

The Grande Old Dam of Foster's Pond Turns 162: An Engineer's Take

Lee Wooten, P.E.

GEI Consultants, Inc.

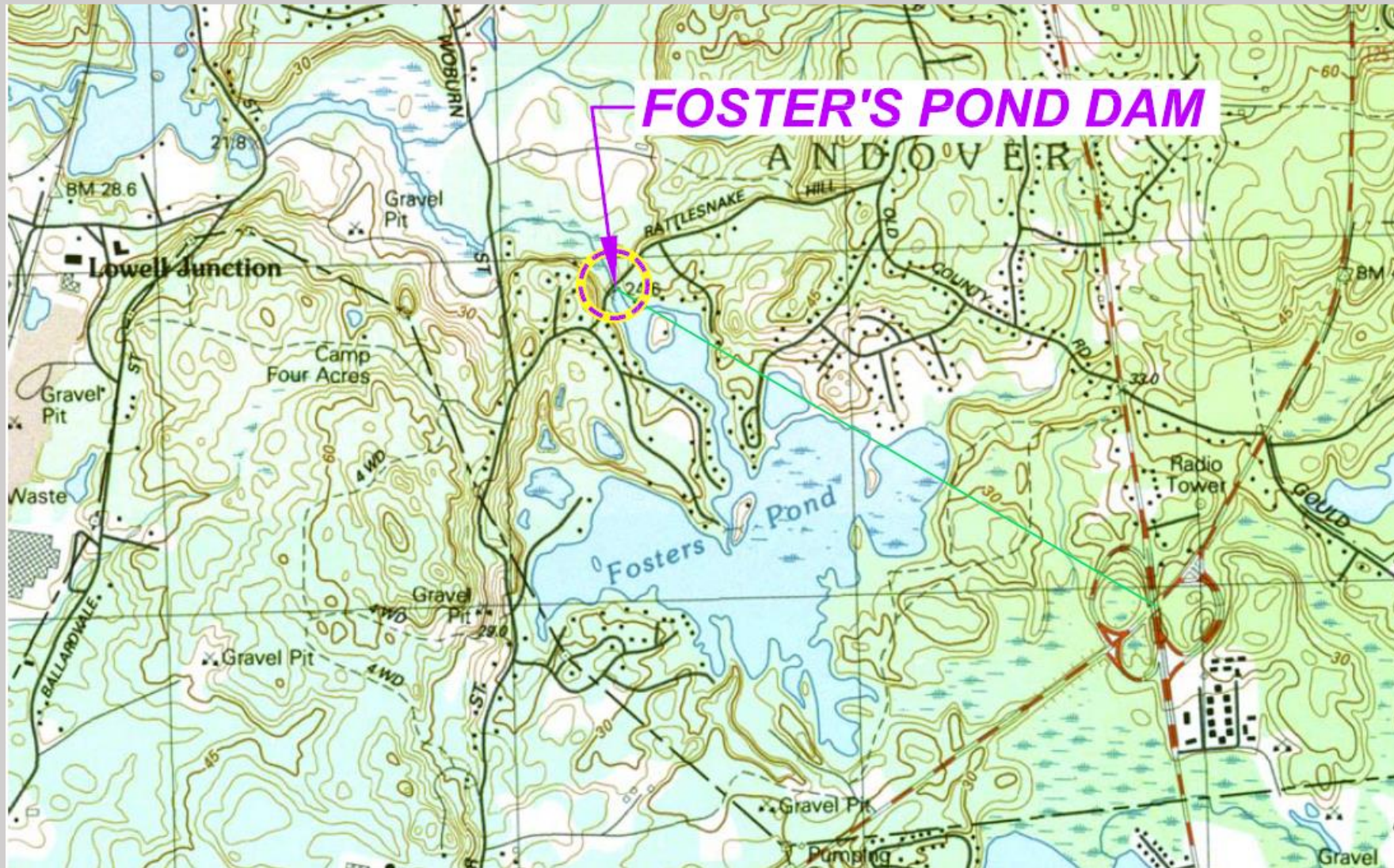


Outline (Answers to Your Questions)

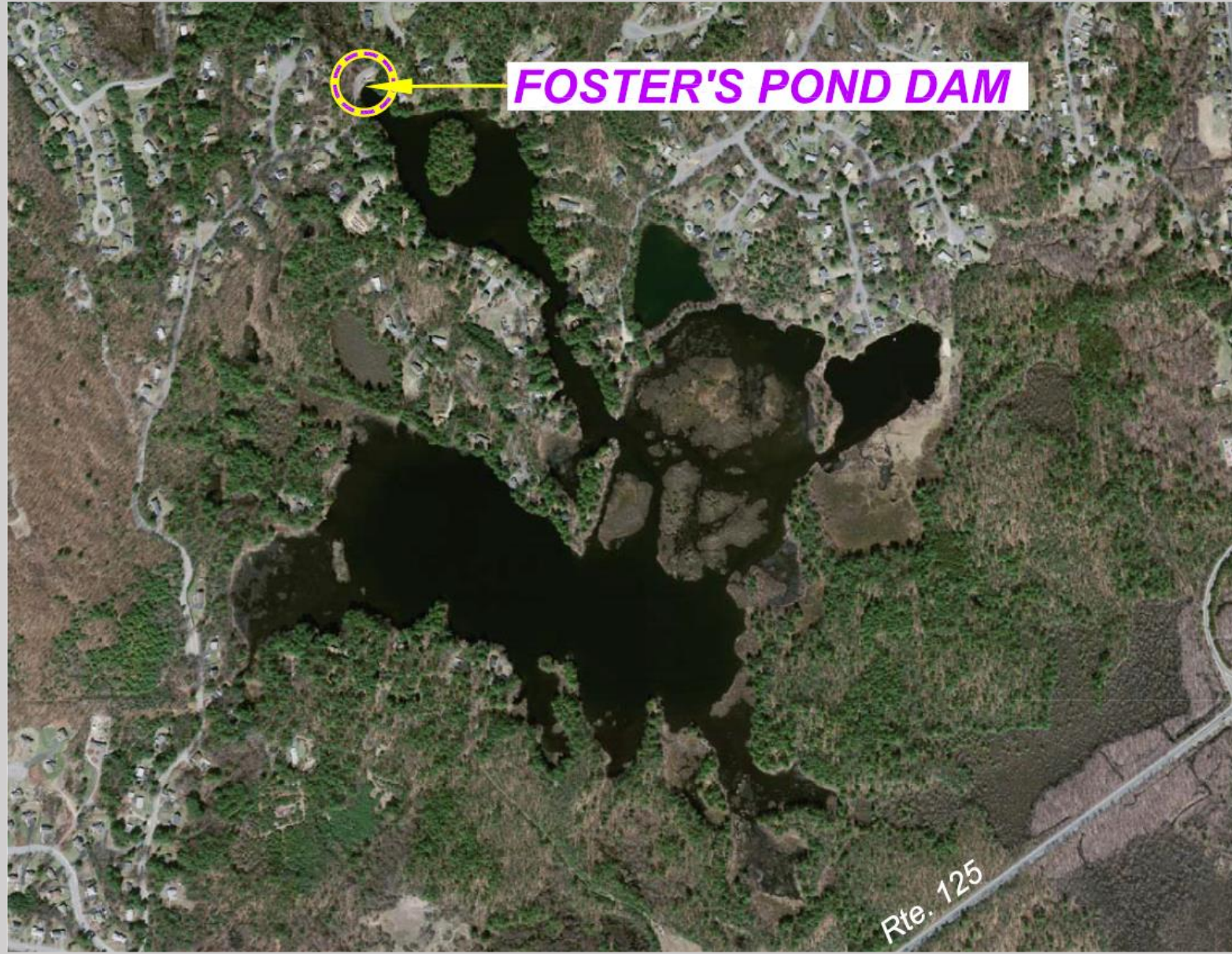
- We have a dam? - Foster's Pond Dam Basics & Dams 101
- Why are we paying for this engineer? – Dam Safety Regulations Primer
- Okay, why is our dam regulated? – Historical dam failures
- Can our dam fail? – Let me count the ways.
- What do we do if the dam is in danger of failing? – Fosters Pond Emergency Action Plan

We have a dam? – Yes (lucky you)

Foster's Pond Dam Basics & Dams 101



Foster's Pond Dam Basics & Dams 101



Foster's Pond Dam Basics & Dams 101



Foster's Pond Dam Basics & Dams 101

Embankment

Spillway

Embankment



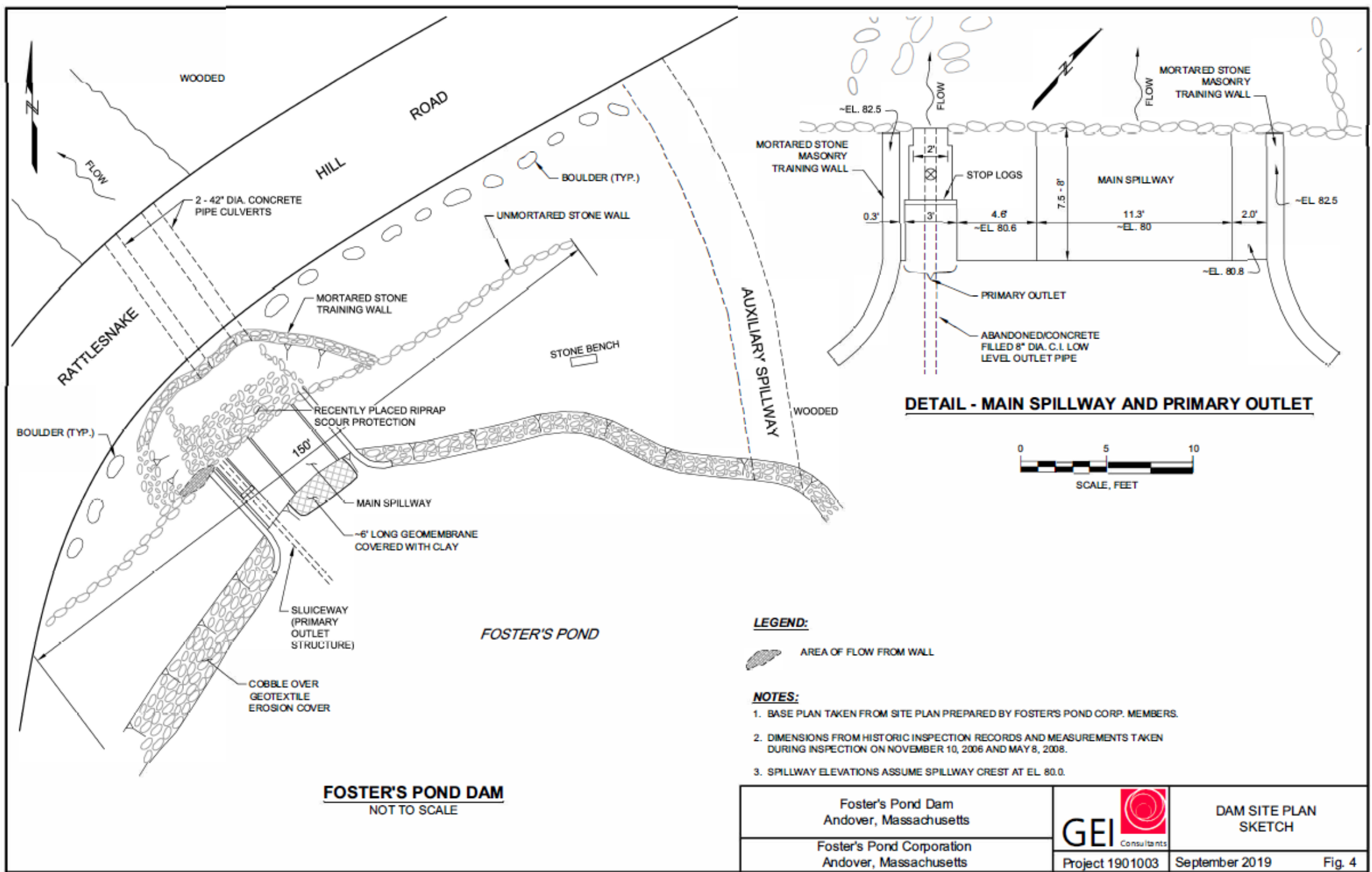
**Auxiliary
Spillway**

Sluice Gate

Foster's Pond Dam Basics & Dams 101

Auxiliary
Spillway





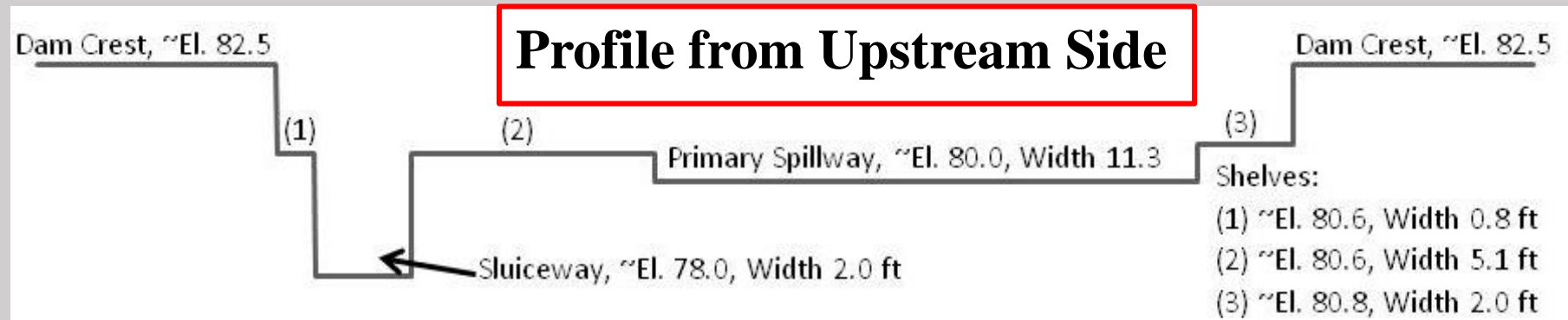
Foster's Pond Dam Basics & Dams 101

**42-Inch-Diameter
Culverts**

Plunge Pool



Foster's Pond Dam Basics & Dams 101



View from Downstream Side



Foster's Pond Dam Basics & Dams 101

National ID #		MA00153
River Name		Frye's Brook (inflow) to Shawsheen River about 1 mil
Hazard Class	—————→	Significant
Size Class	—————→	Intermediate
Dam Type		Earthfill w/ downstream stone masonry
Dam Purpose		Recreational
Structural Height of Dam (feet)		~10.1
Hydraulic Height of Dam (feet)		~7.6
Drainage Area (sq. mi.)		1.58
Reservoir Surface Area (sq. mi.)		0.19
Normal Impoundment Volume (acre-feet)		~538
Max Impoundment Volume ((top of dam) acre-feet)		~867
Spillway Type		Broad crested weir
Spillway Length (feet)		21.2
Principal Spillway Capacity* (cfs)	—————→	~194
Auxiliary Spillway Capacity* (cfs)	—————→	~57
Low-Level Outlet Capacity* (cfs)		~33 with full pool
Spillway Design Flood* (flow rate - cfs)	—————→	100-year / 191 cfs

Why are we paying for this engineer? – Dam Safety Regulations Primer

(Because you have to.)

MGL Chapter 253, Section 46. The owner of any dam shall cause to be filed with the commissioner ... a dam inspection form, containing information relative to the present condition, safety and adequacy of the dam and such other information as the commissioner may require by regulation, signed by a registered professional civil engineer.

Why are we paying for this engineer?

– Dam Safety Regulations Primer

(Because you have to.)

302 CMR 10.07 (2) Dam owners shall periodically inspect all dams in accordance with the following schedule. These time periods are the maximum time between inspections; more frequent inspections may be performed at the discretion of the Commissioner.

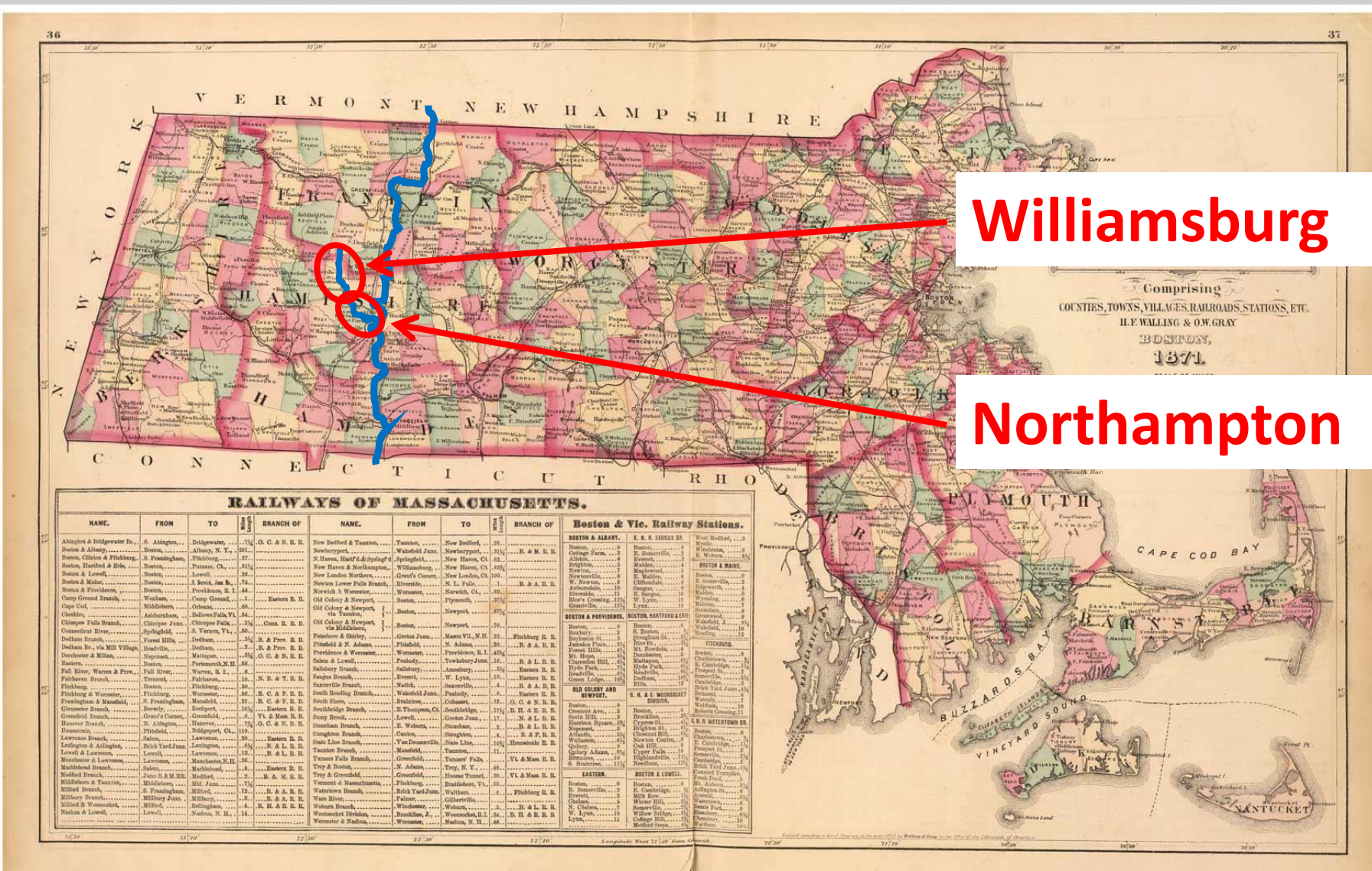
PHASE I FORMAL INSPECTION FREQUENCY

Hazard Potential	Inspection Frequency
Low	Ten Years
Significant	Five Years
High	Two Years

Okay, why is our dam regulated? – historical dam failures

Because dams have a history of failing and killing people.

- Williamsburg Reservoir Dam – 1874
- Mud Pond Dam failure - 1886
- South Fork Dam - Johnstown flood – 1889
- Francis Dam – 1928
- Lee Lake Dams – 1968

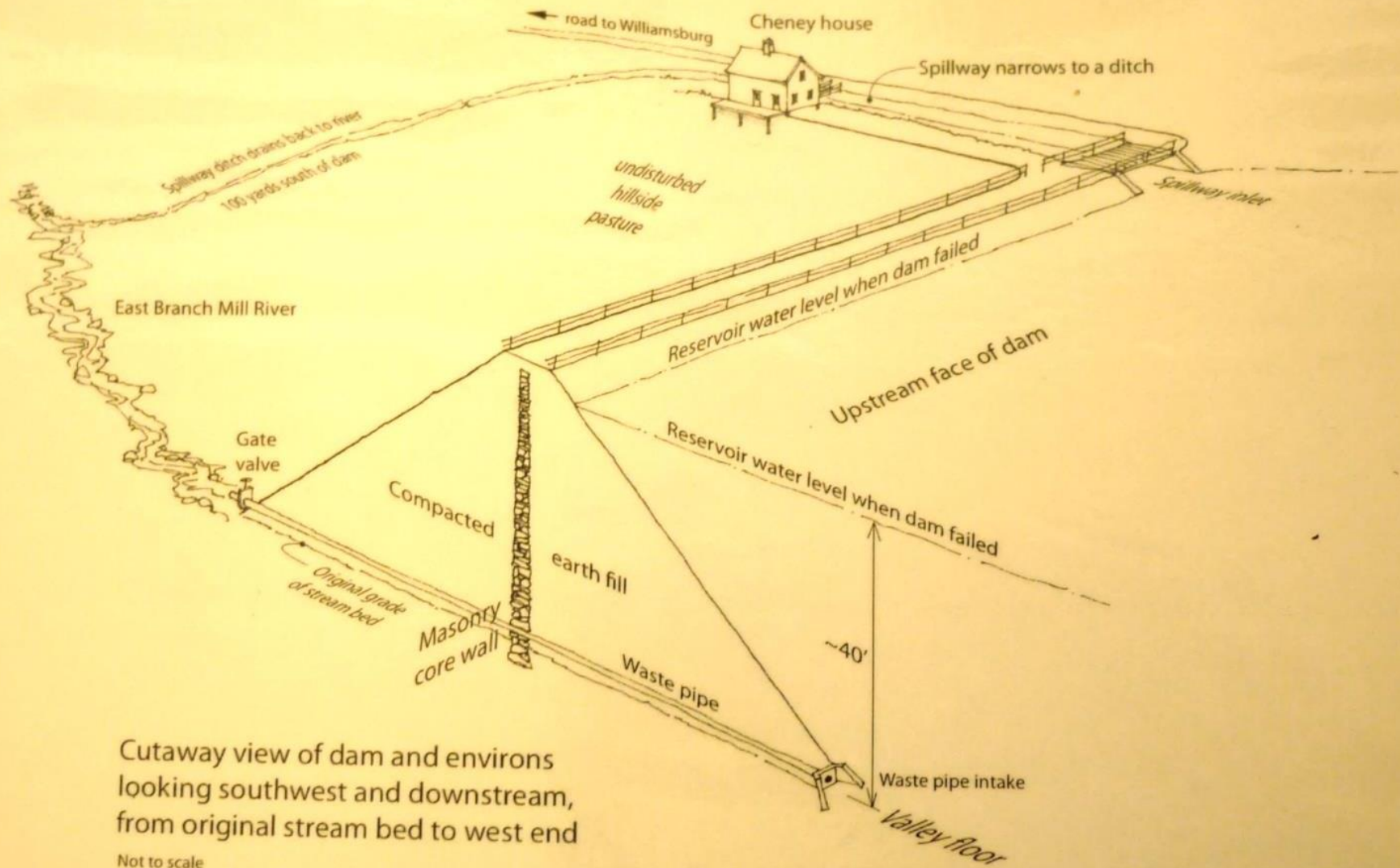


Williamsburg

Northampton

Map of Massachusetts 1871 Walling & Gray from "Official Topographical Atlas of Massachusetts" Rumsey Collection www.old-maps.com

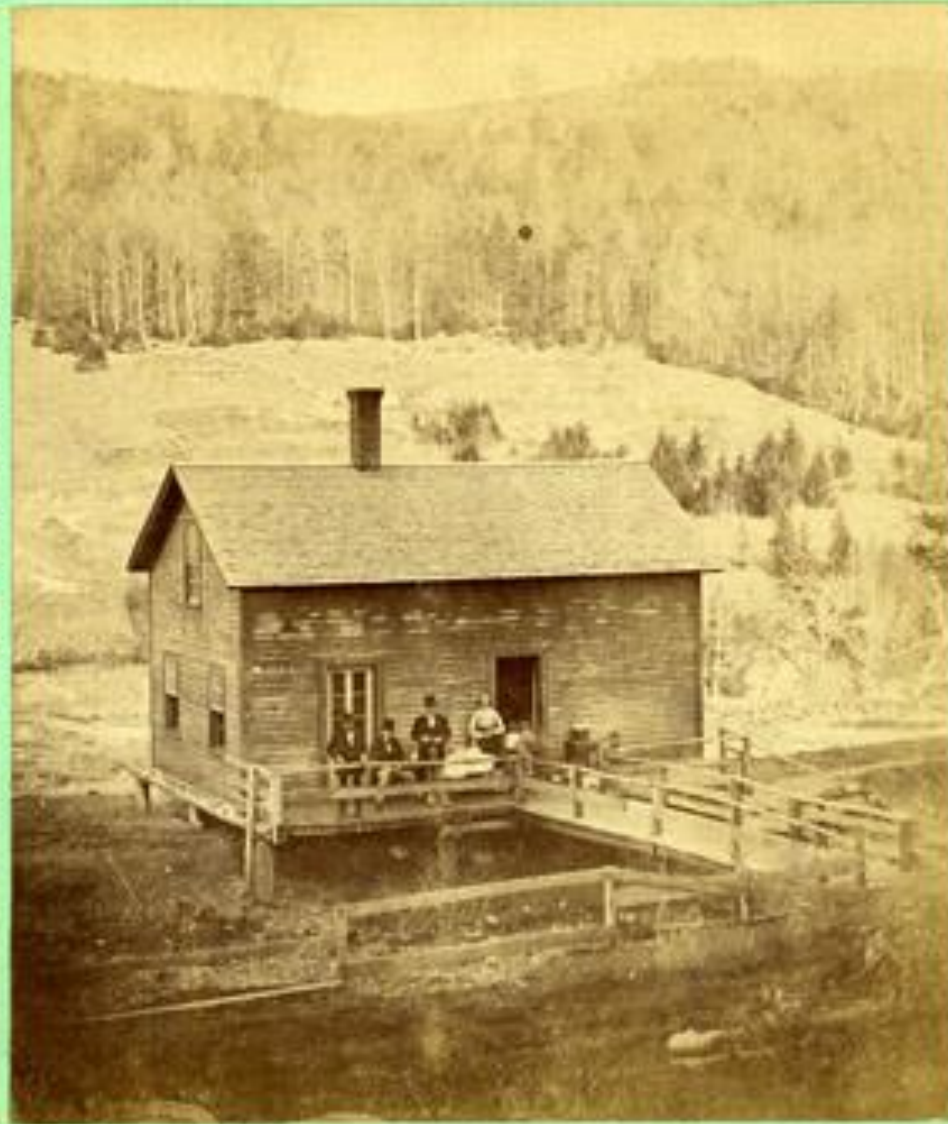
The Williamsburg Reservoir Dam Failure of 1874



Cutaway view of dam and environs looking southwest and downstream, from original stream bed to west end
 Not to scale

The Williamsburg Reservoir Dam Failure of 1874

Knowlton Brothers, Northampton, Mass.



Views of the Flood in Mill River Valley.

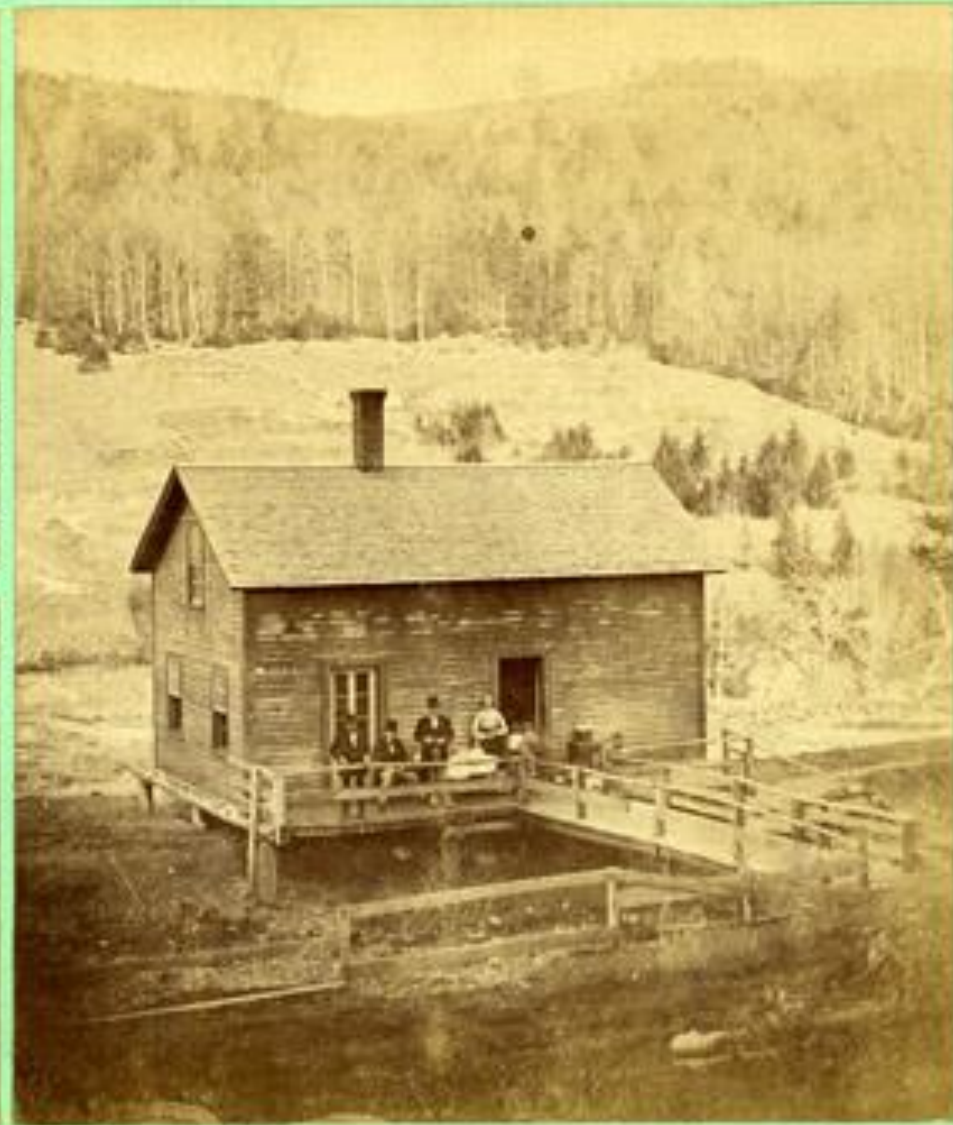
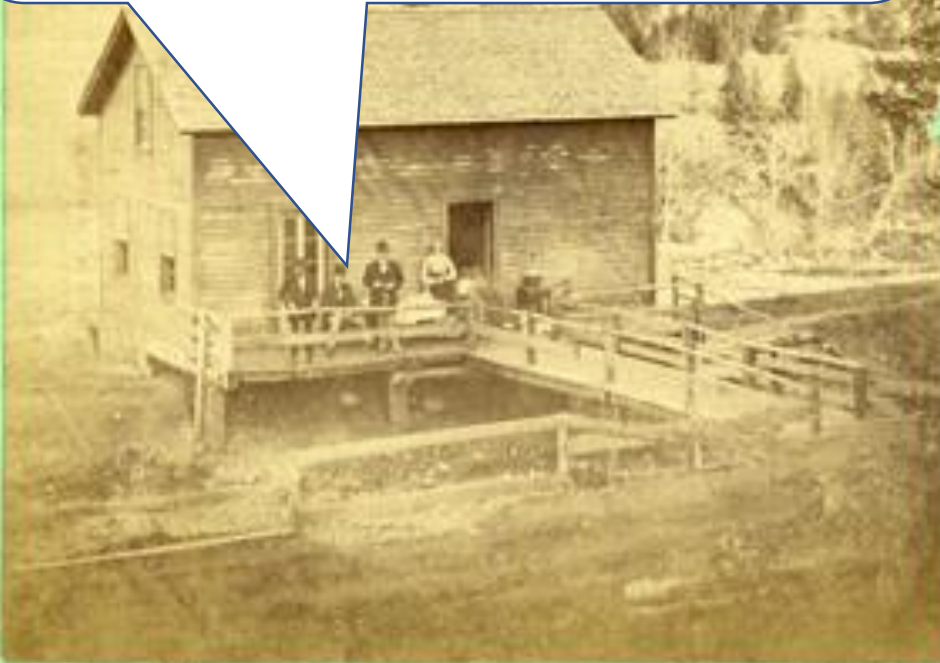
View at Williamsburgh Reservoir. (Descriptive List the other side.)

Caretaker's Cabin and the Cheney family

Saturday, May 16, 1874

Knovlton Brothers, Northampton Mass.

**“For God’s sake, George,
look there,”**



Views of the Flood in Mill River Valley.

View at Williamsburgh Reservoir. (Descriptive List the other side.)

The Williamsburg Reservoir Dam Failure of 1874

1874 EAP Responders

- George Cheney
- Collins Graves
- Jerome Hillman
- Myron Day





The Williamsburg Reservoir Dam Failure of 1874

The Dam

Williamsburg

57 Deaths

Skinnerville

4 Deaths

Haydenville

27 Deaths

Leeds

51 Deaths

Florence Meadows



Newspaper Sketch (Artist's Concept) of the Valley after the Flood

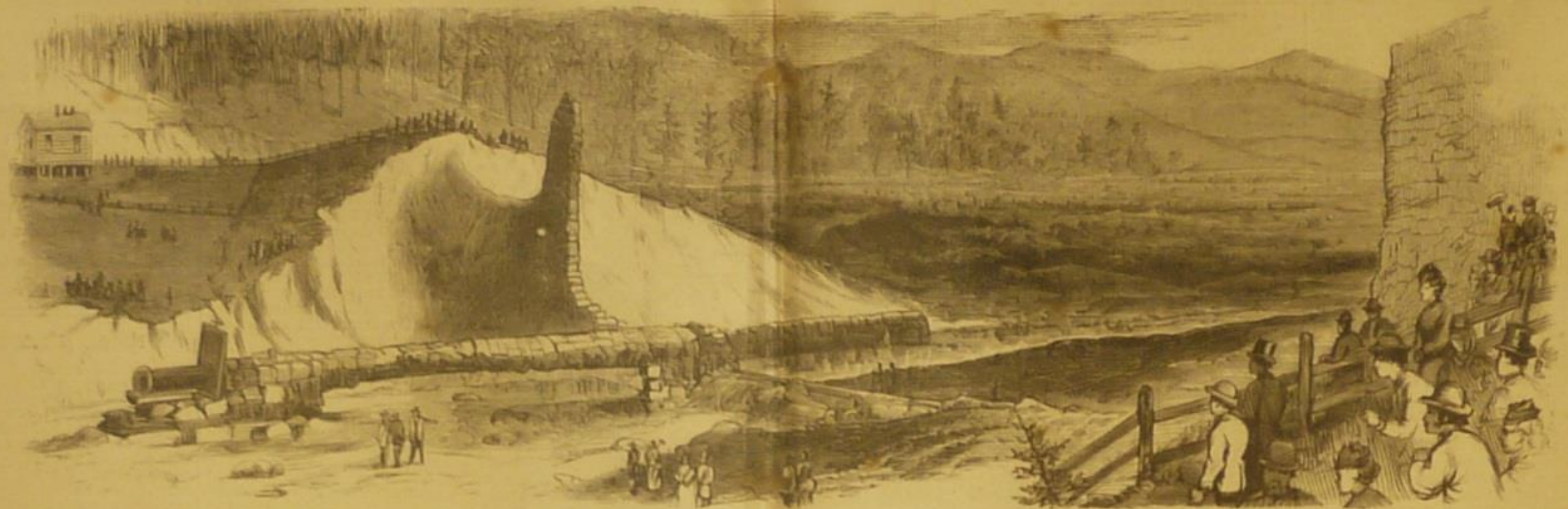
Total Fatalities – 139

Damages ~\$200,000

The flood killed:

- **those who did not hear the warnings (not in factories),**
- **those who could not flee fast enough,**
- **those who lingered or tried to save either friends or family in the face of the floodwave, and**
- **those unlucky enough to pick the wrong escape route**

43 deaths were children under the age of 10



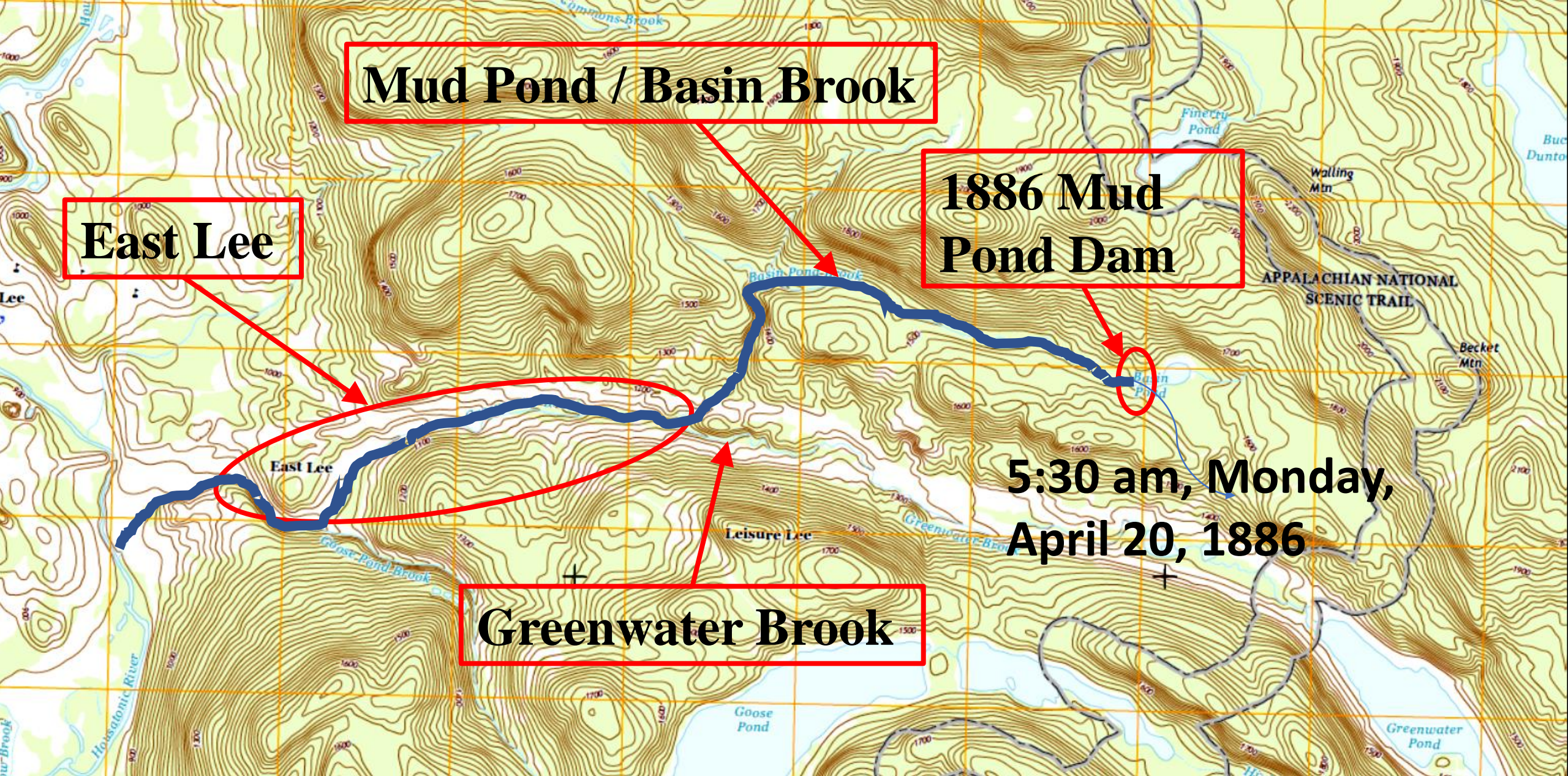
THE RUINED RESERVOIR AT WILLIAMSBURG.

The Williamsburg Reservoir Dam Failure of 1874

1886 – Mud Pond Dam Failure



Mud Pond / Lake Lee Dam Failures, East Lee, MA



Mud Pond / Basin Brook

East Lee

1886 Mud Pond Dam

Greenwater Brook

**5:30 am, Monday,
April 20, 1886**

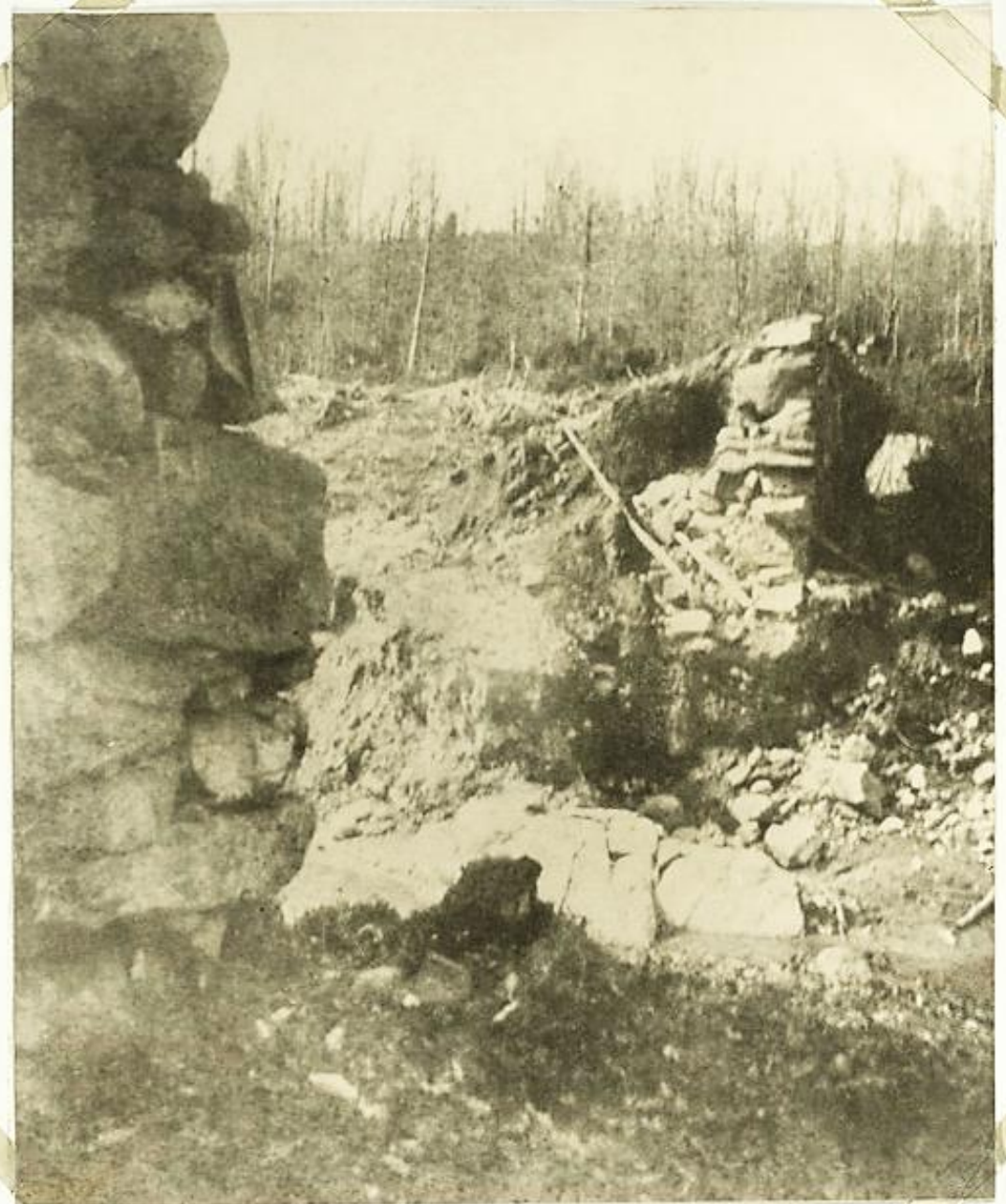
Mud Pond Failure, East Lee, MA

Mud Pond Dam

Failure: 5:30 am, Monday, April 20, 1886

The theory of the disaster is that the ground was so thoroughly soaked with water that probably a small stream found its way through the bottom, and, no one visiting the place, this was unnoticed until Gonsett was alarmed by the roar of the water. NY Times "Swept Away by a Flood," 1886

Mud Pond Failure, East Lee, MA



The Mud Pond Dam after the Break Looking Up Stream.







C. P. Culling, Photographer,

Lee, Mass.



C. P. Culling, Photographer.

Lee, Mass.



The picture shows all that Mad Ford left of the John McLaughlin machine shop which stood in the left just east of where the road to Texas Ford now leaves route 30 in East Lee.

The brick shown is the Greenwater pond bench, which today (1947) is about 100 feet southwestward and much nearer the old log home on the pier between the two brooks, near the junction.

Just above here on the Greenwater stream was the second mill built in Lee. It was a combination grist-and-saw mill built by John Strong in the 1770s and operated by his son James after John's death in 1790 until James went to Boston as Representative in 1810.

In the track of this devastating flood from where it began in Cape-street, through East Lee proper, then to Water-street, where Goose Pond brook intersects, there is hardly a house but is injured more or less, and in the upper part of Cape-street the destruction is more severe. Houses everywhere have from one to six feet of mud on the floors; fences are gone, lawns spoiled, furniture wrecked. and everywhere the work is shown of this unexpected destructive force. On the streams six bridges are carried away, the highways are gullied and in some places are washed away to the depth or several feet. ("Swept Away by a Flood," NY Times, 1886)

Mud Pond Dam Failure, East Lee, MA

Seven Deaths:

- *Mr. & Mrs. A. N. White*
- *Alice Irene White - age 9*
- *Ida May White – age 11*
- *Simeon Dowd*
- *Mrs. Theodore King*
- *Mrs. Charles King*



A satellite map of Pennsylvania and surrounding regions. The map shows the Appalachian Mountains in the south and the South Fork Reservoir Dam failure site in the north. A red circle highlights the location of Johnstown, and a red box contains the title text. Major cities like Pittsburgh, Philadelphia, and New Jersey are also labeled. A scale bar indicates 80 miles.

**1889 – South Fork
Reservoir Dam Failure
& Johnstown Flood**

Pittsburgh

Johnstown

Pennsylvania

Appalachian Mountains

New Jersey

Philadelphia

80 mi

Image Landsat / Copernicus
© 2020 Google

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google



South Fork Fishing and Hunting Club

South Fork Reservoir Dam Failure
May 31, 1889 (overtopping)



COPYRIGHTED
1889
HISTED
PITTS
PA
No 18

LIBRARY OF CONGRESS
COPYRIGHT
JUN 24 1889
17848 W

JOHNSTOWN FLOOD, MAY 31st, 1889.

LOSS FROM 10,000 TO 12,000 LIVES.

PHOTOGRAPHED BY

Histed.

PITTSBURGH, PA.

1889 – South Fork Reservoir Dam Failure & Johnstown Flood



1889 – South Fork Reservoir Dam Failure & Johnstown Flood



1889 – South Fork Reservoir Dam Failure & Johnstown Flood



1889 – South Fork Reservoir Dam Failure & Johnstown Flood



1889 – South Fork Reservoir Dam Failure & Johnstown Flood



1889 – South Fork Reservoir Dam Failure & Johnstown Flood

South Fork Reservoir Dam Failure Consequences

- 2,209 Deaths
 - 99 entire families
 - 396 children
 - 124 women & 198 men widowed
 - 750 unidentified victims
 - Bodies found as far away as Cincinnati and as late as 1988
- 1,600 homes destroyed
- \$17 million in damages

1928 St. Francis Dam Failure



St. Francis Dam Background

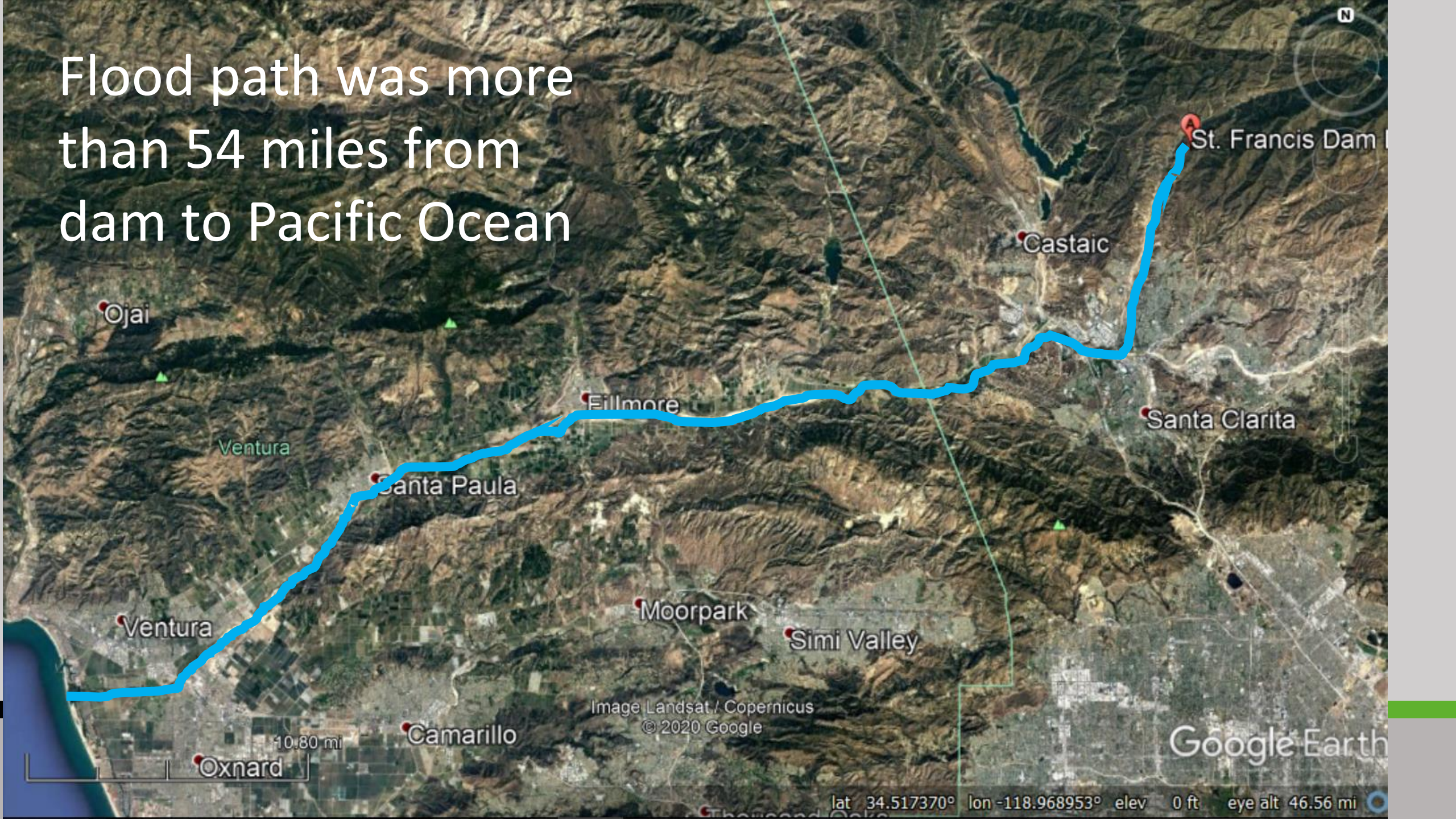
- Water storage reservoir for the City of Los Angeles
- Designed by the L.A. Bureau of Water & Power, under William Mullholland
- Built in 1924
- 185 feet high, 700 ft long (main dam)
- Curved concrete dam

1928 St. Francis Dam Failure

11:57 p.m. on March 12, 1928

(12 hours after inspection by Mulholland)

Flood path was more than 54 miles from dam to Pacific Ocean





1928 St. Francis Dam Failure



1928 St. Francis Dam Failure

1928 St. Francis Dam Failure Consequences

- 432+ deaths (2nd worst CA disaster, after 1906 earthquake and fire, bodies found as far away as Mexico)
- \$7 million in damages
- Led to the licensure of engineers in CA

1968 – Lake Lee Dam Failure



Lake Lee Dam Failure, East Lee, MA

Mass Pike (I-90) under construction

Rt. 20, Otis Turnpike

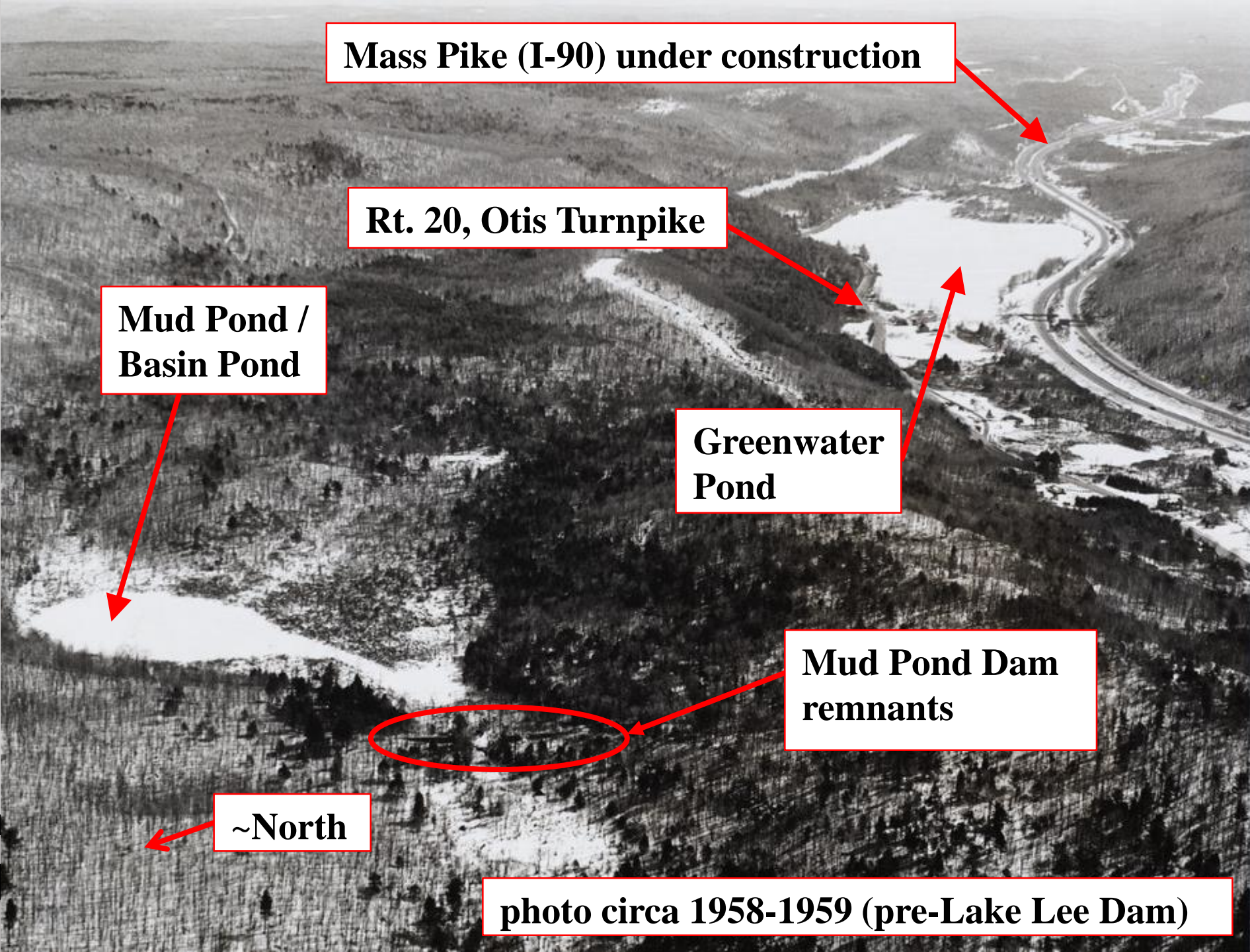
**Mud Pond /
Basin Pond**

**Greenwater
Pond**

**Mud Pond Dam
remnants**

~North

photo circa 1958-1959 (pre-Lake Lee Dam)



PROPOSED DAM

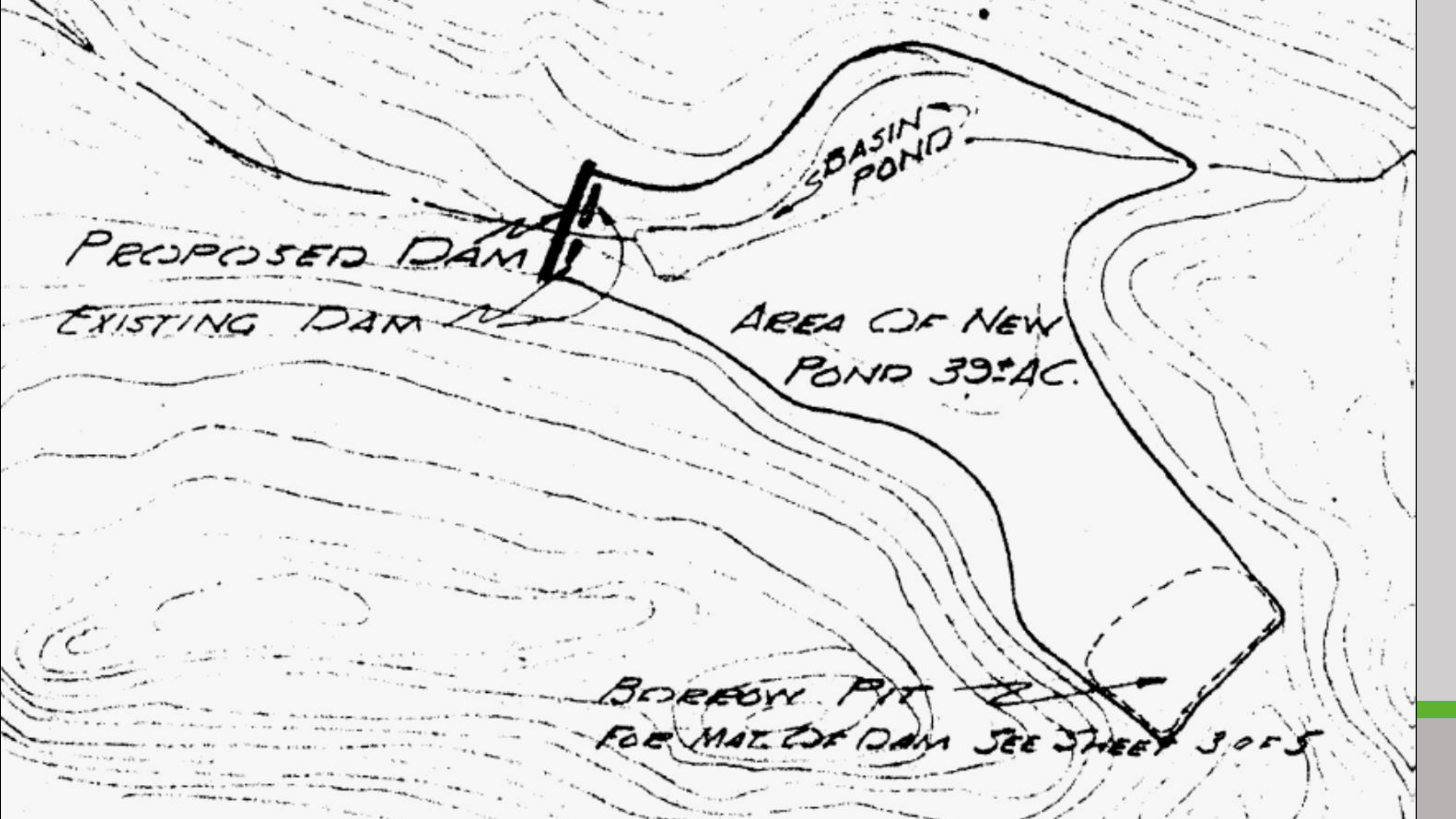
EXISTING DAM

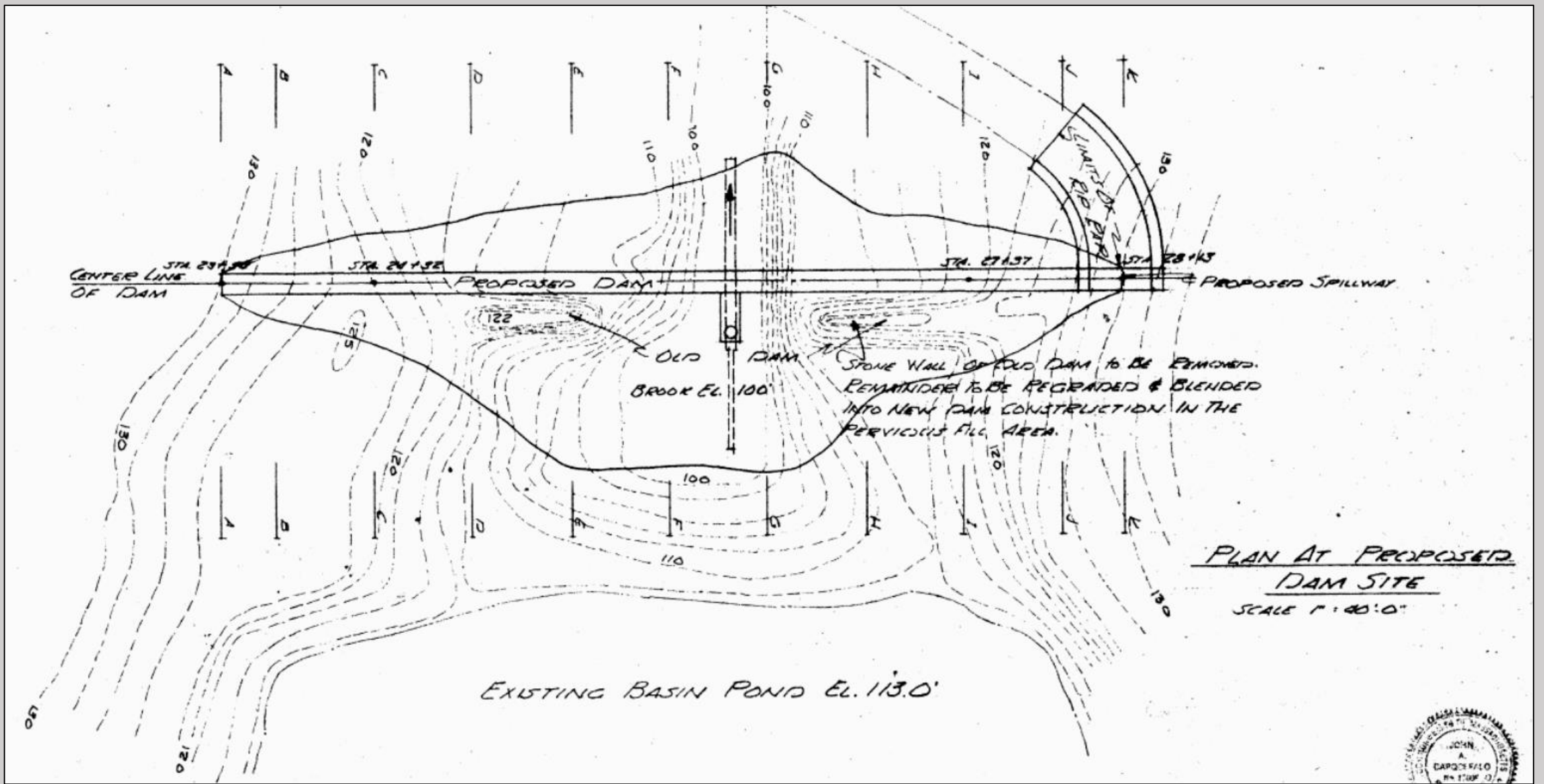
Basin Pond

AREA OF NEW
POND 39 AC.

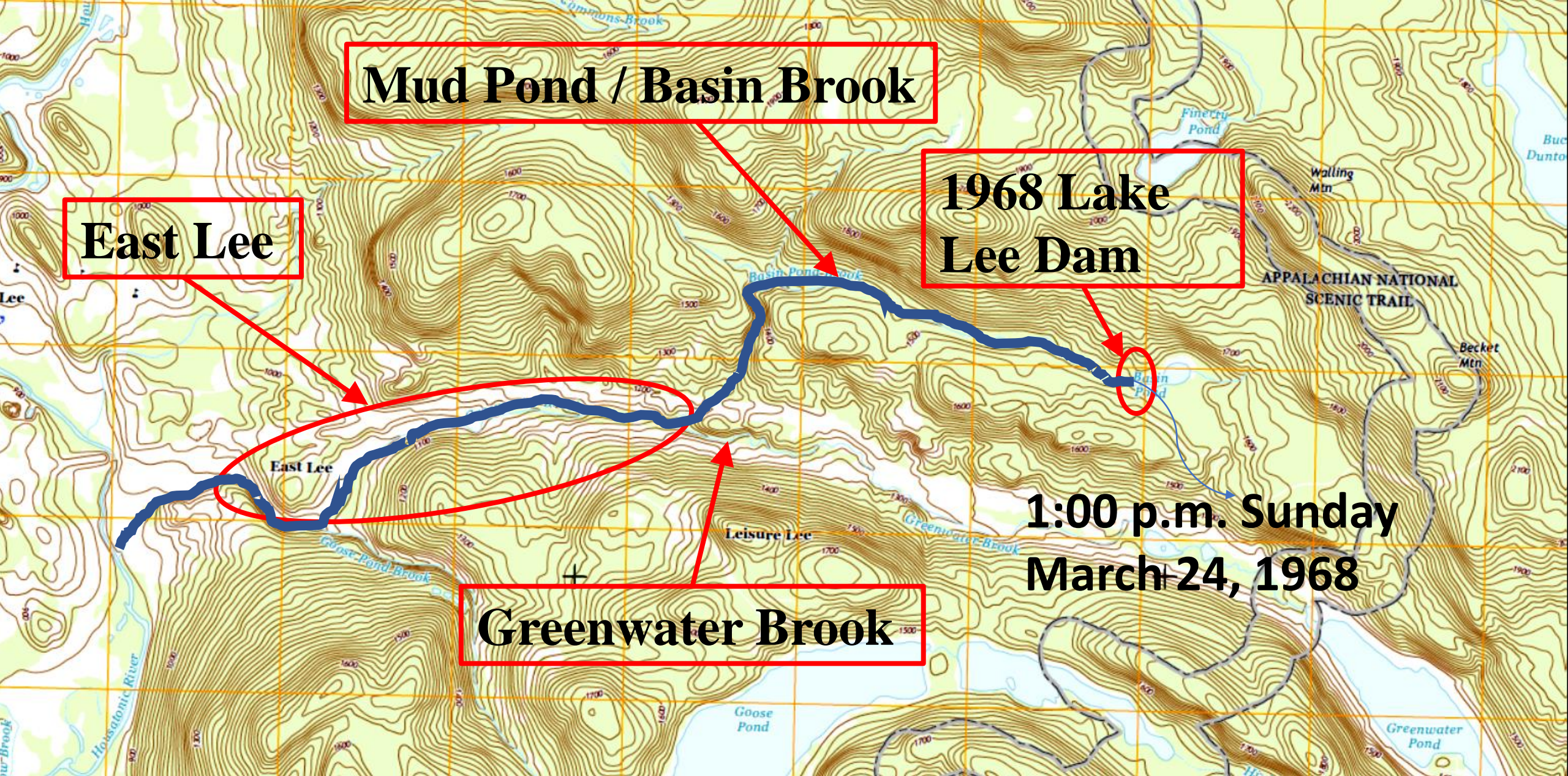
BORROW PIT

FOR MAT. OF DAM SEE SHEET 3055

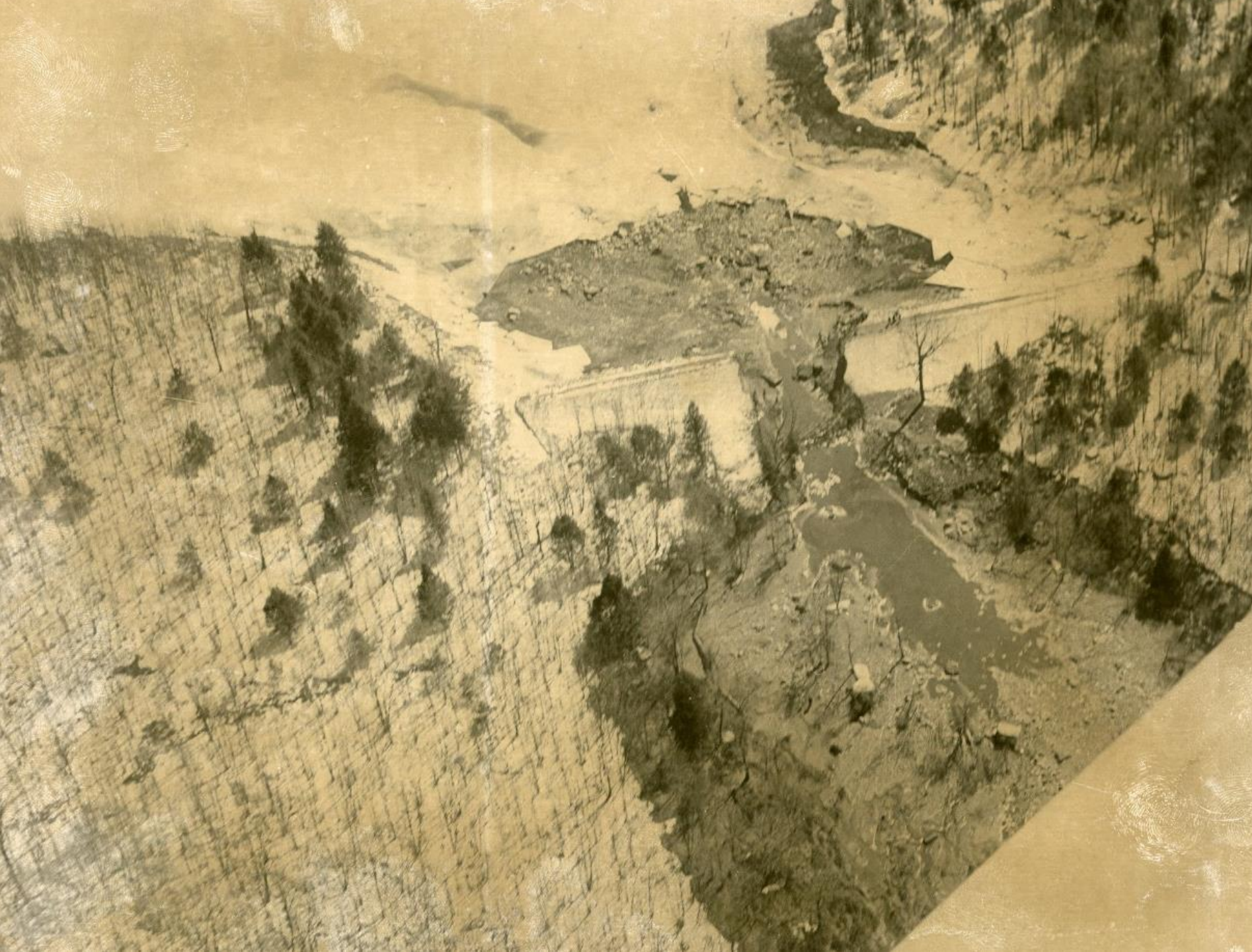




Lake Lee Dam Failure, East Lee, MA



Mud Pond Failure, East Lee, MA



**Lake Lee Dam
after breach**



Lake Lee
Dam
after
breach



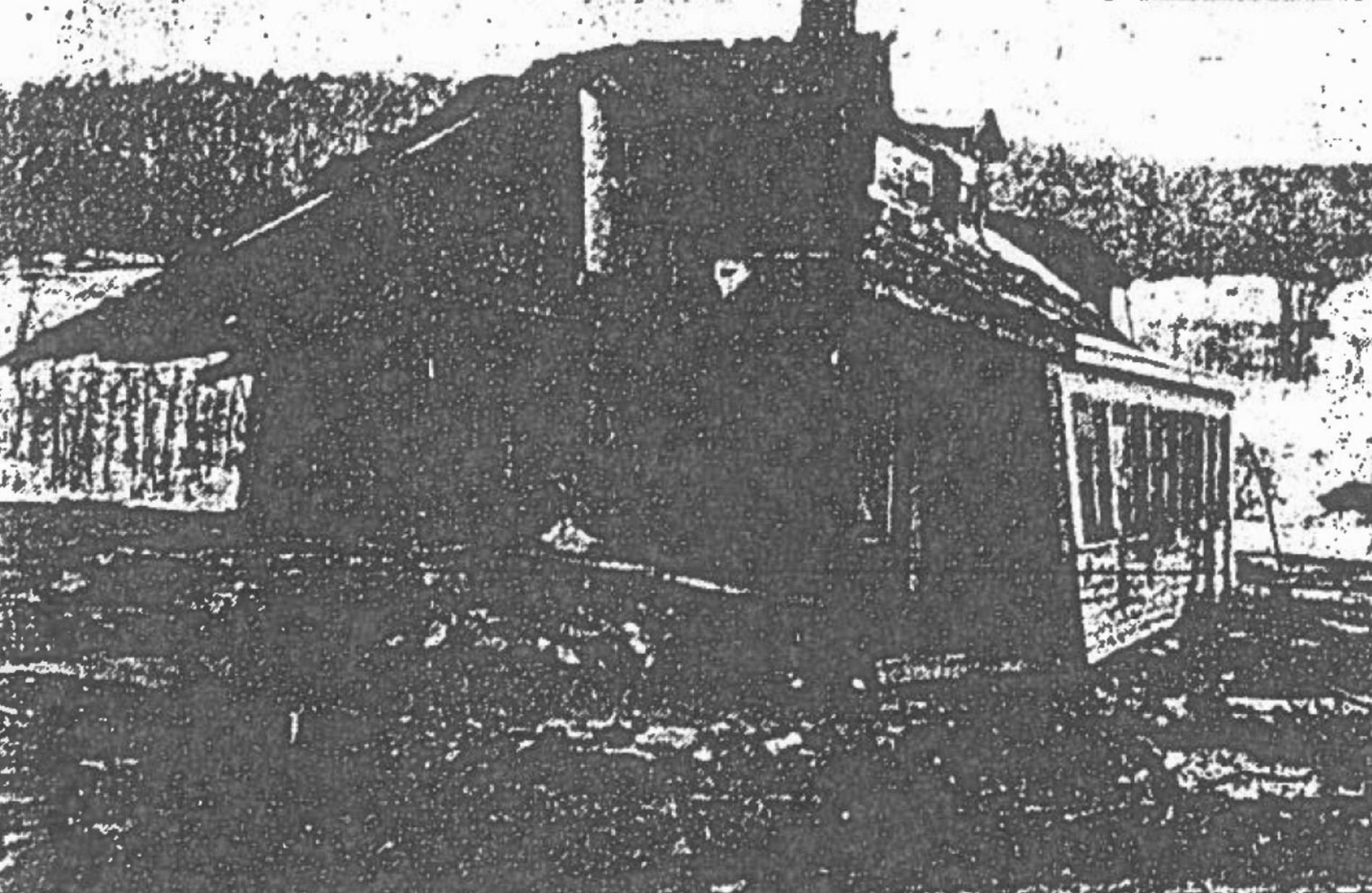


**Gage House
after flood
(2nd story
only, on
other side of
Rt. 20)**



Wrecked car near Gage house

Note Gage house 2nd story in background



**Remains
of Olive
Cordonier
house**

Lake Lee Dam Failures, East Lee, MA



**Clark-Aiken
plant after
flood**

Lake Lee Dam Failures, East Lee, MA



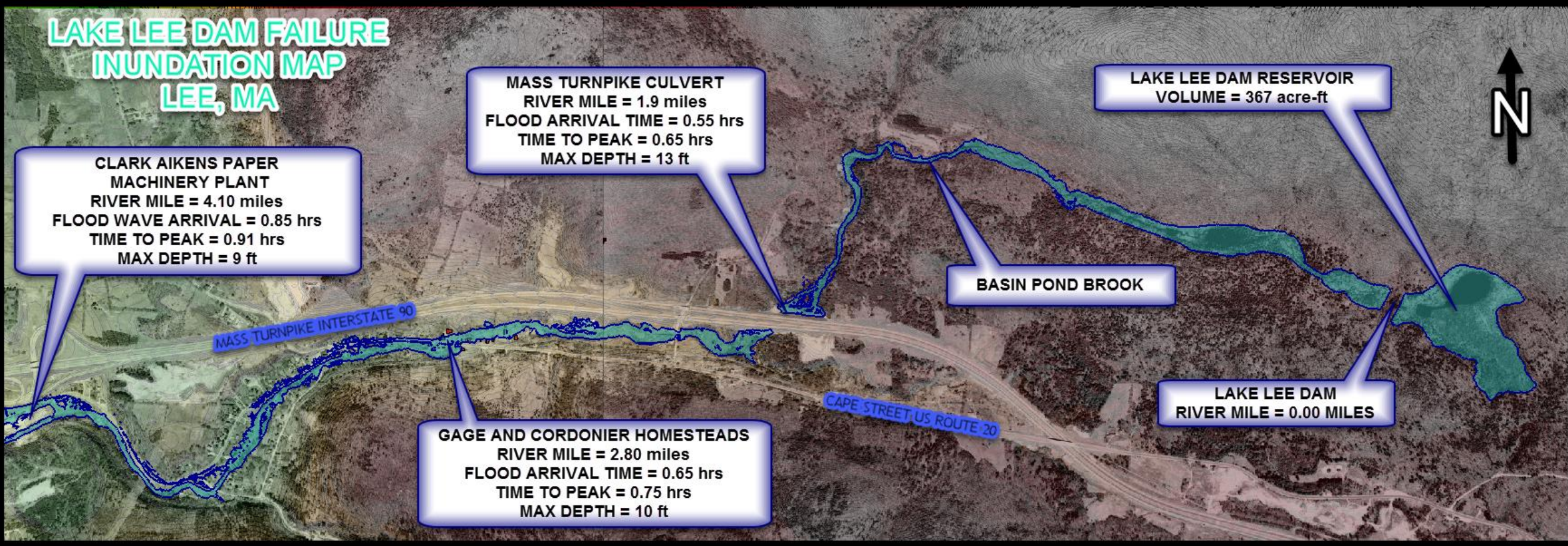
**Clark-Aiken
plant after
flood**

Lake Lee Dam Failures, East Lee, MA

Lake Lee Dam Failure

~1:00 p.m. Sunday March 24, 1968

LAKE LEE DAM FAILURE INUNDATION MAP LEE, MA



Lake Lee Dam Failures, East Lee, MA

Two Deaths:

- Edward Gage
- Olive Cordonier

Damages >\$5,000,000



**Retrieval of Olive Cordonier
body one day after the flood**

Mud Pond Dam Failure, East Lee, MA

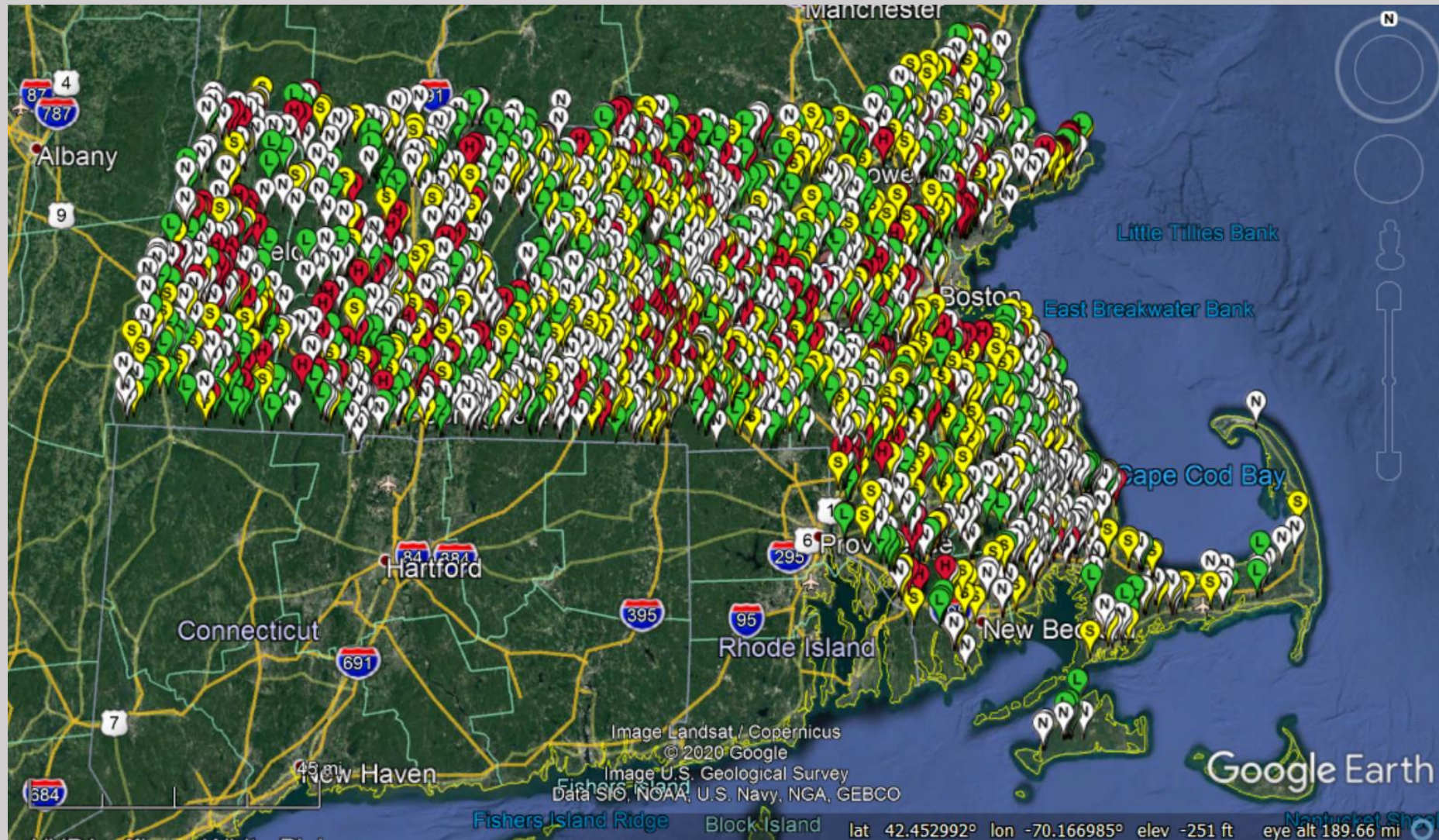
Massachusetts Regulatory Evolution

- Colonial laws – protect fisheries
- Early 1800's – rights of mill owners, of upstream from pond flooding, & for downstream flows
- 1854 – first dam safety regulations
- 1875 – More County Commissioner oversight*
- 1970 – Dam regulation transferred to state officials**

* Post Williamsburg

** Post Lake Lee

Okay, why is our dam regulated? – ...and there are lots of dams in MA



Okay, why is our dam regulated? – ...and there are lots of dams in MA

- More than 3000 dams
- 1327 Regulated Dams
 - 328 High Hazard Dams
 - 642 Significant Hazard Dams ← **Foster's Pond Dam**
 - 357 Low Hazard Dams

Okay, why is our dam regulated? – Foster's Pond Dam Hazard Category

From 302 CMR 10.06 (3) Hazard Classification
Table – Significant Hazard Potential dams are:

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 interruption of use or service of relatively important facilities.

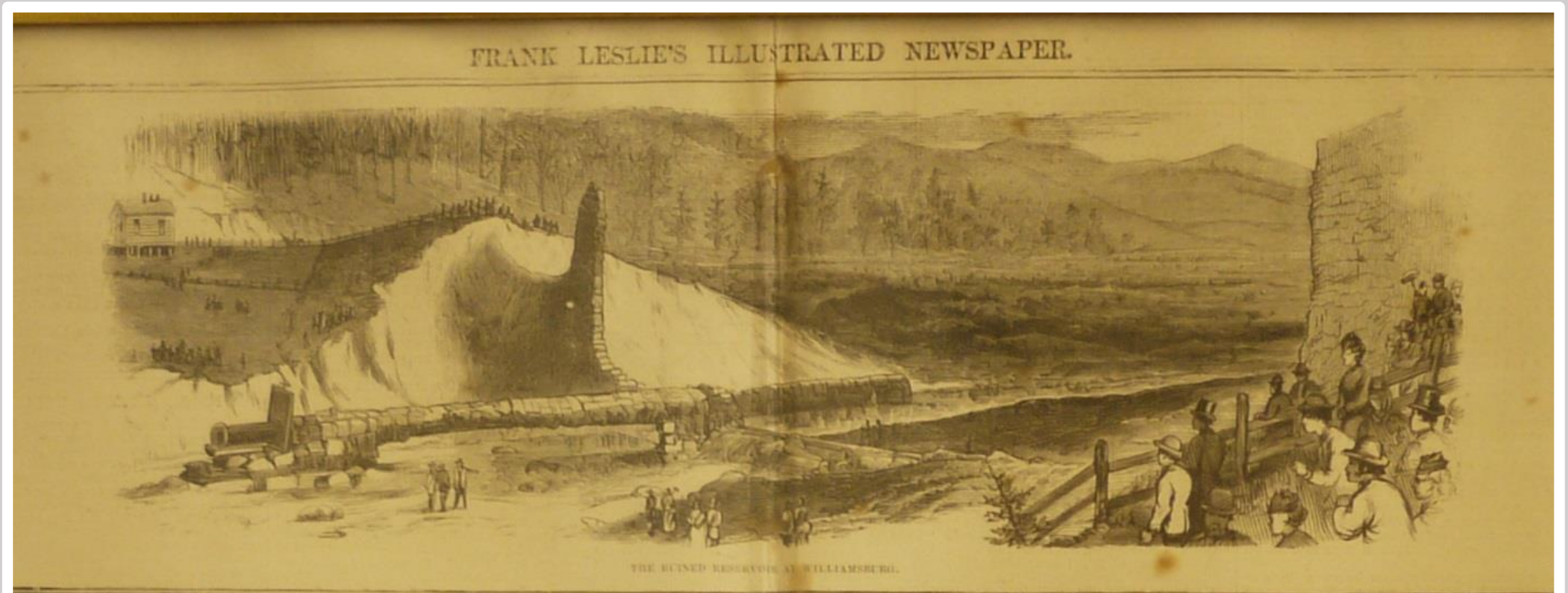
Can our dam fail? – Let me count the ways.

- Overtopping
erosion of
embankments
(South Fork
Reservoir Dam
/ Johnstown
Flood)



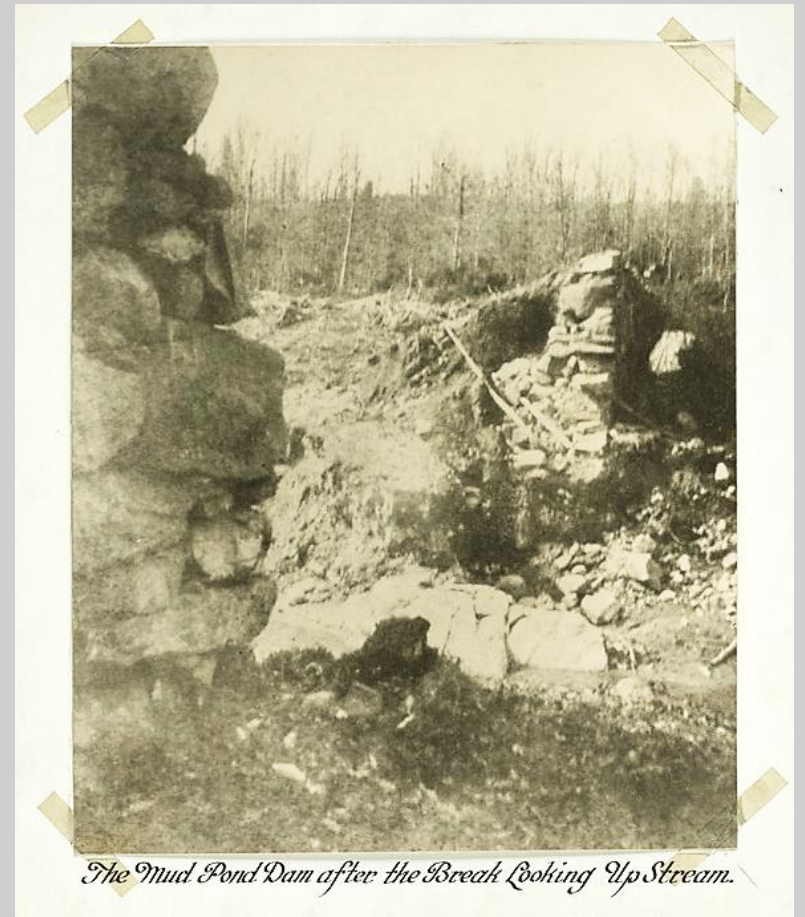
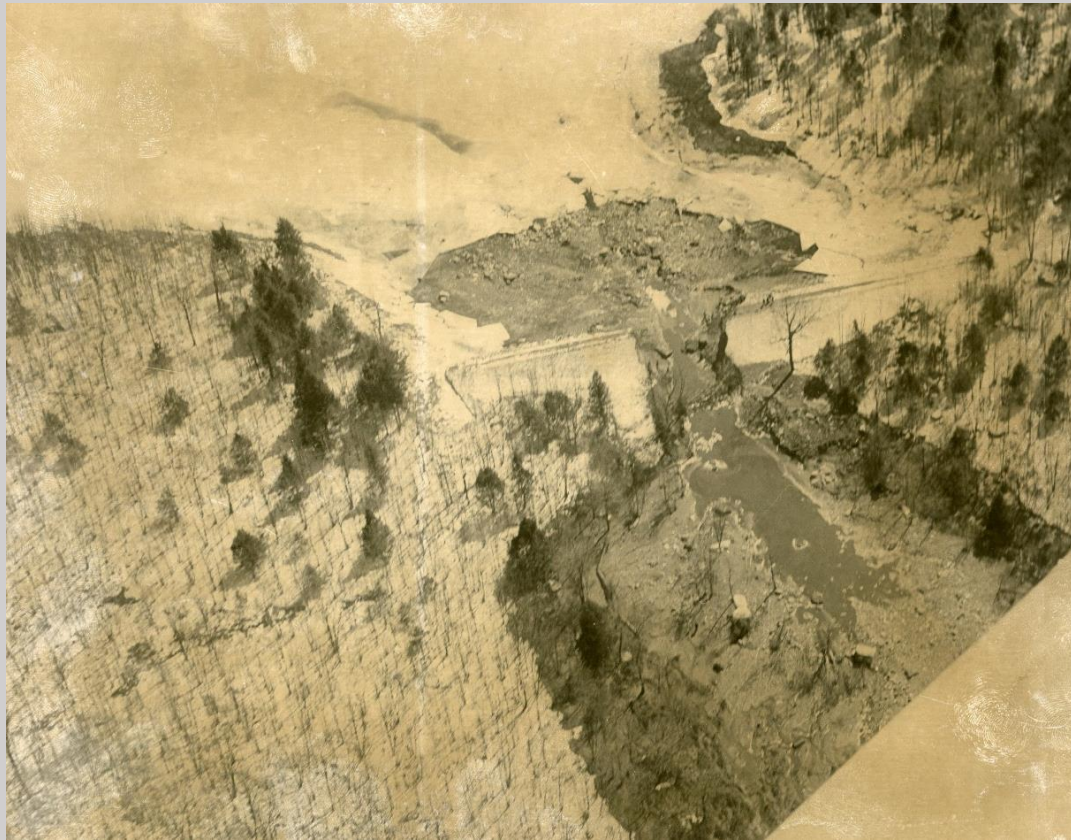
Can our dam fail? – Let me count the ways.

- Internal erosion of embankments by seepage (Williamsburg Reservoir Dam)



Can our dam fail? – Let me count the ways.

- Internal erosion of foundation by seepage (Mud Pond and Lake Lee Dams)



Can our dam fail? – Let me count the ways.

- Instability of dam slopes or walls (St. Francis Dam)



Can our dam fail? – Let me count the ways.

- Erosion of spillway (Oroville Dam, 2017 non-failure, but severe damage and large scale evacuation)



Can our dam fail? – Let me count the ways.

March 2010 Storm

Foster's Pond Dam high pool

Woburn Street flooding



Can our dam fail? – Let me count the ways.



Can our dam fail? – Let me count the ways.



Sinkhole

What do we do if the dam is in danger of failing?

Foster's Pond Emergency Action Plan



EMERGENCY ACTION PLAN

for

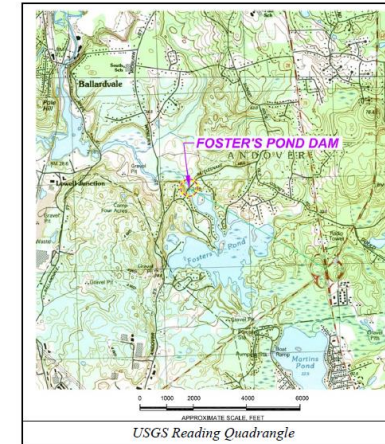
Foster's Pond Dam

Andover, Essex County, Massachusetts

National I.D. Number: MA00153

State ID Number: 5-5-9-10

Dam Location: 42.61361° N / 71.14146° W



Dam Owner:

Foster's Pond Corporation
c/o Stephen Cotton, President
19 Pomeroy Road, Andover, MA 01810
Owner Daytime Phone: 978-475-5679
Owner Emergency Phone: 978-475-5679

Dam Caretaker:

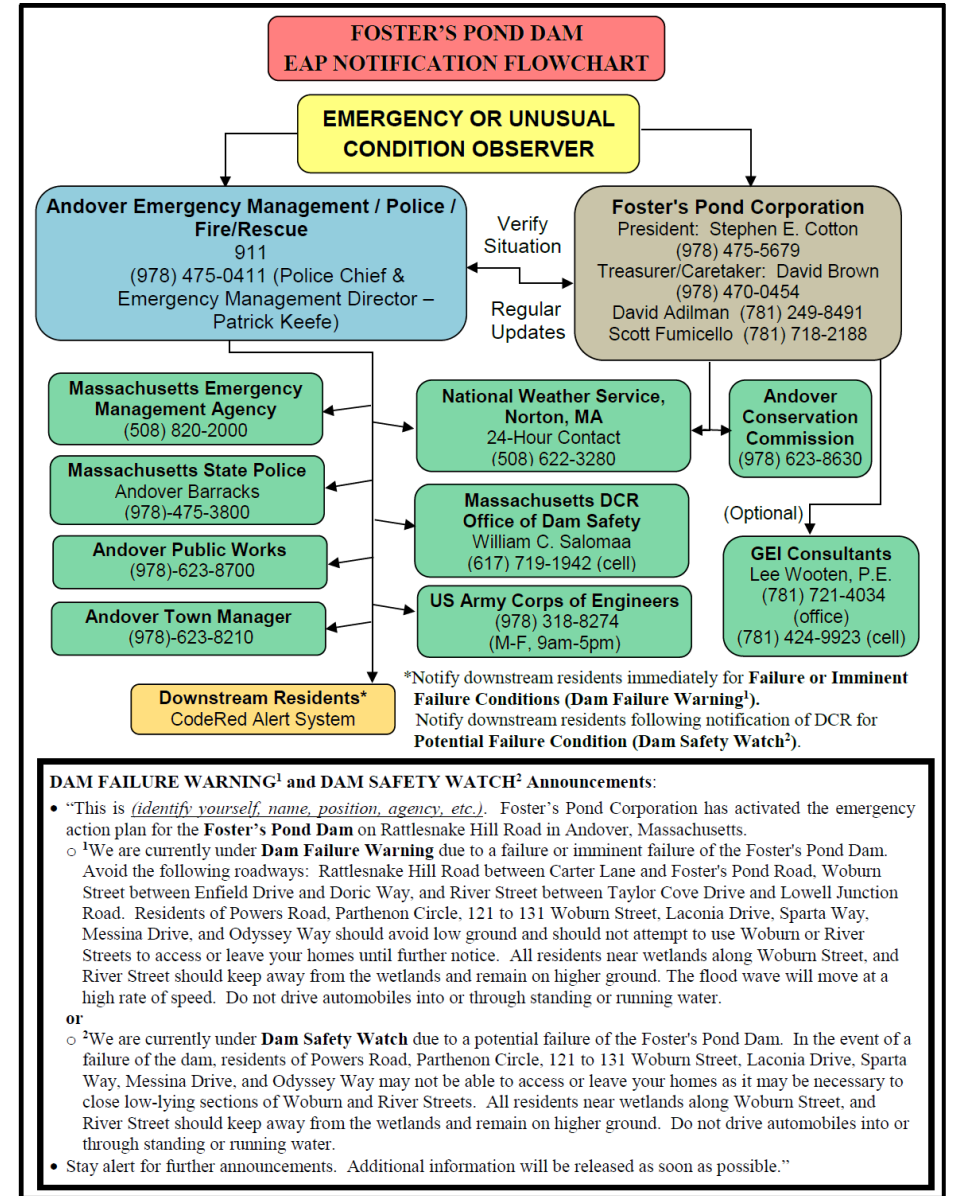
David Brown
31 Glenwood Road, Andover, MA 01810
Caretaker Daytime Phone: 978-470-0454
Caretaker Emergency Phone: 978-470-0454

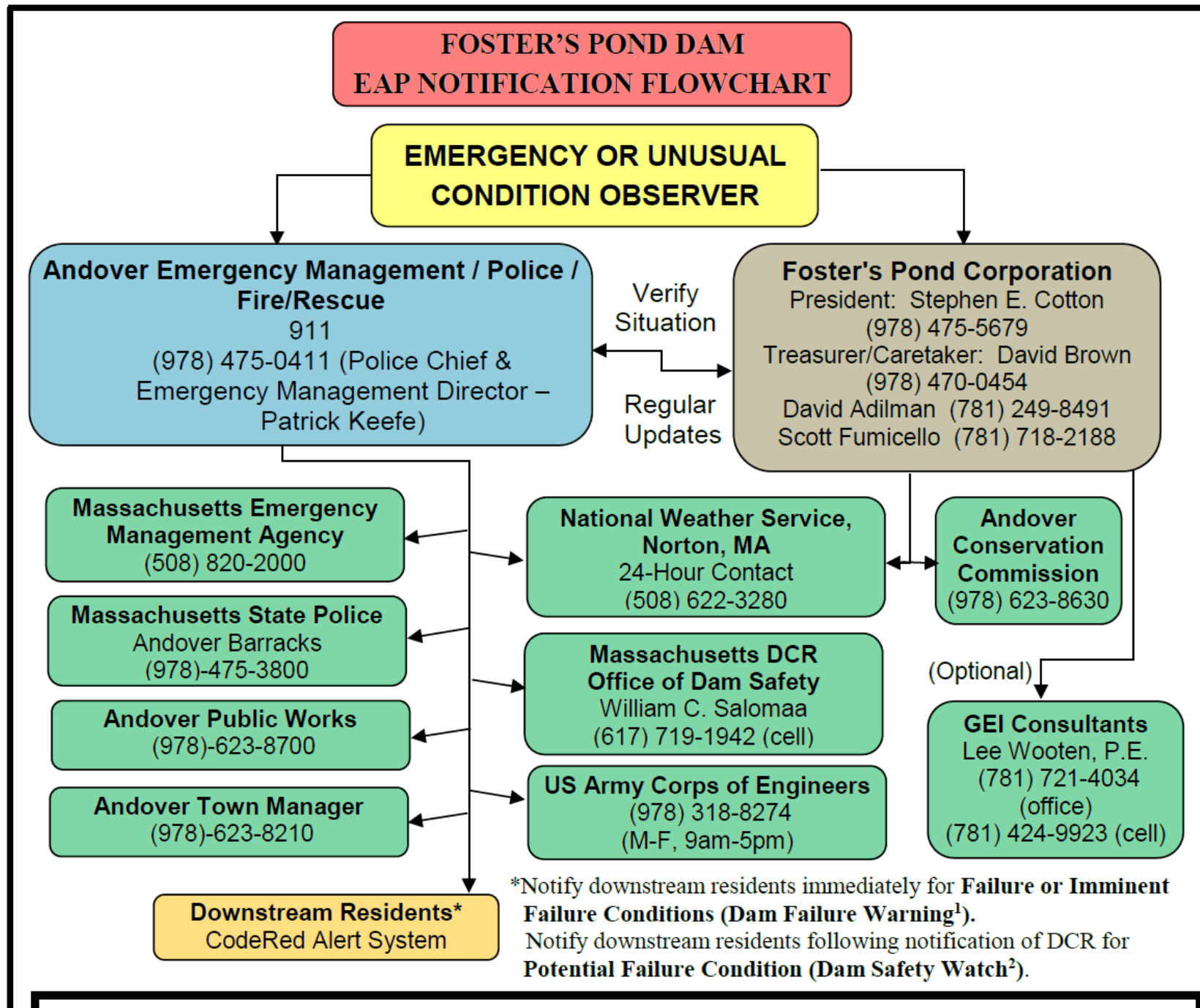
Plan Developed September 2019
Revision Number Date September 2019

What do we do if the dam is in danger of failing?

EAP Notification Flowchart

Emergency Action Plan, Foster's Pond Dam

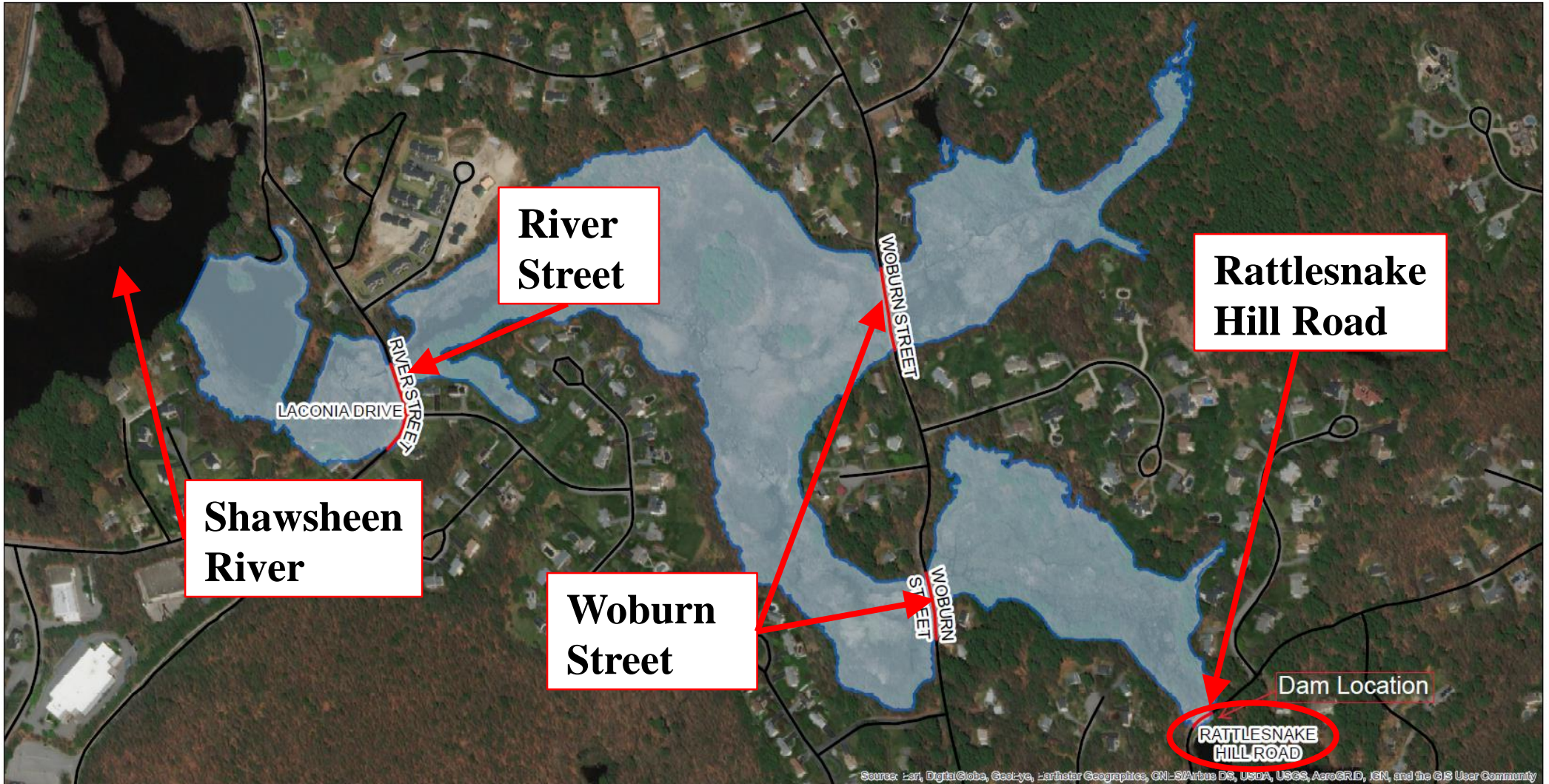




Potential Failure Condition (Dam Safety Watch).



DAM FAILURE WARNING¹ and DAM SAFETY WATCH² Announcements:

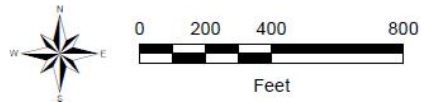
- “This is *(identify yourself, name, position, agency, etc.)*. Foster’s Pond Corporation has activated the emergency action plan for the **Foster’s Pond Dam** on Rattlesnake Hill Road in Andover, Massachusetts.
 - ¹We are currently under **Dam Failure Warning** due to a failure or imminent failure of the Foster's Pond Dam. Avoid the following roadways: Rattlesnake Hill Road between Carter Lane and Foster's Pond Road, Woburn Street between Enfield Drive and Doric Way, and River Street between Taylor Cove Drive and Lowell Junction Road. Residents of Powers Road, Parthenon Circle, 121 to 131 Woburn Street, Laconia Drive, Sparta Way, Messina Drive, and Odyssey Way should avoid low ground and should not attempt to use Woburn or River Streets to access or leave your homes until further notice. All residents near wetlands along Woburn Street, and River Street should keep away from the wetlands and remain on higher ground. The flood wave will move at a high rate of speed. Do not drive automobiles into or through standing or running water.
 - or
 - ²We are currently under **Dam Safety Watch** due to a potential failure of the Foster's Pond Dam. In the event of a failure of the dam, residents of Powers Road, Parthenon Circle, 121 to 131 Woburn Street, Laconia Drive, Sparta Way, Messina Drive, and Odyssey Way may not be able to access or leave your homes as it may be necessary to close low-lying sections of Woburn and River Streets. All residents near wetlands along Woburn Street, and River Street should keep away from the wetlands and remain on higher ground. Do not drive automobiles into or through standing or running water.
- Stay alert for further announcements. Additional information will be released as soon as possible.”



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNR/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND:

-  Inundation
-  Inundated roads



Emergency Action Plan
 Foster's Pond Dam
 Andover, Massachusetts
 Foster's Pond Corporation
 Andover, Massachusetts



FOSTER'S POND DAM
 INUNDATION
 BOUNDARY
 Project 1901003 September 2019 Fig. 1

What do we do if the dam is in danger of failing?

Individuals

- Call 911.
- Do not walk, bike, or drive through flooded streets, especially if water is flowing.

Foster's Pond Corporation

- Refer to the EAP.
- Generally don't try to fix the dam during a flood event.

Related Books on Dam Failures

- **In the Shadow of the Dam, The Aftermath of the Mill River Flood of 1874** by Elizabeth Sharpe
- **The Johnstown Flood** by David McCullough
- **Floodpath, The Deadliest Man-Made Disaster of 20th Century America and the Making of Modern Los Angeles** by Jon Wilkman
- **No One Had a Tongue to Speak, The Untold Story of One of History's Deadliest Floods** by Utpal Sandesara and Tom Wooten

Questions?