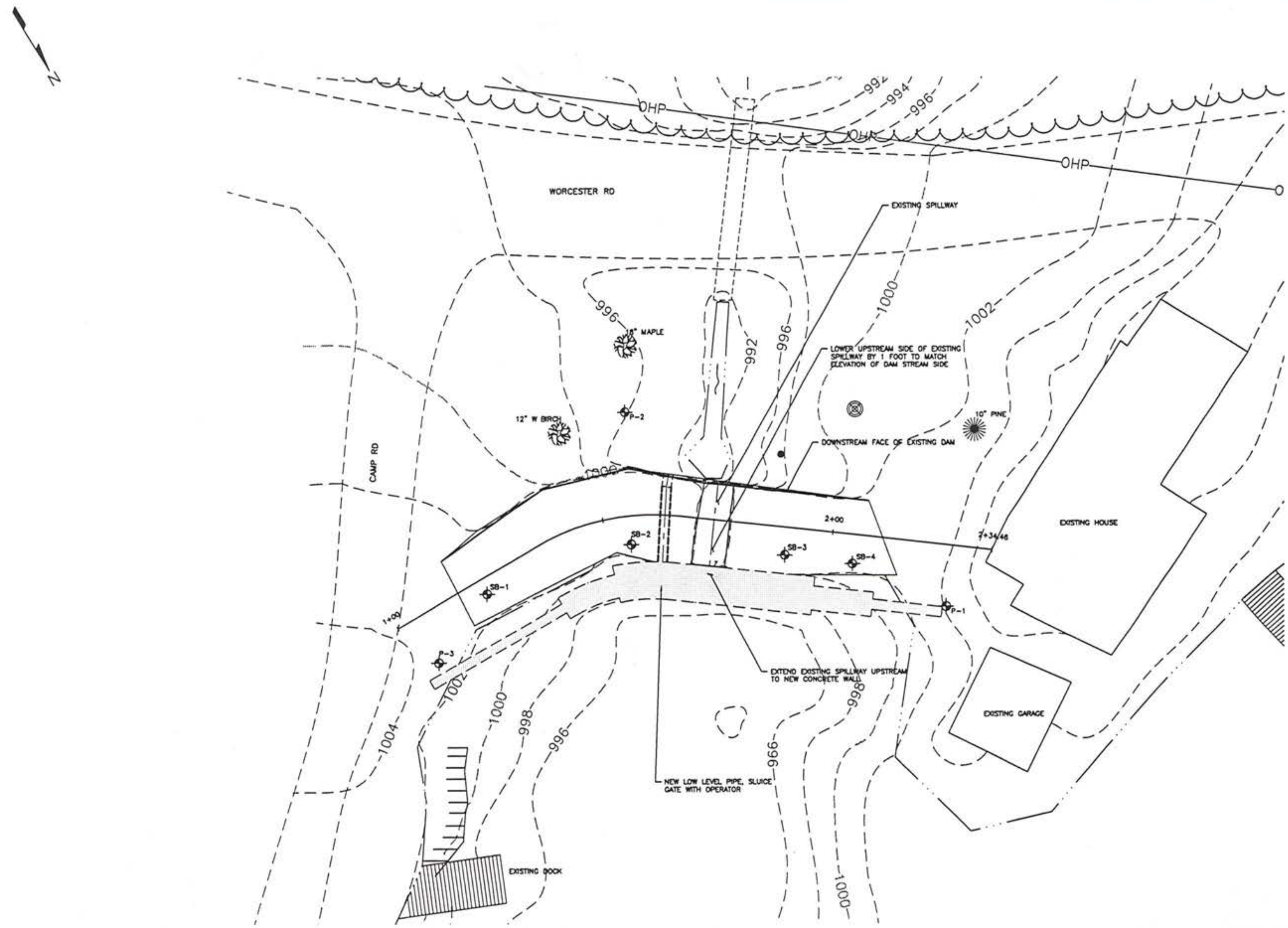
SITE LOCATION MAP

DRAWN BY: JDA	DATE: 10/08/03
CHECKED BY:	PROJ. NO. 618450L
PROJ. ENG.	DRAW. NO.

0 500 Feet

The following is a summary of existing dam geometric data:

State Identification Number:	Department of Environmental Conservation No. 40.09	
Drainage Area:	Size:	1.38 square miles
	Type:	Pasture and woodland with moderately steep to very steep sloping terrain.
Elevations (feet, assumed):	Top of Dam	1002.5 (average)
	Spillway Invert	1001.0
	Stream bed at base of dam	991.7
Lake Surface Area (acres):	Top of dam	75 acres
	Spillway Invert	72 acres
Lake Storage (acre-feet):	Top of dam	1,000 ac-ft
	Spillway Invert, Water Level	724 ac-ft
Dam:	Type:	Sand / Gravel with Laid Up Stone Wall
	Overall Length:	120 feet
	Height:	10.8 feet at maximum section
	Top width:	17.1-feet
	Side Slopes:	1V: 3 H upstream slope Vertical downstream slope
Spillways:	Primary Spillway:	5.8 -foot length fixed weir sluiceway
	Auxiliary Spillway:	None
	Emergency Spillway:	None



PLAN VIEW

SCALE: 1"=10'

10 0 10 20 40

SCALE: 1" = 10'

NO.	DATE	REVISIONS	BY	CK'D

DuBois & King inc.
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

CURTIS POND DAM

NEW CONCRETE WALL
CONCEPTUAL SITE PLAN

DRAWN BY EBS	DATE DEC. 2003
CHECKED BY	PROJ. NO. 618450
PROJ. ENG.	DRAW. NO.
SHEET 1	OF 6

II. GEOTECHNICAL INVESTIGATION

Overview

A geotechnical investigation was conducted as part of this project. The objective is to estimate the depth to ledge to facilitate a new concrete wall, and to estimate the type and condition of the dam earth fill and foundation material.

The investigation consisted of field observations and sampling, followed by evaluation of the results. The primary component of the investigation was obtaining a series of soil borings through the dam fill and to the ledge foundation. A boring plan was prepared by DuBois & King and submitted to the Dam Safety Office for review and comment. The final boring plan, included 4 borings to be taken along the upstream side of the dam. The need for borings in the pond, which would be under a new concrete footing was considered, but ultimately eliminated from the plan because the costs to obtain the borings from the water exceeded current study budgets.

Field Investigation

The borings were obtained on October 20th and 21st, 2003. On-site supervision was provided by Mr. Shawn R. Patenaude, EI of DuBois & King and the borings were drilled by Green Mountain Borings of Barre, Vermont. Four (4) borings were drilled, and three (3) soil probes to ledge were obtained. The location of the borings is shown on the dam base map and the boring logs are appended to this report.

Several of the borings were advanced using a portable tripod system with a 3.25-inch inside diameter hollow stem auger. A tripod was used due to the concern of loads inducted into the dam using a full size drill rig. A truck mounted drill rig was used at one boring location. Continuous Standard Penetration Tests (STP) was taken from the surface to the bottom of the boring and each sample was recovered using a standard 2-inch diameter split-spoon sampler. The total depth of the borings varied between 3-feet and 13-feet and extended to refusal, which has been assumed to be ledge. Ledge cores were not performed.

Subsurface Conditions

The field soil identification of the recovered samples indicates that the earthfill portion of the dam consists of sands, with embedded small stones and rock fragments. Traces of wood and silts were also encountered. The density varies from loose to medium dense, with 12-inch blow counts ranging between 2 and 15. The depth to ledge was recorded at each boring and probe. This depth is illustrated on the attached engineering drawing (Dam Profile).

III. HYDROLOGIC AND HYDRAULIC ANALYSIS

Overview

A detailed Hydrologic and Hydraulic Analysis (H&H) was also conducted as part of this study. The primary purpose of an H&H Analysis is to determine the flood event that the pond and dam outlet works can safely pass, and which flood events could potentially cause the dam to fail. This knowledge, combined with the Hazard Classification and other related information will determine if the existing hydraulic capacity of the dam meets current dam safety standards utilized by the Vermont Dam Safety Section.

Hydrologic Model

The inflow hydrographs into the pond were developed using the Soil Conservation Service (SCS) Unit Hydrograph procedures contained in the U.S. Army Corps of Engineers HEC-HMS computer model. The watershed parameters required for this model includes the drainage area, SCS runoff curve number, lag time, and rainfall depth vs. duration of the storm event being analyzed.

The total drainage area of Curtis Pond Dam was measured to be 1.38 square miles. The drainage boundary was outlined on the U.S.G.S. Quadrangle for the Calais area, and then the area was plainmetered. The watershed area was divided into three sub-basins, each representing a relatively homogeneous area, having uniform land use and topographic features. Since the SCS Unit Hydrograph Methodology assumes that the hydrologic parameters such as, time of concentration, land use, soil type, etc., are consistent over the area, the use of homogeneous sub-basins will more accurately model the rainfall runoff into the pond.

The storm events considered for this study includes the 2-year, 10-year, 25-year, 50-year and 100-year, 24-hour event (SCS Type II). It also included the ¼, ½, ¾ and the full Probable Maximum Flood (PMF) rainfall events. The rainfall values used for the 24-hour storms were obtained from the Northeast Regional Climate Center (NRCC) Atlas of Precipitation Extremes for the Northeastern United States and Southeastern Canada. The probable maximum precipitation (PMP) was developed in accordance with the procedure outlined in Hydrometeorological Reports 51 and 52, with the storm centered over the 1.38 square mile watershed.

The stage-surface area relationship of the pond was developed from data obtained from the Dam Safety Office Curtis Pond Dam files and the aforementioned topographic map provided by the Department. Additional area versus elevation values were measured from the USGS map and combined with the file information.

Hydraulic Analysis – Spillway Capacity

An existing condition rating curve for Curtis Pond Dam was prepared to establish the relationship between the stage (depth of water) and the discharge over the dam at various elevations. Individual rating curves for the principal spillway and the top of the dam were computed, and then combined.

Discharge over the spillway and the top of the dam were computed using the standard weir equation. Field measurements were used in the weir lengths and elevations.

Results

The results of the H&H Analysis are summarized in the following Table. The values in this table present the storm frequency, peak inflow, routed outflow and maximum lake level. The results indicate that the dam is subjected to overtopping at and above the 25-year storm event.

Dam safety standards indicate that a dam should have adequate hydraulic spillway capacity to pass a design flood and remain stable. Overtopping may occur; however, the dam should not have the potential to wash out.

For Curtis Pond Dam, the current hazard classification is SIGNIFICANT. Therefore, the dam should be able to safely pass a ½-PMF without dam failure. Under existing conditions, the dam would be overtopped by approximately 2.8-feet of water. Because there is no structural component that would resist this depth of overtopping, the dam would have a high potential for failure. Therefore, the hydraulic capacity of the dam is considered to be inadequate.

Table 1
Existing Conditions
Flood Routing Results Summary

Flood Frequency	Total Inflow Peak Discharge (cfs)	Routed Outflow Peak Discharge (cfs)	Maximum Lake Level (assumed datum)	Available Freeboard (ft)
2-Year	239	8	1001.7	0.8
10-year	520	20	1002.2	0.3
25-year	764	44	1002.6	-0.1
50-Year	951	86	1002.8	-0.3
100-year	1,222	161	1003.1	-0.6
500-year	1,521	271	1003.3	-0.8
¼-PMP	1,561	330	1003.5	-1.0
½- PMP	3,959	1,804	1005.3	-2.8
¾ - PMP	6,508	4,168	1006.8	-4.3
1-PMP	8,802	6,063	1007.6	-5.1

Notes: Freeboard is measured from the top of the dam to the maximum lake level
Initial Water Level: El. 1001.0 (lake level at beginning of flood)
Top of Dam: El. 1002.5 (Average)

IV. DAM-BREAK ANALYSIS

Overview

A dam-break flood analysis was also conducted as part of this study. This analysis consisted of developing a computer model to route a hypothetical dam-breach hydrograph downstream, and to prepare an inundation map to illustrate the associated limits of flooding. The limits of the study extend from Curtis Pond Dam downstream for approximately 1.1 miles to the Kent Corners area.

The primary purpose of conducting a dam-break flood analysis for Curtis Pond is to prepare an inundation map. This map, which illustrates the approximate extent of flooding for the dam-break conditions modeled, is a key component of the EAP.

The magnitude of a dam-break flood event depends on several important factors. They include the volume of water impounded behind the dam, the length and height of the dam and the length of time that it takes for the dam to fail. In addition, the limits of inundation are dependent upon antecedent stream conditions, the geometry of the valley and the presence of other hydraulic structures further downstream such as road crossings and other dams.

Methodology

Two types of hypothetical dam failure scenarios were evaluated in this study. They include: 1) a Sunny-day failure; and 2) A Storm-day failure during the 100-year storm event. In addition, a non-dam failure during the 100-year flood was also considered to gauge the effects of a dam-break during storm conditions.

The dam-break flood analysis was conducted using Boss Corporation's 1992 release of the National Weather Service Dam-Breach Flood Forecasting Computer Model (NWS DAMBRK) developed by D.L. Fread. Input parameters for the computer model include stage-storage-discharge relationships of the dams and other flow structures, downstream valley cross-section geometry of the channel and floodplain and the associated roughness coefficients. Primary output from the model includes maximum water surface elevations, velocities and rate of discharge at each cross-section. This information is then plotted onto a base map and the inundation limits are created.

The base map for the dam-break analysis was prepared using the digital orthophoto map and associated digital elevation model (DEM) obtained from the Vermont Mapping Program. The base map was developed using ARC-View Version 3 and is compatible with the Vermont GIS System. A Digital Terrain Model (DTM) was prepared using the DEM data and five-foot interval contours were created. These contours were used in plotting the inundation limits.

The vertical datum used in the DEM data is different than the vertical datum assumed by the Department when conducting the topographic survey. Therefore, the elevations shown on the dam base map created from the ground survey differ from the elevations shown on the orthophoto base map. This vertical difference was resolved simply by creating 2 different dam-break models. One model was generated at the dam only, and a breach discharge hydrograph was developed for each of the 2 failure scenarios. Then a second dam-break model was created to route the breach discharge hydrographs downstream to Kent Corners.

Downstream Structures

There are several existing structures located in the stream between the dam and Kent Corners. They include four road crossings, remnants of an old stone dam behind the Maple Corners General Store and the Robinson's Mill stone dam.

The first road crossings is located immediately downstream of the dam. This crossing was not included in the dam-break model. There is a potential that the road would not wash out, and therefore act as a dam. Water would impound behind the road and reduce the hydraulic head of the breach, thus reducing the peak rate of discharge during a breach. Because it is unclear at what point the road would wash out, the most conservative way to develop the breach discharge hydrograph was to assume that the road has no hydraulic influence on the dam.

The old stone dam located behind Maple Corners Country Store was not included in the model. The dam would be expected to wash out early in a breach, resulting in minimal influence to flood limits in the area. The remaining road crossings between the dam and the Robinson's Mill Dam were coded into the model, and the water surface elevations were based on discharge over the road. Storage of water behind the roads was also accounted for in the model.

Breach Parameters

The discharge hydrograph from a dam failure, or breach discharge hydrograph, is a function of the routed inflow hydrograph and the breach parameters (time of breach formation, size, and shape of breach) associated with a hypothetical dam failure. Breach parameters are established based on Federal Energy Regulatory Commission (FERC) Guidelines.   The following sketch illustrates the various dam-breach parameters in a typical stone dam. The total flow from the dam during a dam failure is a combination of flows through the breach opening and the spillways. As the breach in the dam develops, so does the breach discharge. Table 2 indicates the breach parameters established for the Sunny-day and Storm-day dam failure.

Definition Sketch of Breach Parameters

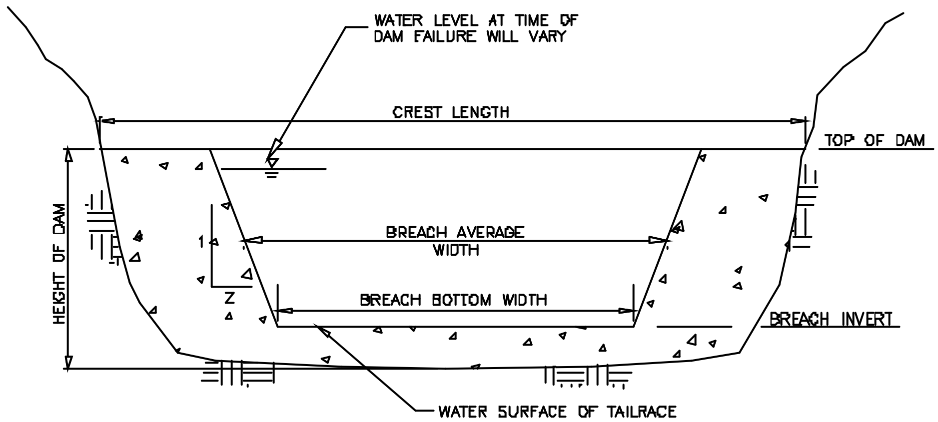


Table 2
Computed Dam-Breach Parameters
For Curtis Pond Dam

Sunny-Day Failure Condition	
Initial pool level at start of computations	El. 1001.0 (Assumed vertical datum)
Pool level at dam failure	El. 1001.0
Breach invert	El. 992.1
Breach bottom width	31.0 feet with side slopes 0.5H: 1.0V
Time to complete formation of breach	0.25 hours
Assumed pre-breach flow immediately downstream of the dam	10 cfs

Storm-Day Failure (100-year) Condition	
Initial pool level at start of computations	El. 1001.0
Pool level at dam failure	El. 1003.0
Breach invert	El. 992.1
Breach bottom width	31 feet with side slopes 0.5H: 1.0V
Time to complete formation of breach	0.25 hours
Assumed pre-breach flow immediately downstream of the dam prior to dam failure	146 cfs

Dam-Break Results

The summary of the dam-break results for the Sunny-day and Storm-day failures are presented in Table 3.

Table 3
Summary of Dam-Break Analysis

	Sunny-Day Failure	**100-Year Storm-day**	
		With Dam Failure	**Without Dam Failure**
Location downstream of dam	**Peak Discharge And Water Surface Elevation**	**Peak Discharge And Water Surface Elevation**	**Peak Discharge And Water Surface Elevation**
Curtis Pond Dam[1] (0 feet) Sta. 0+00	1,449 cfs	2,239 cfs	150 cfs
County Road (640-feet) Sta. 6+40	1,447 cfs El. 1197.2	2,200 cfs El. 1197.8	150 cfs El. 1195.8
Valley (1,000-feet) Sta. 10+00	1,445 cfs El. 1178.6	2,216 cfs El. 1179.8	150 cfs El. 1176.6
Valley (1,600-feet) Sta. 16+00	1,443 cfs El. 1162.0	2,200 cfs El. 1163.1	150 cfs El. 1160.4
Valley (2,200-feet) Sta. 22+00	1,437 cfs El. 1153.3	2,165 cfs El. 1154.4	150 cfs El. 1151.2
Valley (2,600-feet) Sta. 26+00	1,407 cfs El. 1151.7	2,098 cfs El. 1152.3	150 cfs El. 1150.2
Kent Road (2,825-feet) Sta. 28+25	1,396 cfs El. 1151.0	2,063 cfs El. 1151.7	150 cfs El. 1150.1
Valley (3,200-feet) Sta. 32+00	1,383 cfs El. 1148.6	2,042 cfs El. 1149.4	150 cfs El. 1145.7
Kent Road (3,860-feet) Sta. 38+60	1,380 cfs El. 1140.4	2,038 cfs El. 1141.0	150 cfs El. 1139.1
Robinson's Mill Pond (4,200-feet) Sta. 42+00	1,378 cfs El. 1136.4	2,034 cfs El. 1137.0	150 cfs El. 1135.5

[1] Maximum outflow from dam

Sunny-Day

The limits of inundation resulting from a Sunny-Day dam-break are shown on the appended Inundation Plan. There are approximately 10 homes located within the inundation limits. The first flood elevation of these building are unknown, so it is not conclusive of the homes themselves are flooded, or if they are higher than the peak water surface elevation. The Washington County Substation is also located within the inundation limits, but ground survey would be required to confirm if water reaches the filled base of the site.

The Sunny-Day breach is expected to wash out each of the road crossings. The depth of overtopping is expected to be at least several feet, and the duration is expected to last up to several hours, which is probably sufficient to wash out the graveled roads. It is unclear if Robinson's Mill Dam would be washed out during a Sunny-Day dam failure, as the structural condition of the dam was not evaluated. However, the Sunny-Day peak breach discharge at the dam is expected to exceed 1,000 cfs, which is nearly 10 times that of a 100-year flood, so there would be a high probability of failure of Robinson's Dam. The additional volume from the mill pond would not be expected to significantly increase the discharge hydrograph from Curtis Pond.

Storm-Day

As previously indicated, a 100-year Storm-day dam-break analysis was conducted for a "with" and "with-out" failure of Curtis Pond Dam. The purpose of conducting a "with" and "with-out" was to estimate the additional limits of downstream flooding caused by the dam failure during an extreme storm event.

As indicated in Table 3, there is a significant increase in the peak breach discharge and associated water surface levels for both the 100-year "with" and "with-out" scenarios. This is because there is a large pond volume to drainage area ratio, so the volume of water in Curtis Pond during a dambreak greatly influences the peak breach discharge.

The limits of Storm-Day inundation are very similar to a Sunny-Day dam failure. This is because the large surface area of the pond stores the 100-year inflow hydrograph, and the routed outflow is small by comparison (1,222 cfs inflow, 161 cfs routed outflow). Therefore, there is little antecedent discharge in the brook immediately before the beach, resulting in a small change in inundation limits.

Dam Size and Hazard Classification

The size and hazard classification of the dam is based on guidelines provided in the U.S. Army Corps of Engineers, Recommended Guidelines for Safety Inspection of Dams, ER 1110-2-106, Washington, DC, March 1980. These guidelines are used by the State of Vermont for the purposes of determining inspection frequency, design standards and hydraulic capacity of the spillways.

Based on the information shown on Table 4 of the guidelines, the size of Curtis Pond is classified as INTERMEDIATE. Storage impounded by the dam at the top of dam (1,000 acre-feet) is equal to the 1,000 acre-feet, value shown in Table 4.

Table 4
Size Classification

ASACE ER-1110-2-106, Table 1 **Size Classification**		
Category	**Impoundment**	
	Storage (Ac-ft)	**Height (Ft)**
Small	< 1000 and > 50	< 40 and > 25
Intermediate	1000 and < 50,000	40 and < 100
Large	> 50,000	100

The downstream hazard classification of the dam is based on its potential for the loss of life and property damage in the downstream areas if it were to fail. The hazard classification does not refer to the existing condition of the dam.

There are a number of homes subject to inundation during a Sunny-Day and Storm-Day dambreak. Therefore, there is a potential for loss of life. However, a ground survey is required to obtain the first floor elevation of the homes to determine the actual number that would be flooded.

Regarding the potential for economic loss, the dam itself, the town highway and the culverts are subject to overtopping and washout during a Storm-day dam-break. However, based on the Table 2 of the Corps guidelines (Table 5 below), the Economic Loss is considered MINIMAL, because there is no appreciable development, agriculture or industry.

As previously stated, the existing hazard classification of the dam is SIGNIFICANT. Until a ground survey is conducted and the number of homes subject to flooding is confirmed, the hazard classification should remain as is.

Table 5
Hazard Potential Classification

ASACE ER-1110-2-106, Table 2 **HAZARD POTENTIAL CLASSIFICATION**		
Category	**Loss of Life (Extent of Development)**	**Economic Loss (Extent of Development)**
Low	None Expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agricultural)
Significant	Few (No urban development and no more than a small number of inhabitable structures)	Appreciable (Notable, agriculture, industry, or structures)
High	More than a few	Excessive (Extensive community, industry, or agriculture)

V. SUMMARY OF DEFICIENCIES

A number of deficiencies of the dam have been identified as a result of this engineering analysis and are summarized below.

Inadequate Spillway Hydraulic Capacity

As indicated above, the dam is subject to overtopping during the 25-year storm event. Dam safety design standards indicate that a dam spillway hydraulic capacity for a SIGNIFICANT hazard classification dam should be able to safely pass the ½ Probable Maximum Precipitation event.

The dam is expected to be overtopped by approximately 2.8-feet during the ½ PMP (see Table 1, page 8). The existing stone dam is not expected to be stable at this level of overtopping. The probable mode of failure of the walls would be erosion and washout. A complete failure of the dam would be expected.

However, there is no practical way to pass a ½ PMP event without overtopping the dam unless it is completely rebuilt with a massive spillway, which is not warranted given the setting of this site. It is DuBois & King's professional opinion that the dam should be capable of safely passing the 500-year storm event.

Seepage Through the Embankment

There is significant seepage occurring through the dam. Because there is no seepage control (mineral filter), there is a high probability of transport of fines through the sand /

soil backfill. Indeed, sinkholes have developed along the upstream crest of the dam, suggesting that active piping is occurring. Under existing conditions, the dam is vulnerable to a piping failure (fines through the embankment).

Inoperable Low-level Outlet

The existing low-level outlet, which can be seen as the 2-foot square opening in the stonewall, does not work. The location of the inlet to this opening is not known, and is probably buried under the embankment. Siphons and pumping are the only available methods of lowering the pond water level. It is very important to have the ability to lower the pond for repair or emergency situations.

VI. NEW CONCRETE WALL

There has been significant discussion over the recent years on how to best repair and stabilize Curtis Pond Dam. One alternative that has been identified is a new concrete wall. The wall would be constructed along the upstream edge of the existing dam, along the edge of the pond. The existing stone dam would remain in place, and the new concrete wall dam would be designed to carry the hydrostatic pressures of a significant storm event.

The new concrete wall would be overtopped during a 50-year or greater storm event. However, the wall would be designed to remain stable to at least the 100-year storm, and therefore Curtis Pond would not breach. The existing stone dam would remain vulnerable to washout, but even if it failed, the new concrete wall would not, and therefore a breach would not occur.

DuBois & King has designed a number of similar, new concrete wall repairs to dams. The advantage of a new concrete wall include minor impacts to the area (as opposed to remove and replace), relatively low cost, minor environmental impacts, ease of construction and retainage of the historic stone dam.

The new concrete wall would be pinned directly to ledge. This will significantly reduce seepage through the dam, which will prolong the service life of the existing stone dam. It will also significantly reduce the potential for piping of fines, as the concrete wall would provide a near impervious barrier for the movement of fines. The results of the subsurface investigation indicate that ledge is relatively shallow below grade. Therefore, a new concrete wall will not be very tall, nor significantly expensive.

DuBois & King has conducted a construction cost estimate for a new concrete wall. We have performed a conceptual level design of the wall and have estimated the required geometry, such as wall and footing depth and width. The construction quantities have been identified and measured. The unit prices of the construction quantities have been estimated using recent similar projects. A summary construction cost estimate has been prepared and is summarized on a spreadsheet, which is appended to this report.

The total project costs for this project has been estimated by combining the construction costs with the cost of a temporary dam, the costs to conduct engineering, to prepare construction documents, to obtain the environmental permits and to oversee construction. The total project costs are $228,044, which includes the construction cost of $178,044.

It is expected that a temporary dam would be installed immediately upstream of the existing dam. This will allow Curtis Pond to remain full, or nearly full during construction. Retainage of the pond will allow for use by the public as well as protecting wildlife habitat and wetlands.

VII. SUMMARY AND RECOMMENDATIONS

The existing Curtis Pond Dam has been and continues to deteriorate. It is considered to be in poor condition for a number of reasons, including movement of the stones, excessive seepage, piping and active sinkholes, inadequate hydraulic capacity and a inoperable low level drain.

Collectively, these deficiencies represent a progressive deterioration of the dam and suggest that its structural integrity and associated safety continue to decline. This condition provides justification to identify and evaluate alternatives to create a permanent and low maintenance structure and to plan for the implementation of a preferred alternative.

DuBois & King Inc. recommends construction of a new concrete dam wall to be installed along the upstream edge of the existing dam. This alternative meets the goals and objectives of creating a safe, low cost and low maintenance dam.

APPENDIX A

CONSTRUCTION COST ESTIMATE

CURTIS POND DAM IMPROVEMENTS

CONCEPTUAL CONSTRUCTION COST ESTIMATE
NEW CONCRETE WALL UPSTREAM OF EXISTING DAM

This Estimate includes a new Concrete Wall to be constructed Upstream of the Existing Stone Dam.

ALTERNATIVE NO. 1 CONSTRUCTION COST ESTIMATE

	DESCRIPTION OF THE ITEM	UNITS	CONTRACT QUANTITY	UNIT PRICE	COST
(a)	**MOBILIZATION (6.0% of Sub Total)**	**LUMP SUM**	**1**	**$8,000.00**	**$8,000**
(b)	**CLEARING & GRUBBING DAM SITE (2.0% of Sub Total)**	**ACRE**	**1**	**$3,000.00**	**$3,000**
(c)	**DEWATERING & CONTROL OF WATER (Porta-Dam)**	**LUMP SUM**	**1**	**$25,000.00**	**$25,000**
(d)	**DAM FOUNDATION PREPARATION**				
	PARTIAL EXCAVATION OF EARTH DAM	CUBIC YARDS	500	$5.00	$2,500
	FOUNDATION EXCAVATION	CUBIC YARDS	20	$100.00	$2,000
	PARTIAL REMOVAL OF STONE WALL	LUMP SUM	1	$2,500.00	$2,500
(e)	**NEW CONCRETE WALL**				
	DRILL & GROUT REINFORCING BARS TO LEDGE FOUNDATION	EACH	40	$80.00	$3,200
	SUB-FOOTING (Concrete, Class C)	CUBIC YARD	30	$400.00	$12,000
	STRUCTURAL FOOTING (Concrete, Class B)	CUBIC YARD	60	$500.00	$30,000
	STRUCTURAL WALL (Concrete, Class B)	CUBIC YARD	50	$600.00	$30,000
	LOW LEVEL DUCTILE IRON PIPE	LINEAR FOOT	25	$100.00	$2,500
	24-INCH SLUICE GATE	LUMP SUM	1	$7,500.00	$7,500
(f)	**CIVIL / SITE COMPONENTS**				
	RECONSTRUCT STONE WALL	LUMP SUM	1	$2,500.00	$2,500
	GRANULAR BACKFILL BEHIND CONCRETE WALL	CUBIC YARDS	275	$20.00	$5,500
	STONEFILL, TYPE II	CUBIC YARDS	30	$40.00	$1,200
(g)	**SEDIMENT & EROSION CONTROL MEASURES**				
	GEOTEXTILE SILT FENCE	SQUARE YARDS	100	$5.00	$500
	TOPSOIL	CUBIC YARDS	40	$50.00	$2,000
	GRUBBING MATERIAL	SQUARE YARDS	20	$35.00	$700
	SEED	POUNDS	20	$15.00	$300
	FERTILIZER	POUNDS	50	$5.00	$250
	HAY MULCH	TONS	1	$785.00	$785
	EROSION CONTROL MATTING	SQUARE YARDS	100	$5.00	$500

SUB-TOTAL =	**$142,435**
25% CONTINGENCY =	$35,609
CONSTRUCTION COST =	**$178,044**
ENGINEERING & PERMITTING BUDGET =	**$28,000**
CONSTRUCTION ENGINEERING =	**$22,000**
TOTAL ESTIMATED PROJECT COST =	**$228,044**

Estimate Preparation Date:	7-Nov-03
Spread Sheet Print Date:	2-Feb-04
Estimate Prepared By:	J.W. Tucker, P.E.
Estimate Checked By:	SRPatenaude, E.I.

APPENDIX B

PHOTOGRAPHS

View of the inlet upstream of the dam.

View of the spillway channel and pedestrian bridge.

Upstream view of Curtis Pond Dam.

View looking along the dam. Note the slight lean of the downstream face.

APPENDIX C

BORING LOGS

GREEN MOUNTAIN BORING

PO Box 218
East Barre, VT 05649

To: Dubois & King
ATTN: Jeff Tucker
Route 66 Professional Center
Randolph, Vermont 05060

Date	10/21/03
Job Name/Site	Curtis Pond Dam/Calais, Vermont
Job Number	03064
Crew	Michael McGinley/Tyler Sabin
Inspector .	

HOLE #	OFFSET	STATIC LEVEL	SOILS	AUGER REFUSAL	DEPTH
P-1	-	1.5'	Tripod probe until refusal	4.5'	4.5'
P-2	-	3'	Rebar until refusal	5'	5'
P-3	-	1.5'	Rebar until refusal	4'9"	4'9"

TOTAL FOOTAGE: 14'3"

AUGERS USED: Solid

GREEN MOUNTAIN BORING
PO Box 218 ° East Barre, Vermont 05649 ° 802 476-5073

TO:	Dubois & King ATTN: Jeff Tucker Route 66 Professional Center Randolph, Vermont 05060	PROJECT NAME: LOCATION: GMB JOB #:	Curtis Pond Dam Calais, Vermont 03064	SHEET: DATE: HOLE #: LINE & STA. OFFSET:	1 10/20/03 B-1

Ground Water Observations None at 0 hours	Augers-Size I.D. Split Spoon Hammer Wt. Hammer Fall	3.25" 1 3/8" 140# 30"	Surface Elevation: Date Started: Date Completed: Boring Foreman: Inspector: Soils Engineer:	 10/20/03 10/20/03 Michael McGinley Jeff Tucker

LOCATION OF BORING:

Sample Depths From/To (Feet)	Type of Sample	Blows per 6" on Sampler	Moisture Density or Consist.	Strata Change Elev.	Soil Identification	Sample No.	Sample Pen. Inches	Sample Rec. Inches
0-2	Dry	4/3/6/2	Damp		Sand, small stones and fractured rock	1	24	8
2-4	Dry	2/15/40/100 for 4"	Wet/Dry	2.5'	Sand, into weathered rock, into ledge	2	24	24
					Split spoon refusal at 3'10"			

Ground Surface to: 2'   Used 3.25" augers, then split spoon to refusal at 3'10"

SUMMARY B-1

Earth Boring	3'10"
Rock Coring	
Samples	2

GREEN MOUNTAIN BORING

PO Box 218 ° East Barre, Vermont 05649 ° 802 476-5073

TO:	Dubois & King ATTN: Jeff Tucker Route 66 Professional Center Randolph, Vermont 05060	PROJECT NAME:	Curtis Pond Dam	SHEET:	2
		LOCATION:	Calais, Vermont	DATE:	10/20/03
				HOLE #:	B-2
				LINE & STA.	
		GMB JOB #:	03064	OFFSET:	

Ground Water Observations	Augers-Size I.D.	3.25" Tripod	Surface Elevation:	
	Split Spoon	1 3/8"	Date Started:	10/20/03
None at 0 hours	Hammer Wt.	140#	Date Completed:	10/20/03
	Hammer Fall	30"	Boring Foreman:	Michael McGinley
			Inspector:	Jeff Tucker
			Soils Engineer:	

LOCATION OF BORING: As marked

Sample Depths From/To (Feet)	Type of Sample	Blows per 6" on Sampler	Moisture Density or Consist.	Strata Change Elev.	Soil Identification	Sample No.	Pen. Inches	Rec. Inches
0-2	Dry	2/1/1/2	Dry		Sand and small stones	1	24	4
2-4	Dry	11/8/5/3	Dry		Weathered rock with a trace of sand	2	24	16
4-6	Dry	4/8/4/3	Dry		Rock fragments with a trace of sand	3	24	12
6-8	Dry	4/6/8/7	Wet		Weathered rock, trace of sand	4	24	8
8-10	Dry	9/9/6/15	Wet		Weathered rock, trace of sand	5	24	16
10-12	Dry	9/50/15/12	Wet		Rock fragments, trace of sand	6	24	12
14	Dry	13/11/15/100 for 2"	Wet		Till and rock fragments	7	24	24
					Split spoon refusal at 13'8"			

Ground Surface to: 12' Used 3.25" augers, then split spoon to refusal at 13'8"

SUMMARY B-2	
Earth Boring	13'8"
Rock Coring	
Samples	7

GREEN MOUNTAIN BORING
PO Box 218 ° East Barre, Vermont 05649 ° 802 476-5073

TO:	Dubois & King ATTN: Jeff Tucker Route 66 Professional Center Randolph, Vermont 05060	PROJECT NAME: LOCATION: GMB JOB #:	Curtis Pond Dam Calais, Vermont 03064	SHEET: DATE: HOLE #: LINE & STA. OFFSET:	3 10/20/03 B-3

Ground Water Observations None at 0 hours	Augers-Size I.D. Split Spoon Hammer Wt. Hammer Fall	3.25" Tripod 1 3/8" 140# 30"	Surface Elevation: Date Started: Date Completed: Boring Foreman: Inspector: Soils Engineer:	 10/20/03 10/20/03 Michael McGinley Jeff Tucker

LOCATION OF BORING: As marked

Sample Depths From/To (Feet)	Type of Sample	Blows per 6" on Sampler	Moisture Density or Consist.	Strata Change Elev.	Soil Identification	Sample No.	Sample Pen. Inches	Sample Rec. Inches
0-2	Dry	2/3/1/1	Dry		Sand and small stones with rock fragments	1	24	10
2-4	Dry	1/1/10/8	Wet		Sand and small stones with rock fragments	2	24	6
4-6	Dry	4/5/7/3	Wet		Sand and small stones with rock fragments	3	24	6
6-8	Dry	2/2/8/12	Wet		Organics (wood), sand, trace of silt, small stones	4	24	10
8-10	Dry	25/35/100 for 3"	Wet		Rock fragments	5	24	12
					Split spoon refusal at 9'3"			

Ground Surface to: 8' Used 3.25" augers, then split spoon to refusal at 9'3"

SUMMARY B-3

Earth Boring	9'3"
Rock Coring	
Samples	5

GREEN MOUNTAIN BORING
PO Box 218 ° East Barre, Vermont 05649 ° 802 476-5073

TO:	Dubois & King ATTN: Jeff Tucker Route 66 Professional Center Randolph, Vermont 05060	PROJECT NAME: LOCATION: GMB JOB #:	Curtis Pond Dam Calais, Vermont 03064	SHEET: DATE: HOLE #: LINE & STA. OFFSET:	4 10/20/03 B-4

Ground Water Observations None at 0 hours	Augers-Size I.D. Split Spoon Hammer Wt. Hammer Fall	3.25" Tripod 1 3/8" 140# 30"	Surface Elevation: Date Started: Date Completed: Boring Foreman: Inspector: Soils Engineer:	 10/20/03 10/20/03 Michael McGinley Jeff Tucker

LOCATION OF BORING: As marked

Sample Depths From/To (Feet)	Type of Sample	Blows per 6" on Sampler	Moisture Density or Consist.	Strata Change Elev.	Soil Identification	Sample		
						No.	Pen. Inches	Rec. Inches
0-2	Dry	1/1/1/2	Damp		Sand, small stones, trace of organics	1	24	3
2-4	Dry	2/2/8/8	Wet		Sand, small stones, trace of silt, rock fragments	2	24	6
4-6	Dry	6/9/9/12	Wet		Sand, small stones, rock fragments, trace of silt	3	24	8
6-8	Dry	1/4/35/100 for 5"	Wet		Sand, small stones, till like material, rock fragments	4	24	16
					Split spoon refusal at 7'11"			

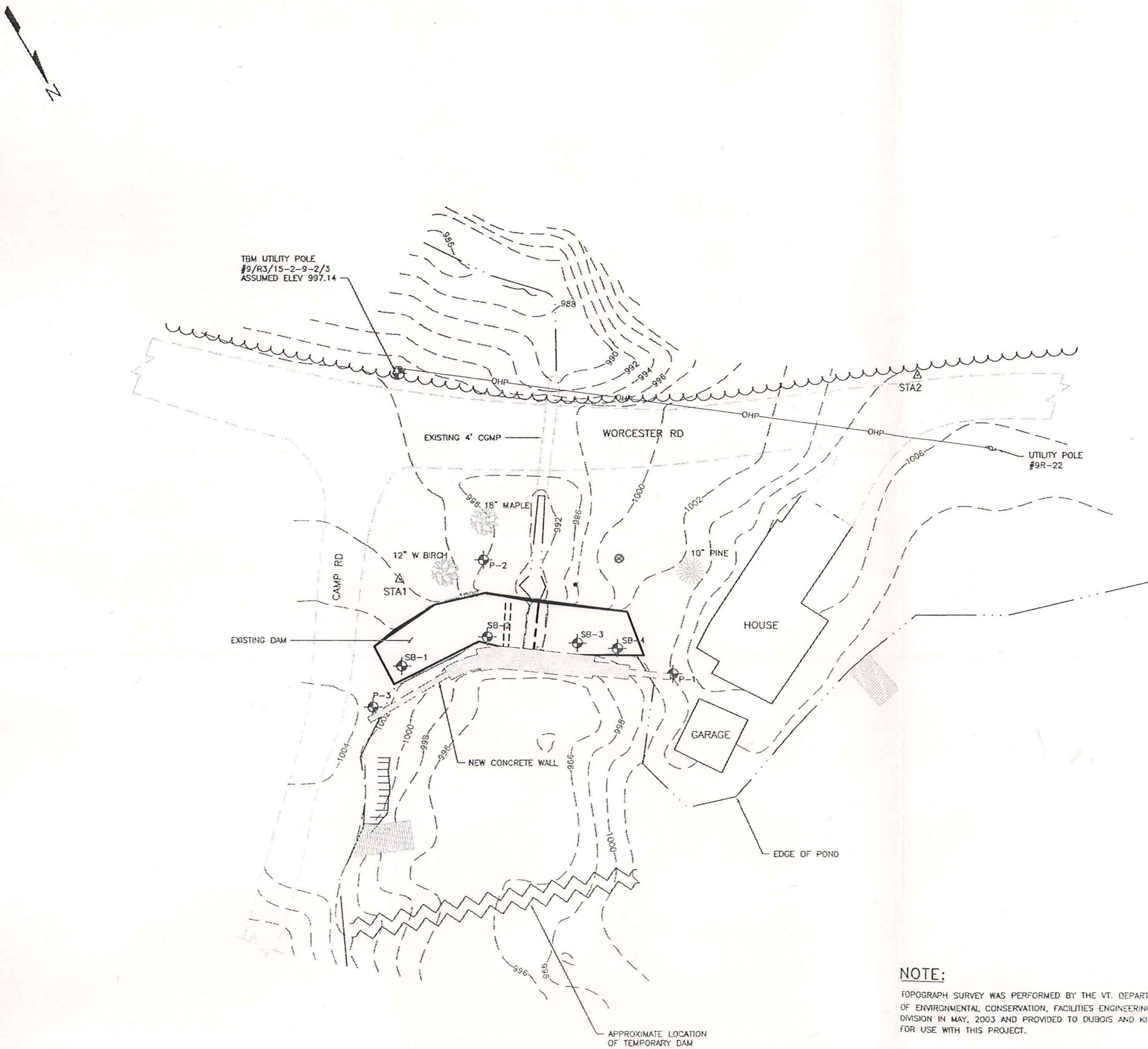
Ground Surface to: 6' Used 3.25" augers, then split spoon to refusal at 7'11"

SUMMARY B-4

Earth Boring	7'11"
Rock Coring	
Samples	4

APPENDIX D

ENGINEERING PLANS



PLAN VIEW

SCALE: 1"=20'

20 0 20 40 80

SCALE: 1" = 20'

NOTE:

TOPOGRAPH SURVEY WAS PERFORMED BY THE VT. DEPARTMENT OF ENVIRONMENTAL CONSERVATION, FACILITIES ENGINEERING DIVISION IN MAY, 2003 AND PROVIDED TO DUBOIS AND KING FOR USE WITH THIS PROJECT.

LEGEND

EXISTING

- CONTOUR – 2 FT INTERVAL
- CONTOUR – 10 FT INTERVAL
- WATER LEVEL (O.H.W. or O.L.W.)
- LEDGE
- STA1 SURVEY STATION
- BURIED PROPANE TANK
- LIGHT POLE
- TREE LINE
- 10" PINE TREE (CONIFER)
- 18" MAPLE TREE (DECIDUOUS)
- DOCK
- SB-4 BORING
- P-1 AUGER PROBE

NO.	DATE	REVISIONS	BY	CK'D

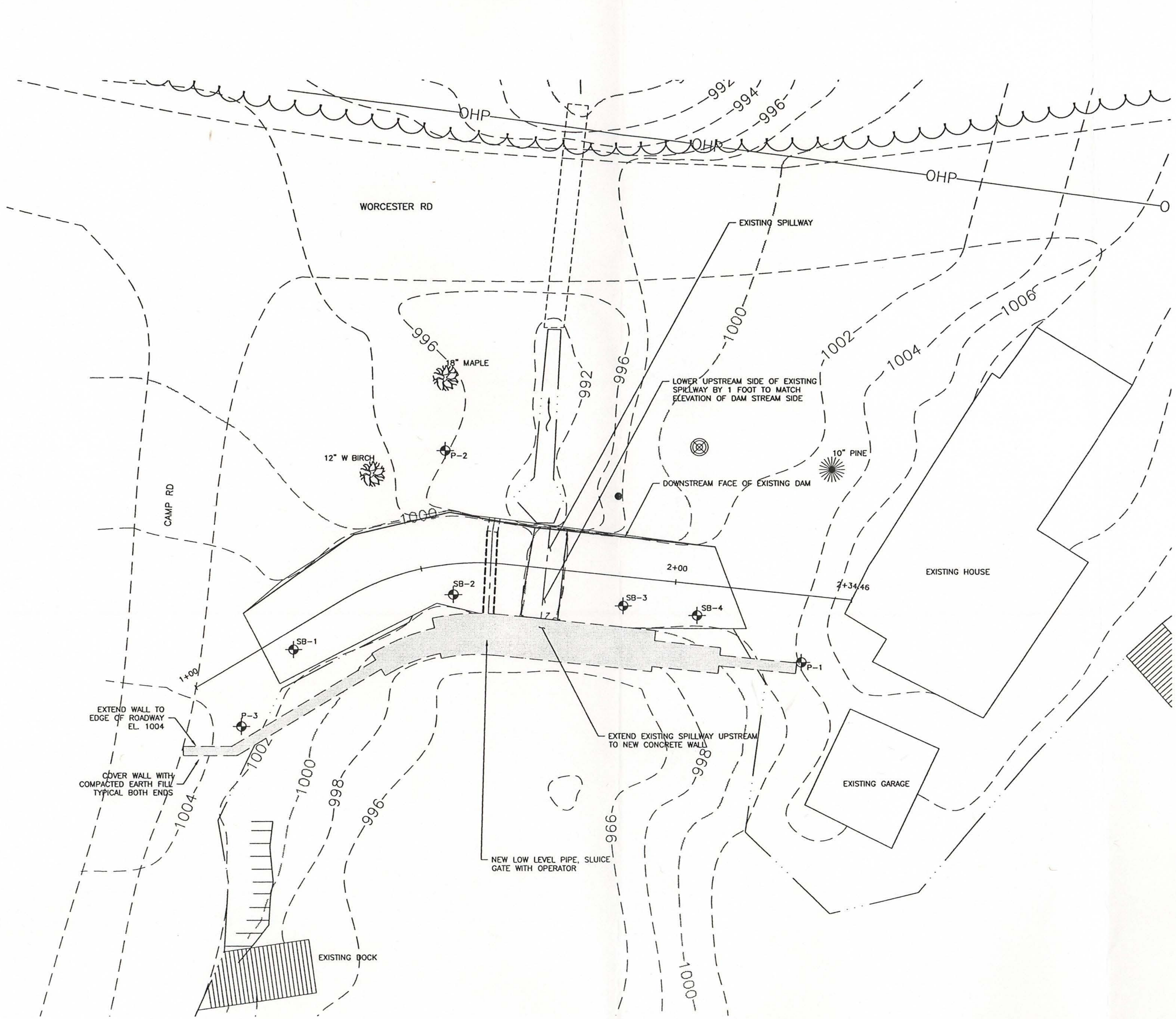
DuBois & King inc.
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

CURTIS POND DAM

NEW CONCRETE WALL
CONCEPTUAL SITE PLAN

DRAWN BY: EBS	DATE: DEC. 2003
CHECKED BY:	PROJ. NO. 618450
PROJ. ENG.:	DRAW. NO.
SHEET 1	OF 6



PLAN VIEW

SCALE: 1"=10'

10 0 10 20 40

SCALE: 1" = 10'

NO.	DATE	REVISIONS	BY	CK'D

DuBois & King inc.

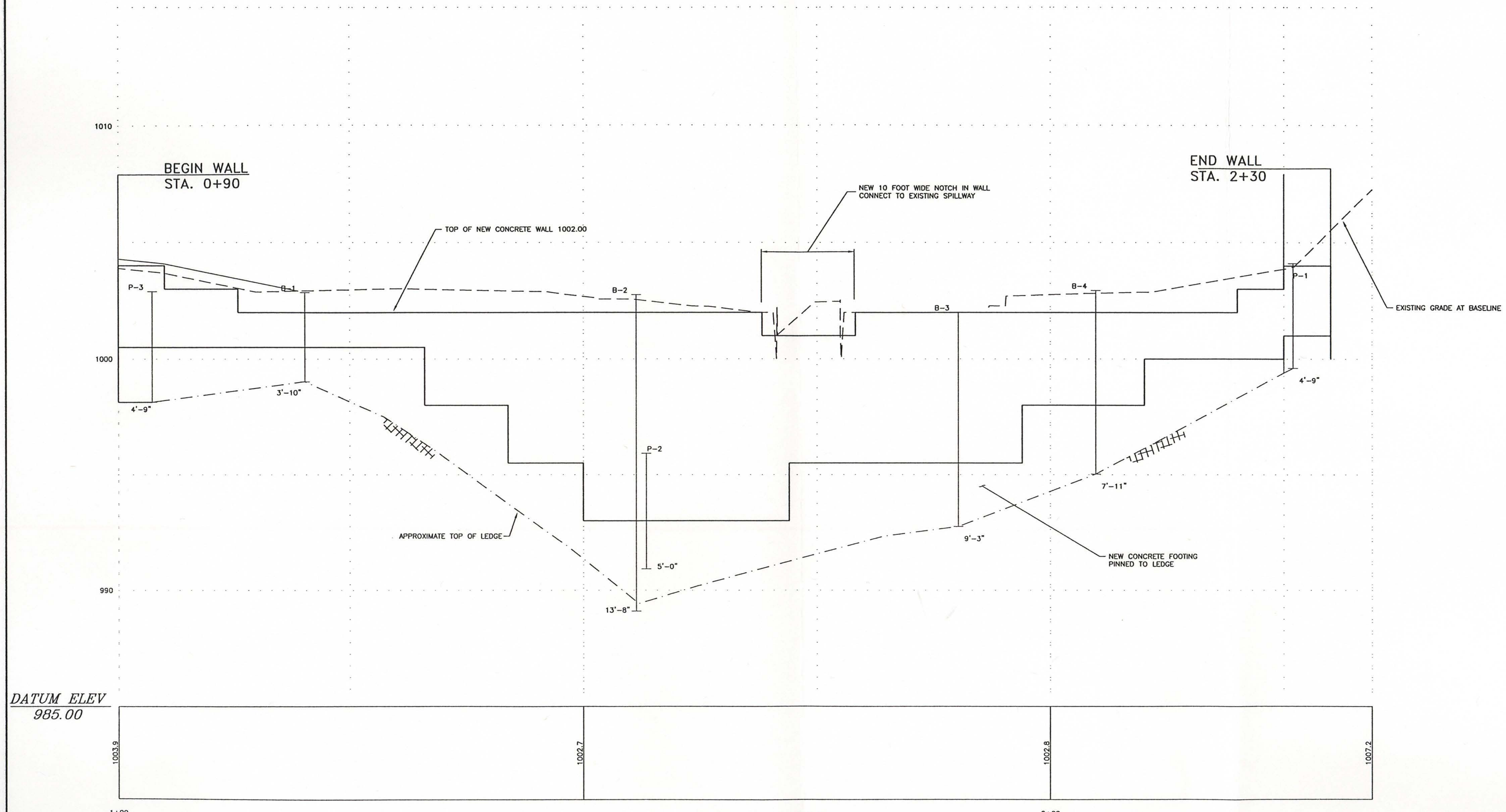
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

CURTIS POND DAM

NEW CONCRETE WALL
ENLARGED CONCEPTUAL SITE PLAN

DRAWN BY	DATE
EBS	DEC. 2003
CHECKED BY	PROJ. NO. 618450
PROJ. ENG.	DRAW. NO.
SHEET 2	OF 6



BASELINE PROFILE

SCALE: HORIZ. 1"=5'
VERT. 1"=2'

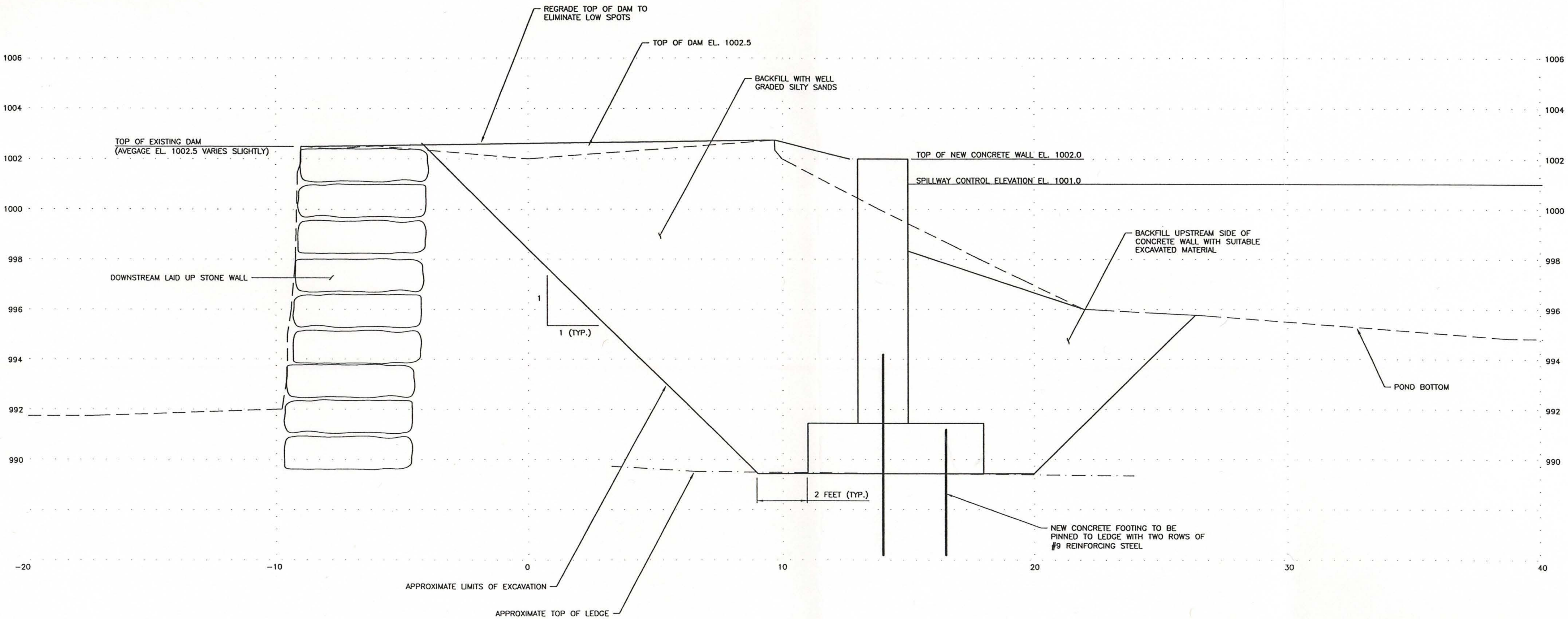
NO.	DATE	REVISIONS	BY	CK'D

DuBois & King inc.
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

CURTIS POND DAM

DRAWN BY: EBS	DATE: DEC. 2003
CHECKED BY:	PROJ. NO.: 618450
PROJ. ENG.:	DRAW. NO.:
SHEET 3	OF 6



TYPICAL SECTION

SCALE: 1"=2'

2 0 2 4 8

SCALE: 1" = 2'

NO.	DATE	REVISIONS	BY	CK'D

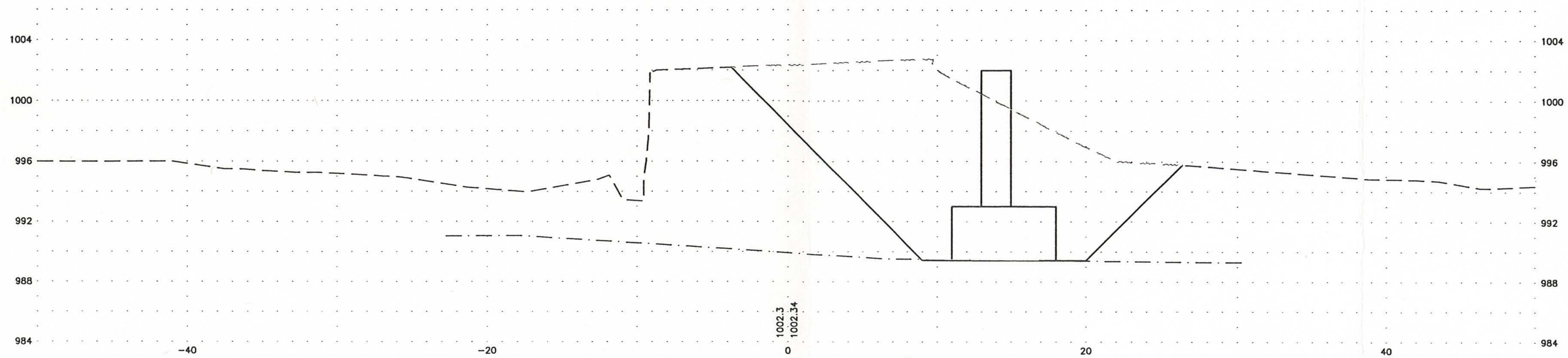
DuBois & King inc.
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

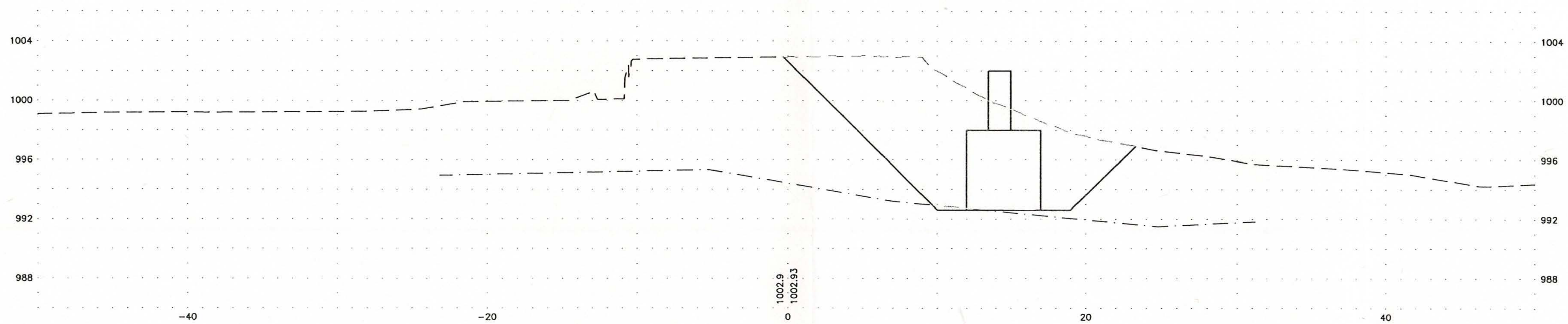
CURTIS POND DAM

DRAWN BY: EBS	DATE: DEC. 2003
CHECKED BY	PROJ. NO. 618450
PROJ. ENG.	DRAW. NO.
SHEET 4	OF 6

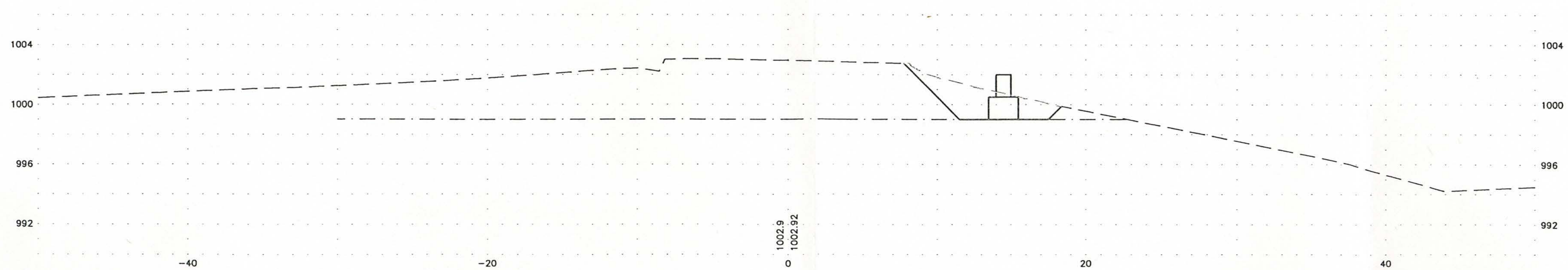
1+60



1+40



1+20



EMBANKMENT SECTIONS

SCALE: 1"=4'

4 0 4 8 16

SCALE: 1" = 4'

NO.	DATE	REVISIONS	BY	CK'D

DuBois &King inc.

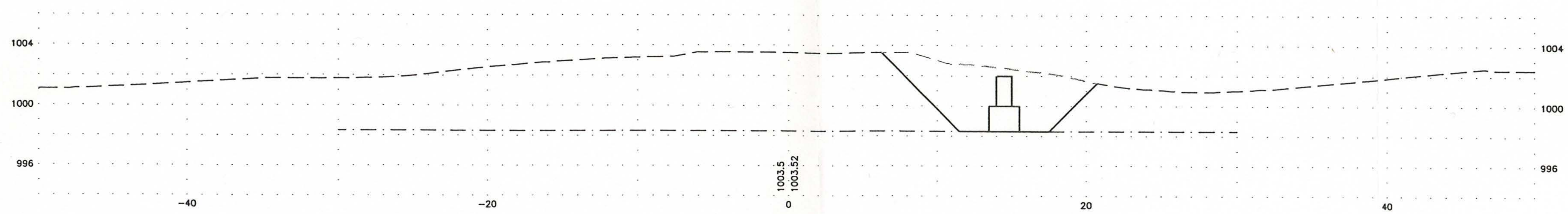
engineering planning management development

CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

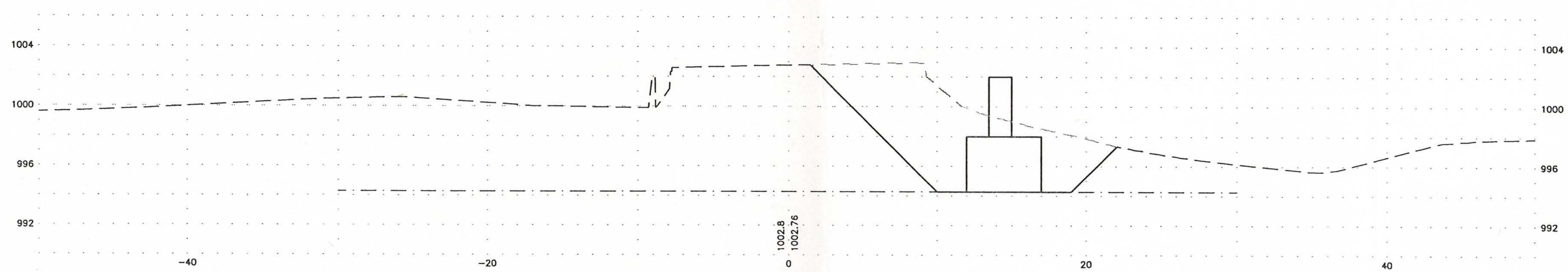
CURTIS POND DAM

DRAWN BY: EBS	DATE: DEC. 2003
CHECKED BY	PROJ. NO. 618450
PROJ. ENG.	DRAW. NO.
SHEET 5	OF 6

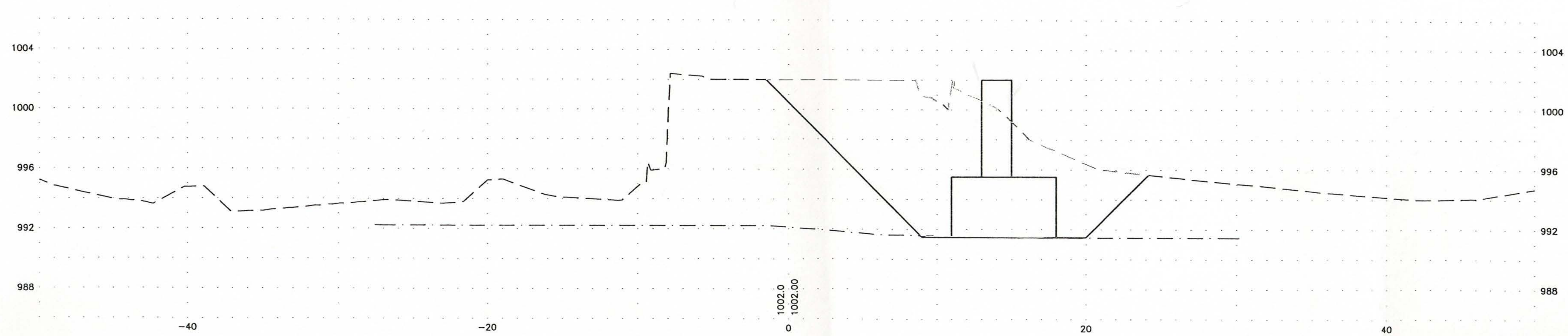
2+20



2+00



1+80



EMBANKMENT SECTIONS

SCALE: 1"=4'

4 0 4 8 16

SCALE: 1" = 4'

NO.	DATE	REVISIONS	BY	CK'D

DuBois & King inc.

engineering planning management development

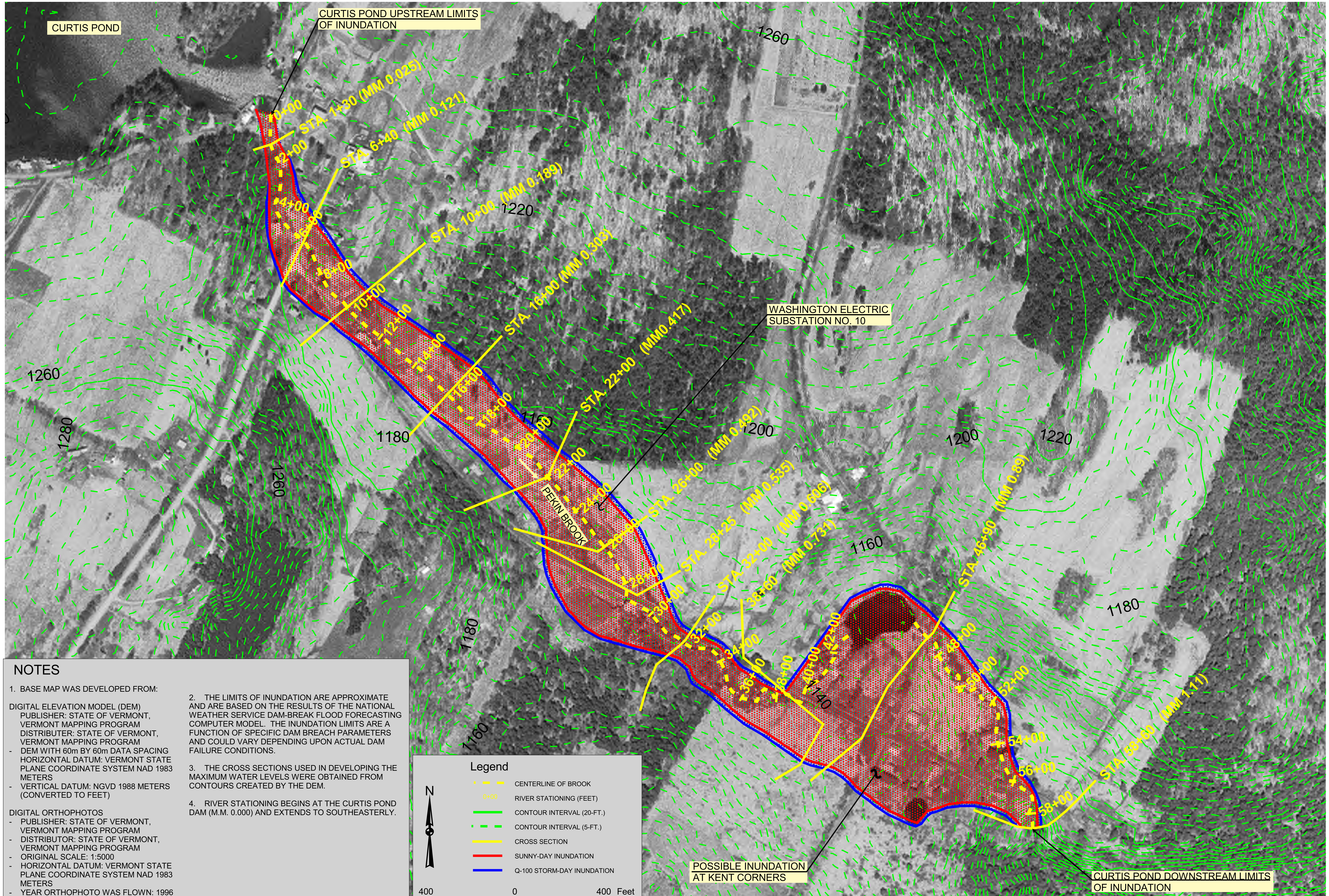
CURTIS POND DAM REPAIR COMMITTEE
CALAIS, VERMONT

CURTIS POND DAM

DRAWN BY EBS	DATE DEC. 2003
CHECKED BY	PROJ. NO. 618450
PROJ. ENG.	DRAW. NO.
SHEET 6	OF 6

APPENDIX E

INUNDATION MAP



NOTES

1. BASE MAP WAS DEVELOPED FROM:

DIGITAL ELEVATION MODEL (DEM)
- PUBLISHER: STATE OF VERMONT, VERMONT MAPPING PROGRAM
- DISTRIBUTER: STATE OF VERMONT, VERMONT MAPPING PROGRAM
- DEM WITH 60m BY 60m DATA SPACING
- HORIZONTAL DATUM: VERMONT STATE PLANE COORDINATE SYSTEM NAD 1983 METERS
- VERTICAL DATUM: NGVD 1988 METERS (CONVERTED TO FEET)

DIGITAL ORTHOPHOTOS
- PUBLISHER: STATE OF VERMONT, VERMONT MAPPING PROGRAM
- DISTRIBUTOR: STATE OF VERMONT, VERMONT MAPPING PROGRAM
- ORIGINAL SCALE: 1:5000
- HORIZONTAL DATUM: VERMONT STATE PLANE COORDINATE SYSTEM NAD 1983 METERS
- YEAR ORTHOPHOTO WAS FLOWN: 1996

2. THE LIMITS OF INUNDATION ARE APPROXIMATE AND ARE BASED ON THE RESULTS OF THE NATIONAL WEATHER SERVICE DAM-BREAK FLOOD FORECASTING COMPUTER MODEL. THE INUNDATION LIMITS ARE A FUNCTION OF SPECIFIC DAM BREACH PARAMETERS AND COULD VARY DEPENDING UPON ACTUAL DAM FAILURE CONDITIONS.

3. THE CROSS SECTIONS USED IN DEVELOPING THE MAXIMUM WATER LEVELS WERE OBTAINED FROM CONTOURS CREATED BY THE DEM.

4. RIVER STATIONING BEGINS AT THE CURTIS POND DAM (M.M. 0.000) AND EXTENDS TO SOUTHEASTERLY.

Legend

- CENTERLINE OF BROOK
- RIVER STATIONING (FEET)
- CONTOUR INTERVAL (20-FT.)
- CONTOUR INTERVAL (5-FT.)
- CROSS SECTION
- SUNNY-DAY INUNDATION
- Q-100 STORM-DAY INUNDATION

N

400 0 400 Feet

DUBOIS & KING
RANDOLPH, VERMONT

CURTIS POND DAM
TOWN OF CALAIS, VERMONT
DAM-BREAK FLOOD ANALYSIS
INUNDATION PLAN
PEKIN BROOK
NOVEMBER 2003