May 17, 2023

Rhode Island Department of Environmental Management
Office of Compliance & Inspection Dam Safety Program
235 Promenade Street
Providence, RI 02908-5767

RE: **Hazard Classification Change Request**
**RI04441 Shoestring Mill Pond Dike (648)**
**Scituate, Rhode Island**
(Pare Project No. 14256.42)

RIDEM Dam Safety:

On behalf of our client, the Providence Water Supply Board (PW), Pare Corporation (Pare) has developed this letter report as a formal request to change the hazard classification of Shoestring Mill Pond Dike from Significant to Low. The following letter report and associated attachments provide a summation of the information collected and analyses completed that have led to this hazard classification change determination and this corresponding request.

Included within this letter request are the following five sections:

1. Overview
2. Description of the Dam
3. Hydrologic and Hydraulic Modelling
4. Dam Failure Impact Assessment
5. Conclusions

## *Section 1: Overview*

The Shoestring Mill Pond Dam embankment warrants removal from the state's inventory as a jurisdictional structure. The dam is formally breach at the presumed location of the historic spillway; the breach is sufficiently sized such that differential heads due to constrictions at the location of the embankment do not artificially elevate the level of the stream.

Shoestring Mill Pond Dike warrants reclassification from Significant to Low due to the following reasons:

1. Failure of the dike during normal baseflow conditions results in minimal to low impacts to the downstream area.
    a. The 4.9-foot rise at the Central Avenue crossing results in shallow overtopping of the roadway up to 12 inches in depth; this overtopping is not expected to result in significant impacts to the roadway itself or emergency access use of the roadway.
    b. The 6.0-foot rise at the E Road crossing results in shallow overtopping of the roadway up to 3 inches in depth; this overtopping is not expected to result in significant impacts to the roadway itself or emergency access use of the roadway.

2. Failure of the dike during a 500-year storm event (the assumed spillway design flood – SDF) results in low impacts to the downstream area. Specific impacts include:
    a. The 5.2-foot rise at the Central Avenue crossing results in shallow overtopping of the roadway up to 16 inches in depth; this overtopping is not expected to result in significant impacts to the roadway itself or emergency access use of the roadway.
    b. The 12-inch rise at the E Road crossing results in shallow overtopping of the roadway up to 13 inches in depth; this overtopping is not expected to result in significant incremental impacts to the roadway itself or emergency access use of the roadway.

It should be noted that the dike embankment appears to have been originally constructed to impound a normal pool on the order of 10 or more feet higher than current stream flow conditions; however, given the adequately sized breach in the dam embankment, the site does not currently impound significant volumes of water. During normal conditions, storage is estimated to be near 4 acre-feet with no water impounded at the dam and water depths averaging less than 2 foot upstream of the dike. During the 500-year event, storage is estimated to be near 9 acre feet with depths generally estimated to be less than 3.5 feet. Further, the thickness of the dike embankment at the elevation of the 500-year storm event is on the order of 75 feet, 9 times thicker than industry design guidance[1]; as such, phreatic conditions which would lead to failure of the embankment are improbable.

The following sections provide additional information on the dike, the hydrologic and hydraulic (H&H) analyses completed and dam break modelling that was developed to facilitate the dam failure impact assessment, as well as the results of that assessment.

***Section 2: Description of the Dam***

**Purposes:** The Shoestring Mill Pond Dam and Dike was constructed at some point between 1883 and 1943 (per USGS maps) and was presumably for water supply purposes to support mill activity; the ownership transferred to PW at some point. PW has never utilized or relied upon the impoundment or dam for water supply purposes; the dam and impoundment currently serve no apparent purpose.

**Dam Geometry:** The dam embankment, located at the northern end of the impoundment, is a former embankment that has been fully breached for some time (presumably during one of the three great flood events in past history 1938, 1954, or 1955; however, it appears that formalization of the breach was completed subsequent to the presumed failure event). Visually, and confirmed by this study, the breach is of sufficient size to pass extreme storm events without artificially impounding water to any degree; and therefore, should not be considered a hydraulic control structure. The dike embankment, located at the southern end of the impoundment, is a 400-foot long 23-foot-high earthen embankment.

There is a natural 1- to 1.5-foot-high stone weir located 100 feet upstream of the former dam embankment centerline that creates a shallow impoundment, Shoestring Mill Pond, that has an average water depth of 1.5 feet, a maximum water depth of 5 feet (at the dike), and a storage volume of 4 acre-feet at normal pool (El. 333.8). The storage volume of the impoundment at the 500-year pool level (El. 335.4 per this study) is 9 acre-feet.

The contributing drainage area to the impoundment, dam, and dike is 970 acres (1.52 $mi^2$), of which 1.01$mi^2$ is the drainage area of Pine Swamp Reservoir and 0.51$mi^2$ is from an adjoining but separate drainage area south of the Pine Swamp Drainage Area. This southern drainage area includes several upstream hydraulic structures including a dam/roadway crossing at Peck Hill Road, a dam at Madison

[1] Table 5-1 "Earth Dams and Reservoirs TR-60", United States Department of Agriculture Natural Resources Conservation Services Conservation Engineering Division, July 2005.

Pond, and road crossings at William Henry Road and Central Avenue. The land cover of the drainage area primarily consists of undeveloped woodlands with the exception of some light residential development along William Henry and Peck Hill Road.

**Hazard Class:** Shoestring Mill Pond Dike was originally classified as a Low Hazard dam until a simplified 2008 dam break analysis that resulted in the suggestion to change the hazard classification to Significant.

## *Section 3: Hydrological and Hydraulic (H&H) Modelling*

A H&H model was developed for the dam in support of the dam removal feasibility evaluation that was completed in August 2022. The model and modelling conditions were refined during the development of this request as needed to provide the specific information requested within ACER Technical Memorandum No. 11 "Downstream Hazard Classification Guidelines" developed by the Assistant Commissioner – Engineering and Research, Denver, Colorado, USBR 1988.

The H&H model of existing conditions for the dam includes a HydroCAD model and a two-dimensional HEC-RAS Model of the targeted areas of interest. The HydroCAD Model was used to develop the inflow hydrographs for the HEC-RAS model, while the HEC-RAS model was used to determine the hydraulic conditions expected to occur within the project inundation area.

### 3.1 Hydrological Model

As Shoestring Mill Pond Dam and Dike site was downstream of Pine Swamp, a single model was developed for both sites. The watershed (drainage area) for Pine Swamp Reservoir Dam and shoestring Mill Pond Dam and Dike, and the area downstream of the dam was subdivided into eight sub-basins (7 through 14) and time of concentration ($t_c$); CN was developed from the land cover data set[2] merged with the hydrologic soils group data set[3], while $t_c$ was developed utilizing the segmental/velocity method[4]. Table 1 below provides the hydrological information for each sub-basin:

**Table 1: Drainage Area Parameters**

| *DA ID* | *Name* | *Size (Acres / Square Miles)* | *Imp Area (Acres)* | *% Imp* | *CN[5]* | *LFP (miles)* | *Tc (hrs.)* | *Baseflow (CFS)* |
|---|---|---|---|---|---|---|---|---|
| **7** | **Pine Swamp** | **647/1.01** | **47.4** | **7.32%** | **72** | **1.02** | **9.2** | **2.02** |
| 8 | Peck Hill | 58/0.09 | 0.6 | 0.98% | 59 | 0.41 | 1.6 | 0.18 |
| 9 | Madison Pond | 74/0.12 | 5.4 | 7.26% | 62 | 0.24 | 2.4 | 0.23 |
| 10 | William Henry | 100/0.16 | 7.3 | 7.34% | 58 | 0.43 | 2.6 | 0.31 |
| 11 | Central Avenue | 34/0.05 | 2.9 | 8.43% | 62 | 0.14 | 1.3 | 0.11 |
| 12 | Shoestring | 57/0.09 | 2.9 | 5.09% | 62 | 0.47 | 1.9 | 0.18 |
| | **Shoestring Total** | **970/1.52** | - | - | - | - | - | **1.01** |
| 13 | E Road DS of SS Dam | 44/0.07 | 3.2 | 0.30% | 55 | 0.38 | 1.2 | 0.14 |
| 14 | E Road DS of SS Dike | 93/0.15 | 0.1 | 3.39% | 66 | 0.47 | 1.8 | 0.29 |

Each sub-basin was routed through an impoundment / hydraulic structure with hydraulic information obtained from field data collection, historical information, and available LiDAR terrain data. A total of nine hydraulic structures were included within the model including Pine Swamp Reservoir Dam, Brandy Brook Road, Shoestring Reservoir Dam, E Road downstream of dam, E Road downstream of dike,

[2] 2020 Land Cover/Land Use developed by RIGIS, released on April 1, 2021: https://www.rigis.org/datasets/edc::land-use-and-land-cover-2020/about

[3] 2021 Soils developed by URI Environment Data Center and RIGIS, released on July 29, 2022: https://www.rigis.org/datasets/edc::soils/about

[4] Part 630 Hydrology National Handbook – Chapter 15 Time of Concentration, USDA-NRCS (May 2010)

[5] Average curve number with impervious areas

Central Avenue downstream of dike, Central Avenue, William Henry Road, Madison Pond Dam, and Peck Hill Road.

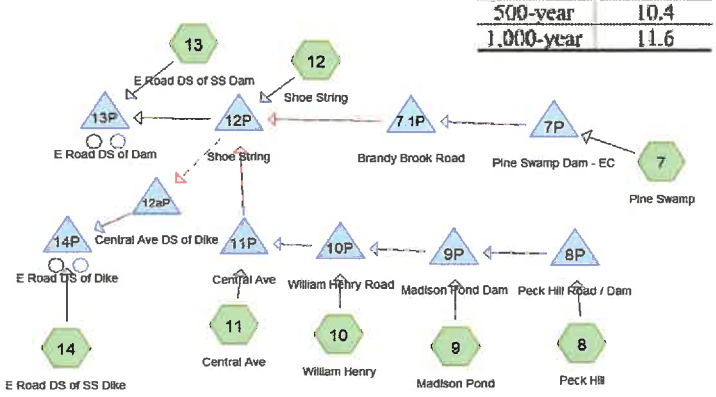
To complete the model inputs, rainfall data (1-year through 1000-year) was obtained from NOAA Atlas 14[6]. Rainfall depth values for all NOAA recurrent storm events are provided in the table to the right.

Table 2: Rainfall

| Storm Event | Depth (in) |
|---|---|
| 1-year | 2.8 |
| 2-year | 3.4 |
| 5-year | 4.3 |
| 10-year | 5.1 |
| 25-year | 6.2 |
| 50-year | 7.0 |
| 100-year | 7.9 |
| 200-year | 8.9 |
| 500-year | 10.4 |
| 1,000-year | 11.6 |

The watershed information, hydraulic structure information, and rainfall data were all combined as inputs into a single H&H model completed utilizing HydroCAD. Th e Soil Conservation Service (SCS) TR-20 "runoff method" was assigned to the model and the Initial Abstraction to Retention Ratio (Ia/S) was set at 0.2. A base unit hydrograph gamma value of 484 (SCS) was used and applied to each drainage area node. A 3-minute time step was used.

The routing diagram of the model is provided below. Each green hexagon (7-14) is a sub-basin while each blue triangle (7P-14P) is an impoundment / hydraulic structure. The hydraulic structure of interest / focus for this analysis is structure #7P that represents the Pine Swamp Reservoir Dam.




The existing conditions hydrologic model served as the baseline for use in the dam failure analysis and hazard class assessment.

### 3.2 HEC-RAS Model

The two-dimensional hydraulic model was developed in HEC-RAS 6.3.0 that extended 7,500 feet upstream of the dam (along the reservoir), and 1,300 feet downstream of the dam to Scituate Reservoir. The model required the development of terrain, land cover data, boundary conditions, two-dimensional mesh, as well as hydraulic structures.

#### 3.2.1 Terrain Development

The model terrain was developed from available LiDAR terrain, the CAD surface generated from the field survey performed in July 2022, and the reservoir area generated from available bathymetry for the Providence Water Small Impoundment Investigation.

#### 3.2.2 Manning's Layer

Land cover data available from MassGIS was used in conjunction with NRCS and ACOE tabulated values of Manning's roughness coefficient (n) values to assign a Manning's n value to the various land covers present in the model. Override regions were then used as needed to improve the accuracy of the land cover data set, particularly along the river channel where the data set was either not identifying the full channel limits or not identifying the channel at all.

[6] NOAA Atlas 14 Rainfall Data https://hdsc.nws.noaa.gov/hdsc/pfds/

### 3.2.3 Mesh

A two-dimensional mesh was developed for the hydraulic model with cell sizes ranging from 5-foot to 60-foot. Small cell sizes (5-foot) were used along roadways and channels. Larger cell sizes (up to 60-foot) were used outside of the main channel and elsewhere.

### 3.2.4 Hydraulic Structures

In total, five hydraulic structures from upstream to downstream were included in the model. The following presents a list of those structures and a description of how they were represented within the model:

**Pine Swamp Reservoir Dam:** Modeled as an embankment.

**Brandy Brook Road (Town owned road):** Modeled as a two-lane roadway with two twin 30-inch diameter concrete pipes.

**Central Avenue (Town owned road):** Modeled as a two-lane roadway with a 2'H x 2'W box culvert.

**East Road (Route 116 – Stated owned road) DS of Dam:** Modeled as a two-lane roadway embankment with 4.5'W x 6.25'H concrete box culvert.

**Central Avenue (DS of Shoestring):** Modeled as a two-lane roadway with 2'W x 1.5'H box culvert.

**East Road (route 116) DS of Dike:** Modeled as a 6'W x 3.6'H concrete arch culvert.

### 3.2.5 Boundary Conditions

Six boundary conditions were included within the model including Pine Swamp inflow, Central Avenue inflow, Shoestring inflow, E Road downstream of Shoestring dike inflow, E Road downstream of dike inflow, a stage hydrograph at Scituate Reservoir, and a normal depth boundary condition for dike seepage.

### 3.2.6 Scenarios

Four scenarios were performed for the purpose of this request including baseflow event, dike failure during baseflow, 500-year event, and dike failure during the 500-year event.

## *Section 4: Dam Failure Impact Assessment*

### 4.1 Sunny Day Dam Failure Impact Assessment

The dam failure analysis revealed that a dike failure during a sunny day event (normal baseflow conditions) is expected to have minimal to low impact within the downstream area. The image on the following page below shows the comparison of the failure (pink) and non-failure (blue) inundation areas during the sunny day event.

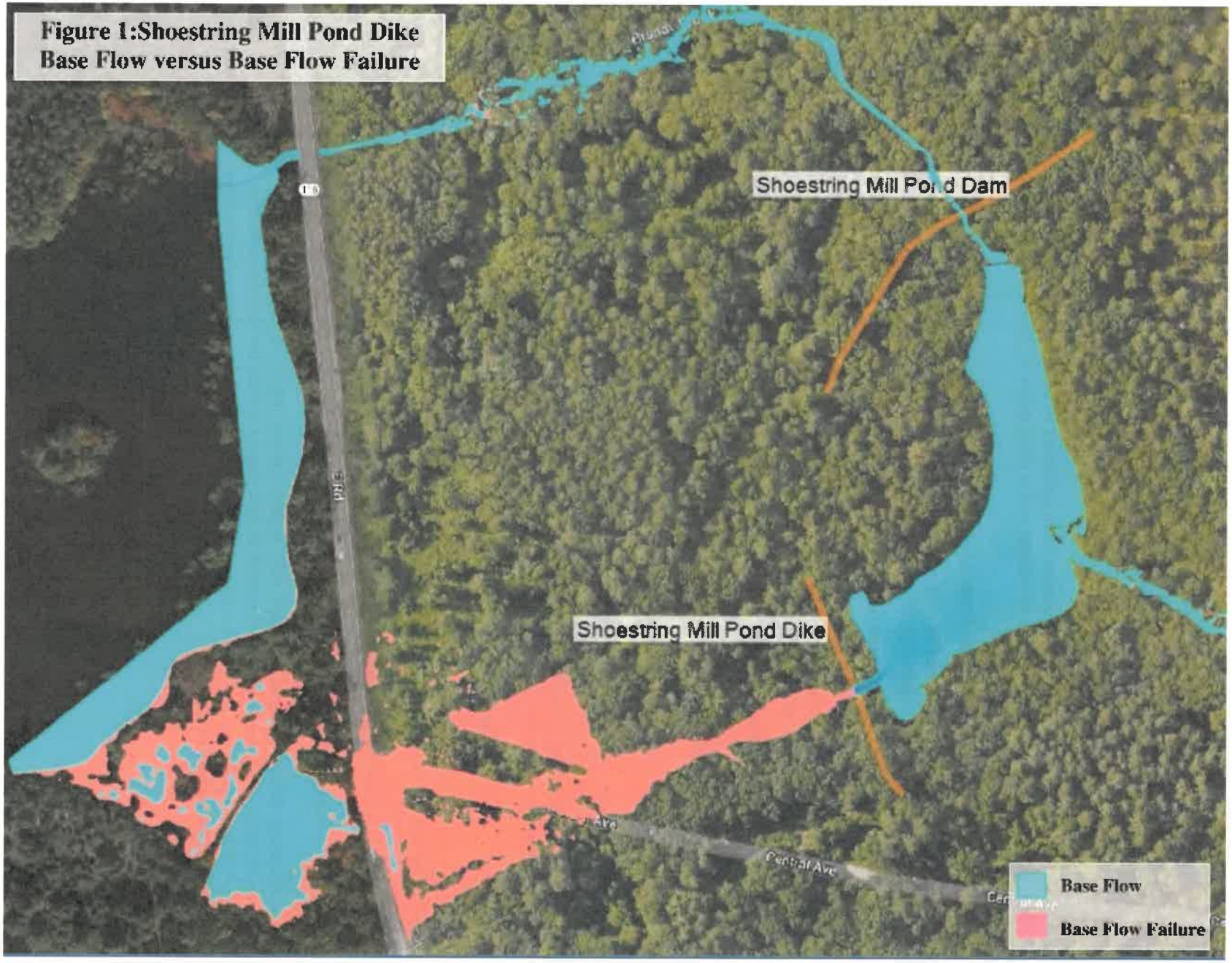


Figure 1:Shoestring Mill Pond Dike
Base Flow versus Base Flow Failure
Shoestring Mill Pond Dam
Shoestring Mill Pond Dike
Base Flow
Base Flow Failure

The following provides a detailed description of the impact assessment at each of the 2 identified crossings including Central Avenue and E Road (Route 116).

a. **Central Avenue:** Dike failure during normal baseflow conditions results in a 4.9-foot rise in river levels upstream of the roadway from El. 306.7 to EL. 311.6. This rise results in shallow overtopping of the roadway up to 12 inches in depth. The velocity of the overtopping flow is generally low to moderate within the footprint of the roadway and along the downstream slope of the roadway (2-6 ft/sec).
   - Overtopping conditions of these depths and velocities fall within the "Low Danger Zone" on ACER TM 11 Figure 4.0; these conditions are unlikely to result in damage to the roadway,
   - The roadway may become impassable during the isolated peak of overtopping, limited to a 20-minute duration; emergency vehicles could likely still pass the roadway at these flood depths.

b. **E Road (Route 116):** Dike failure during normal baseflow conditions results in a 6.0-foot rise in river levels from El. 288.7 to El. 294.7. This results in shallow overtopping of the roadway up to 3 inches in depth. The velocity of the overtopping flow is generally low within the footprint of the roadway and along the downstream slope of the roadway (0.5-2.3 ft/sec).
   - Overtopping conditions of these depths and velocities fall within the "Low Danger Zone" on ACER TM 11 Figure 4.0; these conditions are unlikely to result in damage to the roadway,
   - The roadway may become impassable during the isolated peak of overtopping, limited to a 20-minute duration; emergency vehicles could likely still pass the roadway at these flood depths.

### 4.2 500-year Dam Failure Impact Assessment:

The dam failure analysis revealed that a dike failure during a 500-year event is expected to have low to moderate impacts within the downstream area. The notable impact areas include the Central Avenue crossing and E Road (Route 116). The image on the following page shows the comparison of the failure (pink) and non-failure (blue) inundation areas during the 500-year event.

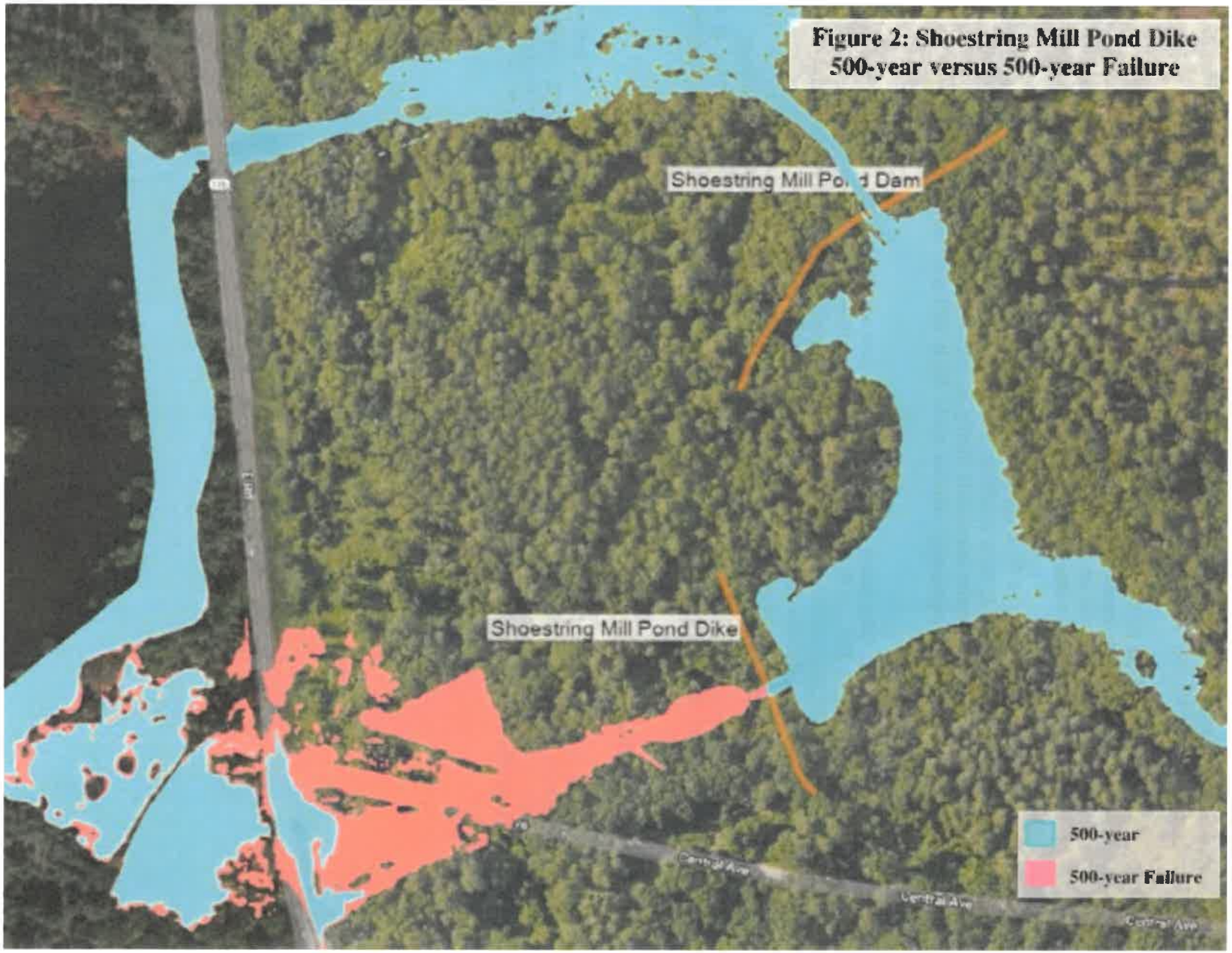


Figure 2: Shoestring Mill Pond Dike
500-year versus 500-year Failure
Shoestring Mill Pond Dam
Shoestring Mill Pond Dike
500-year
500-year Failure

The following provides a detailed description of the impact assessment at each of the 2 identified locations including Central Avenue and E Road (Route 116) stream crossings:

a. **Central Avenue:** Dike failure during the 500-year event results in a 5.2-foot rise in river levels upstream of the roadway from El. 306.7 to EL. 311.9. The rise in river levels results in roadway overtopping up to 16 inches in depth. The velocity of the overtopping flow is generally low within the footprint of the roadway and along the downstream slope of the roadway (2-7 ft/sec).
   - Overtopping conditions of these depths and velocities fall within the "Low Danger Zone" on ACER TM 11 Figure 4.0; these conditions are unlikely to result in damage to the roadway,
   - The roadway may become impassable during the peak of overtopping; emergency vehicles could likely still pass the roadway at these flood depths. The duration of the peak of overtopping is relatively long at 6 hours due primarily to the timing of the base event and the fact that with a failure of the dike, all flow from the base event is redirected from its normal flow path through the former Shoestring Dam site through the dike, which normally sees no flow.

b. **E Road (Route 116):** Dike failure during the 500-year event results in a 12-inch rise in river levels from El. 294.7 to El. 295.7. This rise results in the depth of roadway overtopping increasing from 1 inch under the base event to 13 inches with dike failure. The velocity of the overtopping flow is generally low within the footprint of the roadway and along the downstream slope of the roadway (0.5-3 ft/sec).
   - Overtopping conditions of these depths and velocities fall within the "Low Danger Zone" on ACER TM 11 Figure 4.0; these conditions are unlikely to result in damage to the roadway,
   - The roadway may become impassable during the isolated peak of overtopping; emergency vehicles could likely still pass the roadway at these flood depths. The duration of the peak of overtopping is relatively long at 8 hours due to the base event as described within Note A of the Central Avenue discussion included above.

***Section 5: Conclusions***

Completed dam break studies suggest that no loss of life is expected, inundated roadways are not expected to washout, and resulting economic damages are predicted to be "low"; therefore, dam failure impacts meet the definition of a low hazard potential dam as per 250-RICR-130-05-1 §1.5-A.16. As such, Shoestring Mill Pond Dike warrants reclassification from Significant to Low.

Additionally, the Shoestring Mill Pond Dam embankment warrants removal from the state's inventory as a formal embankment structure as it is and has been fully and sufficiently breached.

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We trust that the information presented herein is sufficient for RIDEM to concur with Pare's conclusion that Shoestring Mill Pond Dike warrants a hazard classification change from Significant to Low and that Shoestring Mill Pond Dam warrants removal from the state's inventory of jurisdictional dam structures.

If RIDEM should have any questions, comments, or require additional information, please do not hesitate to contact us by email (mdunn@parecorp.com) or phone (508-543-1755).

Sincerely,

PARE CORPORATION

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Attachments (From 2022 Dam Removal Feasibility & Impact Analysis Report)
- Photographs
- Figures
  - Figure 1: Locus Plan
  - Figure 2: Aerial Plan
- Plan Sheets
  - Sheet 4.0: Shoestring Mill Pond Overall Site Plan
  - Sheet 4.1 Shoestring Mill Pond Dam Sections
  - Sheet 4.2: Shoestring Mill Pond Impoundment Plan

Information Available Upon Request:
- H&H Models (HydroCAD and HEC-RAS)
- Dam Removal Feasibility & Impact Analysis Report

Photo No. 1.: View of the former Shoestring Mill Pond Dam site looking right. Note that the dam has been fully breached for some time.

Photo No. 2.: View of the natural stone weir located 100 feet upstream of the former dam embankment.

Photo No. 3.: View of the channel through the former dam from 50 feet upstream of former dam centerline looking downstream.

Photo No. 4.: Channel through the former dam from 20 feet downstream of former dam centerline looking upstream.

Photo No. 5.: Channel through the former dam from 200 feet downstream of the former dam centerline looking upstream.

Photo No. 6.: Downstream channel from 200 feet downstream of the former dam centerline looking downstream.

Photo No. 7.: View of the Route 116 culvert crossing downstream of the former Shoestring Mill Pond Dam site.

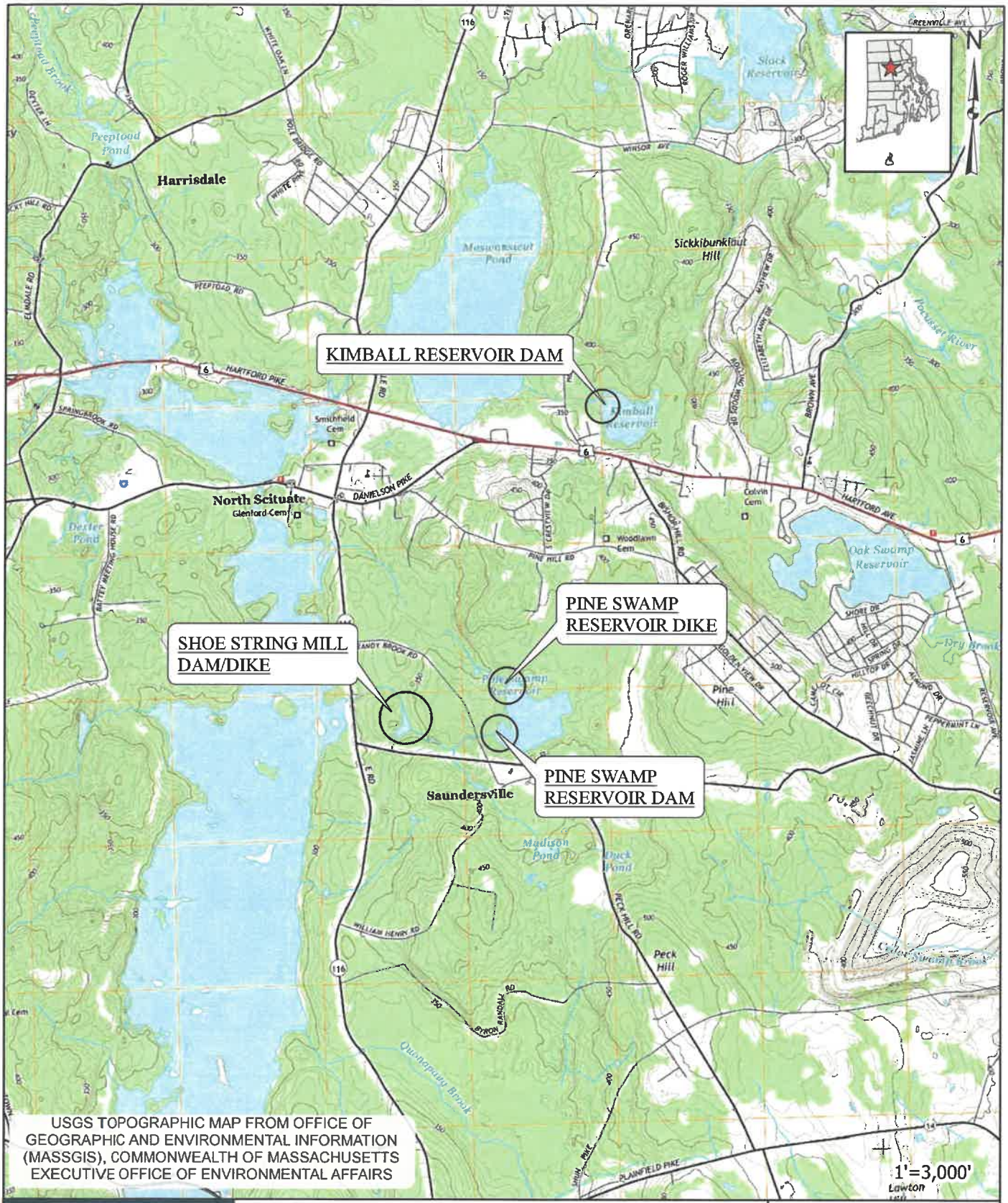
Photo No. 8.: Shoestring Mill Dike embankment from the left abutment looking right.

Photo No. 9.: Area downstream of the dike embankment from the crest of the dike at mid-length looking downstream.

Photo No. 10.: View of Central Avenue located downstream of the dike embankment. Note the alignment of the culvert crossing along Central Avenue (red line) in the foreground and the location of the Route 116 culvert crossing (yellow arrow) in the background

Photo No. 11.: Upstream end of the Central Avenue culvert crossing.

Photo No. 12.: Upstream end of the Route 116 culvert crossing located downstream of the dike.




USGS TOPOGRAPHIC MAP FROM OFFICE OF GEOGRAPHIC AND ENVIRONMENTAL INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

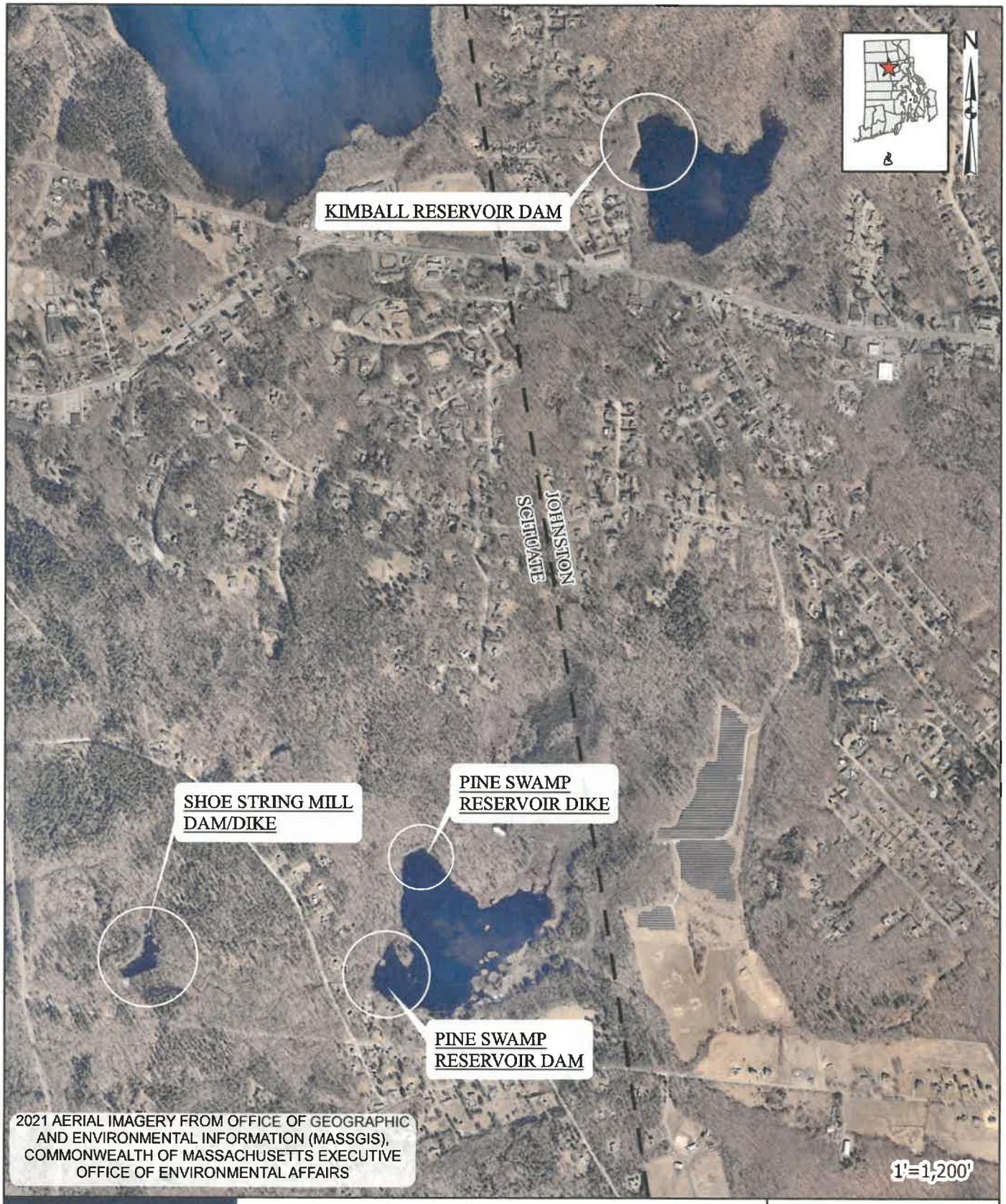
PARE CORPORATION

DAM REMOVAL FEASIBILITY & IMPACT ANALYSIS STUDY
KIMBALL RESERVOIR DAM - PINE SWAMP RESERVOIR DAM - SHOESTRING MILL POND DAM/DIKE

JOHNSTON-SCITUATE, RHODE ISLAND
PROVIDENCE WATER

# LOCUS PLAN

AUGUST 2022 FIGURE 1




PARE CORPORATION

DAM REMOVAL FEASIBILITY & IMPACT ANALYSIS STUDY
KIMBALL RESERVOIR DAM - PINE SWAMP RESERVOIR DAM - SHOESTRING MILL POND DAM/DIKE

JOHNSTON-SCITUATE, RHODE ISLAND
PROVIDENCE WATER

# AERIAL PLAN

AUGUST 2022 FIGURE 2