--- CHARLES RIVER DAM AT SOUTH NATICK ---

PHASE I

INSPECTION / EVALUATION REPORT

---

Dam Name: Charles River Dam at South Natick

NID ID#: MAA00341

Owner: Town of Natick

Town: Natick

Consultant: GZA GeoEnvironmental, Inc.

Date of Inspection: December 3, 2021
February 25, 2022
GZA File No. 01.0019114.82

Mr. William McDowell, P.E.
Town Engineer, Town of Natick
Department of Public Works
75 West Street
Natick, Massachusetts 01240

Re: Phase I Inspection/Evaluation Report
Charles River Dam at South Natick
NID # MA 00341
Middlesex County

Dear Mr. McDowell:

In accordance with our agreement with the Town of Natick (Town, Client) dated October 25, 2021, GZA GeoEnvironmental, Inc. (GZA) has completed our visual inspection of the Charles River Dam located off Mill Lane in South Natick, Massachusetts. The site visit was conducted on December 3, 2021. The purpose of our efforts was to provide the Massachusetts Department of Conservation and Recreation, Office of Dam Safety (DCR-ODS) with an updated, formal Phase I inspection in order for the Town to maintain compliance with 302 CMR 10.00 Dam Safety Regulations, pertaining to inspection frequency. The inspection also fulfills an Order from the ODS to complete a visual inspection of the Dam by December 15, 2021. This inspection report updates GZA’s Phase I inspection conducted on November 30, 2017.

Based on our inspection, the dam is currently in **POOR** condition. This is a downgrade from the 2017 inspection due to the trees on the right embankment of the dam. A further discussion of our evaluation and recommended actions items are presented in the Inspection/Evaluation Report. In addition to an electronic copy transmitted to you, one hard copy of the report and one electronic copy of the report and checklist has been provided on your behalf to the DCR-ODS. In accordance with DCR-ODS format requirements, the report also includes a: (a) Dam Evaluation Summary Detail Sheet, (b) completed checklist, (c) field sketch; and (d) selected photographs with captions. Our services and report are subject to the Limitations found in Appendix A.

We are happy to have been able to assist the Town with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Phase I Inspection/Evaluation report.

Sincerely,

GZA GeoEnvironmental, Inc.

Derek J. Schipper, P.E.
Senior Consultant

Chad W. Cox, P.E.
Consultant/Reviewer

James P. Guarente, P.E.
Associate Principal
EXECUTIVE SUMMARY

This report summarizes the results of a Phase I visual dam inspection conducted by GZA GeoEnvironmental, Inc. (GZA) on December 3, 2021 for the Charles River Dam, located in South Natick, Massachusetts. The dam is owned and operated by the Town of Natick. In general, the Charles River Dam at South Natick is judged to be **POOR** condition. The overall condition of the dam has been downgraded from Fair to Poor due to the presence of trees throughout the embankment at the right side of the dam. The last formal Phase I inspection of the Charles River Dam was performed by GZA on October 13, 2017. GZA performed an additional Phase II evaluation of the dam in 2009, which included detailed Hydrologic and Hydraulic (H&H) Analyses, embankment slope stability and seepage analyses, an underwater inspection of upstream portions of the concrete spillway/training walls, and a condition/functionality assessment of the existing low-level outlet gate works. We also developed recommendations and preliminary cost estimates for selected remedial repair alternatives to address deficiencies identified during our ongoing investigations and analyses. The following is a summary of dam safety issues noted during this recent inspection:

1. Numerous mature trees and woody shrubs and throughout earth embankment on right side of spillway;
2. Fallen tree on downstream slope;
3. Minor erosion with exposed tree roots on embankment crest and parts of downstream slope, likely resulting from pedestrian traffic;
4. Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment;
5. Minor scarping and some erosion at waterline at upstream slope of earth embankment;
6. Deteriorated cast-in-place concrete with cracked, spalled and misaligned sections associated with the low training wall upstream of the left spillway abutment;
7. Some loose and missing stones and loose/missing mortar at stone masonry spillway training walls on both left and right sides of the spillway discharge channel (Charles River);
8. Tree/vegetation growth within joints of left and right stone masonry spillway training wall;
9. Slight lean toward the river of the low retaining wall on right side of the spillway discharge area and loss of ground/ground subsidence behind wall;
10. Deteriorated cast-in-place concrete with cracked, chipped, spalled sections associated with the low-level outlet slide gate structure on the right spillway abutment;
11. Erosion/minor void in concrete along left side of outside concrete wall of outlet structure at waterline;
12. Inoperable slide gates at the outlet works; and
13. Missing upstream warning buoy to deter boats/canoes approaching spillway.
GZA recommends that the Town of Natick perform the following:

**Studies and Analyses:**

1. Prepare written operations and maintenance plan;
2. Continue to review and update the existing Emergency Action Plan (EAP) annually to update contact names/numbers, etc., as appropriate. The Town has handled this annual update in the past;
3. Continue monitoring the condition of stone masonry and concrete spillway training walls;
4. Continue monitoring the condition of concrete associated with slide gate outlet structure;
5. Continue monitoring the leakage at the blocked former outlet for increases in flow rate and clarity of flow; and
6. Conduct a detailed inspection of the downstream face of spillway. It is envisioned that this could be prudently accomplished after the slide gates have been replaced at which time they could be opened slightly to lower the water level enough such that the downstream side of the spillway is clearly exposed.

**Maintenance and Minor Repairs:**

1. Maintain a program of brush removal and grass trimming at the earthen embankment.
2. Remove vegetation which is beginning to re-establish within joints of left stone masonry spillway training wall including, to the extent practicable, removal of associated stumps and root balls.

**Remedial Measures:**

The following more comprehensive remedial measures were formulated based partly on the results of GZA’s 2009 Phase II evaluation and ongoing rehabilitation design considerations and include actions to bring the structure into compliance with Massachusetts Dam Safety Regulations and current engineering practice.

1. Clear trees and woody vegetation from the embankments, crest and downstream toe area. Additionally, remove all roots/root balls associated with trees and vegetation and backfill resulting voids with compacted sand/gravel;
2. Re-surface the upstream embankment with stone rip-rap protection;
3. Re-grade the downstream embankment to a uniform 3H:1V slope. Place proprietary turf reinforcement matting over the crest and downstream slope to address potential for crest overtopping via wave action and erosion of the downstream slope via high backwater conditions;
4. Execute a complete replacement of both gates coupled with appropriate re-configuration/restoration of the concrete superstructure surrounding the gate openings; and
5. Repair/re-build the upstream and downstream training wall portions of the spillway discharge area which exhibit deteriorated concrete, missing stones/mortar, leaning and related deficiencies.

A preliminary opinion of probable construction cost for the repairs and remedial measures recommended above is approximately **$1,800,000 to $2,200,000**.
E1: DESIGN METHODOLOGY
1. Unknown Design – no design records available
2. No design or post-design analyses
3. No analyses, but dam features appear suitable
4. Design or post design analysis show dam meets most criteria
5. State of the art design – design records available & dam meets all criteria

E2: LEVEL OF MAINTENANCE
1. Dam in disrepair, no evidence of maintenance, no O&M manual
2. Dam in poor level of upkeep, very little maintenance, no O&M manual
3. Dam in fair level of upkeep, some maintenance and standard procedures
4. Adequate level of maintenance and standard procedures
5. Dam well maintained, detailed maintenance plan that is executed

E3: EMERGENCY ACTION PLAN
1. No plan or idea of what to do in the event of an emergency
2. Some idea but no written plan
3. No formal plan but well thought out
4. Available written plan that needs updating
5. Detailed, updated written plan available and filed with MADCR, annual training

E4: SEEPAGE (Embankments, Foundations, & Abutments)
1. Severe piping and/or seepage with no monitoring
2. Evidence of monitored piping and seepage
3. No piping but uncontrolled seepage
4. Minor seepage or high volumes of seepage with filtered collection
5. No seepage or minor seepage with filtered collection

E5: EMBANKMENT CONDITION (See Note 1)
1. Severe erosion and/or large trees
2. Significant erosion or significant woody vegetation
3. Brush and exposed embankment soils, or moderate erosion
4. Unmaintained grass, rodent activity and maintainable erosion
5. Well maintained healthy uniform grass cover

E6: CONCRETE CONDITION (See Note 2)
1. Major cracks, misalignment, discontinuities causing leaks, seepage or stability concerns
2. Cracks with misalignment inclusive of transverse cracks with no misalignment but with potential for significant structural degradation
3. Significant longitudinal cracking and minor transverse cracking
4. Spalling and minor surface cracking
5. No apparent deficiencies

E7: LOW-LEVEL OUTLET DISCHARGE CAPACITY
1. No low level outlet, no provisions (e.g. pumps, siphons) for emptying pond
2. No operable outlet, plans for emptying pond, but no equipment
3. Outlet with insufficient drawdown capacity, pumping equipment available
4. Operable gate with sufficient drawdown capacity
5. Operable gate with capacity greater than necessary

E8: LOW-LEVEL OUTLET PHYSICAL CONDITION
1. Outlet inoperative needs replacement, non-existent or inaccessible
2. Outlet inoperative needs repair
3. Outlet operable but needs repair
4. Outlet operable but needs maintenance
5. Outlet and operator operable and well maintained

E9: SPILLWAY DESIGN FLOOD CAPACITY
1. 0 - 50% of the SDF or unknown
2. 50-90% of the SDF
3. 90 - 100% of the SDF
4. >100% of the SDF with actions required by caretaker (e.g. open outlet)
5. >100% of the SDF with no actions required by caretaker

E10: OVERALL PHYSICAL CONDITION OF DAM
1. UNSAFE – Major structural, operational, and maintenance deficiencies exist under normal operating conditions
2. POOR - Significant structural, operation and maintenance deficiencies are clearly recognized under normal loading conditions
3. 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
4. SATISFACTORY - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.
5. GOOD - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF

E11: ESTIMATED REPAIR COST
Estimation of the total cost to address all identified structural, operational, maintenance deficiencies. Cost shall be developed utilizing standard estimating guides and procedures
PREFACE

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.

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. 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.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. 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.

Derek J. Schipper, P.E.
Massachusetts License No.: 47577
Senior Consultant
GZA GeoEnvironmental, Inc.

James P. Guarente, P.E.
Massachusetts License No.: 40103
Associate Principal
GZA GeoEnvironmental, Inc.
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Appendix A: Limitations
Appendix B: Photographs
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Appendix D: Previous Reports and References
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Appendix F: Historic Documentation
1.0 DESCRIPTION OF PROJECT

1.1 GENERAL

1.1.1 Authority

The Town of Natick has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual inspection and develop a report of conditions for the Charles River Dam at South Natick along the Charles River in the town of Natick, Massachusetts. This inspection and report were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws as amended by Chapter 330 of the Acts of 2002. This report is subject to the Limitations in Appendix A.

1.1.2 Purpose of Work

The purpose of this investigation is to inspect and evaluate the present condition of the dam and appurtenant structures in accordance with 302 CMR 10.07 to provide information that will assist in both prioritizing dam repair needs and planning/conducting maintenance and operation.

The investigation is divided into four parts: 1) obtain and review available reports, investigations, and data previously submitted to the owner pertaining to the dam and appurtenant structures; 2) perform a visual inspection of the site; 3) evaluate the status of an emergency action plan for the site and; 4) prepare and submit a final report presenting the evaluation of the structure, including recommendations and remedial actions, and opinion of probable costs.

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 E. 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. References to “left” and “right” are oriented when facing in the downstream direction.

1.2 DESCRIPTION OF PROJECT

1.2.1 Location

Charles River Dam at South Natick is located off of Mill Lane on the Charles River in the Town of Natick, Middlesex County, Massachusetts. The dam is located approximately 170 upstream of Pleasant Street Bridge. The earthen embankment and right spillway training wall is accessed via Pleasant Street. Access to left abutment and spillway training wall is adjacent to Mill Lane through a park area. A locus map and an aerial photograph of the site are provided in Figure 1 and Figure 2 respectively. The dam is located at Latitude 42.2715 °N and Longitude 71.3158 °W.

1.2.2 Owner/Caretaker

The dam is owned and maintained by the Town of Natick. Mr. William McDowell P.E., Town Engineer for the Town of Natick, acts as the primary caretaker for the dam. See Table 1.1 for current owner and caretaker data (names and contact information).
1.2.3 Purpose of the Dam

The dam currently impounds the Charles River and is used for recreational purposes. A small park area, with benches and picnic tables, is located on either side of the dam. The dam’s impoundment is also used for recreation.

1.2.4 Description of the Dam and Appurtenances

The Charles River Dam consists of an approximately 14-foot-high earthen embankment dam on the right bank of the river with an approximately 7-foot-high run-of-the-river concrete ogee-shaped, curved spillway left of the embankment. The embankment portion of the dam is about 200 feet long and its top width is generally about 20 to 30 feet wide. The upstream and downstream embankment slopes are vegetated, including mature trees, and slope at about three foot horizontal to one-foot vertical (3H:1V). A vertical, mortared stone masonry wall comprises portions of the downstream face of the embankment adjacent to the spillway’s left abutment.

The spillway is an approximately 130-foot long uncontrolled, concrete ogee weir and has a curved (upstream) horizontal alignment. The spillway has stone masonry training walls upstream and downstream. There are no nappe breakers on the spillway. Flow is conveyed beneath Pleasant Street about 170 feet downstream via a series of stone masonry arch openings. The remnants of a Denil-type concrete fishway are located at the right side of the spillway.

A concrete low-level outlet structure is located to the right of the spillway. The outlet structure contains two approximately 4-foot-wide by 6-foot-high spigot type, cast iron slide gates located at the base of the concrete outlet structure immediately to the right of the spillway. Discharge from the low level outlet is directly into the downstream river channel. The Rodney Hunt gate operators are located on top of the concrete outlet structure above the gate.

Remnants of a separate low-level sluiceway outlet are located at the downstream toe of the earth embankment portion of the dam approximately 150 feet from the right abutment. The outlet headwall is stone masonry and has been plugged. According to the 1934 Fay, Spofford & Thorndike, Inc., (FST) Drawings made available to GZA, this abandoned outlet consisted of a 12-inch-diameter cast iron pipe encased in 4-inch thick concrete that discharges to a 5-foot wide weir chamber. An apparently abandoned sluiceway channel from this outlet meanders generally parallel to Pleasant Street along the toe of the dam to the main river channel. During periods of elevated flow, the channel is filled with backwater from the river. No intake structure was observable upstream of this outlet.

The grounds on the dam to the right of the spillway and adjacent to the dam left of the spillway are publicly accessible park areas which appear to be well-used. Park benches are present on the left abutment and benches are present on the top of the earth embankment portion of the dam, right of the spillway.
1.2.5 Operations and Maintenance

The dam is operated and maintained by the Town of Natick. There is no formal operations and maintenance plan for the dam. Mr. William McDowell, P.E., Natick Town Engineer has supervisory responsibility for operations and maintenance.

1.2.6 DCR Size Classification

Charles River Dam at South Natick has a maximum structural height of approximately 14 feet and a maximum storage capacity (top of embankment dam) of approximately 500 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 as amended by Chapter 330 of the Acts of 2002, Charles River Dam at South Natick is an Intermediate size structure due to its maximum storage capacity being more than 50 acre-feet but less than 1000 acre-feet. Refer to Appendix E for definitions of height of dam and storage.

1.2.7 DCR Hazard Potential Classification

Charles River Dam at South Natick is located in a residential and commercial area of the Town of Natick. Pleasant Street is located about 170 feet downstream of the dam. Several residential structures are also located downstream of the dam. It appears that a failure of the dam at maximum pool will likely cause loss of life and significant damage to homes, industrial or commercial facilities, important public utilities and buildings and main arterial roadways. Therefore, 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 as amended by Chapter 330 of the Acts of 2002, Charles River Dam at South Natick is classified as a High (Class I) hazard potential dam. GZA concurs with this classification.

1.3 PERTINENT ENGINEERING DATA

1.3.1 Drainage Area

The drainage area for Charles River Dam at South Natick is approximately 165 square miles and extends through the communities of Sherborn, Holliston, Millis, Medway, Milford, Franklin and parts of Medfield, Wrentham, Bellingham, Norfolk, Hopedale and Walpole. The drainage area drains mild to moderately sloped areas (refer to Figure 3).

1.3.2 Reservoir

See Table 1.1 for data about normal, maximum, and spillway design flood (SDF) pools.

1.3.3 Discharges at the Dam Site

There were no records available to GZA regarding discharges at the dam site. However, a U.S. Geological Survey (USGS) gage station (#01103500 Charles River Village/ Dover, MA) is located approximately 6.3 river miles downstream of the Charles River Dam. Daily discharge rates at the gage can be obtained from USGS’s website dating back to 1937. GZA also performed a H&H analysis in 2019 as part of a dam removal feasibility study which includes the most recent peak flow rate estimate for the current SDF (500-year flood). Refer to the Hydrologic/Hydraulic Data in Section 2.5, below, for additional information on past H&H studies at the Charles River Dam.
1.3.4 General Elevations (feet)

The following elevations in feet (referenced to National Geodetic Vertical Datum - 1929) are from the Phase II evaluation topographic survey performed at the dam in January of 2009 by Norwood Engineering Company, Inc.

A. Top of Dam (Right Embankment Portion) 1  116.0
B. Spillway Design Flood Pool 115.9 (2019 GZA Dam Removal Feasibility Study)
C. Normal Pool 110.6
D. Spillway Crest 110.6
E. Upstream Water at during Inspection 111.1 ±
F. Streambed at Toe of the Dam 103.2 ±
G. Low Point along Toe of the Dam 102.0 ±

1.3.5 Main Spillway Data

A. Type Ogee shaped concrete weir
B. Length 130 feet
C. Crest Elevation 110.6 feet
D. Upstream Channel Varies2 (Charles River)
E. Downstream Channel 102.7 ± feet (Charles River)

1.3.6 Additional information and Elevations as Appropriate for Specific Dam

Low Level Outlet

A. Type Two 4’x6’ steel slide gates at right side of spillway.
B. Pipe Invert 104 ± feet (no intake our outlet pipe associated with gates)
C. Pipe Size 4’x6’ maximum gate opening
D. Valve Type Slide gate valves

1.3.7 Design and Construction Records and History

Design and construction records for the dam’s original construction (presumably timber crib) were not available. Portions of the FST design drawings and some construction photographs of the major reconstruction dated 1934 were made available to GZA during the conduct of our Phase II analyses and were included in our Phase II report. Please refer to Appendix F for select historic documentation. It is unknown whether the 1934 reconstruction was at the same location as the original structure. No remnants of the original structure were observed during the 2009 diving survey.

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1  Note FST Drawings depict top of dam at approximately elevation 106 feet. Norwood Engineering survey in 2009 uses NGVD-1929, which apparently is different from that used in 1934.

2  Depth to mudline on front-side of spillway observed to range generally from 2 to 7 feet below top during diving survey conducted as part of 2009 Phase II scope.
1.3.8 Operating Records

No operation records are kept for this run-of-river dam.

1.4 SUMMARY DATA TABLE

See Table 1.1, Summary Data Table, on following page.
### 1.1 Summary Data Table

<table>
<thead>
<tr>
<th>Required Phase I Report Data</th>
<th>Data Provided by the Inspecting Engineer</th>
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<tbody>
<tr>
<td>National ID #</td>
<td>MA00341</td>
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<tr>
<td>Dam Name</td>
<td>Charles River Dam at South Natick</td>
</tr>
<tr>
<td>Dam Name (Alternate)</td>
<td>South Natick Dam</td>
</tr>
<tr>
<td>River Name</td>
<td>Charles River</td>
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<tr>
<td>Impoundment Name</td>
<td>Charles River</td>
</tr>
<tr>
<td>Hazard Class</td>
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<tr>
<td>Size Class</td>
<td>Intermediate</td>
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<tr>
<td>Dam Type</td>
<td>Earth embankment with concrete gravity R-O-R SW</td>
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<td>Dam Purpose</td>
<td>Recreation</td>
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<td>Structural Height of Dam (feet)</td>
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<td>Hydraulic Height of Dam (feet)</td>
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<tr>
<td>Drainage Area (sq. mi.)</td>
<td>165±</td>
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<td>Reservoir Surface Area (acres)</td>
<td>14+/- Dam is on the Charles River.</td>
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<td>Normal Impoundment Volume (acre-feet)</td>
<td>220</td>
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<tr>
<td>Max Impoundment Volume ((top of dam) acre-feet)</td>
<td>~500</td>
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<td>SDF Impoundment Volume* (acre-feet)</td>
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<tr>
<td>Spillway Type</td>
<td>Concrete gravity ogee weir (slightly curved in upstream direction.</td>
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<td>Spillway Length (feet)</td>
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<td>Freeboard at Normal Pool (feet)</td>
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<td>Principal Spillway Capacity* (cfs)</td>
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<td>Auxiliary Spillway Capacity* (cfs)</td>
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<td>Low-Level Outlet Capacity* (cfs)</td>
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<td>Spillway Design Flood* (flow rate - cfs)</td>
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<td>Winter Drawdown (feet below normal pool)</td>
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<td>County Name</td>
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<td>Public Road on Crest</td>
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<td>Public Bridge over Spillway</td>
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<td>EAP Date (if applicable)</td>
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<td>Owner Name</td>
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</tr>
<tr>
<td>Owner Address</td>
<td>75 West Street</td>
</tr>
<tr>
<td>Owner Town</td>
<td>Natick, MA 01760</td>
</tr>
<tr>
<td>Owner Phone</td>
<td>508-647-6551</td>
</tr>
<tr>
<td>Owner Emergency Phone</td>
<td>508-647-6550</td>
</tr>
<tr>
<td>Owner Type</td>
<td>Municipality or Political subdivision</td>
</tr>
<tr>
<td>Caretaker Name</td>
<td>Department of Public Works</td>
</tr>
<tr>
<td>Caretaker Address</td>
<td>75 West Street</td>
</tr>
<tr>
<td>Caretaker Town</td>
<td>Natick, MA 01760</td>
</tr>
<tr>
<td>Caretaker Phone</td>
<td>508-647-6551</td>
</tr>
<tr>
<td>Caretaker Emergency Phone</td>
<td>508-647-6550</td>
</tr>
<tr>
<td>Date of Field Inspection</td>
<td>12/3/2021</td>
</tr>
<tr>
<td>Consultant Firm Name</td>
<td>GZA GeoEnvironmental, Inc.</td>
</tr>
<tr>
<td>Inspecting Engineer</td>
<td>Derek J. Schipper, P.E.</td>
</tr>
<tr>
<td>Engineer Phone Number</td>
<td>781-706-6746</td>
</tr>
</tbody>
</table>
2.0 INSPECTION

2.1 VISUAL INSPECTION

GZA Engineers Derek Schipper, P.E. and Firas Rababaa visually inspected Charles River Dam at south Natick on December 3, 2021. The weather was sunny with temperatures in the 40s °F during the time of the inspection. Photographs to document the current conditions of the Dam were taken during the inspection and are included in Appendix B. The headwater was about 6 inches over the spillway crest (Elevation ~ 111.1) at the time of the visit. Flow over the spillway obscured the inspection of upstream side, crest, and downstream side of the spillway. Underwater areas were not inspected as part of our current scope of work. Note however, that a limited diving survey of the upstream gates, spillway crest and training walls was conducted as part of our 2009 Phase II study. A copy of the completed inspection checklist is included in Appendix C.

2.1.1 General Findings

In general, Charles River Dam at South Natick was found to be in POOR condition. Several deficiencies similar to those identified during the 2017 inspection and 2009 Phase II study were observed during this visual inspection. Those deficiencies are identified in more details in the sections below.

2.1.2 Dam

The dam is generally comprised of earthen embankment and overflow spillway (described below). The embankment crest is heavily vegetated with mature trees, high shrubs, and grass. Grass cover appeared in fair condition with areas of apparent erosion and exposed tree roots due to pedestrian traffic, resulting in an irregular surface at the embankment crest. Upstream and downstream portions of the embankment were also heavily vegetated which prevented the close inspection of the slope condition. One the downstream slope of the right embankment, one side of a double tree snapped off near the base and is leaning in the downstream direction. Shallow standing water was observed at downstream toe due to leakage (less than 1 gpm) through the blocked masonry sluiceway near the right downstream abutment of the dam. The area downstream of the right embankment was backwatered. Upstream slope of the embankment lacks the appropriate riprap cover near normal pool line which makes the area susceptible to wave erosion. The area experiences minor erosion near waterline likely due to visitors who fish near the upstream slope.

The downstream stone masonry walls appeared in fair to poor condition during this inspection. Low concrete training wall upstream of the spillway on the left side appeared in fair condition with spalled, cracked, and misaligned sections of cast-in-place concrete. Woody vegetation was observed growing through joints of downstream masonry training walls. The alignment of the downstream masonry walls are generally good.

2.1.3 Appurtenant Structures

- Primary Spillway

The primary spillway is an Ogee shaped concrete weir and is located left of the earthen embankment. Flow over the spillway is uncontrolled and obscured the visual inspection of the downstream side of the spillway. Upstream portions of the spillway structure were also under-water during the inspection and not observable. However, flow over the crest was smooth as water passed over the spillway. No visible signs of distress were noted during the inspection but a 0.25-inch wide horizontal crack located approximately 2 feet above the mudline was reported during the 2009 Phase II work performed by GZA. The horizontal and vertical alignments of the spillway did not appear to be distorted.
Visible submerged portions of the crest and upstream area were clear of debris at the time of the inspection.
Flow through the concrete fishway on the right side of the spillway was clear but obscured the inspection of the baffles.

- Outlet Structure

The outlet structure consists of two 4’x6’ steel slide gates at right side of spillway. The gates are reported inoperable and in need of replacement rather than repair. Similar to the 2017 inspection, concrete walls associated with the low-level outlet structure were observed in fair to poor condition. At the downstream side of the outlet structure, concrete deterioration, chipping, spalling, efflorescence, pitting, and evidence of past minor leakage were noted. There were signs of past leakage/wetness in concrete at the downstream left wall of the outlet structure. Gate operators have been painted and are in good condition considering their age (circa 1934). No wheel/crank arm for the operators was present at the time of inspection. The Town has a functional homemade crank wheel at DPW headquarters.

The brass stems on the gates appeared to be in fair to good condition at the time of inspection. The right gate was raised slightly in 2008 via the portable crank arm on the right operator to confirm the operability of the stem. A more intense underwater diving inspection undertaken as part of the 2009 Phase II inspection indicated that the slide grooves, the gate hardware including the brass compression wedges were significantly deteriorated.

- Instrumentation

A total of four test borings were drilled as part of the 2009 Phase II work performed by GZA. Observation wells and open standpipe piezometers were placed in three of the borings. The approximate locations of the borings are shown in Figure 5. Water level readings were not taken during this inspection.

2.1.4 Downstream Area

The downstream area is generally comprised of the Charles River. Pleasant Street Bridge passes over the impoundment just downstream of the dam. A park area extends downstream from the dam to the bridge at the left discharge channel overbank. The spillway discharge channel extends into a wooded area with residential development downstream of Pleasant Street Bridge. An island with wooded vegetation and trees is located downstream of the primary ogee spillway.

Based on the 1934 FST drawings, the former sluiceway channel once connected the abandoned low-level outlet to the main stem of the Charles River near the right overbank. This channel appears to occasionally inundate due to backwater effects during high flow. This backwater condition may contribute to the undulation/unevenness currently observed on the downstream earthen embankment.

2.1.5 Reservoir Area

The impoundment is located upstream of an urbanized area in South Natick, MA. The shoreline of the reservoir area is primarily defined by a park and residential area on the left, and a woodland on the right. The bank slopes of the impoundment are generally moderate but appear stable. A minor growth of aquatic vegetation was noted adjacent to left upstream training wall.
2.2 CARETAKER INTERVIEW

Maintenance of the dam is the responsibility of the Town of Natick, Department of Public Works. No dam caretaker was present at the time of the dam inspection. However, Mr. William McDowell, P.E., Town Engineer and dam caretaker, is available in case there is a need to address immediate concerns with the dam. The maintenance of the dam typically includes mowing of the left abutment area and periodic cleanup of debris from the spillway and earthen embankment. The gates have reportedly not been exercised for several decades apart from the efforts in 2008.

2.3 OPERATION AND MAINTENANCE PROCEDURES

2.3.1 Operational Procedures

There is no formal operational procedure at the dam. Development of an Operation and Maintenance Plan (OMP) is recommended.

2.3.2 Maintenance of Dam and Operating Facilities

There is no formal operational procedure or record keeping at the dam. The dam is a run-of-the-river structure and generally requires no special operation. The Town of Natick, Department of Public Works may wish to consider developing one for the dam.

2.4 EMERGENCY WARNING SYSTEM

GZA completed an Emergency Action Plan (EAP) for the dam in December of 2006 for the Town of Natick. The plan was last updated in 2017 by GZA and is on file with DCR-ODS. It is recommended that the EAP and contact names/numbers, etc., is updated annually per DRC dam safety regulations. The Town has handled this annual update in the past.

2.5 AWARENESS OF POTENTIAL DAM RELATED SAFETY HAZARDS AT, NEAR, AND ON DAMS

Charles River Dam is accessed directly from Pleasant Street on the right side of the impoundment. Access to the dam and its appurtenances is unrestricted to the public. Fencing (iron railing) on top on the right upstream and downstream training walls did not cover the full extent of the wall and should be extended to provide additional safety from the River/spillway portion below. Additionally, portions of the iron railing on the left abutment/spillway appeared bent/damaged and should be replaced. No fencing or signage is present along the left side of the spillway discharge channel. Consider installing proper signage warning visitors to the park of the hazards associated with the spillway and river. GZA also recommends installing a barrier/warning signage upstream of the dam to alert boaters to the presence of the spillway. The nature of the spillway also has the potential to create a hydraulic “roller” in the channel downstream of the spillway. Signage should be provided to warn boaters and others of this potential dangerous condition.

2.6 HYDROLOGIC/HYDRAULIC DATA

Based on the Intermediate size and High (Class I) hazard classification for the dam, the regulatory spillway design flood (SDF) for the Charles River dam is the ½ PMF.

Hydrologic/hydraulic analysis of the dam was conducted in 1987 as part of a previous dam inspection report which is contained in DCR’s files. This previous analysis developed the ½ PMF using nomographs, which were produced by the U.S. Army Corps of Engineers in the late 1970s and estimated the ½ PMF peak inflows as 6,600 cfs. The USACE developed their maximum Probable Flood Peak Flow Rates curves from data available for sites on reservoirs in New
England where they had such data for reservoirs or had developed a Standard Project Flood (SPF). The SDF was doubled by the USACE to provide a value of Maximum Probable Flows. The peak flow at the Charles River Gage was estimated by USACE at 65 cfs per square mile. Re-apportioned at the dam, the unit discharge is about 80 cfs per square mile at the dam. This results in a peak full Probable Maximum Flood of 13,200 cfs and one-half the Probable Maximum Flood of 6,600 cfs at the Charles River Dam at South Natick.

GZA conducted an Inflow Design Flood (IDF)\(^3\) analysis as part of our 2009 Phase II assessment to determine if a less severe flood than the ½ PMF may be more appropriate as the Spillway Design Flood (SDF). The IDF selected using this process is the flood above which the increase in downstream water surface elevation, velocity, and/or consequences due to failure of the dam is not considered to present an unacceptable increase in the threat to downstream life and property. In the case of the Charles River Dam at South Natick, a flood less than the ½ PMF may be adopted as the SDF if the consequences of dam failure at flood flows larger than the selected SDF are negligible when compared to the same flood without dam failure (i.e., no increased damage to downstream areas is created by dam failure) in accordance with 302 CMR 10.14(6)(c). The underlying rationale is that there is no significant benefit to public safety gained by improving the dam to pass a flood so large wherein its failure during the flood would not be noticeable. Overall, the consequences of failure are considered acceptable when the incremental effects (depths) of failure on downstream structures are approximately two feet or less\(^4\). The SDF is therefore selected as the highest intensity flood causing incremental impacts of greater than two feet when combined with a dam failure (compared with the no failure scenario.)

The hydraulic computer model HEC-RAS\(^5\) was used to perform one-dimensional hydraulic calculations for unsteady-state flow water surface and to predict the hypothetical dam break wave formation at Charles River Dam at South Natick and the wave’s downstream progression along the Charles River. The IDF analysis was conducted by GZA for scenarios with and without breaching the dam, for both the ½ PMF and 500-year flood conditions. Under the ½ PMF scenario, the peak discharge at Charles River Dam, without dam failure, was about 6,600 cfs. A potential dam break at Charles River Dam, during the ½ PMF, results in a peak flow through the breach opening of about 7,200 cfs. The analyses indicated that the difference in downstream peak depths, with and without Charles River Dam failure, is less than 0.5 feet throughout the downstream reach. Submergence issues affect the flow release for the dam failure.

Under the 500-year flood, Peak flow downstream of the dam without dam failure, is about 5,000 cfs. With dam failure, the peak discharge through the Charles River Dam breach opening is approximately 6,630 cfs. The analyses indicated that the difference in downstream peak depths with and without Charles River Dam failure is less than 1 foot throughout the downstream reach. Submergence issues affect the flow release for the dam failure.

GZA’s 2009 IDF analysis results indicated that the populated areas downstream of Charles River Dam may experience a difference in incremental peak flood depths of less than 0.5 feet with dam failure. This indicates that the 500-year flood may be at the threshold of what constitutes a significant difference in downstream peak flood elevations. GZA, on behalf of the Town petitioned DCR-ODS to adopt the 500-year as the SDF at Charles River Dam. DCR-ODS concurred with GZA’s recommendation and issued the formal petition granting the reduction to the 500-year event on January 4, 2010.

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Topographic survey conducted during the Phase II assessment, shows that the spillway has a maximum available freeboard of about 5.4 ft. (116 ft. NGVD29 (top of dam) – 110.6 ft. NGVD29 (spillway crest)) and a length of approximately 130 feet.

In 2019, as part of a dam removal feasibility study, GZA conducted a H&H analysis to verify the minimum amount of spillway and/or embankment that must be removed to decommission the dam as a regulatory structure. As part of the H&H analysis GZA developed a new one-dimensional steady-state hydraulic model using HEC-RAS software to evaluate changes in water surface elevation resulting from dam removal. GZA utilized a 2016 FEMA Flood Insurance Study (FIS) of the Charles River to estimate peak flow during the SDF (500-year flood). According to the 2016 FIS, the 500-year the peak flow rate at the Charles River Dam is 6,000 cfs which is 1,000 cfs greater than the peak flow rate estimated by GZA in the 2009 IDF analysis. GZA’s 2019 H&H analysis estimated during the SDF that there is only ±0.1’ of freeboard between the maximum water surface elevation (115.1’ NAVD88 or 115.9’NGVD) and the top of the earthen embankment (115.2’ NAVD88 or 116.0 NAVD88). Therefore, spillway capacity is approximately 100% of the 500-year SDF peak flow rate of 6,000 cfs.

The following are based on the 2019 H&H analysis:

A. Spillway Design Flood (SDF) Return Period: 500-year
B. Precipitation (inches) and methodology: Unknown
C. SDF Inflow (cfs): 6,000
D. SDF Outflow (cfs): 6,000
E. Principal Spillway Capacity (cfs): 6,000
F. Auxiliary Spillway Capacity (cfs): N/A
G. Low-level Outlet Capacity (cfs): Unknown
H. Percentage of the SDF that can be safely routed through the reservoir without overtopping the dam: 100%
I. Minimum Freeboard (ft.) (if applicable) 0.1

While the 2019 H&H analyses indicated the spillway has adequate capacity to pass the revised SDF (500-year-flood), the calculated freeboard under this condition was approximately 0.1 feet, which is less than the recommended 2-foot minimum. Wave action under the SDF might potentially cause the embankment to overtop. Thus, it is recommended that measures dealing with overtopping protection be taken to address this deficiency.

2.7 STRUCTURAL AND SEEPAGE STABILITY

2.7.1 Embankment Structural Stability

As part of the Phase II analysis, GZA performed a dimensional stability analysis at the maximum embankment section of the Charles River Dam at South Natick where the risk for instability was assumed to be the greatest. The analyses were performed in general accordance with ODS regulations (302 CMR 10.14(9)) as well as other industry standards from the United States Bureau of Reclamation, United States Army Corp of Engineers, and Federal Energy Regulatory Commission.
The analyses indicated acceptable factors of safety under all loading cases. Based on the overall results of the stability assessment, the embankment was judged to be structurally stable and stability-related corrective actions are not required. Back-up calculations are contained in the Phase II report.

2.7.2 Structural Stability of Non-Embankment Structures

There are no non-embankment structural stability analyses available for Charles River Dam in DCR’s files. The 2009 Phase II scope did not include a structural stability analysis of non-embankment structures. Deterioration of training walls were noted. In addition, the right downstream boulder wall was observed to be leaning in the downstream direction.

2.7.3 Seepage Stability

Seepage Analyses of the earthen embankment were conducted as part of the 2009 Phase II assessment. The seepage analyses indicated that the maximum exit gradient of water in the embankment at the toe of the dam is approximately 0.15 ft/ft under maximum pool conditions (upstream WSEL at ~ 115.1 ft and downstream WSEL at ~ 112.7 ft). Additionally, the calibrated normal pool model indicated that the maximum exit gradient is approximately 0.11 ft/ft. Taking the critical gradient (which is the gradient slope at which soil transport and thus potential piping failure is assumed to begin) typically as 1.0, the computed exit gradient is lower than the critical gradient, indicating that soil transport is likely not a concern at the dam, in GZA opinion.
3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 ASSESSMENTS

In general, the Charles River Dam at South Natick is judged to be **POOR** condition. The overall condition of the dam has been downgraded from Fair to Poor due to the presence of trees throughout the embankment at the right side of the dam. The dam was found to have the following deficiencies:

1. Numerous mature trees and woody shrubs and throughout earth embankment on right side of spillway;
2. Fallen tree on downstream slope;
3. Minor erosion with exposed tree roots on embankment crest and parts of downstream slope, likely resulting from pedestrian traffic;
4. Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment;
5. Minor scarping and some erosion at waterline at upstream slope of earth embankment;
6. Deteriorated cast-in-place concrete with cracked, spalled and misaligned sections associated with the low training wall upstream of the left spillway abutment;
7. Some loose and missing stones and loose/missing mortar at stone masonry spillway training walls on both left and right sides of the spillway discharge channel (Charles River);
8. Tree/vegetation growth within joints of left and right stone masonry spillway training wall;
9. Slight lean toward the river of the low retaining wall on right side of the spillway discharge area and loss of ground/ground subsidence behind wall;
10. Deteriorated cast-in-place concrete with cracked, chipped, spalled sections associated with the low-level outlet slide gate structure on the right spillway abutment;
11. Erosion/minor void in concrete along left side of outside concrete wall of outlet structure at waterline;
12. Inoperable slide gates at the outlet works; and
13. Missing upstream warning buoy to deter boats/canoes approaching spillway.

A comparison to the previously reported condition of the dam is shown below:

<table>
<thead>
<tr>
<th>Previously Identified Deficiency (2017)</th>
<th>Resolution or Current Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature trees and shrubs throughout earth embankment on right side of spillway.</td>
<td>This condition remains and is generally similar to conditions observed in the 2017 inspection.</td>
</tr>
<tr>
<td>Minor erosion at top of earth embankment and downstream embankment due to pedestrian traffic.</td>
<td>This condition remains and is generally similar to conditions observed in the 2017 inspection.</td>
</tr>
<tr>
<td>Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment.</td>
<td>This condition remains and is generally similar to conditions observed in the 2017 inspection.</td>
</tr>
<tr>
<td>Minor scarping at waterline at upstream slope of earth embankment.</td>
<td>Similar condition where observed. Dense vegetative cover obscured view of much of the upstream slope.</td>
</tr>
</tbody>
</table>
3.2 STUDIES AND ANALYSES

GZA recommends that the following investigations be performed by a qualified, registered professional engineer experienced in dam safety:

1. Prepare written operations and maintenance plan;
2. Continue to review and update the existing Emergency Action Plan (EAP) annually to update contact names/numbers, etc., as appropriate. The Town has handled this annual update in the past;
3. Continue monitoring the condition of stone masonry ad concrete spillway training walls;
4. Continue monitoring the condition of concrete associated with slide gate outlet structure;
5. Continue monitoring the leakage at the blocked former outlet for increases in flow rate and clarity of flow; and
6. Conduct a detailed inspection of the downstream face of spillway. It is envisioned that this could be prudently accomplished after the slide gates have been replaced at which time they could be opened slightly to lower the water level enough such that the downstream side of the spillway is clearly exposed.
3.3 RECURRENT MAINTENANCE RECOMMENDATIONS

GZA recommends the following recurrent maintenance level activities that can be undertaken by the dam owner/caretaker and do not require engineering design:

1. Maintain a program of brush removal and grass trimming at the earthen embankment.

Additional detail regarding annual maintenance activities should be listed in an officially prepared Operations and Maintenance (O&M) Manual.

3.4 MINOR REPAIRS RECOMMENDATIONS

GZA recommends the following minor repairs:

1. Remove vegetation which is beginning to re-establish within joints of left stone masonry spillway training wall including, to the extent practicable, removal of associated stumps and root balls.

3.5 REMEDIAL MODIFICATION RECOMMENDATIONS

The following more comprehensive remedial measures were formulated based primarily on the results of GZA’s 2009 Phase II evaluation and include actions to bring the structure into compliance with Massachusetts Dam Safety Regulations and current engineering practice.

1. Clear trees and woody vegetation from the embankments, crest and downstream toe area. Additionally, remove all roots/root balls associated with trees and vegetation and backfill resulting voids with compacted sand/gravel;
2. Re-surface the upstream embankment with stone rip-rap protection;
3. Re-grade the downstream embankment to a uniform 3H:1V slope. Place proprietary turf reinforcement matting over the crest and downstream slope to address potential for crest overtopping via wave action and erosion of the downstream slope via high backwater conditions;
4. Execute a complete replacement of both gates coupled with appropriate re-configuration/restoration of the concrete superstructure surrounding the gate openings; and
5. Repair/re-build the upstream and downstream training wall portions of the spillway discharge area which exhibit deteriorated concrete, missing stones/mortar, leaning and related deficiencies.

3.6 ALTERNATIVES

No Action: The “No Action” alternative is not considered a viable option due to the observed safety deficiencies at the dam in relation to its “High” hazard classification. Failure to address the identified deficiencies would be a violation of Massachusetts Law (G.L c. 253, § 44-49 as amended by Chapter 330 of the Acts of 2002) and Massachusetts regulations (302 CMR 10.00) which require an Owner to properly maintain their dam such that it meets minimum dam safety standards. Failure to correct the dam safety deficiencies identified at the Charles River Dam could endanger downstream public safety and property.

Dam Breach: Breaching or removing the dam in a controlled and engineered manner would eliminate the failure induced flooding threat to downstream public safety posed by an uncontrolled release of the impoundment.
Removal would serve to restore the natural riverine condition along this section of the Charles. The Town is presently seriously considering removal of the dam. GZA has performed a dam breach feasibility study for removal which would likely include breaching the primary spillway. During our studies, GZA performed sampling and environmental chemistry analyses of the upstream sediment. Based on the laboratory results of the sediment samples collected at the Site and comparison to the standards and guidance values developed by the DER, it does not appear that contaminant levels of the sediment would be an impediment to dam removal. The Town continues the process of reviewing options to rehabilitate or remove the dam.

### 3.7 OPINION OF PROBABLE CONSTRUCTION COSTS

<table>
<thead>
<tr>
<th>Study Item</th>
<th>Conceptual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare a formal Operations &amp; Maintenance Plan</td>
<td>$6,000</td>
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<tr>
<td>Continue review of the Emergency Action Plan (EAP) and update contact</td>
<td>See Note 1</td>
</tr>
<tr>
<td>names/numbers, etc.,</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$6,000</strong></td>
</tr>
<tr>
<td><strong>Minor Repairs and Remedial Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Clear trees and woody vegetation from the embankments, crest and</td>
<td>$80,000 - $150,000</td>
</tr>
<tr>
<td>downstream toe area. Additionally remove all roots/root balls</td>
<td></td>
</tr>
<tr>
<td>associated with trees and vegetation and backfill resulting voids</td>
<td></td>
</tr>
<tr>
<td>with compacted sand/gravel.</td>
<td></td>
</tr>
<tr>
<td>Re-surface the upstream embankment with stone rip-rap protection.</td>
<td>$220,000 - $300,000</td>
</tr>
<tr>
<td>Re-grade the downstream embankment to a uniform 3H:1V slope. Place</td>
<td>$200,000 - $350,000</td>
</tr>
<tr>
<td>proprietary turf reinforcement matting over the crest and downstream</td>
<td></td>
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<tr>
<td>slope to address potential for crest overtopping via wave action and</td>
<td></td>
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<tr>
<td>erosion of the downstream slope via high backwater conditions.</td>
<td></td>
</tr>
<tr>
<td>Execute a full gate replacement coupled with appropriate re-configuration</td>
<td>$650,000 - $750,000</td>
</tr>
<tr>
<td>/restoration of the concrete superstructure surrounding the gate</td>
<td></td>
</tr>
<tr>
<td>openings is recommended.</td>
<td></td>
</tr>
<tr>
<td>Repair/re-build the upstream and downstream training wall areas which</td>
<td>$550,000 - $500,000</td>
</tr>
<tr>
<td>deteriorated concrete, missing stones/mortar and related deficiencies.</td>
<td></td>
</tr>
<tr>
<td>Engineering and Permitting</td>
<td>$100,000 - $150,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>~$1,800,000 - $2,200,000</strong></td>
</tr>
</tbody>
</table>

**Notes:**

1. EAP last thoroughly reviewed by GZA in 2017, therefore no budget carried for this item.
2. Cost estimate information presented above is for comparative, or general planning purposes and includes a 20 percent allowance for contingencies. The estimate may involve approximate quantity evaluations and is not sufficiently accurate to develop construction bids, or to predict the actual cost of work. Further, since GZA has no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated above. A more detailed cost estimate would typically be developed by the design engineer during the design as the specific scope of construction services is clarified.
NOTE:
BASEMAP ADAPTED FROM USA TOPO MAPS USING ArcGIS AUTOCAD PLUGIN
NOTE:
BASEMAP ADAPTED FROM USA TOPO MAPS USING ArcGIS AUTOCAD PLUGIN
CHARLES RIVER (IMPACTIONMENT)

TOWN OF NATICK
13 E. CENTRAL STREET
NATICK, MA 01760
APPENDIX A – LIMITATIONS
DAM ENGINEERING REPORT LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of The Town of Natick (Client) for the stated purpose(s) and location(s) identified in the Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party’s sole risk, and without any liability to GZA.

Standard of Care

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. Our services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. If presented, the generalized soil profile(s) and description, along with the conclusions and recommendations provided in our Report, are based in part on widely-spaced subsurface explorations by GZA and/or others, with a limited number of soil and/or rock samples and groundwater /piezometers data and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then appear evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

5. Water level readings have been made in test holes (as described in the Report), monitoring wells and piezometers, at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the groundwater and piezometer levels, however, occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, reservoir and tailwater levels, the presence of subsurface utilities, and/or natural or artificially induced perturbations.

General

6. The observations described in this report were made under the conditions stated therein. The conclusions presented were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the Client.

7. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein available to GZA at the time of the evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.
8. Any GZA hydrologic analysis presented herein is for the rainfall volumes and distributions stated herein. For storm conditions other than those analyzed, the response of the site’s spillway, impoundment, and drainage network has not been evaluated.

9. Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the structure or site, or to structures on the site was unavailable or limited, GZA renders no opinion as to the condition of that portion of the site or structure. In particular, it is noted that water levels in the impoundment and elsewhere and/or flow over the spillway may have limited GZA’s ability to make observations of underwater portions of the structure. Excessive vegetation, when present, also inhibits observations.

10. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. 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 inspection and care can there be any chance that unsafe conditions be detected.

Compliance with Codes and Regulations

11. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

12. This scope of work does not include an assessment of the need for fences, gates, no-trespassing signs, boat/swimmer barriers, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

Cost Estimates

13. Unless otherwise stated, our cost estimates are for comparative, or general planning purposes. These estimates may involve approximate quantity evaluations and may not be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

14. It is recommended that GZA be retained to provide services during any future: site observations, explorations, evaluations, design, implementation activities, construction and/or implementation of remedial measures recommended in this Report. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.
APPENDIX B – PHOTOGRAPHS
Photo 1: Top of embankment from right abutment.

Photo 2: Upstream slope of embankment from right abutment.
Photo 3: Overview of Charles River Dam impoundment.

Photo 4: Blocked outlet at downstream right side of embankment. Note some leakage.
Photo 5: Leakage from blocked outlet at right side of embankment.

Photo 6: Downstream slope of dam. Note flow from leakage through blocked outlet.
**Photo 7:** Fallen tree near downstream toe of embankment.

**Photo 8:** Top, upstream side of embankment near spillway. Note trees near walls.
Photo 9: Overview of primary spillway, fishway, and low-level outlet.

Photo 10: Downstream masonry walls of embankment portion of dam. Note trees.
Photo 11: Area of river between dam spillway and Pleasant Street Bridge.

Photo 12: Flow over primary spillway from right training wall.
Photo 13: Gate Operators.

Photo 14: Missing stones from right, downstream training wall.
Photo 15: Right downstream spillway training wall.

Photo 16: Upstream masonry wall for embankment portion of dam.
Photo 17: Downstream side of low-level outlet structure. Note spalling concrete.

Photo 18: Upstream side of low-level outlet structure and operators.
Photo 19: Backwatered area along the embankment toe.

Photo 20: Masonry wall to left of spillway. Note woody vegetation.
Photo 21: Left downstream masonry wall. Note missing boulders and mortar.

Photo 22: Primary spillway from left abutment.

Photo 24: Vegetation to left upstream side of spillway.
<table>
<thead>
<tr>
<th><strong>NAME OF DAM:</strong></th>
<th>Charles River Dam at South Natick</th>
<th><strong>STATE ID #:</strong></th>
<th>4-9-198-1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REGISTERED:</strong></td>
<td>☑ YES ☐ NO</td>
<td><strong>NID ID #:</strong></td>
<td>MA00341</td>
</tr>
<tr>
<td><strong>STATE SIZE CLASSIFICATION:</strong></td>
<td>Intermediate</td>
<td><strong>STATE HAZARD CLASSIFICATION:</strong></td>
<td>High</td>
</tr>
<tr>
<td><strong>CHANGE IN HAZARD CLASSIFICATION REQUESTED?:</strong></td>
<td>No</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DAM LOCATION INFORMATION**

<table>
<thead>
<tr>
<th><strong>CITY/TOWN:</strong></th>
<th>Natick</th>
<th><strong>COUNTY:</strong></th>
<th>Middlesex</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DAM LOCATION:</strong></td>
<td>South Natick near Pleasant Street</td>
<td><strong>ALTERNATE DAM NAME:</strong></td>
<td>South Natick Dam</td>
</tr>
<tr>
<td><strong>(street address if known)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>USGS QUAD.:</strong></td>
<td>Framingham</td>
<td><strong>LAT.:</strong></td>
<td>42.271555</td>
</tr>
<tr>
<td><strong>LONG.:</strong></td>
<td>-71.315818</td>
<td><strong>DRAINAGE BASIN:</strong></td>
<td>Charles</td>
</tr>
<tr>
<td><strong>RIVER:</strong></td>
<td>Charles River</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IMPOUNDMENT NAME(S):</strong></td>
<td>Charles River</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL DAM INFORMATION**

| **TYPE OF DAM:** | Earth embankment with concrete gravity R-O-R SW | **OVERALL LENGTH (FT):** | 300 |
| **PURPOSE OF DAM:** | Recreation | **NORMAL POOL STORAGE (ACRE-FT):** | 220 |
| **YEAR BUILT:** | ~1934 (rebuilt) | **MAXIMUM POOL STORAGE (ACRE-FT):** | ~500 |
| **STRUCTURAL HEIGHT (FT):** | 14 | **EL. NORMAL POOL (FT):** | 110.6 |
| **HYDRAULIC HEIGHT (FT):** | 7 | **EL. MAXIMUM POOL (FT):** | ~116.0 |

**FOR INTERNAL MADCR USE ONLY**

| **FOLLOW-UP INSPECTION REQUIRED:** | ☐ YES ☐ NO | **CONDITIONAL LETTER:** | ☐ YES ☐ NO |
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1

**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

**DATE OF INSPECTION:** December 3, 2021  
**DATE OF PREVIOUS INSPECTION:** October 13, 2017

**TEMPERATURE/WEATHER:** 45°  
**ARMY CORPS PHASE I:** NO

**CONSULTANT:** GZA GeoEnvironmental, Inc.  
**PREVIOUS DCR PHASE I:** YES

**BENCHMARK/DATUM:** Chisel square east abutment wall over Charles River - 69.2' from east end (RM1). Elevation = 119.64'

**OVERALL PHYSICAL CONDITION OF DAM:** POOR  
**DATE OF LAST REHABILITATION:** 1934

**SPILLWAY CAPACITY:** >100% SDF w/ no actions by Caretaker

**EL. POOL DURING INSPE.:** 111.1± (~6 inches over SW crest)  
**EL. TAILWATER DURING INSPE.:** 104±

**PERSONS PRESENT AT INSPECTION**

<table>
<thead>
<tr>
<th>NAME</th>
<th>TITLE/POSITION</th>
<th>REPRESENTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derek J. Schipper, P.E.</td>
<td>Senior Consultant</td>
<td>GZA GeoEnvironmental, Inc.</td>
</tr>
<tr>
<td>Firas Rababaa</td>
<td>Engineer I</td>
<td>GZA GeoEnvironmental, Inc.</td>
</tr>
</tbody>
</table>

**EVALUATION INFORMATION**

<table>
<thead>
<tr>
<th>E1) TYPE OF DESIGN</th>
<th>4</th>
<th>E8) LOW-LEVEL OUTLET CONDITION</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2) LEVEL OF MAINTENANCE</td>
<td>3</td>
<td>E9) SPILLWAY DESIGN FLOOD CAPACITY</td>
<td>5</td>
</tr>
<tr>
<td>E3) EMERGENCY ACTION PLAN</td>
<td>4</td>
<td>E10) OVERALL PHYSICAL CONDITION</td>
<td>2</td>
</tr>
<tr>
<td>E4) EMBANKMENT SEEPAGE</td>
<td>5</td>
<td>E11) ESTIMATED REPAIR COST</td>
<td>1,800K to 2,200K</td>
</tr>
<tr>
<td>E5) EMBANKMENT CONDITION</td>
<td>2</td>
<td>ROADWAY OVER CREST</td>
<td>NO</td>
</tr>
<tr>
<td>E6) CONCRETE CONDITION</td>
<td>3</td>
<td>BRIDGE NEAR DAM</td>
<td>NO</td>
</tr>
<tr>
<td>E7) LOW-LEVEL OUTLET CAPACITY</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NAME OF INSPECTING ENGINEER:** Derek J. Schipper, P.E.  
**SIGNATURE:** [Signature]
| **NAME OF DAM:** Charles River Dam at South Natick | **STATE ID #:** 4-9-198-1 |
| **INSPECTION DATE:** December 3, 2021 | **NID ID #:** MA00341 |
| **OWNER:** | **ORGANIZATION:** Town of Natick |
| **NAME/TITLE:** | **NAME/TITLE:** Department of Public Works |
| **STREET:** 75 West Street | **STREET:** 75 West Street |
| **TOWN, STATE, ZIP:** Natick, MA 01760 | **TOWN, STATE, ZIP:** Natick, MA 01760 |
| **PHONE:** 508-647-6551 | **PHONE:** 508-647-6551 |
| **EMERGENCY PH. #:** 508-647-6550 | **EMERGENCY PH. #:** 508-647-6550 |
| **FAX:** 508-647-6560 | **FAX:** 508-647-6560 |
| **EMAIL:** wmcdowell@natickma.org | **EMAIL:** wmcdowell@natickma.org |
| **OWNER TYPE:** Municipality or Political subdivision | **OWNER TYPE:** Municipality or Political subdivision |

**PRIMARY SPILLWAY TYPE:** Concrete gravity ogee weir (slightly curved in upstream direction).

| **SPILLWAY LENGTH (FT):** 130 | **SPILLWAY CAPACITY (CFS):** 5,870 |
| **AUXILIARY SPILLWAY TYPE:** n/a | **AUX. SPILLWAY CAPACITY (CFS):** n/a |
| **NUMBER OF OUTLETS:** 2 | **OUTLET(S) CAPACITY (CFS):** unknown |
| **TYPE OF OUTLETS:** 4’ x 6’ slide gates | **TOTAL DISCHARGE CAPACITY (CFS):** 5,870 |
| **DRAINAGE AREA (SQ MI):** 165± | **SPILLWAY DESIGN FLOOD (PERIOD/CFS):** 500 YR. / 6,000 (2009 IDA) |

**HAS DAM BEEN BREACHED OR OVERTOPPED:** ☑️ NO ☐ YES **IF YES, PROVIDE DATE(S):**

**FISH LADDER (LIST TYPE IF PRESENT):** Yes; concrete Denil type; no longer operational.

**DOES CREST SUPPORT PUBLIC ROAD?:** ☑️ NO ☐ YES **IF YES, ROAD NAME:**

**PUBLIC BRIDGE WITHIN 50’ OF DAM?:** ☑️ NO ☐ YES **IF YES, ROAD/BRIDGE NAME: Pleasant Street Bridge ~ 170’ downstream.**

**MHD BRIDGE NO. (IF APPLICABLE):**
NAME OF DAM: Charles River Dam at South Natick  
STATE ID #: 4-9-198-1  
INSPECTION DATE: December 3, 2021  
NID ID #: MA00341  

**EMBANKMENT (CREST)**

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
<th>NA</th>
<th>ACTION</th>
<th>MONITOR</th>
<th>REPAIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREST</td>
<td>1. SURFACE TYPE</td>
<td>Earth with eroded footpath from visitors, some grass with exposed tree roots</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. SURFACE CRACKING</td>
<td>None observed</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. SINKHOLES, ANIMAL BURROWS</td>
<td>None observed</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. VERTICAL ALIGNMENT (DEPRESSIONS)</td>
<td>Uneven surface</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. HORIZONTAL ALIGNMENT</td>
<td>Adequate</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>6. RUTS AND/OR PUDDLES</td>
<td>Minor rutting/eroded zones observed due to pedestrians and exposed tree roots.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. GRASS COVER CONDITION</td>
<td>No maintained grass surface.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. WOODY VEGETATION (TREES/BRUSH)</td>
<td>Numerous trees and woody vegetation throughout embankment.</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. ABUTMENT CONTACT</td>
<td>Good. Natural river channel/wooded area on right. Landscaped park area at left.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ADDITIONAL COMMENTS: (1) Earth embankment (approx 300-feet-long) on right side. Left abutment consists of stone masonry wall at left edge of spillway.  
(2) Presence of heavy vegetative overgrowth throughout embankment obscured close inspection.
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1  
**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

### EMBANKMENT (D/S SLOPE)

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WET AREAS (NO FLOW)</td>
<td>Backwater due to flow restriction at Pleasant Street Bridge.</td>
<td>X</td>
</tr>
<tr>
<td>2. SEEPAGE</td>
<td>Minor leakage through former outlet at right side of abutment (~1 gal per minute)</td>
<td>X</td>
</tr>
<tr>
<td>3. SLIDE, SLOUGH, SCARP</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td>4. EMB.-ABUTMENT CONTACT</td>
<td>Abutment contact appeared in good condition.</td>
<td>X</td>
</tr>
<tr>
<td>5. SINKHOLE/ANIMAL BURROWS</td>
<td>Leaf litter and overgrown brush obscured the inspection of sinkholes/animal burrows (2)</td>
<td>X</td>
</tr>
<tr>
<td>6. EROSION</td>
<td>Minor erosion and wear due to pedestrian traffic</td>
<td>X</td>
</tr>
<tr>
<td>7. UNUSUAL MOVEMENT</td>
<td>None Observed</td>
<td>X</td>
</tr>
<tr>
<td>8. GRASS COVER CONDITION</td>
<td>No maintained grass surface.</td>
<td>X</td>
</tr>
<tr>
<td>9. WOODY VEGETATION (TREES/BRUSH)</td>
<td>Large trees and woody vegetation throughout embankment. (1)</td>
<td>X</td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**  
(1) The left side of a double hemlock tree snapped at the base and has fallen in the downstream direction.
NAME OF DAM: Charles River Dam at South Natick  
STATE ID #: 4-9-198-1

INSPECTION DATE: December 3, 2021  
NID ID #: MA00341

### EMBANKMENT (U/S SLOPE)

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/S SLOPE</td>
<td>1. SLIDE, SLOUGH, SCARP</td>
<td>Heavy vegetation and leaf litter obscured the inspection. (1)</td>
</tr>
<tr>
<td></td>
<td>2. SLOPE PROTECTION TYPE AND COND.</td>
<td>Little slope protection in place. Upstream slope partially eroded.</td>
</tr>
<tr>
<td></td>
<td>3. SINKHOLE/ANIMAL BURROWS</td>
<td>Heavy leaf litter and vegetation obscured observation. Some small rodent holes observed</td>
</tr>
<tr>
<td></td>
<td>4. EMB.-ABUTMENT CONTACT</td>
<td>Abutment contact appeared adequate</td>
</tr>
<tr>
<td></td>
<td>5. EROSION</td>
<td>Minor erosion due to foot traffic.</td>
</tr>
<tr>
<td></td>
<td>6. UNUSUAL MOVEMENT</td>
<td>None Observed</td>
</tr>
<tr>
<td></td>
<td>7. GRASS COVER CONDITION</td>
<td>No maintained grass surface.</td>
</tr>
<tr>
<td></td>
<td>8. WOODY VEGETATION (TREES/BRUSH)</td>
<td>Large trees and woody vegetation throughout embankment.</td>
</tr>
</tbody>
</table>

ADDITIONAL COMMENTS: (1) Minor to moderate scarps observed during previous dam inspections.
### AREA INSPECTED

<table>
<thead>
<tr>
<th>INSTR.</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
<th>ACTION</th>
<th>MONITOR</th>
<th>REPAIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PIEZOMETERS</td>
<td>One open standpipe piezometer was installed as part of GZA's 2009 Phase II study.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. OBSERVATION WELLS</td>
<td>Three observation wells were installed as part of GZA's 2009 Phase II study.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. STAFF GAGE AND RECORDER</td>
<td>None observed.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. WEIRS</td>
<td>None observed.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. INCLINOMETERS</td>
<td>None observed.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. SURVEY MONUMENTS</td>
<td>None observed.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. DRAINS</td>
<td>None observed.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. FREQUENCY OF READINGS</td>
<td>Periodically. Not taken this inspection.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. LOCATION OF READINGS</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ADDITIONAL COMMENTS:
Open standpipe piezometer is within GZ-2. Observation well above piezometer in GZ-2.; one each also in GZ-1 and GZ-3. Refer to the field sketch for approximate plan locations.
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1  
**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

### DOWNSTREAM AREA

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/S AREA</td>
<td>1. ABUTMENT LEAKAGE</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>2. FOUNDATION SEEPAGE</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>3. SLIDE, SLOUGH, SCARP</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>4. WEIRS</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>5. DRAINAGE SYSTEM</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>6. INSTRUMENTATION</td>
<td>None Observed.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>7. VEGETATION WITHIN 15 FT</td>
<td>heavy vegetation and bush</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>8. ACCESSIBILITY</td>
<td>Dam is accessed through park area from the right abutment, left and right sides of spillway used as parks</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>9. DOWNSTREAM HAZARD DESCRIPTION</td>
<td>Residential structures and public roads/bridges located downstream of dam/spillway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Date of Last EAP Update</td>
<td>2017</td>
<td></td>
</tr>
</tbody>
</table>

### ADDITIONAL COMMENTS:
Downstream area beyond spillway channel is normally under water at this run-of-the-river dam spillway. Geometry of downstream channel is such that water, particularly during periods of high flow, pools along the downstream area and up over the toe of the earthen embankment portion. This backwater condition may contribute to the unevenness of the downstream embankment.
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1  
**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

### MISCELLANEOUS

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RESERVOIR DEPTH (AVG)</td>
<td>Depth varies but generally but generally less than 10 feet deep based on GZA bathymetric survey.</td>
<td></td>
</tr>
<tr>
<td>2. RESERVOIR SHORELINE</td>
<td>Residential development with wooded area along east and west shoreline</td>
<td></td>
</tr>
<tr>
<td>3. RESERVOIR SLOPES</td>
<td>Moderate grass slopes</td>
<td></td>
</tr>
<tr>
<td>4. ACCESS ROADS</td>
<td>Dam is accessed through park area from Pleasant St S</td>
<td></td>
</tr>
<tr>
<td>5. SECURITY DEVICES</td>
<td>None observed</td>
<td></td>
</tr>
<tr>
<td>6. WATER PUBLIC HAZARDS &amp; PROTECTION</td>
<td>Railing near both spillway abutments covering short portion of impoundment (1)</td>
<td></td>
</tr>
<tr>
<td>7. LAND-SIDE PUBLIC HAZARDS &amp; PROTECTION</td>
<td>None observed (2)</td>
<td></td>
</tr>
<tr>
<td>7. VANDALISM OR TRESPASS</td>
<td>![YES][1] ![NO][2]</td>
<td>WHAT:</td>
</tr>
<tr>
<td>8. AVAILABILITY OF PLANS</td>
<td>![YES][3] ![NO][2]</td>
<td>DATE: Limited (3)</td>
</tr>
<tr>
<td>9. AVAILABILITY OF DESIGN CALCS</td>
<td>![YES][3] ![NO][2]</td>
<td>DATE:</td>
</tr>
<tr>
<td>11. AVAILABILITY OF O&amp;M MANUAL</td>
<td>![YES][3] ![NO][2]</td>
<td>DATE:</td>
</tr>
<tr>
<td>12. CARETAKER/OWNER AVAILABLE</td>
<td>![YES][3] ![NO][2]</td>
<td>DATE: Not present during inspection</td>
</tr>
<tr>
<td>13. CONFINED SPACE ENTRY REQUIRED</td>
<td>![YES][3] ![NO][2]</td>
<td>PURPOSE:</td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**  
(1) Iron railing should be extended to the upstream and downstream end to provide additional safety from river/spillway portions. Damaged portions of railings near left abutment should be replaced. Install warning buoy to deter boats/canoes approaching spillway.  
(2) Consider installing signage with instructions and guidelines for dam visitors.  
(3) GZA reviewed a limited number of design drawings (circa 1934) during our 2009 Phase II evaluation.
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1  
**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

---

**PRIMARY SPILLWAY**

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPILLWAY TYPE</td>
<td>Uncontrolled, arch shaped concrete weir.</td>
<td>X</td>
</tr>
<tr>
<td>WEIR TYPE</td>
<td>Ogee style.</td>
<td>X</td>
</tr>
<tr>
<td>SPILLWAY CONDITION</td>
<td>Flow over spillway (~ 6 in) obscured observation (1)</td>
<td>X</td>
</tr>
<tr>
<td>TRAINING WALLS</td>
<td>Mortared stone masonry, generally in fair condition. (2)</td>
<td>X</td>
</tr>
<tr>
<td>SPILLWAY CONTROLS AND CONDITION</td>
<td>Uncontrolled</td>
<td></td>
</tr>
<tr>
<td>UNUSUAL MOVEMENT</td>
<td>None Observed</td>
<td>X</td>
</tr>
<tr>
<td>APPROACH AREA</td>
<td>River area generally free of debris/waste</td>
<td>X</td>
</tr>
<tr>
<td>DISCHARGE AREA</td>
<td>Heavily vegetated island located downstream of spillway.</td>
<td>X</td>
</tr>
<tr>
<td>DEBRIS</td>
<td>Dead tree log observed stuck on spillway downstream face. Remove dead logs to avoid obstructing flow over the spillway</td>
<td>X</td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**  
(1) Previous diving inspection in 2009 indicated that condition of concrete above the mudline was satisfactory. Sediment, tree waste, and debris submerged beneath the waterline on upstream side.  
(2) Deteriorated concrete and missing boulders at waterline on left and right downstream sides of spillway discharge channel. Low stone walls on right and left sides missing stones in localized areas. Missing stones from downstream left training wall segment appeared similar to 2017 inspection. Low stone wall on right side also has a slight lean towards the river.
**NAME OF DAM:** Charles River Dam at South Natick  
**STATE ID #:** 4-9-198-1

**INSPECTION DATE:** December 3, 2021  
**NID ID #:** MA00341

### AUXILIARY SPILLWAY

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPILLWAY</strong></td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>SPILLWAY TYPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEIR TYPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPILLWAY CONDITION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRAINING WALLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPILLWAY CONTROLS AND CONDITION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNUSUAL MOVEMENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPROACH AREA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISCHARGE AREA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEBRIS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**

---

Dam Safety Inspection Checklist v.3.1
**NAME OF DAM:** Charles River Dam at South Natick  

**STATE ID #:** 4-9-198-1  

**INSPCTION DATE:** December 3, 2021  

**NID ID #:** MA00341

---

### OUTLET WORKS

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE</strong></td>
<td>Two 4’x6’ steel slide gates at right side of spillway.</td>
<td>X</td>
</tr>
<tr>
<td><strong>INTAKE STRUCTURE</strong></td>
<td>Concrete structure observed in fair condition with some rusty walls and spalls (1)</td>
<td>X</td>
</tr>
<tr>
<td><strong>TRASHRACK</strong></td>
<td>None Observed</td>
<td></td>
</tr>
<tr>
<td><strong>PRIMARY CLOSURE</strong></td>
<td>Rodney Hunt spigot-type slide gates (circa 1934) on concrete platform. (2)</td>
<td>X</td>
</tr>
<tr>
<td><strong>SECONDARY CLOSURE</strong></td>
<td>None Observed</td>
<td></td>
</tr>
<tr>
<td><strong>CONDUIT</strong></td>
<td>None Observed</td>
<td>X</td>
</tr>
<tr>
<td><strong>OUTLET STRUCTURE/HEADWALL</strong></td>
<td>Same as intake concrete structure in fair/poor condition.</td>
<td>X</td>
</tr>
<tr>
<td><strong>EROSION ALONG TOE OF DAM</strong></td>
<td>Flow obscured observations</td>
<td>X</td>
</tr>
<tr>
<td><strong>SEEPAGE/LEAKAGE</strong></td>
<td>None observed</td>
<td>X</td>
</tr>
<tr>
<td><strong>DEBRIS/BLOCKAGE</strong></td>
<td>Minor debris floating on gates downstream face</td>
<td>X</td>
</tr>
<tr>
<td><strong>UNUSUAL MOVEMENT</strong></td>
<td>None Observed</td>
<td>X</td>
</tr>
<tr>
<td><strong>DOWNSTREAM AREA</strong></td>
<td>Clear of debris/waste</td>
<td>X</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**ADDITIONAL COMMENTS:**  

(1) Gate guides on the upstream side showed rusting and are in fair/poor condition.  

(2) Gate operators have been painted and Brass stems on gates appeared in good conditions. The gates were not operated during this inspection. No wheel/crank arm was present during the inspection. Homemade crank wheel is available at DPW.  

Right gate raised slightly in 2008 via portable crank arm on right operator to confirm stem operability. As part of 2009 Phase II
<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
<th>NO ACTION</th>
<th>MONITOR</th>
<th>REPAIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREST</td>
<td></td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TYPE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SURFACE CONDITIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONDITIONS OF JOINTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNUSUAL MOVEMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HORIZONTAL ALIGNMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VERTICAL ALIGNMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ADDITIONAL COMMENTS:

---

NAME OF DAM: Charles River Dam at South Natick
STATE ID #: 4-9-198-1
INSPECTION DATE: December 3, 2021
NID ID #: MA00341

CONCRETE/MASONRY DAMS (CREST)
NAME OF DAM: Charles River Dam at South Natick  
STATE ID #: 4-9-198-1  
INSPECTION DATE: December 3, 2021  
NID ID #: MA00341

**DOWNSTREAM MASONRY SPILLWAY TRAINING WALLS**

<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/S WALLS</td>
<td>WALL TYPE</td>
<td>Mortared stone masonry along right and left sides from spillway down to the Pleasant St. road crossing some 170 feet downstream.</td>
</tr>
<tr>
<td></td>
<td>WALL ALIGNMENT</td>
<td>Minor to moderate loss of ground behind length of low wall along the right side. (1)</td>
</tr>
<tr>
<td></td>
<td>WALL CONDITION</td>
<td>Fair. Some missing stones and mortar particularly at waterline. (2)</td>
</tr>
<tr>
<td></td>
<td>HEIGHT: TOP OF WALL TO MUDLINE</td>
<td>min:</td>
</tr>
<tr>
<td></td>
<td>SEEPAGE OR LEAKAGE</td>
<td>None observed.</td>
</tr>
<tr>
<td></td>
<td>ABUTMENT CONTACT</td>
<td>Adequate.</td>
</tr>
<tr>
<td></td>
<td>EROSION/SINKHOLES BEHIND WALL</td>
<td>Aforementioned loss of ground behind portions of wall, likely due to past flooding during which water level in discharge channel overtops training walls. No significant change since last inspection.</td>
</tr>
<tr>
<td></td>
<td>ANIMAL BURROWS</td>
<td>None observed.</td>
</tr>
<tr>
<td></td>
<td>UNUSUAL MOVEMENT</td>
<td>Wall portions particularly low wall on right side lean toward the River.</td>
</tr>
<tr>
<td></td>
<td>WET AREAS AT TOE OF WALL</td>
<td>Base of walls are submerged as they define the discharge channel geometry.</td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**

1. Left side generally even with localized loss of ground and missing stones. Alignment generally good.  
2. Right wall in generally similar condition to 2017 inspection. Localized displacement of stones at left training wall. Some erosion at back of wall due to pedestrian foot traffic, about 20 feet downstream of high/low transition. Loss of stone and loss of ground at some locations between 6 and 12 inches deep. Approximately 60 ft. downstream of high/low transition, a 1/2" wide crack at training wall with 12" square by 6" deep depression.
<table>
<thead>
<tr>
<th>AREA INSPECTED</th>
<th>CONDITION</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALL TYPE</td>
<td>Mortared stone masonry at right side of spillway in good condition. (1)</td>
<td>X</td>
</tr>
<tr>
<td>WALL ALIGNMENT</td>
<td>Right side good; Left side slightly uneven due to presence of past tree growth through stone.</td>
<td>X</td>
</tr>
<tr>
<td>WALL CONDITION</td>
<td>Right side good; left side at spillway fair with some deteriorated mortar, unevenness and tree presence; low training portion upstream of spillway fair to poor (1).</td>
<td>X</td>
</tr>
<tr>
<td>HEIGHT: TOP OF WALL TO MUDLINE</td>
<td>min: 2.5 feet max: 4.5 feet avg: 3.5 feet ±</td>
<td>X</td>
</tr>
<tr>
<td>ABUTMENT CONTACT</td>
<td>Adequate.</td>
<td>X</td>
</tr>
<tr>
<td>EROSION/SINKHOLES BEHIND WALL</td>
<td>None observed on right side; minor loss of ground on backside of low training wall portion along left side upstream of spillway (2).</td>
<td>X</td>
</tr>
<tr>
<td>ANIMAL BURROWS</td>
<td>None observed.</td>
<td>X</td>
</tr>
<tr>
<td>UNUSUAL MOVEMENT</td>
<td>Low (cast-in-place concrete) training wall upstream of left spillway spalled, cracked, uneven and partially leaning into the river. In need of repairs.</td>
<td>X</td>
</tr>
<tr>
<td>VEGETATION</td>
<td>Small trees and brush growing from masonry wall just upstream of spillway.</td>
<td>X</td>
</tr>
</tbody>
</table>

**ADDITIONAL COMMENTS:**

1. Mortared stone masonry at left side of spillway fair with minor to moderate cracking, loose stone/mortar observed. First 40' top of low left wall section separated from curb up to 4.5". Low training walls upstream of left spillway training wall consists of cracked, spalled, mis-aligned sections of deteriorated cast-in-place concrete. Segment (approximately 100 feet) from spillway upstream leaning toward the river moderately to heavily cracked/deteriorating/displaced and in need of repair.

2. Presence of depressions and unevenness in paved walkway behind wall section at spillway indicative of possible underlying minor erosion issue/loss of ground behind/through wall in this area. Concrete wall deteriorated/eroded near waterline.
APPENDIX D – PREVIOUS REPORTS & REFERENCES
PREVIOUS REPORTS AND REFERENCES

The following is a list of reports, drawings and photos that were located during the file review, or were referenced in previous reports.

1. Charles River Dam at South Natick Phase I Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, October 13, 2017.
2. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, September 9, 2015.
3. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, May 23, 2013.
4. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, June 20, 2011.
5. Charles River Dam at South Natick Phase II Dam Safety Engineering Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, October 2009.
6. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, October 2 and 8, 2008.
7. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, September 18, 2006.
8. Series of six drawings by Fay, Spofford & Thorndike, Inc. (FST) depicting proposed major reconstruction of the existing dam at Charles River in Natick, dated 1933 to 1934 obtained from FST archives.
9. Series of eleven photographs supposedly depicting conditions at the dam pre circa 1934 obtained from the Town of Natick Historical Society.
10. Series of ten photographs supposedly depicting conditions at the dam post circa 1934 obtained from the Town of Natick Historical Society.

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

APPENDIX E – DEFINITIONS
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 exist, 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 (and properly documented) 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 failure.


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 (Structural Height) – 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 lowest point on the crest of the dam.

Hydraulic Height – means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

Maximum Water Storage Elevation – means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.

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.

Maximum Storage Capacity – The volume of water contained in the impoundment at maximum water storage elevation.

Normal Storage Capacity – The volume of water contained in the impoundment at normal water storage elevation.

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.

Satisfactory – 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.

* Structural deficiencies include but are not limited to the following:

- Excessive uncontrolled seepage (e.g., upwelling of water, evidence of fines movement, flowing water, erosion, etc.).
- Missing riprap with resulting erosion of slope.
- Sinkholes, particularly behind retaining walls and above outlet pipes, possibly indicating loss of soil due to piping, rather than animal burrows.
- Excessive vegetation and tree growth, particularly if it obscures features of the dam and the dam cannot be fully inspected.
- Deterioration of concrete structures (e.g., exposed rebar, tilted walls, large cracks with or without seepage, excessive spalling, etc.).
- Inoperable outlets (gates and valves that have not been operated for many years or are broken).
APPENDIX F – HISTORIC DOCUMENTATION