ALTERNATIVES REPORT

HOUGHTON POND DAM

MA00444 / 4-9-136-6

HOLLISTON, MASSACHUSETTS

PREPARED FOR:

TOWN OF HOLLISTON
703 WASHINGTON STREET
HOLLISTON, MA 01746

PREPARED BY:

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PARE PROJECT NO. 21214.00/201

May 2022

PARE CORPORATION

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prepared for: Town of Holliston
703 Washington Street
Holliston, MA 01746

prepared by: Pare Corporation
10 Lincoln Road Suite 210
Foxboro, MA 02035

Authority

The Town of Holliston, MA has retained Pare Corporation (Pare) to evaluate conditions of the Houghton Pond Dam in Holliston, Massachusetts and to develop a report of conceptual design alternatives to address known deficiencies at the dam. This inspection, report, and evaluations were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws.

PREFACE

The assessment of the condition of the dam is based upon available data, visual inspections, subsurface investigations, hydrologic and hydraulic studies, topographic surveys and stability analyses as well as supplemental information developed by others during previous evaluations of the dam.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team and other information collected as part of the evaluation.

It is critical to note that the condition of the dam is evolutionary in nature and depends on numerous and constantly changing internal and external conditions. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Allen R. Orsi, P.E.
Massachusetts License No.: 46904
Vice President
Pare Corporation

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1.0 PROJECT INFORMATION

1.1 General

1.1.1 Authority

The Town of Holliston has retained Pare Corporation (Pare) to develop a report of alternative approaches to address known and/or approximated deficiencies at the dam. This inspection, report, and evaluations were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws.

1.1.2 Purpose of Work

The purpose of this study is to utilize available information pertaining to the dam to develop an initial understanding of the level of effort which may be required to advance a variety of alternatives for the dam site including dam removal, dam repair, dam rehabilitation, and no action

This investigation consisted of six parts: 1) Review available reports, investigations, and data previously submitted to the owner pertaining to the dam and appurtenant structures; 2) Complete a field review of existing conditions of the dam; 3) Develop conceptual designs to either remove, repair, or rehabilitate the dam; 4) Develop opinions of probable cost for each of the identified alternatives; and 6) Prepare and submit a final report presenting the findings of the completed work.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in Appendix D. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and 6) condition rating.

1.2 Description of Project

1.2.1 General

Sections of this report are based upon available documentation, including previous inspection reports and other available information as identified in Appendix C. Other historical information obtained during the inspection, including information provided by the caretaker, has also been incorporated in this report. This material is intended to provide general information. The accuracy of this referenced information was not verified as part of this study.

Elevations that are included in this evaluation reported reference the North American Vertical Datum of 1988 (NAVD88) based upon available survey completed as part of the 2017 Phase II Inspection & Investigation Report.

1.2.2 Location

Houghton Pond Dam is in the Town of Holliston, Middlesex County, Massachusetts near coordinates 42.21172ºN/71.42757ºW. The dam is accessible from State Route 16 as follows: Follow State Route 16 approximately 0.1 miles west from its northern intersection with State Route 126. The dam is

located north of Rt 16 / Rt 126 in the rear of the Dunkin Donuts at 441 Washington Street, as indicated on Figure 1: Locus Plan.

1.2.3 Owner/Operator

The dam is currently owned by the Town of Holliston. The Town of Holliston DPW is responsible for operation and maintenance of the dam.

Table 1-1: Owner/Operator Information

	Dam Owner	Dam Caretaker
Name	Town of Holliston	Town of Holliston DPW
Mailing Address	703 Washington Street	703 Washington Street
Town	Holliston, MA 01746	Holliston, MA 01746
Daytime Phone	508.429.0608	508.429.0615
Emergency Phone	508.429.4631 (Fire Dept)	508.429.4631 (Fire Dept)
Email Address		

1.2.4 Purpose of Dam

The dam, which was reportedly originally constructed for ice harvesting, currently impounds water for recreational use.

1.2.5 Description of the Dam and Appurtenances

As shown in Figure 3: Existing Site Plan, Houghton Pond Dam is an approximately 150 foot long earthen embankment with a maximum height of approximately 10 feet. The dam system consists of three primary elements: the earthen embankment retained along the upstream and downstream sides by stone masonry walls; the uncontrolled auxiliary spillway; and, the stop log controlled primary spillway.

The earthen embankment of the dam consists of an approximately 100-foot long section located right of the spillway system. The embankment consists of an upstream dry set stone masonry wall constructed of variable sized stones and granite blocks averaging approximately 3 to 4 feet in diameter. The crest of the dam is approximately 15 feet wide and generally flat with a slight pitch in the downstream direction. The downstream side of the dam is also retained by a dry set stone masonry wall constructed of irregular stones generally from 2 to 4 feet in diameter.

The discharge structures at the dam are located at the left abutment and consist of a 29-foot wide uncontrolled auxilairy spillway and a 7.2-foot wide stop log regulated primary spillway. The auxliary spillway consists of an earthen approach area to a granite block crest. Dry set granite blocks confine the right side of the auxilary spillway while a concrete wall that also functions as the right wall of the primary spillway confines the left side of the auxiliary spillway. Flow over the crest of the auxiliary spillway cascades over a riprapped slope to the natural discharge channel at the toe of the spillway.

The primary spillway consists of a 7.2-foot wide sluice structure regulated by timber stop logs at the left abutment of the dam. Concrete wingwalls extend from upstream of the structure. The left wall extends perpendicularly from the upstream end of the spillway into the left abutment. The right wing wall extends at a 45º angle upstream of the spillway into the impoundment. Discharges over the stoplogs drop to a concrete lined channel before entering the natural downstream channel.

1.3 Pertinent Data

1.3.1 Size Classification

Houghton Pond Dam has a maximum structural height of approximately 10 feet and a reported maximum storage capacity of 132 acre-feet. Therefore, in accordance with Department of Conservation and Recreation Office of Dam Safety classification, under Commonwealth of Massachusetts Dam Safety rules and regulations stated in 302 CMR 10.00, Houghton Pond Dam is an **Intermediate** size structure.

1.3.2 DCR Hazard Classification

Houghton Pond Dam is located in an area where the associated downstream hazards include commercial development in the area above the culvert located downstream of the dam, Washington Street (Rt.16/126), Curve Street, Factory Pond, Woodland Street, St Mary's Cemetery, Lowland Street, residential properties, commercial properties, and utilities along those streets and along the river. Therefore, failure of the structure "will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)." As such, in accordance with Department of Conservation and Recreation classification procedures, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00, Houghton Pond Dam is classified as a **High** (Class I) hazard potential structure.

The hazard potential classification is consistent with the hazard potential classification within the MADCR Office of Dam Safety dam database.

1.4 Inspection History

Based upon a review of available information provided by the Town of Holliston and the MADCR Office of Dam Safety, the site has a history of developing conditions resulting in the current poor condition rating. The following tables provides a summary of past inspections and noted conditions:

Table 1-2: Inspection History Summary

Date	Inspector	Dam Condition	Noted Deficiencies
May 10, 2021	Lenard Engineering, Inc.	POOR	Heavy brush and woody vegetation located on and within 20 feet of the dam.
			Deteriorated upstream and downstream stone masonry walls on the right half of the dam, including tilting, bulging, displaced stones, and missing capstones.
			Sinkholes in the right crest behind the right upstream and downstream faces.
			Missing boulders at the base of the left downstream channel wall.
			Spalling, minor cracks and erosion of the concrete primary spillway training walls and stop log slots, especially at the water line.
			Voids under weir blocks of the auxiliary spillway, poorly aligned stones in right training wall, and missing stones at the top of the ogee.
			Seepage along the auxiliary spillway toe.
			Inadequate spillway capacity.
			Erosion behind left spillway training wall.
			Lack of low-level outlet and controls
			Beaver dam causing elevated water levels in the pond.

2.0 ENGINEERING DATA

2.1 General

2.1.1 Drainage Area

As reported in the 2017 Phase II Report, "The drainage area for Houghton Pond is approximately 2.64 square miles and is contained wholly within the community of Holliston. The topography consists primarily of hilly terrain. The weighted run off curve number (CN) value of 66 was derived from SCS methodology in accordance with land uses shown on MassGIS Orthophotographs and NRCS soil surveys."

2.1.2 Reservoir Information

The following table provides a general overview of impoundment geometric properties. Data is based upon information presented within previous reports.

Table 2-1: Reservoir Properties

	Elevation	Surface Area (acres)	Storage Volume (acre-feet)
Normal Pool	163.5±	18.5 ±	55 ±
Maximum Pool	181.3±	30 ±	132 ±
SDF Pool	183.0±	33 ±	252 ±

2.1.3 Discharges at the Dam Site

No records of discharges at the dam site were made available during the preparation of this report.

2.1.4 General Elevations (feet)

Elevations are based upon information provided within available inspection reports and survey completed as part of the 2017 Phase II. Elevations reportedly referenced NAVD88.

A.	Top of Dam	181.3
B.	Spillway Design Flood Pool	183.0
C.	Normal Pool (Top of Stop Log)	176.4±
D.	Downstream Channel	171.1±

2.1.5 Primary Spillway

A.	Type	Controlled Sluiceway
B.	Width	7.2 feet
C.	Elevations	
	1. Top Stop Log Slots	176.4
	2. Invert	171.8

2.1.6 Auxiliary Spillway

A.	Type	Concrete Weir / Stone Masonry Gravity Section
B.	Width	29 feet

C. Crest Elevation 179.8

2.2 Design and Construction Records

No design or construction records were available during the preparation of this report. As indicated in previous reports, "The original design and construction information is not available for this dam. The structure is thought to have been built prior to 1898, with the concrete spillway structure likely added at a later date."

3.0 BASIS OF ALTERNATIVES ANALYSIS

The scope of this study provides for the development of alternatives to comply with current state dam safety regulations and to address known deficiencies at the dam. Where available, the study references previously completed studies and detailed analyses. In the absence of detailed evaluations, the scope of the work includes developing approximations of the dam's current compliance with applicable regulations based upon available published information and the engineer's judgment. The following provides the basis for which the dam has been assessed.

3.1 Structural Stability

Available documentation for the dam includes visual inspections and assessments of the dam stability. As indicated in the 2021 Phase I Report:

> A structural stability analysis has not been performed. Based on observations at the time of inspection, the non-embankment structures appear to be stable. It should be noted that the dam is under DCR Orders to maintain water levels 4 feet below top of spillway wall and that under these conditions, the observations were made. With these lowered water levels, the non-embankment structures will likely continue to be more stable until the deficiencies can be corrected. Deficiencies which affect the long-term service of this dam include: concrete spalling, erosion, and exposed aggregate of the main spillway training walls; footpath behind the left main spillway training wall; missing boulder of the left downstream training wall and subsequent sinkhole on top; inappropriate vegetative growth in the auxiliary spillway; and gaps under the auxiliary spillway capstones.

In addition to previously reported observations, significant displacement of both the upstream and downstream walls was observed during site visit completed as part of this study. This apparent displacement suggests that the actual geometry of the stone masonry retaining walls along the upstream and downstream sides of the dam is less than assumed during previous analysis and that the walls are inherently unstable.

3.1.1 Embankment (Slope) Stability

Available documentation for the dam includes visual inspections and assessments of the dam stability. As indicated in the 2021 Phase I Report:

> In 2017, GeoInsight, Inc. prepared this evaluation report to characterize geotechnical conditions at Houghton Pond Dam. The results of GeoInsight's analyses indicated that the earthen dam embankment [left of the spillway] currently appears stable under static conditions but is likely subject to deformation during a seismic event, with the likelihood increasing with the strength of the seismic energy. The stability is very dependent upon conditions that are currently not completely defined, including slope geometry on the upstream face into the pond, internal conditions within the west embankment, and actual configuration of the block walls.

3.1.2 Embankment (Seepage) Stability

As indicated in the 2021 Phase I Report:

As part of GeoInsights report in 2017, a limited seepage analysis was also conducted. A seepage analysis was performed by estimating the hydraulic gradient through the dam using an assumed homogeneous permeability of the dam material based on the soil data from borings. The results of the evaluation indicated that the dam could be seeping from approximately 1 to 2 gallons per minute (gpm) per linear foot of dam. Given the presence of observable seepage at several locations along the toe near the discharge stream, this seepage rate does not seem unreasonable. Obvious loss of embankment material potentially associated with seepage was not apparent during site visits: GeoInsight did not observe sloughs or other obvious evidence of unstable conditions at the downstream face of the dam during their investigation.

Current site observation did not identify any areas of seepage concern; however, given the reduced level of the impoundment, seepage concerns may be present during historic normal operating levels as well as during elevated pool conditions during storm events.

3.1.3 Spillway Stability

No previous evaluations of the stability of the spillway and appurtenant training walls at the dam has been completed. The right upstream wall is currently misaligned and generally appears unstable. No apparent displacement of the spillway section has been previously noted.

3.2 Spillway Design Flood Compliance

Given the size and hazard potential classification for the dam, the spillway design flood is one half of the probable maximum flood (½PMF) event.

The 2007 Emergency Action Plan (EAP) developed a hydrologic model to determine peak inflow associated with the ½ PMF storm; In order to develop the inflow hydrograph for the ½ PMF, a 72-hour precipitation event was analyzed using the HMR52 program, which critically orients the ½ PMF values to maximize the event over the watershed. The ½ PMF event has an inflow hydrograph with peak inflow of 1,700 cfs in response to 18.95 inches of rainfall over the watershed.

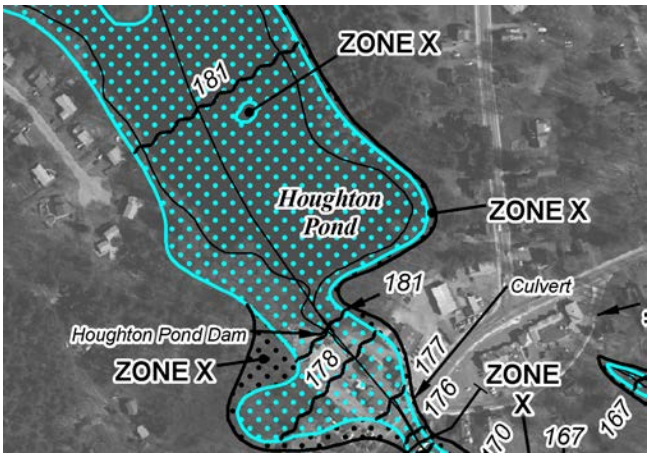


Image 3-1: *FIS Panel in Area of Houghton Pond Dam*

As part of the 2017 Phase II Inspection/Evaluation Report, detailed hydrologic and hydraulic studies were completed. As indicated in that report, the 50-year peak flow was determined using the TR-20 method with a NRCS Type III Rainfall Distribution. The ½ PMF hydrograph was generated utilizing the U.S. Army Corps of Engineers HMR-51 and HMR-52 methodology for a basin area of 10 square miles or less. The ½ Probable Maximum Precipitation (½ PMP) rainfall event was determined to yield 15.75 inches and 18.5 inches for 24-hr and 72-hour storm durations respectively. These rainfall values were utilized in 24- and 72-hour rainfall distribution mass diagram curves developed for analysis of large storms. The 50-year rainfall of 7.35 inches was obtained from NOAA data for Holliston. The study determined representation peak flows of 1,243 cfs and 2,833 cfs for the 50-year and ½ PMF storm, respectively.

The effective Flood Insurance Study (FIS) for the dam (FIS Number 25017CV001C, dated July 6, 2016), reports a 100-year flow of 500 cfs from the Bogastow Brook upstream of the impoundment. The FIS suggests that the 100-year water surface elevation will rise to near El. 181.5, near the crest of the dam.

The USGS StreamStats application also provides estimates of peak flows for recurrent storm events based upon statewide regression equations; USGS StreamStats predictions are presented in Table 3-1.

Table 3-1: Summary of Hydrologic Data

	Storm Event Peak Flow (cfs)			
Source	**50-yr**	**100-yr**	**500-yr**	**½ PMF**
2007 EAP	NA	NA	NA	1,700
2017 Phase II	1,243	NA	NA	2,833
USGS StreamStats Value (Lower Limit-Upper Limit)	322 (148-701)	382 (170-858)	543 (224-1320)	NA
FEMA FIS	400	500	750	NA

Given available studies, it appears that the dam may be able to accommodate up to roughly the 100-year storm event; however, overtopping is expected to occur during storm larger than the 100-year storm event, including the ½ PMF spillway design flood. As such, modification of the dam is required to meet current design requirements.

To support the development of conceptual designs, a spillway design flood of 1,700 cfs has been selected. While the 2017 Phase II study suggests a higher SDF flow, this value may be conservation as evidenced by 50-year flow rates exceeding flow rates predicted by regression equations as well as within the FEMA FIS.

3.3 Uncertainty

A number of previous studies have been completed for this dam with notable deviations between peak flow rates determined; a detailed review of the completed studies was beyond the scope of work. As such, determination of the reason for this difference is unknown and introduced a degree of risk and uncertainty as to the appropriate design flow rates.

Refined hydrologic and hydraulic analysis incorporating current modeling methods and data sets and accounting for routing effects of the impoundment may find SDF flows higher or lower than those presumed herein.

Detailed stability analysis of the upstream and downstream retaining walls has not been completed as design / subsurface geometry of the walls is unknown. Stability analyses for the spillway have also not been completed. Results of detailed analysis may find conclusions differing from those assumed herein.

4.0 ALTERNATIVES ANALYSIS

4.1 Alternatives Analysis

For the purposes of this evaluation, four design alternatives were considered to address the concerns at the site. These alternatives include 1) Dam Repair; 2) Dam Rehabilitation; 3) Dam Removal; and 4) No Action. The general scope of each of these alternatives includes the following:

1) ***Dam Repair:*** Includes maintenance, repair, and/or replacement of existing features at the dam to restore their original design functionality. Repair generally includes upgrading existing facilities to address known structural deficiencies; however, measures to address regulatory deficiencies are beyond the scope of a repair program.

2) ***Dam Rehabilitation:*** Includes repairs and modifications to the dam to address physical deficiencies as well as to upgrade the dam to comply with applicable design requirements, such as spillway design flood requirements and meeting required factors of safety. In general, dam rehabilitation alters the current design to provide a structure compliant with all design requirements.

3) ***Dam Removal:*** Includes complete removal of the spillway control structure and portions of the dam as necessary to fully drain the impoundment. The extent of removal for the purposes of this evaluation assumes that the difference in water surface elevation across the former dam location is less than 6-feet, which would classify the remaining structure as non-jurisdictional. It should be noted that ecological restoration permit process requires that the removal results in no increase to water surface elevation upstream of the dam location during a 500-year storm event; as such, extent of required removal may exceed that considered as part of this study.

4) ***No Action:*** Includes maintaining the current level of operations, maintenance, and inspection at the dam; no repairs or remedial measures are to be completed.

For each alternative considered (except removal), it is assumed that the Town would acquire land rights and/or an easement to access the embankment right of the spillway. An access road would be created through this area to provide access to the dam for maintenance and inspection purposes.

It should also be noted that a narrow saddle located roughly 200 feet west of the right abutment may represent a dike structure; the function and requirements to upgrade this section should be considered as part of any repair or rehabilitation design.

4.1.1 Dam Repair

The scope of a dam repair program may include:

1. Control of Water and Diversions: Dependent upon the scope of the work, flow could be diverted through the existing primary spillway; stoplogs would be removed to implement a temporary drawdown on the order of 3 feet to allow for safe completion of repair work. Pumped or siphon bypass may be required if work on the primary spillway walls or controls is included in the repair program.

   In conjunction with the diversion, control of water will also be required. It is anticipated that this would include the installation of a temporary cofferdam (Port-A-Dam or bulk sandbags).

2. Clearing and grubbing of trees and other unwanted vegetation along the length of the dam. Fill and compact resulting holes. Clearing would extend a minimum of 20 feet beyond the limits of the embankment downstream of the dam as well as into each abutment.

3. Structural repairs to the spillway and associated walls including:
   - Rebuilding/repairing the right training wall at the auxiliary spillway.
   - Restoring the auxiliary spillway weir integrity
   - Rebuilding/repairing the right training wall at the primary spillway.
   - Concrete maintenance repairs along the primary spillway left training wall.

4. Repair of displaced portions of the upstream wall. Given the observed condition, repair will likely require complete replacement.

5. Repair of displaced portions of the downstream wall. Given the observed condition, repair will likely require complete replacement.

The dam repair program is expected to extend the serviceable life of the structure and enable the implementation of a routine maintenance program. The program may not fully address all dam safety deficiencies at the dam. For example, this repair program would not address any concerns regarding the spillway design flood compliance, stability issues that may exist and have not been visually apparent during past inspections, or stability concerns beyond those identified during the 2017 Phase II.

The general character and limits of the dam repair program are shown on Figure 3.1: Dam Repair Concept.

4.1.2 Dam Rehabilitation

The scope of a dam rehabilitation program may include:

1. Control of Water and Diversions: Control of water would likely be similar to that required for the repair alternative.

2. Clearing and grubbing of trees and other unwanted vegetation along the length of the dam. Fill resulting holes. Clearing would extend a minimum of 20 feet beyond the limits of the rehabilitated dam structure.

3. Modify the dam to accommodate the spillway design flood (½PMF storm event) without overtopping of the dam or abutment areas or spillway walls. Based upon conceptual designs and given structural concerns at elements of the existing auxiliary spillway, replacement of the auxiliary spillway with a new gated spillway appeared most feasible. The spillway replacement would include:

   - Maintain the existing primary spillway; if desired, provide an upward operating slide gate or stoplog with improved operability.
   - Maintain the existing top of dam elevation.
   - Demolish the existing auxiliary spillway in its entirety. Construct a new auxiliary spillway of similar width that includes five 5-foot-wide bays equipped with operable controls. Controls may include upward operating gates, downward operating gates,

and/or stoplogs. Based upon conceptual design, the top of the gates/stoplogs could be set near the current auxiliary spillway crest; the invert of each bay would be near El. 175.1 (approximately 4.7 feet below the current auxiliary spillway crest.

- Provide a catwalk spanning the spillway to facilitate access for operations and inspection. If an access easement to the embankment right of the spillway cannot be established, the catwalk could be replaced with a bridge design to support maintenance equipment loads.

As part of conceptual design, additional design options were considered but eliminated from additional study. These included:

a) Overtopping Protection: This approach would result in a peak water surface elevation during the SDF near El. 183; at this elevation, approximately 500 linear feet of the right abutment would require additional repair (such as dikes or supplemental overtopping protection; as such, overtopping protection was not considered a feasible option.
b) Spillway Widening: The existing auxiliary spillway would need to be widened to more than 200 feet wide; as such, this option was not considered practical or cost efficient.
c) Raise Crest of Dam with Existing Spillways: The crest of the dam would need to be raised to near El. 185 and require more than 500 linear feet of dike; as such, this approach not was considered practical.

It should be noted that operation flooding in the downstream area is likely to occur in the event of severe rainfall requiring spillway gate operation due to the limited capacity of the culvert beneath the downstream development. As such, if rehabilitation is selected as the preferred approach, additional hydraulic modeling and dam break analysis is recommended to determine if 1) An inflow design flood in lieu of the prescriptive SDF is justified for this dam; and 2) Operational guidelines can be developed such that preemptive actions can be taken in the downstream area if operational flooding becomes necessary to protect the dam.

4. Address downstream wall stability issues. Two options to rehabilitate the wall were identified:

a) Replacement: Demolish and remove the existing downstream wall; excavate to suitable subgrade elevation and construct a new downstream wall. The new wall could be constructed reusing stone from the existing wall, using reinforced cast-in place concrete, or with precast concrete units.
b) Buttressing: Demolish and remove the existing downstream wall. Construct an earthen slope at 3H:1V (or other slope meeting maintenance requirements and slope stability factors of safety). Stone from the demolished wall could be repurposed to create a rock toe at the lower portion of the proposed slope; however, filter layers would be required to provide a transition from the embankment fill to the rock toe.

5. Address upstream wall stability issues. Two options to rehabilitate the wall were identified:

a) Replacement: Demolish and remove the existing upstream wall; excavate to suitable subgrade elevation and construct a new wall. The new wall could be constructed reusing stone from the existing wall, using reinforced cast-in place concrete, or with precast concrete units. Stone from the existing wall could also be used to provide erosion protection along the upstream toe of the new wall.

b) Buttressing: Demolish and remove the existing wall. Construct an earthen slope at 2.5H:1V (or other slope meeting maintenance requirements and slope stability factors of safety). Stone from the demolished wall could be repurposed to provide upstream slope protection; however, importing of bedding stone and geotextile fabric would likely be required to meet design requirements.

6. Establish a maintainable surface covering along the crest of the dam and embankment sections. Provide stone riprap or other surfaces in areas prone to scarping and erosion.

The dam rehabilitation program is expected to fully address all of the noted deficiencies at the dam and provide a structure that satisfies or exceeds regulatory requirements.

The general character and limits of the dam rehabilitation program are shown on Figure 4.2A & 4.2B: Dam Rehabilitation Concept Alt1 & Alt 2.

4.1.3 Dam Removal

As for all dams, breaching of the dam and river restoration is an alternative for addressing the dam safety concerns. Houghton Pond currently only supports passive recreational activities. No water supply, wells, or other resources supported by the impoundment, or the dam have been identified as part of the current evaluation. Removal of the dam would also have limited impact on peak flows during storm events to the downstream area due to the small size of the impoundment, limited flow attenuation offered by the outlet structures, and relatively large floodplain downstream of the dam. As such, breaching of the dam may be a feasible approach for this site.

No information pertaining to the quantity or quality of sediment is available for this site; as such, it is unknown if sediment mitigation measures would be required. Additional consideration of sediment upon the feasibility of dam removal would be required if removal is a preferred approach.

A dam removal program would likely consist of complete demolition and removal of the vertical extents of the dam in the vicinity of the spillways. Preliminary hydraulic evaluations suggest that a roughly trapezoidal breach with bottom width of roughly 25 feet would be required to pass dam removal design flows, which were conservatively considered as 600 cfs for the 500-year storm event; this size breach would also meet stream crossing standards of 1.2 times the bankfull width (given a bankfull width of roughly 20 feet predicted by USGS StreamStats).

Impoundment area restoration would likely include a natural revegetation program with supplemental planting and bank stabilization measures as deemed necessary during final design activities; should sediment characterization and quantification indicate concerns with in-stream management of sediment, additional measures to either remove and dispose of sediment, stabilize sediment in place, or otherwise remove sediment from the system will need to be implemented.

In addition to environmental considerations, public outreach would also play a critical role in a dam removal program.

The general character and limits of the dam rehabilitation program are shown on Figure 4.3: Dam Removal Concept.

4.1.4 No Action / Status Quo

Implement and continue maintenance activities at the dam. This option would not address the existing deficiencies at the dam or result in compliance with current state dam safety regulations. As such, this option was not considered further.

4.2 Opinions of Probable Cost

The following opinions of probable cost have been developed for the conceptual alternatives noted above based upon limited information as presented within Section 3.0. The costs shown herein are based on a limited investigation and are provided for general information only. This should not be considered an engineer's estimate, as actual construction costs may be somewhat less or considerably more than indicated. For more detailed information utilized for the development of the opinions of probable cost, refer to Appendix C.

Table 4-1: Conceptual Opinion of Probable Costs

	Alternative Rehabilitation			
Work Item	**Repair**	**Alt 1**	**Alt 2**	**Removal**
General Requirements	$ 27,720.00	$ 73,560.00	$ 73,560.00	$ 38,360.00
Mobilization / Demobilization	$ 20,000.00	$ 65,000.00	$ 65,000.00	$ 60,000.00
Clearing and Grubbing	$ 13,705.00	$ 6,905.00	$ 6,905.00	$ 4,405.00
E&S Controls	$ 7,400.00	$ 7,400.00	$ 7,400.00	$ 6,600.00
Control of Water	$ 58,360.00	$ 60,300.00	$ 60,300.00	$ 13,150.00
Embankment Work	$ 51,400.00	$ 113,400.00	$ 125,050.00	$ -
Auxiliary Spillway Work	$ 96,775.00	$ 241,225.00	$ 241,225.00	$ -
Spillway Work	$ 118,000.00	$ 140,687.50	$ 140,687.50	$ -
Dam Removal Work	$ -	$ -	$ -	$ 54,500.00
Sediment Management	$ -	$ -	$ -	Unknown
Subtotal w/ Bonds	$ 397,360.00	$ 716,477.50	$ 728,127.50	$ 179,015.00
Design Contingency	$ 137,900.00	$ 248,150.00	$ 252,350.00	$ 62,300.00
Engineering and Design	$ 55,000.00	$ 150,000.00	$ 150,000.00	$ 100,000.00
Permitting	$ 15,000.00	$ 40,000.00	$ 40,000.00	$ 75,000.00
Construction Administration	$ 60,000.00	$ 80,000.00	$ 95,000.00	$ 50,000.00
Conceptual Opinion of Probable Cost	**$ 666,000.00**	**$ 1,235,000.00**	**$ 1,266,000.00**	**$ 467,000.00**

When comparing costs, the total cost including design, engineering, permitting, construction, and long-term maintenance should be considered. The applicability of environmental permits needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of MADEP, local conservation commissions, or other regulatory agencies.

4.3 Life Cycle Analysis

An analysis was conducted to estimate the life cycle cost of 15 years for the repair alternative and 30 years for other alternatives in order to develop a better understanding of the true costs of each alternative. The National Institute of Standards and Technology (NIST) Life Cycle Cost Manual Handbook 135 with the 2019 Supplement was used to determine the life cycle costs for the proposed alternatives (NIST, 1995). At this level of study, a simple method was utilized that accounts for initial investment, capital replacement, energy, and operation, maintenance, and repair.

Operations and Maintenance (O&M) costs for the dam structure consists of gate operation (if provided/installed), mowing and other vegetation maintenance, debris removal, and other miscellaneous items. O&M includes routine activities but does not account for intermittent repairs or other minor repairs to address identified deficiencies.

The estimated yearly O&M cost estimate is $4,000 for Alternatives 1, 2, and 4. Estimated O&M costs for Alternative 3 are $500 to account for post-dam removal maintenance (mowing, cleanup, etc.) of any publicly accessible areas created or restored as part of the dam removal program.

The present cost for each alternative was determined based on the life cycle cost period (15 years for repairs, 30 years for other alternatives), considering initial capital costs, assumed design life, and yearly O&M costs. Capital replacement costs were determined based on the assumed remaining design life at the end of the life cycle cost analysis period. Note that the costs in Removal option do not include environmental restoration components, allowing for a focused analysis on the infrastructure costs. Additional life cycle costs may be realized should sediment management or invasive species management be required as part of dam removal activities.

Table 4-2: Life Cycle Cost Analysis

	Alternative			
	Repair	Alt 1	Alt 2	Removal
Initial Capital Investment				
Discount Factor	1	1	1	1
Initial Capital Cost	$666,000	$1,235,000	$1,266,000	$467,000
Capital Replacement Cost				
Assumed Design Life (yrs)	15	30	30	N/A
Assumed CIP Cost Percentage	100%	40%	40%	0%
Discount Factor	0.642	0.412	0.412	0.412
Operations & Maintenance				
O&M Costs	$6,000	$4,000	$4,500	$250
Discount Factor	11.938	19.6	19.6	19.6
Total Present Cost	**$ 1,165,200**	**$ 1,516,928**	**$ 1,562,837**	**$ 471,900**

4.4 Potential Permitting Requirements

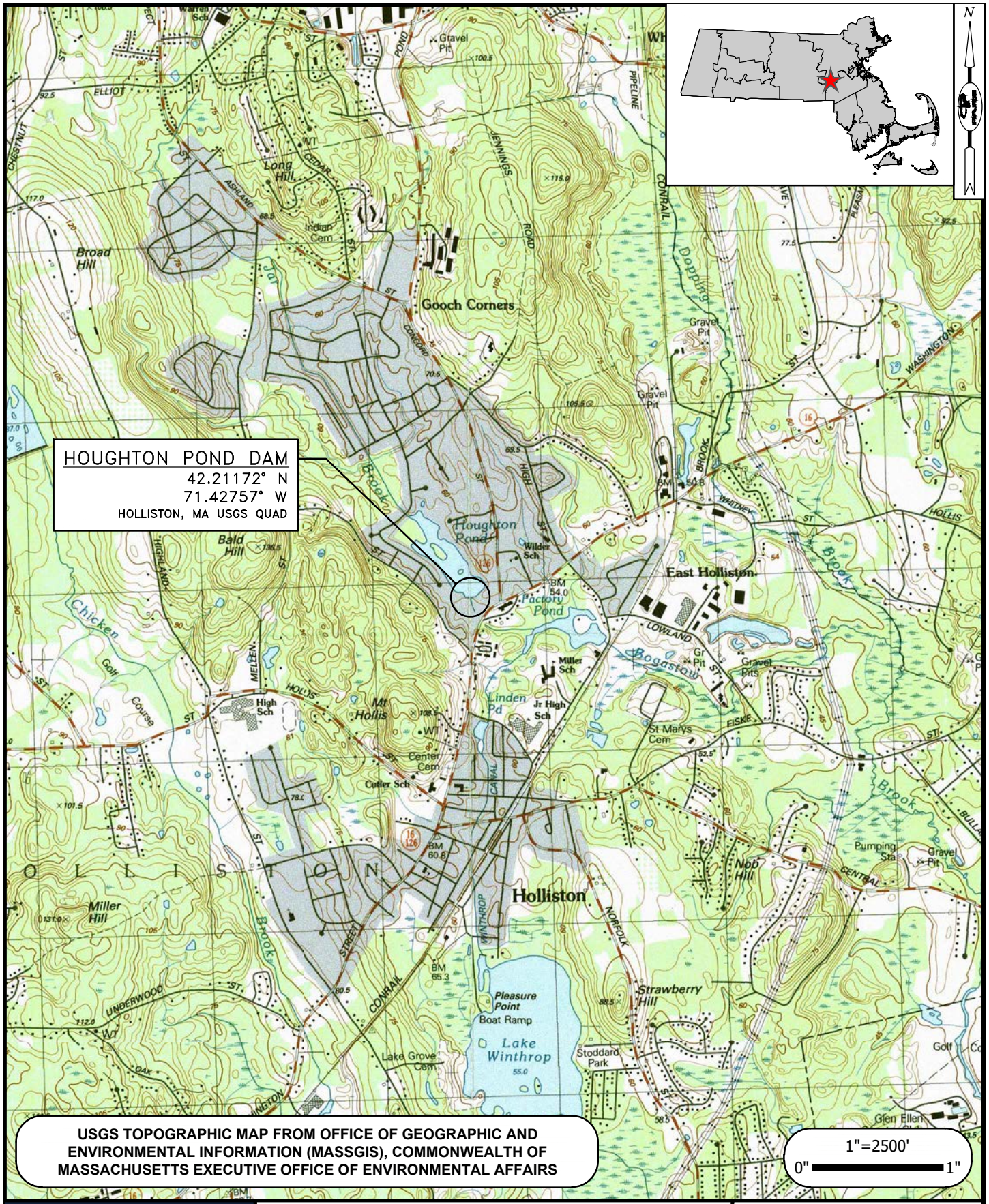
The following table presents the potential permitting requirements for each of the alternatives considered. Depending upon the final scope of work, the required permitting may vary from that set forth below.

Table 4-3: Potential Permitting Requirements

	Alternative		
	#1 Dam Repair	#2 Dam Rehabilitation (Alt 1 or Alt 2)	#3 Dam Removal
NOI	Yes	Yes	Yes
MEPA	Potentially	ENF/EENF	EIR
ACOE GP	SV	PCN	IP
DCR Dam Safety	Part A & B	Part A & B	Part A & B
WQC	No	YES	Yes

FIGURES

Houghton Pond Dam
Holliston, Massachusetts



PARE CORPORATION

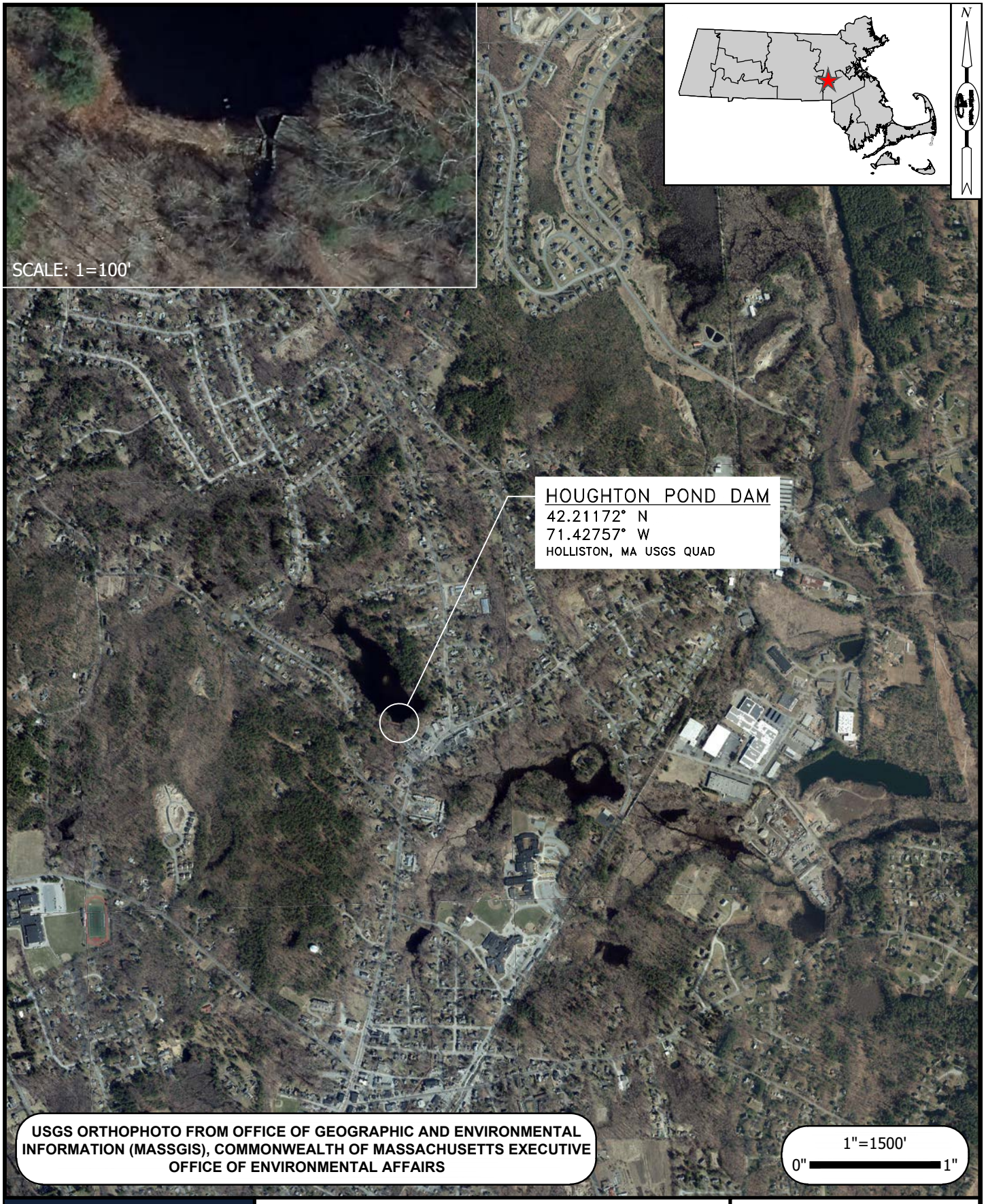
HOUGHTON POND DAM

MA00444

HOLLISTON, MASSACHUSETTS

LOCUS PLAN

MARCH 2022 FIGURE 1



PARE CORPORATION

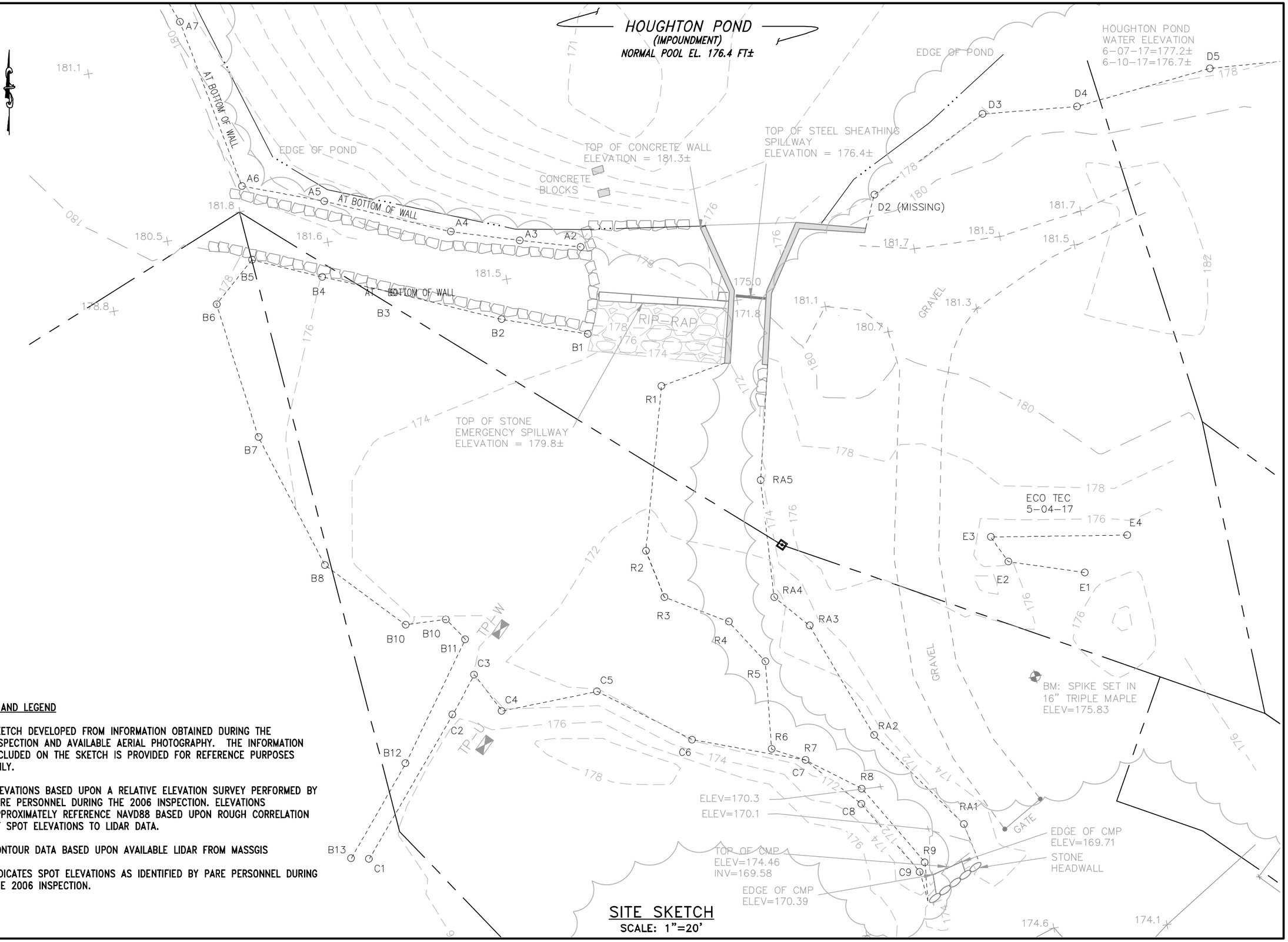
HOUGHTON POND DAM

MA00444

HOLLISTON, MASSACHUSETTS

AERIAL PLAN

MARCH 2022 FIGURE 2



SITE SKETCH
SCALE: 1"=20'

NOTES AND LEGEND

1. SKETCH DEVELOPED FROM INFORMATION OBTAINED DURING THE INSPECTION AND AVAILABLE AERIAL PHOTOGRAPHY. THE INFORMATION INCLUDED ON THE SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATIONS BASED UPON A RELATIVE ELEVATION SURVEY PERFORMED BY PARE PERSONNEL DURING THE 2006 INSPECTION. ELEVATIONS APPROXIMATELY REFERENCE NAVD88 BASED UPON ROUGH CORRELATION OF SPOT ELEVATIONS TO LIDAR DATA.
3. CONTOUR DATA BASED UPON AVAILABLE LIDAR FROM MASSGIS

100.00^X INDICATES SPOT ELEVATIONS AS IDENTIFIED BY PARE PERSONNEL DURING THE 2006 INSPECTION.

PARE
PARE CORPORATION
ENGINEERS - SCIENTISTS - PLANNERS
10 LINCOLN ROAD, SUITE 210
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508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

HOUGHTON POND DAM
MA00444
HOLLISTON, MASSACHUSETTS
TOWN OF HOLLISTON

REVISIONS:

PROJECT NO.:	21214.00/201
DATE:	MARCH 2022
SCALE:	AS NOTED
DESIGNED BY:	MLP
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

SITE SKETCH

FIGURE NO.: 3

Y:\JOBS\21_Jobs\21214.00_Holliston-HollistonDamsAlternatives-MA\Task_201_-_Houghton_Pond_Dam_Alternatives\dwgs\FIG_3_SITE_SKETCH.dwg

HOUGHTON POND
(IMPOUNDMENT)
NORMAL POOL EL. 176.4 FT±

REPAIR/REPLACE THE UPSTREAM AND DOWNSTREAM MASONRY WALL

REBUILD/REPAIR RIGHT TRAINING WALL

REPAIR TRAINING WALLS (SEAL AND PATCH CONCRETE)

COFFERDAM

REBUILD/REPAIR RIGHT TRAINING WALL

REBUILD/REPAIR THE AUXILIARY SPILWAY WEIR

CLEAR AND GRUB TO 20 FEET BEYOND THE DAM LIMITS

TOP OF STEEL SHEATHING SPILLWAY ELEVATION = 176.4±

TOP OF STONE EMERGENCY SPILLWAY ELEVATION = 179.8±

HOUGHTON POND WATER ELEVATION
6-07-17=177.2±
6-10-17=176.7±

ECO TEC
5-04-17

BM: SPIKE SET IN 16" TRIPLE MAPLE ELEV=175.83

ELEV=170.3
ELEV=170.1

TOP OF CMP ELEV=174.46 INV=169.58

EDGE OF CMP ELEV=170.39

EDGE OF CMP ELEV=169.71

STONE HEADWALL

D2 (MISSING)

AT BOTTOM OF WALL

CONCRETE BLOCKS

RIP-RAP

GRAVEL

GATE

EDGE OF POND

DAM REPAIR
SCALE: 1"=20'

PARE
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SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

HOUGHTON POND DAM
MA00444
HOLLISTON, MASSACHUSETTS
TOWN OF HOLLISTON

REVISIONS:

PROJECT NO.:	21214.00/201
DATE:	MARCH 2022
SCALE:	AS NOTED
DESIGNED BY:	MLP
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

DAM REPAIR

FIGURE NO.: 4.1

Y:\JOBS\21 Jobs\21214.00 Holliston-HollistonDamsAlternatives-MA\Task 201 - Houghton Pond Dam Alternatives\dwgs\FIG 4.1 DAM REPAIR.dwg

HOUGHTON POND
(IMPOUNDMENT)
NORMAL POOL EL. 176.4 FT±

REGRADE THE EMBANKMENT

CONSTRUCT CAST IN PLACE / MASONRY UPSTREAM WALL

REMOVE & DISPOSE EXISTING UPSTREAM WALL

COFFERDAM

REPAIR TRAINING WALLS (SEAL AND PATCH CONCRETE)

DEMOLISH THE RIGHT TRAINING WALL

CONSTRUCT NEW TRAINING WALL

REMOVE STEEL SHEETING; INSTALL STOP LOGS CONTROL INVERT EL. 175.1

INSTALL CATWALK

REMOVE & DISPOSE EXISTING DOWNSTREAM WALL

CONSTRUCT CAST IN PLACE / MASONRY DOWNSTREAM WALL

CLEAR AND GRUB TO 20 FEET BEYOND THE DAM LIMITS

DEMOLISH THE EXISTING AUXILIARY SPILLWAY

CONSTRUCT NEW AUXILIARY SPILLWAY WITH SLIDE GATES/STOP LOGS CONTROL INVERT EL. 175.1

TAIL COFFERDAM (IF REQUIRED)

TOP OF CONCRETE WALL ELEVATION = 181.3±

TOP OF STEEL SPILLWAY ELEVATION = 176.4±

TOP OF STONE EMERGENCY SPILLWAY ELEVATION = 179.8±

HOUGHTON POND WATER ELEVATION
6-07-17=177.2±
6-10-17=176.7±

ECO TEC 5-04-17

BM: SPIKE SET IN 16" TRIPLE MAPLE ELEV=175.83

ELEV=170.3
ELEV=170.1

TOR OF CMP ELEV=174.46 INV=169.58

EDGE OF CMP ELEV=170.39

EDGE OF CMP ELEV=169.71

STONE HEADWALL

GATE

GRAVEL

CONCRETE BLOCKS

EDGE OF POND

BOTTOM OF WALL

D2 (MISSING)

ALTERNATE 1

CONSTRUCT CAST IN PLACE / MASONRY UPSTREAM WALL

REMOVE & DISPOSE EXISTING UPSTREAM WALL

ALTERNATE 1
CONSTRUCT CAST IN PLACE / MASONRY DOWNSTREAM WALL

REMOVE & DISPOSE EXISTING DOWNSTREAM WALL

SECTION
SCALE: 1"=8'

DAM REHABILITATION OPTION 1
SCALE: 1"=20'

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10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

HOUGHTON POND DAM
MA00444
HOLLISTON, MASSACHUSETTS
TOWN OF HOLLISTON

REVISIONS:

PROJECT NO.:	21214.00/201
DATE:	MARCH 2022
SCALE:	AS NOTED
DESIGNED BY:	MLP
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

DAM REHABILITATION
OPTION 1

FIGURE NO.:
4.2A

Y:\JOBS\21 Jobs\21214.00 Holliston-HollistonDamsAlternatives-MA\Task 201 - Houghton Pond Dam Alternatives\dwgs\FIG 4.2A DAM REHAB.dwg

HOUGHTON POND
(IMPOUNDMENT)
NORMAL POOL EL. 176.4 FT±

CONSTRUCT UPSTREAM SLOPE 2.5H:1V

REMOVE & DISPOSE EXISTING UPSTREAM WALL

REGRADE THE EMBANKMENT

REMOVE & DISPOSE EXISTING DOWNSTREAM WALL

CONSTRUCT DOWNSTREAM SLOPE 3H:1V

CLEAR AND GRUB TO 20 FEET BEYOND THE DAM LIMITS

COFFERDAM

REPAIR TRAINING WALLS (SEAL AND PATCH CONCRETE)

DEMOLISH THE RIGHT TRAINING WALL; CONSTRUCT NEW TRAINING WALL

INSTALL CATWALK

REMOVE STEEL SHEETING; INSTALL STOP LOGS CONTROL INVERT EL. 175.1

DEMOLISH THE EXISTING AUXILIARY SPILLWAY

CONSTRUCT NEW AUXILIARY SPILLWAY WITH SLIDE GATES/STOP LOGS CONTROL INVERT EL. 175.1

TAIL COFFERDAM (IF REQUIRED)

HOUGHTON POND WATER ELEVATION
6-07-17=177.2±
6-10-17=176.7±

TOP OF CONCRETE WALL ELEVATION = 181.3±

TOP OF STEEL SHEET SPILLWAY ELEVATION = 176.4±

TOP OF STONE EMERGENCY SPILLWAY ELEVATION = 179.8±

EDGE OF POND

AT BOTTOM OF WALL

RIP RAP

GRAVEL

ECO TEC
5-04-17

BM: SPIKE SET IN 16" TRIPLE MAPLE
ELEV=175.83

ELEV=170.3
ELEV=170.1

TOP OF CMP
ELEV=174.46
INV=169.58

EDGE OF CMP
ELEV=170.39

EDGE OF CMP
ELEV=169.71

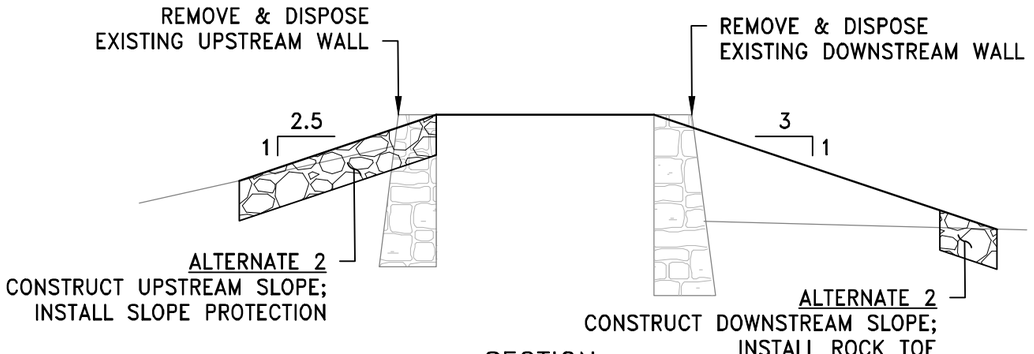
STONE HEADWALL

GATE

TP-1 W

A7 A6 A5 A4 A3 A2 A1
B6 B5 B4 B3 B2 B1 B8 B10 B10 B11 C3
R1 R3 R4 R5 R6 R7 R8 R9
RA5 RA4 RA3 RA2 RA1
C6 C7 C8 C9
D2 (MISSING) D4 D5
E1 E2 E3 E4

SECTION
SCALE: 1"=8'



DAM REHABILITATION OPTION 2
SCALE: 1"=20'

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10 LINCOLN ROAD, SUITE 210
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508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

HOUGHTON POND DAM
MA00444
HOLLISTON, MASSACHUSETTS
TOWN OF HOLLISTON

REVISIONS:

PROJECT NO.:	21214.00/201
DATE:	MARCH 2022
SCALE:	AS NOTED
DESIGNED BY:	MLP
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

DAM REHABILITATION
OPTION 2

FIGURE NO.:
4.2B

Y:\JOBS\21 Jobs\21214.00 Holliston-HollistonDamsAlternatives-MA\Task 201 - Houghton Pond Dam Alternatives\dwgs\FIG 4.2B DAM REHAB.dwg

HOUGHTON POND
(IMPOUNDMENT)
NORMAL POOL EL. 176.4 FT±

COMPLETE SEDIMENT MANAGEMENT ACTIVITIES AS/IF REQUIRED

CONSTRUCT CHANNEL

EXCAVATE EMBANKMENT TO RESTORE STREAM CHANNEL

REMOVE & DISPOSE SPILLWAY, AUXILIARY SPILLWAY, UPSTREAM AND DOWNSTREAM WALLS COMPLETELY

EDGE OF POND

TOP OF CONCRETE WALL ELEVATION = 181.3±

CONCRETE BLOCKS

TOP OF STEEL SHEATHING SPILLWAY ELEVATION = 176.4±

AT BOTTOM OF WALL

RIP-RAP

TOP OF STONE EMERGENCY SPILLWAY ELEVATION = 179.8±

GRAVEL

ECO TEC
5-04-17

BM: SPIKE SET IN 16" TRIPLE MAPLE
ELEV=175.83

ELEV=170.3
ELEV=170.1

TOP OF CMP
ELEV=174.46
INV=169.58

EDGE OF CMP
ELEV=170.39

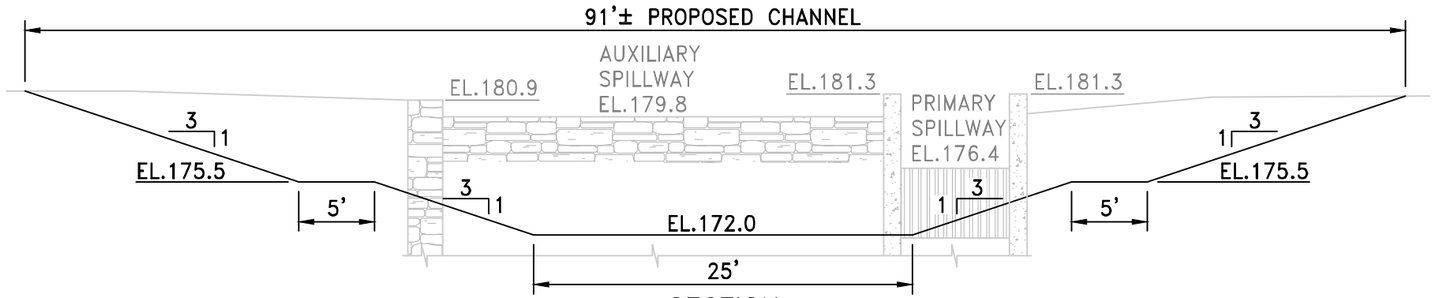
EDGE OF CMP
ELEV=169.71

STONE HEADWALL

GATE

TPLW

DAM REMOVAL
SCALE: 1"=20'



SECTION
SCALE: 1"=10'

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508-543-1755

SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

HOUGHTON POND DAM
MA00444
HOLLISTON, MASSACHUSETTS
TOWN OF HOLLISTON

REVISIONS:

PROJECT NO.:	21214.00/201
DATE:	MARCH 2022
SCALE:	AS NOTED
DESIGNED BY:	MLP
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

DAM REMOVAL

FIGURE NO.:
4.3

Y:\JOBS\21 Jobs\21214.00 Holliston-HollistonDamsAlternatives-MA\Task 201 - Houghton Pond Dam Alternatives\dwgs\FIG 4.3 DAM REMOVAL.dwg

APPENDIX A
Visual Dam Inspection Limitations
Houghton Pond Dam
Holliston, Massachusetts

VISUAL DAM INSPECTION LIMITATIONS

Visual Inspection

1. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

2. In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team.

3. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

4. It is critical to note that the condition of the dam is evolutionary in nature and depends on numerous and constantly changing internal and external conditions. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Use of Report

1. The applicability of other environmental permits (ie., NOI, PGP, Water Quality Certificate, etc.) needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of MADEP, the local conservation commission or other regulatory agency.

2. This report has been prepared for the exclusive use of the Town of Holliston for specific application to the reference Houghton Pond Dam in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

3. This report has been prepared for this project by Pare. This report is for preliminary evaluation purposes only and is not necessarily sufficient to support design or repairs or recommendations or to prepare an accurate bid.

APPENDIX B
Opinion of Probable Costs
Houghton Pond Dam
Holliston, Massachusetts

PARE CORPORATION

Project:	Houghton Pond Dam	**Project No.:**	21214/201
Subject:	Opinions of Probable Costs		
Computation By:	MLP	**Date:**	April 2022
Check By:	ARO	**Date:**	April 2022

CONCEPTUAL DESIGN OPINION OF PROBABLE COST

Alternate 1: Dam Repair

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Construction Trailer and Utilities	2	MON	$ 2,700.00	$ 5,400.00	Engineering Judgement	
Project Superintendent	2	MON	$ 8,200.00	$ 16,400.00	Engineering Judgement	
QC Plans	10	HR	$ 75.00	$ 750.00	Engineering Judgement	
Submittals	10	HR	$ 75.00	$ 750.00	Engineering Judgement	
Schedules	10	HR	$ 75.00	$ 750.00	Engineering Judgement	
Meetings	8	EA	$ 150.00	$ 1,200.00	Engineering Judgement	
Project Sign	1	LS	$ 1,000.00	$ 1,000.00	Engineering Judgement	
Proctor Tests	1	TEST	$ 225.00	$ 200.00	Laboratory Quote plus markup	
Sieve Analyses	2	EA	$ 110.00	$ 220.00	Laboratory Quote plus markup	
Concrete Sampling/Testing	2	EA	$ 500.00	$ 1,000.00	Recent project bids	
Concrete Compression Tests	1	EA	$ 50.00	$ 50.00	Laboratory Quote plus markup	
Field Density Testing	0	DAY	$ 500.00	$ -	Recent project bids	
Chemical Soil Tests	0	EA	$ 1,000.00	$ -	Recent project bids	
Subtotal				**$ 27,720.00**		
Mobilization & Demobilization						
Mobilization	1	LS	$ 15,000.00	$ 15,000.00	Engineering Judgment	Assume 5% M&D total
Demobilization	1	LS	$ 5,000.00	$ 5,000.00	Engineering Judgment	
Subtotal				**$ 20,000.00**		
Clear and Grub						
Clear and Grub	0.5	ACRE	$ 5,000.00	$ 2,500.00	RSMEANS 31 11 10.10 0200	
Clear Trees up to 24"	3	EA	$ 500.00	$ 1,500.00	RSMEANS 31 13 13 20 3150	
Engineered Fill Imported	9	TN	$ 25.00	$ 225.00	Recent Project Costs	
Engineered Fill Placed	4.5	CY	$ 40.00	$ 180.00	Recent Project Costs	
Loam Embankment	400	SY	$ 7.00	$ 2,800.00	RSMEANS 32 91 19 13 0800	
Import Loam	70	CY	$ 70.00	$ 4,900.00	10 Means 33 46 16.35 0041	
Slope Seed	400	SY	$ 4.00	$ 1,600.00	Engineering's Judgement	
Subtotal				**$ 13,705.00**		
Erosion Control						
Straw bales	150	LF	$ 9.00	$ 1,350.00	RSMEANS 31 25 14 16 0600	
Silt Fence	150	LF	$ 10.00	$ 1,500.00	MassDOT Price bid	
Maintenance and Removal	1	LS	$ 3,000.00	$ 3,000.00	Engineer's Judgment	
Turbidity Barrier	50	LF	$ 30.00	$ 1,500.00	Recent project bids	
Subtotal				**$ 7,400.00**		
Control of Water / Water Diversion						
Implement Drawdown	1	LS	$ 15,000.00	$ 15,000.00	Engineer's Judgment	
Small Sand Bag	60	EA	$ 6.00	$ 360.00	Engineer's Judgment	0.5'x2'x1'
Large Sand Bag	40	EA	$ 200.00	$ 8,000.00	Engineer's Judgment	3'x3'x3'
Install and Remove Sand Bag	6	DAY	$ 5,000.00	$ 30,000.00	Engineer's Judgment	
Install and Remove Siphon for drawdown	1	LS	$ 5,000.00	$ 5,000.00	Engineer's Judgment	
Subtotal				**$ 58,360.00**		
Embankment Work						
Remove existing stonewalls	1	LS	$ 10,000.00	$ 10,000.00	Engineering's Judgement	
Upstream Wall Replacement	23	CY	$ 900.00	$ 20,700.00	MassDOT weight bid for Masonry Mortar	$700 for dry wall
Downstream Wall Replacement	23	CY	$ 900.00	$ 20,700.00	Engineering's Judgement	
Subtotal				**$ 51,400.00**		
Auxiliary Spillway						
Training Wall & Weir Demolition	1	LS	$ 20,000.00	$ 20,000.00	Engineering's Judgement	
Proposed Training Wall	14	CY	$ 900.00	$ 12,600.00	MassDOT weight bid for Masonry Mortar	
Proposed Weir	20	CY	$ 900.00	$ 18,000.00	MassDOT weight bid for Masonry Mortar	
Proposed Foundation Slab/Footing	30	CY	$ 1,250.00	$ 37,500.00	Engineering's Judgement	
Excavation & Prep	130	CY	$ 25.00	$ 3,250.00	Engineering's Judgement	
Backfill	70	CY	$ 40.00	$ 2,800.00	Engineering's Judgement	
Import EF	105	TN	$ 25.00	$ 2,625.00	Engineering's Judgement	
Subtotal				**$ 96,775.00**		
Spillway work						
Right Training Wall Demolition	1	LS	$ 10,000.00	$ 10,000.00	Engineering's Judgement	
Excavation &Prep	80	CY	$ 25.00	$ 2,000.00	Engineering's Judgement	
New Right Training Wall	35	CY	$ 1,500.00	$ 52,500.00	Engineering's Judgement	
Spillway backfill	45	CY	$ 40.00	$ 1,800.00	Engineering's Judgement	
Import EF	68	TN	$ 25.00	$ 1,700.00	Engineering's Judgement	
Seal and Patch Concrete	1	LS	$ 50,000.00	$ 50,000.00	Engineering's Judgement	
Subtotal				**$ 118,000.00**		

SUBTOTAL	$	393,360.00
Contract Bonds	$	4,000.00
Design Contingency	**$**	**137,900.00** 35%
OPINION OF PROBABLE CONSTRUCTION COST	**$**	**536,000.00**
Engineering & Design	$	55,000.00
Permitting	$	15,000.00
Construction Phase Services	$	60,000.00
OPINION OF PROBABLE CONSTRUCTION COST	**$**	**666,000.00**

PARE CORPORATION

Project:	Factory Pond Dam	**Project No.:**	21214.00
Subject:	Opinions of Probable Costs		
Computation By:	MLP	**Date:**	April 2022
Check By:	ARO	**Date:**	April 2022

CONCEPTUAL DESIGN OPINION OF PROBABLE COST

Alternate 2: Dam Rehabilitation Alt 1

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Same As Alt 2	1	LS	$ 73,560.00	$ 73,560.00	See Alt 2	
Subtotal				**$ 73,560.00**		
Mobilization & Demobilization						
Same As Alt 2	1	LS	$ 65,000.00	$ 65,000.00	See Alt 2	
Subtotal				**$ 65,000.00**		
Clear and Grub						
Same As Alt 2	1	LS	$ 6,905.00	$ 6,905.00	See Alt 2	
Subtotal				**$ 6,905.00**		
Erosion Control						
Same As Alt 2	1	LS	$ 7,400.00	$ 7,400.00	See Alt 2	
Subtotal				**$ 7,400.00**		
Control of Water / Water Diversion						
Same As Alt 2	1	LS	$ 60,300.00	$ 60,300.00	See Alt 2	
Subtotal				**$ 60,300.00**		
Embankment Work Alt 1						
Remove existing stonewalls	1	LS	$ 30,000.00	$ 30,000.00	Engineering's Judgement	
Upstream Wall Replacement	40	CY	$ 900.00	$ 36,000.00	MassDOT weight bid for Masonry Mortar	
Downstream Wall Replacement	40	CY	$ 900.00	$ 36,000.00	MassDOT weight bid for Masonry Mortar	
Excavation	120	CY	$ 25.00	$ 3,000.00	RSMEANS 31 37 13 10 0200	Assume 2 feet for each wall
Backfill	60	CY	$ 40.00	$ 2,400.00	Engineering's Judgement	
Import EF	90	TN	$ 25.00	$ 2,250.00	Engineering's Judgement	
Loam embankment	150	SY	$ 7.00	$ 1,050.00	RSMEANS 32 91 19 13 0800	
Import Loam	30	CY	$ 70.00	$ 2,100.00	10 Means 33 46 16.35 0041	
Seed	150	SY	$ 4.00	$ 600.00	Engineering's Judgement	
Subtotal				**$ 113,400.00**		
Auxiliary Spillway						
Same As Alt 2	1	LS	$ 241,225.00	$ 241,225.00	See Alt 2	
Subtotal				**$ 241,225.00**		
Spillway work						
Same As Alt 2	1	LS	$ 140,687.50	$ 140,687.50	See Alt 2	
Subtotal				**$ 140,687.50**		
			SUBTOTAL	$ 708,477.50		
			Contract Bonds	$ 8,000.00		
			Design Contingency	**$ 248,150.00**	35%	
			OPINION OF PROBABLE CONSTRUCTION COST	**$ 965,000.00**		**Alt 1**
			Engineering & Design	$ 150,000.00		
			Permitting	$ 40,000.00		
			Construction Phase Services	$ 80,000.00		
			OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,235,000.00**		

PARE CORPORATION

Project:	Factory Pond Dam	**Project No.:**	21214.00
Subject:	Opinions of Probable Costs		
Computation By:	MLP	**Date:**	April 2022
Check By:	ARO	**Date:**	April 2022

CONCEPTUAL DESIGN OPINION OF PROBABLE COST

Alternate 2: Dam Rehabilitation Alt 2

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Construction Trailer and Utilities	5	MON	$ 2,700.00	$ 13,500.00	Engineering Judgement	
Project Superintendent	5	MON	$ 8,200.00	$ 41,000.00	Engineering Judgement	
QC Plans	20	HR	$ 75.00	$ 1,500.00	Engineering Judgement	
Submittals	20	HR	$ 75.00	$ 1,500.00	Engineering Judgement	
Schedules	20	HR	$ 75.00	$ 1,500.00	Engineering Judgement	
Meetings	20	EA	$ 150.00	$ 3,000.00	Engineering Judgement	
Project Sign	1	LS	$ 1,000.00	$ 1,000.00	Engineering Judgement	
Proctor Tests	2	TEST	$ 200.00	$ 400.00	Laboratory Quote plus markup	
Sieve Analyses	6	EA	$ 110.00	$ 660.00	Laboratory Quote plus markup	
Concrete Sampling/Testing	5	EA	$ 500.00	$ 2,500.00	Recent project bids	
Concrete Compression Tests	20	EA	$ 50.00	$ 1,000.00	Laboratory Quote plus markup	
Field Density Testing	10	DAY	$ 500.00	$ 5,000.00	Recent project bids	
Chemical Soil Tests	1	EA	$ 1,000.00	$ 1,000.00	Recent project bids	
Subtotal				**$ 73,560.00**		
Mobilization & Demobilization						
Mobilization	1	LS	$ 45,000.00	$ 45,000.00	Engineering Judgment	
Demobilization	1	LS	$ 20,000.00	$ 20,000.00	Engineering Judgment	
Subtotal				**$ 65,000.00**		
Clear and Grub						
Clear and Grub	1	ACRE	$ 5,000.00	$ 5,000.00	RSMEANS 31 11 10.10 0200	
Clear Trees up to 24"	3	EA	$ 500.00	$ 1,500.00	RSMEANS 31 13 13 20 3150	
Engineered Fill Imported	9	TN	$ 25.00	$ 225.00	Recent Project Costs	
Engineered Fill Placed	4.5	CY	$ 40.00	$ 180.00	Recent Project Costs	
Subtotal				**$ 6,905.00**		
Erosion Control						
Straw bales	150	LF	$ 9.00	$ 1,350.00	RSMEANS 31 25 14 16 0600	
Silt Fence	150	LF	$ 10.00	$ 1,500.00	RSMEANS 31 25 14 16 1000 + markup	
Maintenance and Removal	1	LS	$ 3,000.00	$ 3,000.00	Engineer's Judgment	
Turbidity Barrier	50	LF	$ 30.00	$ 1,500.00	Recent project bids	
Subtotal				**$ 7,400.00**		
Control of Water / Water Diversion						
Implement Drawdown	1	LS	$ 10,000.00	$ 10,000.00	Engineer's Judgment	
Small Sand Bag	50	EA	$ 6.00	$ 300.00	Engineer's Judgment	0.5'x2'x1'
Large Sand Bag	50	EA	$ 200.00	$ 10,000.00	Engineer's Judgment	3'x3'x3'
Install and Remove Sand Bag	6	DAYS	$ 5,000.00	$ 30,000.00	Engineer's Judgment	
Install and Remove Siphon/Bypass for drawdown	1	LS	$ 10,000.00	$ 10,000.00	Engineer's Judgment	
Subtotal				**$ 60,300.00**		
Embankment Work Alt 2						
Remove existing stonewalls	1	LS	$ 30,000.00	$ 30,000.00	Engineering's Judgement	
Regrade Upstream and Downstream Slope	850	CY	$ 40.00	$ 34,000.00	Engineering's Judgement	
Import EF	1275	TN	$ 25.00	$ 31,875.00	Engineering's Judgement	
Upstream Slope & Rock toe Riprap	165	SY	$ 85.00	$ 14,025.00	RSMEANS 31 37 13 10 0200	
Import Riprap	184	TN	$ 40.00	$ 7,360.00	RSMEANS 31 37 13 10 0350	
Geotextile Fabric	165	SY	$ 6.00	$ 990.00	RSMEANS 3132 19 16 1550 plus markup	
Loam DS Slope & Right Embankment	300	SY	$ 7.00	$ 2,100.00	RSMEANS 32 91 19 13 0800	
Import Loam	50	CY	$ 70.00	$ 3,500.00	MassDOT Price Bid	
Seed	300	SY	$ 4.00	$ 1,200.00	MassDOt Price Bid	
Subtotal				**$ 125,050.00**		
Auxiliary Spillway						
Spillway Demolition	1	LS	$ 50,000.00	$ 50,000.00	Engineering's Judgement	
Slide Gate	5	LS	$ 12,000.00	$ 60,000.00	Engineering's Judgement	
Proposed Training Wall	30	CY	$ 1,500.00	$ 45,000.00	Engineering's Judgement	
Proposed Weir	20	CY	$ 1,500.00	$ 30,000.00	Engineering's Judgement	
Proposed Foundation Slab/Footing	40	CY	$ 1,250.00	$ 50,000.00	Engineering's Judgement	
Excavation & Prep	125	CY	$ 25.00	$ 3,125.00	Engineering's Judgement	
Backfill	40	CY	$ 40.00	$ 1,600.00	Engineering's Judgement	
Import EF	60	TN	$ 25.00	$ 1,500.00	Engineering's Judgement	
Subtotal				**$ 241,225.00**		
Spillway work						
Right Training Wall Demolition	1	LS	$ 10,000.00	$ 10,000.00	Engineering's Judgement	
Excavation &Prep	50	CY	$ 25.00	$ 1,250.00	Engineering's Judgement	
New Right Training Wall	25	CY	$ 1,500.00	$ 37,500.00	Engineering's Judgement	
Spillway backfill	25	CY	$ 40.00	$ 1,000.00	Engineering's Judgement	
Import EF	37.5	TN	$ 25.00	$ 937.50	Engineering's Judgement	
Seal and Patch Concrete	1	LS	$ 50,000.00	$ 50,000.00	Engineering's Judgement	
Stop log	1	LS	$ 15,000.00	$ 15,000.00	Engineering's Judgement	
Install Catwalk	1	LS	$ 25,000.00	$ 25,000.00	Engineering's Judgement	
Subtotal				**$ 140,687.50**		
			SUBTOTAL	$ 720,127.50		
			Contract Bonds	$ 8,000.00		
			Design Contingency	**$ 252,350.00**	35%	
			OPINION OF PROBABLE CONSTRUCTION COST	**$ 981,000.00**		
			Engineering & Design	$ 150,000.00		**Alt 2**
			Permitting	$ 40,000.00		
			Construction Phase Services	$ 95,000.00		
			OPINION OF PROBABLE CONSTRUCTION COST	**$ 1,266,000.00**		

Project:	Factory Pond Dam	**Project No.:**	21214.00
Subject:	Opinions of Probable Costs		
Computation By:	MLP	**Date:**	April 2022
Check By:	ARO	**Date:**	April 2022

CONCEPTUAL DESIGN OPINION OF PROBABLE COST

Alternate 3: Dam Removal

Item	Quantity	Unit	Unit Price	Total	Source	Notes
General Bid Items						
Construction Trailer and Utilities	3	MON	$ 2,700.00	$ 8,100.00	Engineering Judgement	
Project Superintendent	3	MON	$ 8,200.00	$ 24,600.00	Engineering Judgement	
QC Plans	12	HR	$ 75.00	$ 900.00	Engineering Judgement	
Submittals	10	HR	$ 75.00	$ 750.00	Engineering Judgement	
Schedules	12	HR	$ 75.00	$ 900.00	Engineering Judgement	
Meetings	12	EA	$ 150.00	$ 1,800.00	Engineering Judgement	
Project Sign	1	LS	$ 1,000.00	$ 1,000.00	Engineering Judgement	
Proctor Tests	1	TEST	$ 225.00	$ 200.00	Laboratory Quote plus markup	
Sieve Analyses	1	EA	$ 110.00	$ 110.00	Laboratory Quote plus markup	
Concrete Sampling/Testing	0	EA	$ 500.00	$ -	Recent project bids	
Concrete Compression Tests	0	EA	$ 50.00	$ -	Laboratory Quote plus markup	
Field Density Testing	0	DAY	$ 500.00	$ -	Recent project bids	
Chemical Soil Tests	0	EA	$ 1,000.00	$ -	Recent project bids	
Subtotal				**$ 38,360.00**		
Mobilization & Demobilization						
Mobilization	1	LS	$ 40,000.00	$ 40,000.00	Engineering Judgment	
Demobilization	1	LS	$ 20,000.00	$ 20,000.00	Engineering Judgment	
Subtotal				**$ 60,000.00**		
Clear and Grub						
Clear and Grub	0.5	ACRE	$ 5,000.00	$ 2,500.00	RSMEANS 31 11 10.10 0200	
Clear Trees up to 24"	3	EA	$ 500.00	$ 1,500.00	RSMEANS 31 13 13 20 3150	
Engineered Fill Imported	9	TN	$ 25.00	$ 225.00	Recent Project Costs	
Engineered Fill Placed	4.5	CY	$ 40.00	$ 180.00	Recent Project Costs	
Subtotal				**$ 4,405.00**		
Erosion Control						
Straw bales	150	LF	$ 9.00	$ 1,350.00	RSMEANS 31 25 14 16 0600	
Silt Fence	150	LF	$ 5.00	$ 750.00	RSMEANS 31 25 14 16 1000 + markup	
Maintenance and Removal	1	LS	$ 3,000.00	$ 3,000.00	Engineer's Judgment	
Turbidity Barrier	50	LF	$ 30.00	$ 1,500.00	Recent project bids	
Subtotal				**$ 6,600.00**		
Control of Water / Water Diversion						
Implement Drawdown	1	LS	$ 5,000.00	$ 5,000.00	Engineer's Judgment	
Small Sand Bag	25	EA	$ 6.00	$ 150.00	Engineer's Judgment	0.5'x2'x1'
Large Sand Bag	15	EA	$ 200.00	$ 3,000.00	Engineer's Judgment	3'x3'x3'
Install and Remove Sand Bag	1	LS	$ 5,000.00	$ 5,000.00	Engineer's Judgment	
Subtotal				**$ 13,150.00**		
Structures Demolition						
Concrete/Wall Disposal	123	TN	$ 300.00	$ 36,900.00	Engineering's Judgement	
Channel Excavation	440	CY	$ 15.00	$ 6,600.00	Engineering's Judgement	Calculated in CADD
Dispose Material	440	CY	$ 25.00	$ 11,000.00	Engineering's Judgement	
Subtotal				**$ 54,500.00**		
Sediment Management						
Dredging & Disposal	TBD	-	-	$ -	Sediment Management Reqts Unknown	
Subtotal				**$ -**		

SUBTOTAL	$	177,015.00
Contract Bonds	$	2,000.00
Design Contingency	**$**	**62,300.00**
		35%
OPINION OF PROBABLE CONSTRUCTION COST	**$**	**242,000.00**
Engineering & Design	$	100,000.00
Permitting	$	75,000.00
Construction Phase Services	$	50,000.00
OPINION OF PROBABLE CONSTRUCTION COST	**$**	**467,000.00**

APPENDIX C
Previous Reports and References
Houghton Pond Dam
Holliston, Massachusetts

PREVIOUS REPORTS AND REFERENCES

The following documents were identified within the dam safety database or reference as part of this work:

1. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: May 10, 2021.
2. "Emergency Action Plan for Houghton Pond Dam", Lenard Engineering. March 18, 2019.
3. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: December 20, 2018
4. "Houghton Pond Dam Phase II", Lenard Engineering. Date of Inspection: November 27, 2017.
5. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: August 16, 2017
6. Dam Registration Certificate dated August 3, 2017.
7. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: November 10, 2016.
8. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: June 13, 2013.
9. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: June 8, 2012.
10. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: June 6, 2012.
11. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: December 16, 2011.
12. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: June 6, 2011.
13. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: December 3, 2010.
14. "6-Month Follow-up Dam Safety Visual Inspection – Houghton Pond Dam", Lenard Engineering. Date of Inspection: June 23, 2010.
15. "Houghton Pond Dam Phase I Inspection/Evaluation Report", Lenard Engineering. Date of Inspection: June 9, 2010.
16. "Emergency Action Plan for Houghton Pond Dam", Pare Corporation. June 2007.
17. "Houghton Pond Dam Municipally Owned Dam Inspection/Evaluation Report, Houghton Pond Dam", Department of the Army New England Division, Corps of Engineers. Date of Inspection: July 1979.

The following references were utilized during the preparation of this report and the development of the recommendations presented herein:

1. "Design of Small Dams", United States Department of the Interior Bureau of Reclamation, 1987
2. "ER 110-2-106 - Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979.
3. "Guidelines for Reporting the Performance of Dams" National Performance of Dams Program, August 1994.
4. 302 CMR: Department of Conservation and Recreation Section 10.00 Dam Safety
5. Massachusetts State Building Code Sec. 1612.4.9
6. Massachusetts Wetlands Protection Act Regulations 310 CMR 10.00

APPENDIX D
Common Dam Safety Definitions
Houghton Pond Dam
Holliston, Massachusetts

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to 302 CMR10.00 Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA. Please note should discrepancies between definitions exits, those definitions included within 302 CMR 10.00 govern for dams located within the Commonwealth of Massachusetts.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom. including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Size Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

Large – structure with a height greater than 40 feet or a storage capacity greater than 1,000 acre-feet.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 50 to 1,000 acre-feet.

Small – structure with a height between 6 and 15 feet and a storage capacity of 15 to 50 acre-feet.

Non-Jurisdictional – structure less than 6 feet in height or having a storage capacity of less than 15 acre-feet.

Hazard Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

Unsafe - Major structural, operational, and maintenance deficiencies exist under normal operating conditions.

Poor - Significant structural, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

Satisfaction - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.