Plainville, MA

Turtle Brook Culvert at Shepard St

In Turnpike Lake

June 2021

CULVERT EVALUATION REPORT

315 Norwood Park South
2nd Floor
Norwood, Massachusetts 02062
781.255.1982
www.BETA-Inc.com

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CULVERT EVALUATION REPORT

Prepared by: BETA GROUP, INC.
Prepared for: Town of Plainville

June 2021

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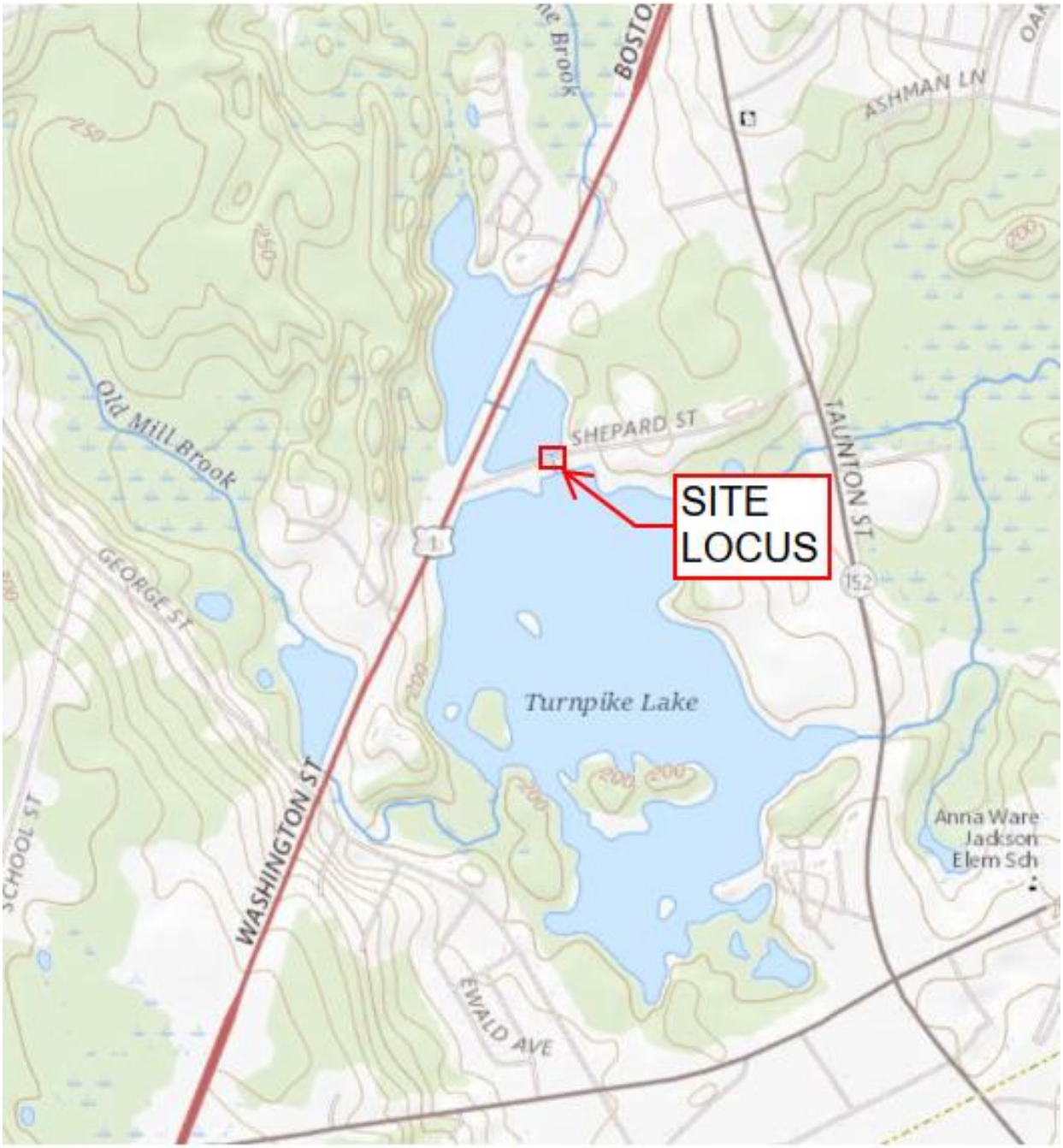
1.0 PROJECT LOCUS

Figure 1-1: Project Locus – USGS



2.0 OBJECTIVE OF REPORT

This report is provided to document the existing condition, capacity and vulnerable of this culvert to climate change. It is meant to evaluate potential issues such structural stability and flooding issues associated with higher current rainfall depths. This information will be utilized to prioritize capital improvement projects for the protection of public infrastructure, roadway and utilities, potentially improve the environment and connectivity of the stream.

The culvert was analyzed for the 10- and 100-year storm events for capacity and flooding purposes.

3.0 CALCULATION METHODS AND ASSUMPTIONS

The hydrologic and hydraulic flow calculations were completed stormwater runoff is analyzed using the following:

- Flood Insurance Study revised June 9, 2014
- Flood Insurance Rate Map Norfolk County. Massachusetts 25021C0339F effective July 16, 2015 provided by Federal Emergency Management Agency
- Culvert information was obtained via a field observation completed in May 2021.
- StreamStats flows data (workspace ID: MA20210504144106929000) (see Appendix C):
- HydroCAD 10.00 to verify capacity based on storage in the upper and middle Turnpike Lake
- Technical Paper No. 40 (TP-40) Rainfall Frequency Atlas of the United States
- NOAA Atlas 14 Point Precipitation Frequency Estimates

4.0 PROJECT AREA LOCATION AND CULVERT DESCRIPTION

Turtle Brook flows into the north end of and through Turnpike Lake which is bisected by Washington Street and Shepard Street.

The culvert system at Shepard Street consists of two corrugated metal pipes (CMPs) with a stone headwall on either side. The west CMP is 2'-6" in diameter and the east CMP is 2'-0" in diameter. The north headwall is approximately 19'-9" long and 1'-9" high. The south headwall is approximately 21'-0" long and 2'-10" high. The south headwall continues on to a masonry wall on the southeast side. The direction of flow is north to south and the depth of flow varies.

The roadway width over the structure is 19'-8" with a 6'-0" shoulder to the headwall on the north side and a 6'-4" shoulder to the headwall on the south side. There is a speed bump located on the west approach.

There are overhead wires on the south side. There is no guardrail present over the culvert or at either approach.

5.0 CULVERT CONDITION

The overall condition of the structure is fair with a few deficiencies noted. The condition of the CMPs were good, with no deficiencies noted. Both headwalls have some areas of hairline cracks and loose/missing mortar. The north headwall is displaced up to 5" and has several cracks (See Photos 5 and 6). The south headwall is also displaced about 6" and has several cracks (See Photos 12 and 13). The south headwall was found to have undermining of at least 6" in depth. The south headwall continues to a stone masonry wall to the southeast. This southeast wall has heavy vegetation and is displaced (Photo 14). There appears

to be a scour hole present just outside the south entrance to the CMPs. The flow elevation rapidly drops off at this location, approximately 18" out from the CMPs.

The roadway over the culvert and at each approach is in good condition. There is an area of heavy ponding on the north side of the east approach (Photo 16). There is a newly installed speed bump on the west approach (Photo 15).

6.0 DATA COLLECTION

The following are the data sources and hydrologic data use for this evaluation

Table 6-1: Data Sources

Data Type	Source	Details
Culvert Data	BETA Group, Inc. (2021)	Field Measurements
Structural Evaluation	BETA Group, Inc. (2021)	
Project Locus	USGS	
Aerial Mapping	Google Earth (2020)	
Flood Data	Flood Insurance Rate Map (FIRM) Zone AE –elevation 199	Community Panel No. 25021C 0339F
Stream Profile	FEMA – FIS Norfolk County, MA	Turtle Brook Flood Profile 228P
StreamStats Report	USGS (2020)	Workspace ID: MA20210504144106929000

Table 6-2: Hydrologic Data

Hydraulic Design Data			**Flood of Record**	
Drain Area	4.28 sq. mi.		Discharge	Unknown
Bank Full Width			Frequency	Unknown
Design Flood Discharge	165 cfs*		Maximum Elevation	Unknown
Design Flood Frequency	10-year		Date	March 1968
Base (100-year) Flood Data*				
Base Flood Discharge*	334 cfs*		Base Flood Elevation	199 (NGVD)

*Adjusted for Climate Change – See Appendix E

7.0 HydroCAD Model – Verify Capacity Estimating Lake Storage

A basic HydroCAD model was developed using rainfall data from, watershed area from StreamStats data, with estimated surface condition (CN) and time of concentration chosen to approximate the estimated flows from StreamStats data for the 10 year storm event. The lake area was approximated using the surface area provided by MassGIS (Oliver) and the measurements of the culvert from the field observations. Note elevations are on an assume datum.

The results indicate that the culverts are adequate to accommodate the 10-year storm event. The difference between the peak elevation for the lake and the roadway elevation is 0.6± feet.

8.0 Conclusions and Recommendations

8.1. Structure

The overall condition of the CMPs is good, and the headwalls are fair condition. Based on recent inspection findings, BETA recommends that the following items be addressed:

- Address undermining and fill in scour void on the south side with rip rap. This should be considered a High Priority to protect against future deterioration.
- Rebuild stone masonry walls to avoid washout and protect roadway surface.
- Clear vegetation around masonry walls.

Inspections should be conducted at intervals not exceeding 12 months to monitor overall culvert conditions.

8.2. Flood Impacts

The existing culverts can convey the design storm flow without over topping the road. Any replacement of this structure should consider providing a culvert that meets the Massachusetts Stream Crossing Standards to provide better connectivity for aquatic species.

The road will continue to flood during the 100-year storm event unless the downstream outlets to the lake are improved.

8.3. Cost Estimate

BUDGETARY COST ESTIMATE

Repairs

Construction:	$32,000
Engineering:	$8,000
Total:	$40,000

APPENDIX A
Structures Inspection Field Report

Town of Plainville, Massachusetts

Bridge/Culvert Inspection Checklist

General:

Street Name: Shepard Street Waterway: Turnpike Lake Culvert ID:

Inspectors:

Name: Peter Kotowski Position: Senior Structural Engineer

Name: Brandon Nelson Position: Staff Engineer

Name: None Position: None

Inspection Conditions:

Date: 5/12/2021 Weather: Sunny/Partly Cloudy Temp: 54°F

General Information:

Bridge Type: (2) Corrugated Metal Pipes Construction Date: Unknown

Hydraulic Opening Height (Feet): 2'-6" & 2'-0" Diameter Pipes Out-To-Out Length (Feet): 4.25

Hydraulic Opening Width/Span Length (Feet): 2'-6" & 2'-0" Diameter Pipes Depth of Fill Over Culvert Inches: Varies 6" (Min.) - 11

Depth of Flow During Inspection: 1.25' Direction of Flow: South

Utilities Carried By Structure: Overhead Wires, Water

Drainage Structures: NA

Recommendations: Fill Scour Voids at South opening; Rebuild Stone Masonry Headwalls; Clear Overgrown Vegetation

Abutments/Culvert Sidewalls:

North Sidewall: Wall is displaced approx. 5"-18"; 1.5" wide crack over pipe; 1/4" wide crack @ eastern end

South Sidewall: 6" undermining of headwall; 6" leteral displacement

Center Pier: NA

Channel Walls: NA

Abutment North Sidewall Rating: 6 Abutment South Sidewall Rating: 6

Center Pier Rating: NA Channel Wall Rating: NA

Superstructure/Culvert Roof:

Condition Notes: NA

Rating: NA

Culvert Floor/Channel

Scour: Approx. 3.7' of Scour noted at downstrDebris: NA Floor/Channel Rating: 5

Floor/Channel Notes: No debris noted

Town of Plainville, Massachusetts

Bridge/Culvert Inspection Checklist

Training/Wingwalls:

North East Wall:	Headwall	North West Wall Type:	Masonry Brick	North West Wall Rating:	6
North East Wall:	Areas of loose/missing stones				
North West Wall:	NA	North West Wall Type:	NA	North West Wall Rating:	NA
North West Wall:	NA				
South East Wall:	Wingwall	South East Wall Type:	Stone Masonry	South East Wall Rating:	6
South East Wall:	Areas of loose/missing stones				
South West Wall:	Wingwall	South West Wall Type:	Stone/Masonry	South West Wall Rating:	6
South West Wall:	Areas of loose/missing stones				
Head Wall:	See Sidewall Notes	Head Wall Type:	See Sidewall Note	Head Wall Rating:	
Head Wall Notes:	See Sidewall Notes				

Roadway Condition:

Culvert/Bridge Roadway Condition:	Minor cracking	Culvert/Roadway (Feet):	19.67'
Culvert/Bridge Roadway Settlement:	NA	Culvert/Roadway Rating:	6
Culvert/Bridge Roadway Alignment:	Straight		
North Roadway Approach Condition:	NA	North Roadway (Feet):	NA
North Roadway Approach Settlement:	NA	North Roadway Rating:	NA
North Roadway Approach Alignement:	NA		
South Roadway Approach Condition:	NA	South Roadway (Feet):	NA
South Roadway Approach Settlement:	NA	South Roadway Rating:	NA
South Roadway Approach Alignement:	NA		
East Roadway Approach Condition:	Water ponding; Minor cracking	East Roadway (Feet):	19.67'
East Roadway Approach Settlement:	Hole forming N. side of road	East Roadway Rating:	6
East Roadway Approach Alignement:	Slight horiz. Curve		
West Roadway Approach Condition:	Minor cracking; Speed bump installed	West Roadway (Feet):	19.67'
West Roadway Approach Settlement:	NA	West Roadway Rating:	6
West Roadway Approach Alignement:	Straight		

Safety Barrier

Bridge Rail Type: No guardrail or barrier present

Bridge Rail Condition: NA - No barrier present

Bridge Rail Rating: NA

Approach Rail Notes: NA - No approach safety rail/barrier

VERSA-LOK®
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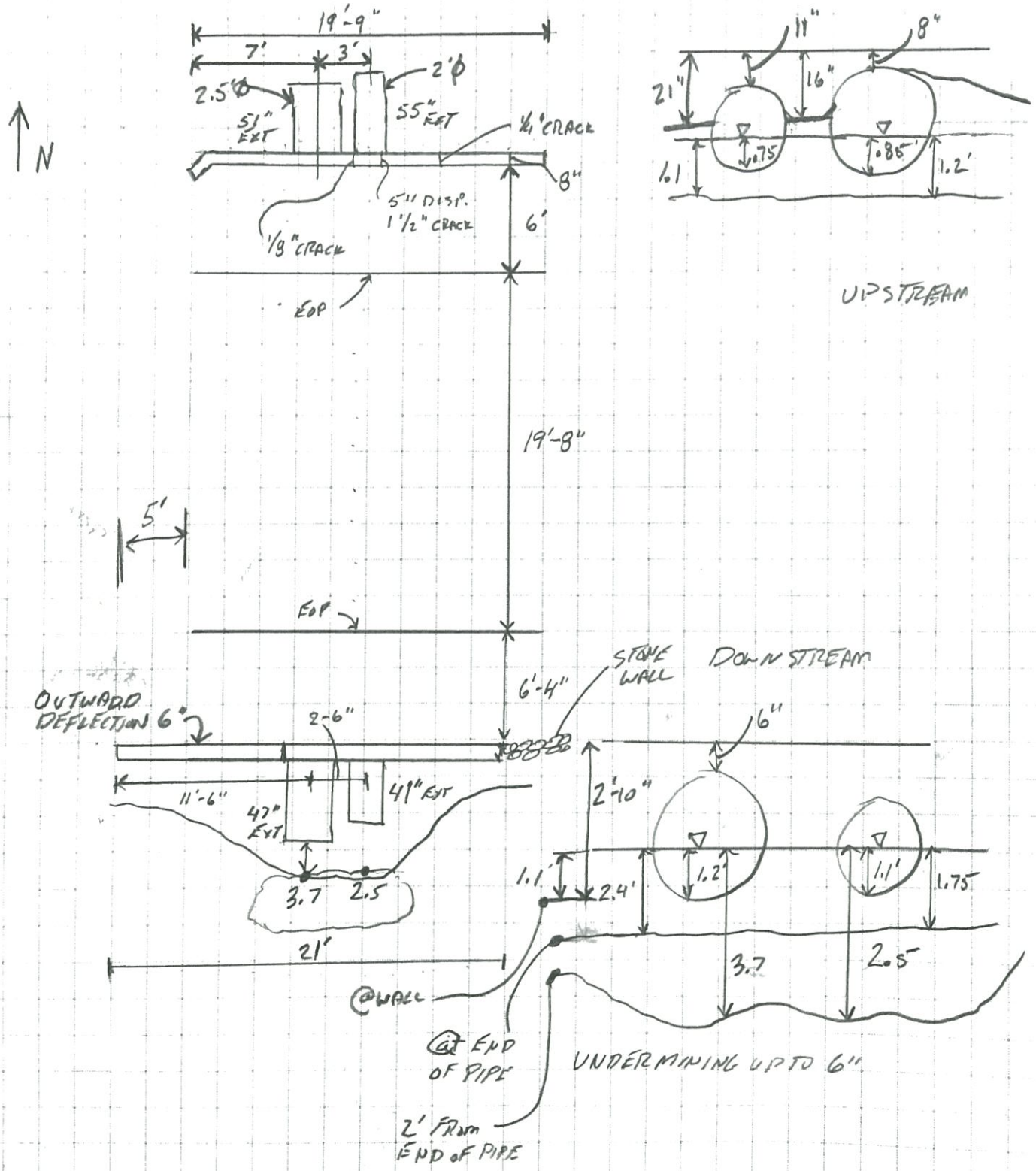
Nashua, NH / Milford, CT
(800) 523-2937

Project _____

Date _____ Prepared By _____

Scale _____ Sheet _____ of _____



APPENDIX B
Photo Survey

Photo 1 Looking Northwest: North Side of CMPs

Photo 2 Looking North: Turnpike Lake

Photo 3 North Side of CMPs

Photo 4 Looking Southwest: Northwest Portion of Headwall

Photo 5 Looking South: North Headwall at CMPs

Photo 6 Looking Southeast: Southeast Portion of Headwall

Photo 7 Looking Southwest: South side of CMPs

Photo 8 Looking South: Turnpike Lake

Photo 9 South Side of CMPs

Photo 10 Looking Southeast: Southwest Headwall Corner

Photo 11 Looking Northwest: Southwest Portion of Headwall

Photo 12 Looking North: South Headwall at CMPs

Photo 13 Looking Northeast: Northeast Portion of Headwall

Photo 14 Looking East: Southeast Masonry Wall

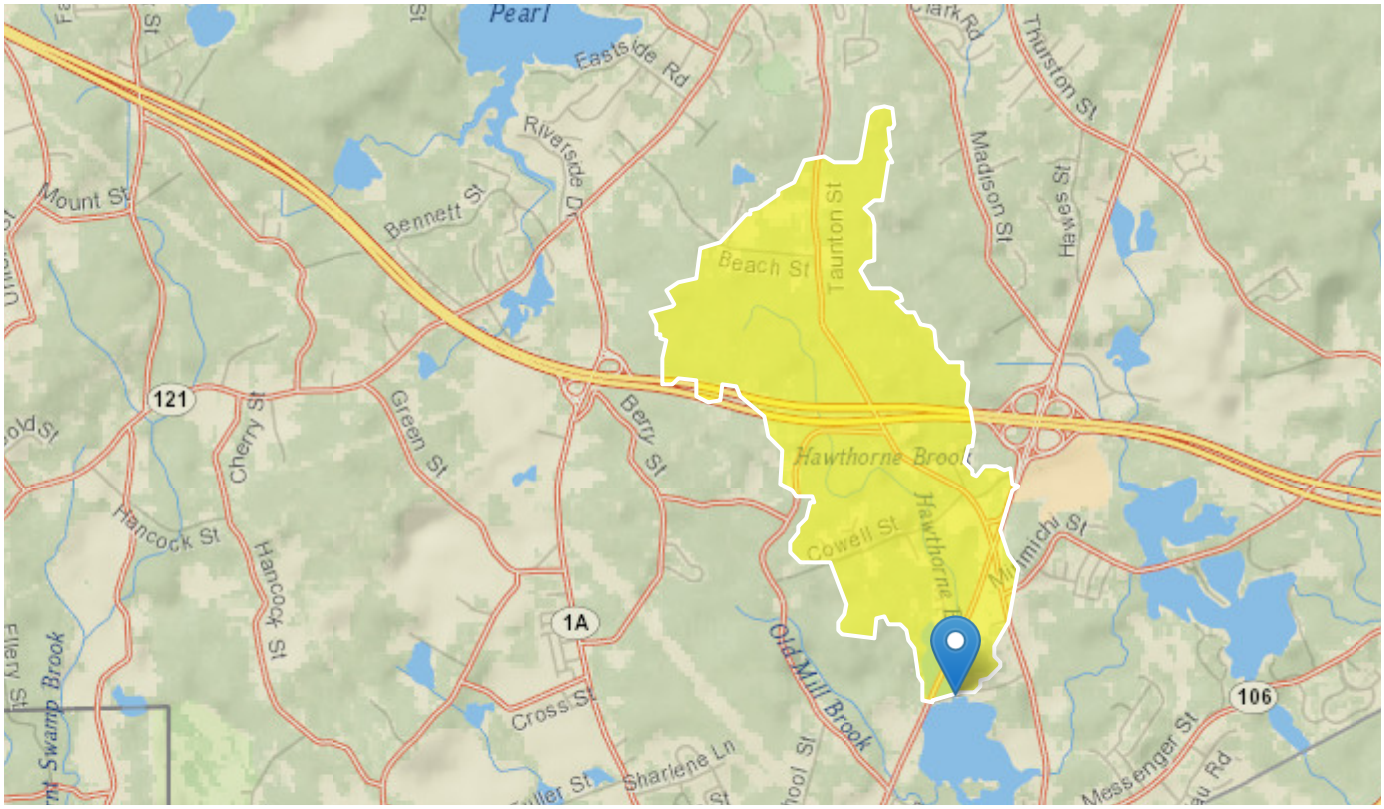
Photo 15 Looking East: West Approach

Photo 16 Looking West: East Approach

APPENDIX C
StreamStats Data

Shepard St Culvert - StreamStats Report

Region ID: MA
Workspace ID: MA20210504144106929000
Clicked Point (Latitude, Longitude): 42.01974, -71.31378
Time: 2021-05-04 10:41:28 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.91	square miles
ELEV	Mean Basin Elevation	272	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	10.34	percent
BSLDEM10M	Mean basin slope computed from 10 m DEM	5.926	percent

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.91	square miles	0.16	512
ELEV	Mean Basin Elevation	272	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	10.34	percent	0	32.3

Peak-Flow Statistics Flow Report [Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SEp
50-percent AEP flood	61.3	ft^3/s	31.3	120	42.3
20-percent AEP flood	102	ft^3/s	51.3	203	43.4
10-percent AEP flood	135	ft^3/s	66.3	275	44.7
4-percent AEP flood	182	ft^3/s	86.4	383	47.1
2-percent AEP flood	221	ft^3/s	102	481	49.4
1-percent AEP flood	263	ft^3/s	117	590	51.8
0.5-percent AEP flood	308	ft^3/s	133	712	54.1
0.2-percent AEP flood	373	ft^3/s	154	904	57.6

Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Bankfull Statistics Parameters [Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.91	square miles	0.6	329
BSLDEM10M	Mean Basin Slope from 10m DEM	5.926	percent	2.2	23.9

Bankfull Statistics Flow Report [Bankfull Statewide SIR2013 5155]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	18.8	ft	21.3
Bankfull Depth	1.12	ft	19.8
Bankfull Area	20.8	ft^2	29
Bankfull Streamflow	52.5	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Application Version: 4.5.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.1

APPENDIX D
FEMA and FIS Study Information

FEMA Flood Insurance Study (FIS) Information

Flooding in the Town of Plainville can occur anytime; however, major flooding usually occurs during the spring as a result of heavy rain combined with snowmelt or late summer-early fall due to tropical storms. The greatest flood in the memory of town officials occurred in March 1968. During that flood, overflow from Turnpike Lake flooded sections of U. S. Route 1 and Shepard Street, and the Ten Mile River flooded part of West Bacon Street.

In Plainville, with the exception of the Ten Mile River and the Whiting Pond Bypass, peak discharges for floods with 10-, 2-, 1- and 0.2-percent-annual-chance recurrence intervals were estimated by use of formula developed by S. William Wandle, Jr. (Reference 90). Discharges for the Ten Mile River and the Whiting Pond Bypass were estimated by the USDA NRCS during the preparation of an Federal Insurance Agency (currently FEMA) Type 15 study of the adjoining Town of North Attleborough (Reference 116). Near the corporate limits, peak discharge of the Ten Mile River does not relate to drainage area because of flow diversion into the Whiting Pond Bypass.

On Turnpike Lake in Plainville there are two small dams. The Plainville Highway Department removes the flashboards of these dams when the water level of the lake approaches flood stage. For the dam computations it has been assumed that all flashboards would be removed. Water can be diverted from Turtle Brook into a canal just below Turnpike Lake Dam No.1. The diverted water can be returned to Turtle Brook upstream from the site of an abandoned mill at Taunton Street. Furthermore, there is a leakage from the canal which is at a higher elevation than the brook. However, because there is no way of knowing how much, if any, water would be diverted into the canal during a flood, it has been assumed that canal flow would be negligible.

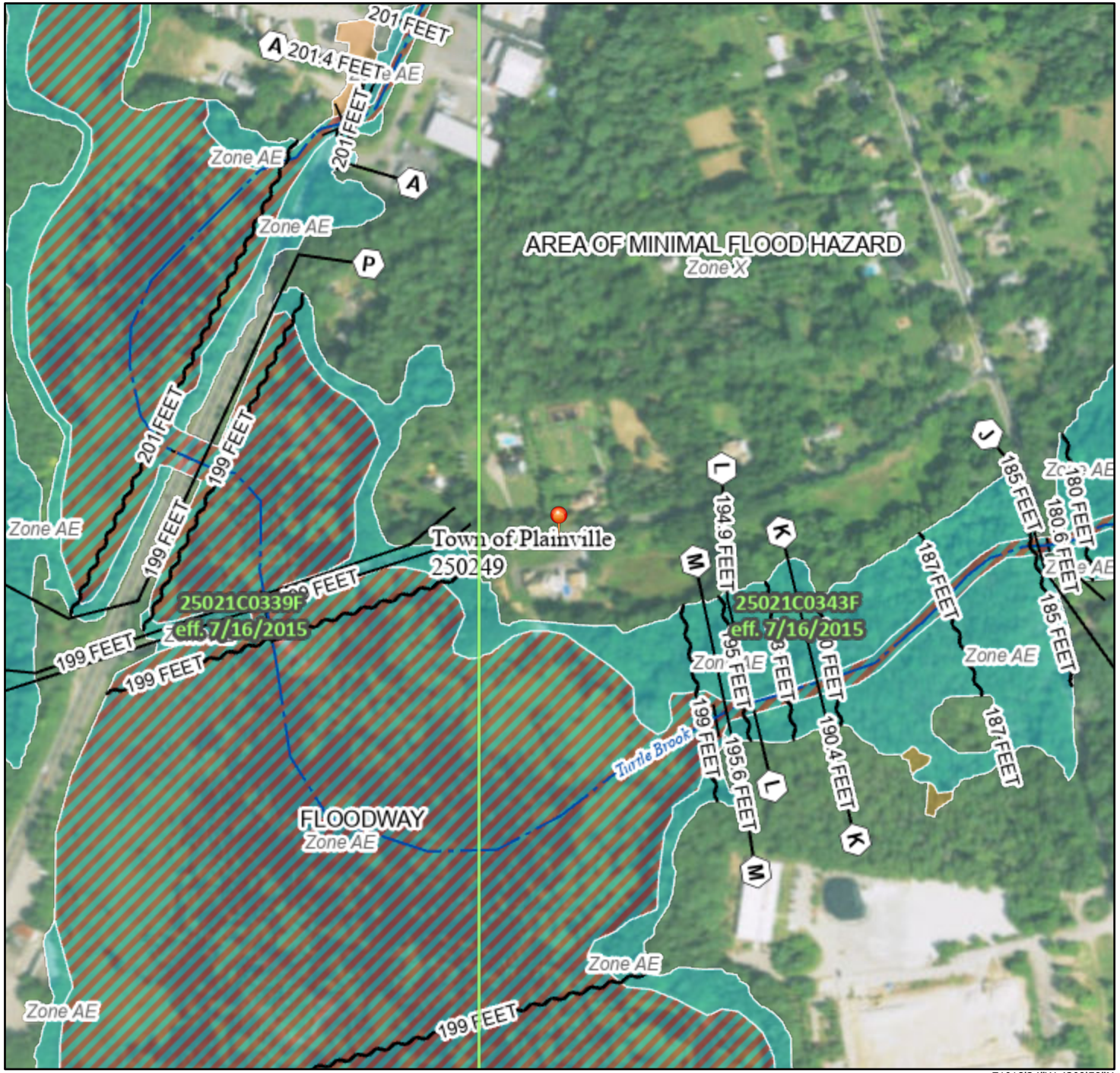
With the exception of the Ten Mile River and the Whiting Pond Bypass, water-surface elevations of floods of the selected recurrence intervals in Plainville were computed using USGS step-backwater computer program E431 (Reference 160). The elevations for the Ten Mile River and the Whiting Pond Bypass were computed at the time of the USDA NRCS Flood Insurance Study of the Town of North Attleboro (Reference 116). Elevations obtained for the Ten Mile River using USDA NRCS field data in the USGS computer program verify those obtained by the USDA NRCS. The flood elevations of Lake Mirimichi were used as starting elevations for Turtle Brook. The starting elevations on Brook No. 1 were determined by dam computations.

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGES (CUBIC FEET PER SECOND) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
SUCKER BROOK					
At confluence with Massapoag Lake	1.10	63	92	104	141
TEN MILE RIVER					
At Plainville downstream corporate limits	4.23	86	150	200	390
At confluence with Whiting Pond Bypass	3.48	94	180	230	420
TURTLE BROOK					
At Mirimichi Street	5.29	260	440	540	830
Above confluence with Sawmill Brook	3.50	145	215	285	495
At Shepard Street	1.88	110	190	235	365

National Flood Hazard Layer FIRMette

FEMA

71°19'1"W 42°1'26"N



71°18'24"W 42°0'59"N

Feet

0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

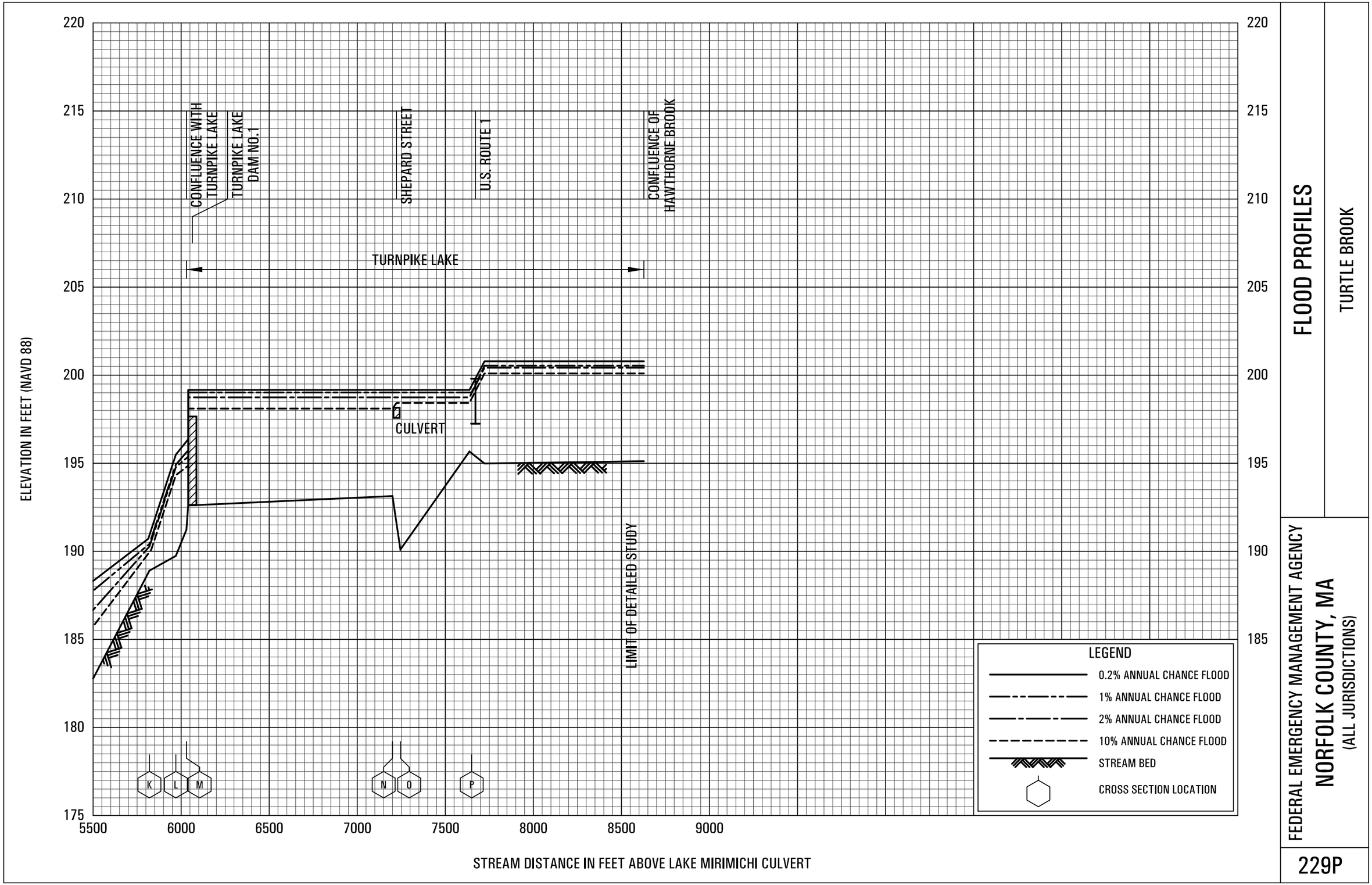
N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/4/2021 at 11:27 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



FLOOD PROFILES

TURTLE BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORFOLK COUNTY, MA

(ALL JURISDICTIONS)

229P

APPENDIX E
Hydrologic Data/Climate Change Adjustment

Hydrologic Data

StreamStats flows data (workspace ID: MA20210504144106929000) will be used to evaluate the culvert which are listed as follows:

10 Yr = 165 cfs 25 Yr. = 182 cfs 50 Yr = 221 cfs 100 Yr = 263 cfs

FEMA FIS Study also lists the flows at this site as follows:

10 Yr = 110 cfs 50 Yr = 190 cfs 100 Yr = 235 cfs

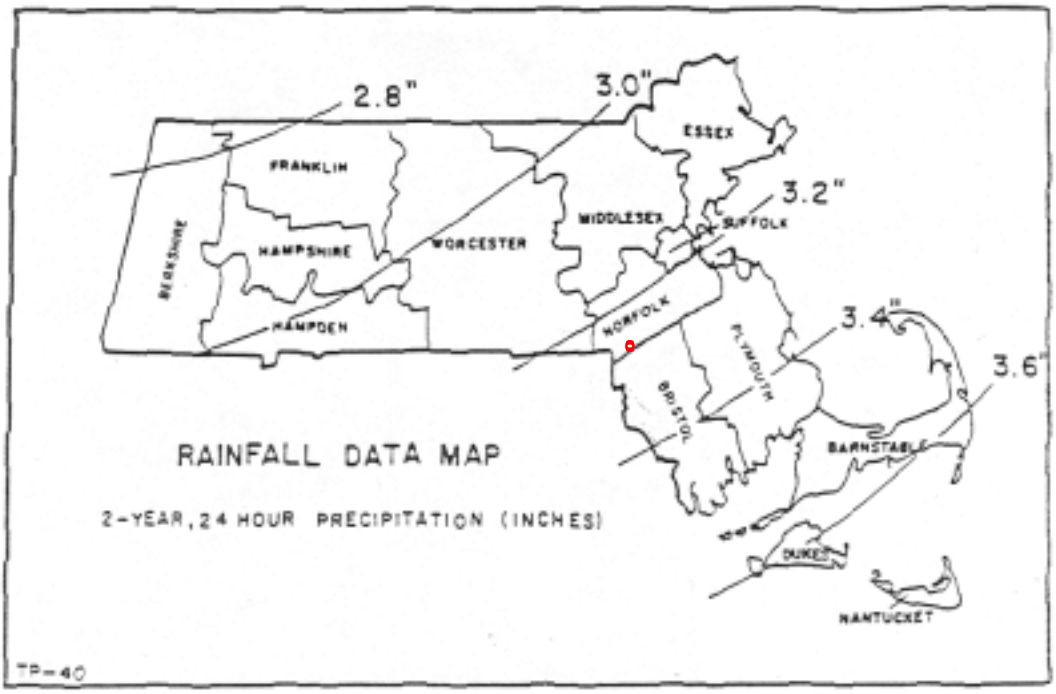
Climate Change Adjustment

To adjust for climate change, BETA incorporated an adjustment of the StreamStats peak flow data using current (NOAA Atlas 14) rainfall data compared to the outdated TP-40 data.

Accommodate Climate Change/Resiliancy
Adjust Streamstats/FEMA FIS Flow Data
By Ratio of TP 40 to NOAA Atlas 14 Rainfall Data

	1	2	3		4	5	
Storm Event (Yr)	**Rainfall TP-40 (in)**	**Δ (in)**	**Flow Data (Streamstata) (cfs)**	**Flow Data (FEMA FIS) (cfs)**	**Flow Data (Streamstata) Δ (cfs)**	**Rainfall Atlas-14 (in)**	**Adjusted Flow (cfs)**
2	3.25		61			3.4	68
		0.9			41		
5	4.15		102			4.38	116
		0.54			33		
10	4.69		135	110		5.2	165
		0.79			47		
25	5.48		182			6.32	231
		0.67			39		
50	6.15		221	190		7.15	286
		0.65			42		
100	6.80	3.55	263	235	202	8.05	334

Adjusted Flow = 3+((5-1)/2)x4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PLYMOUTH
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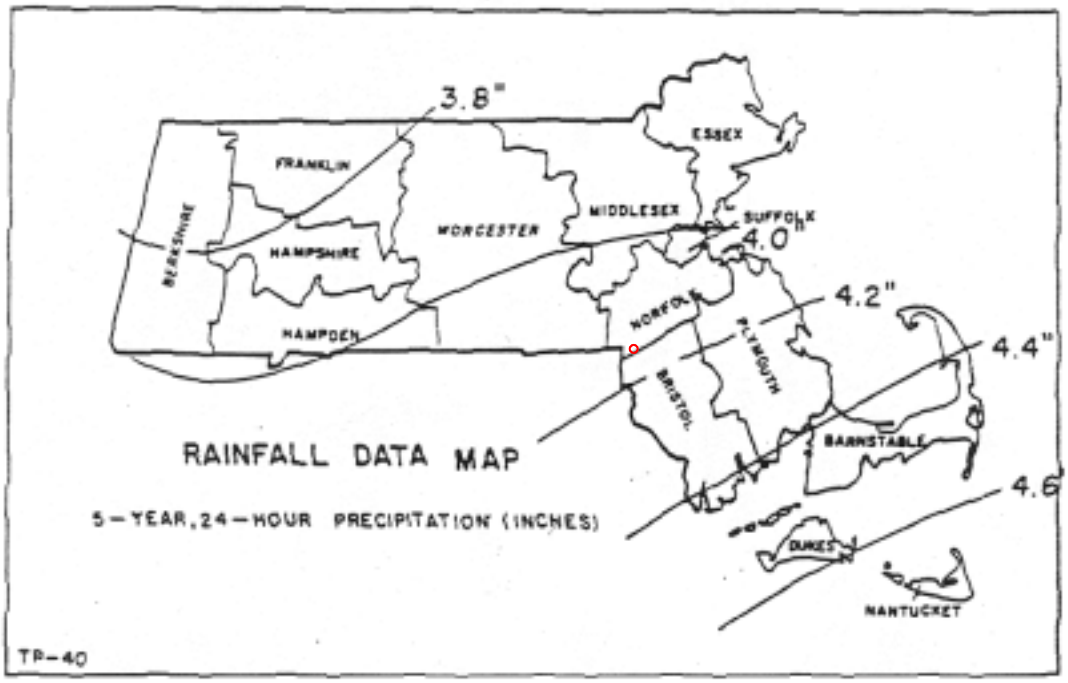
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
2-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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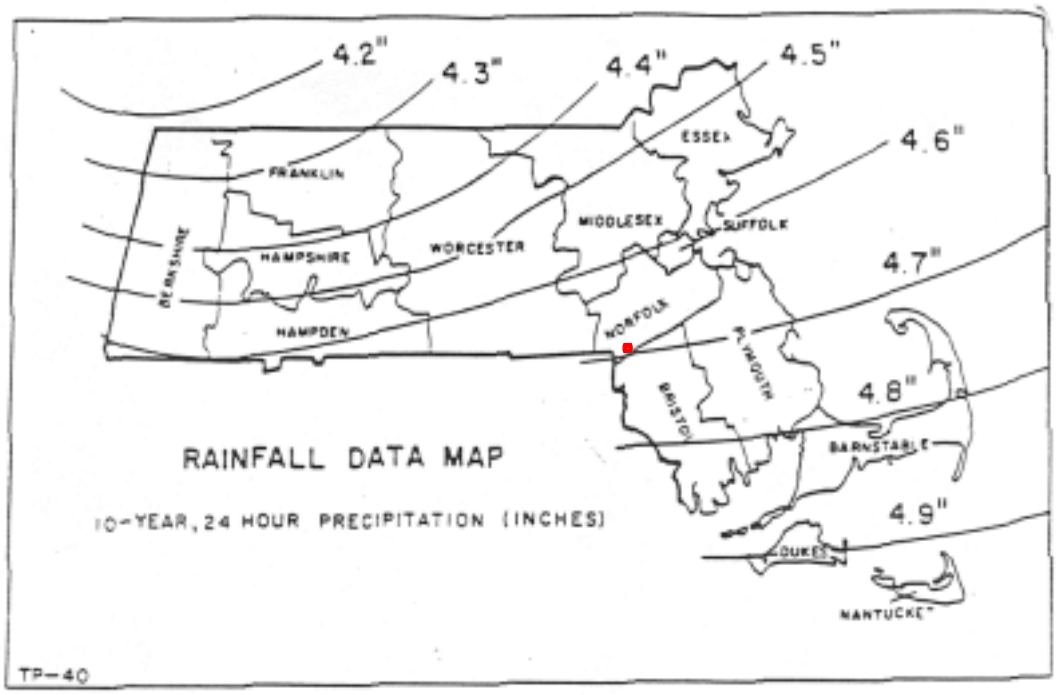
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BARNSTABLE
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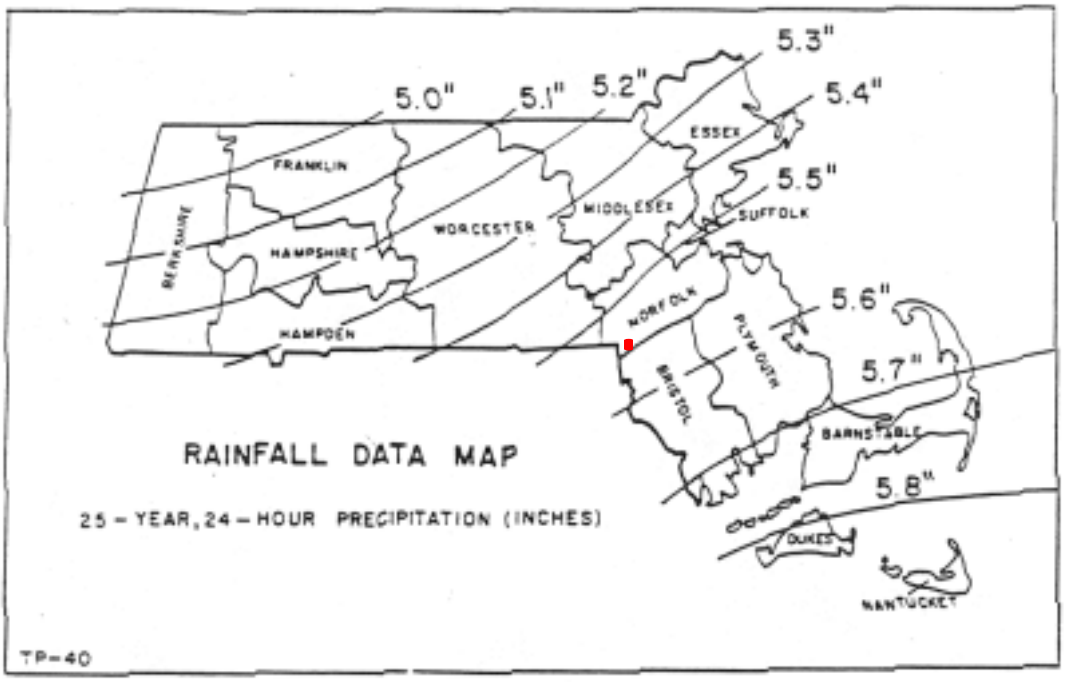
RAINFALL DATA MAP
10-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40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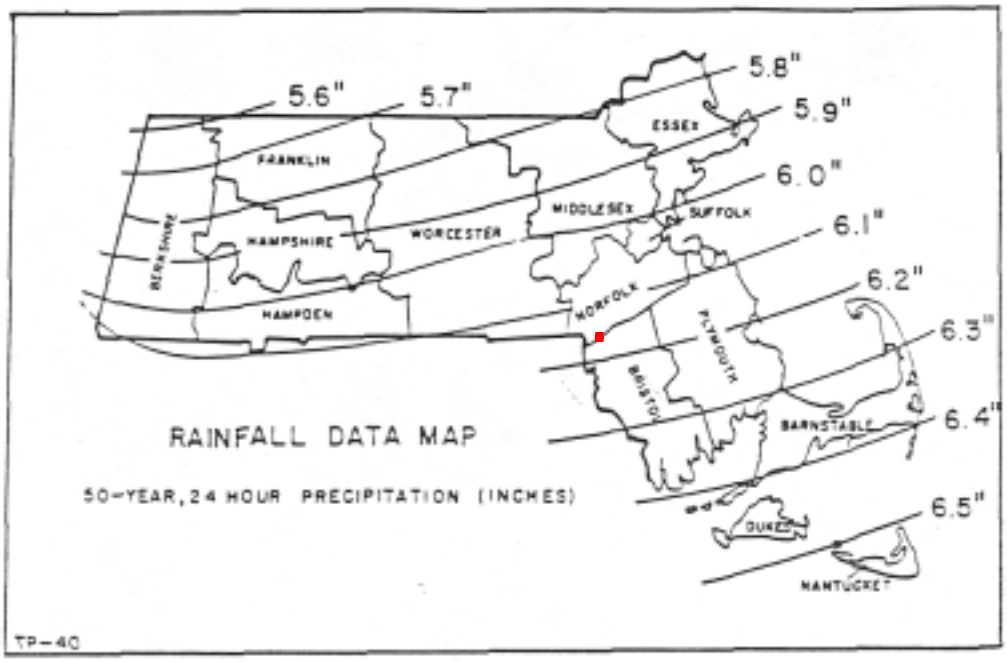
25 - YEAR, 24 - HOUR PRECIPITATION (INCHES)
TP-40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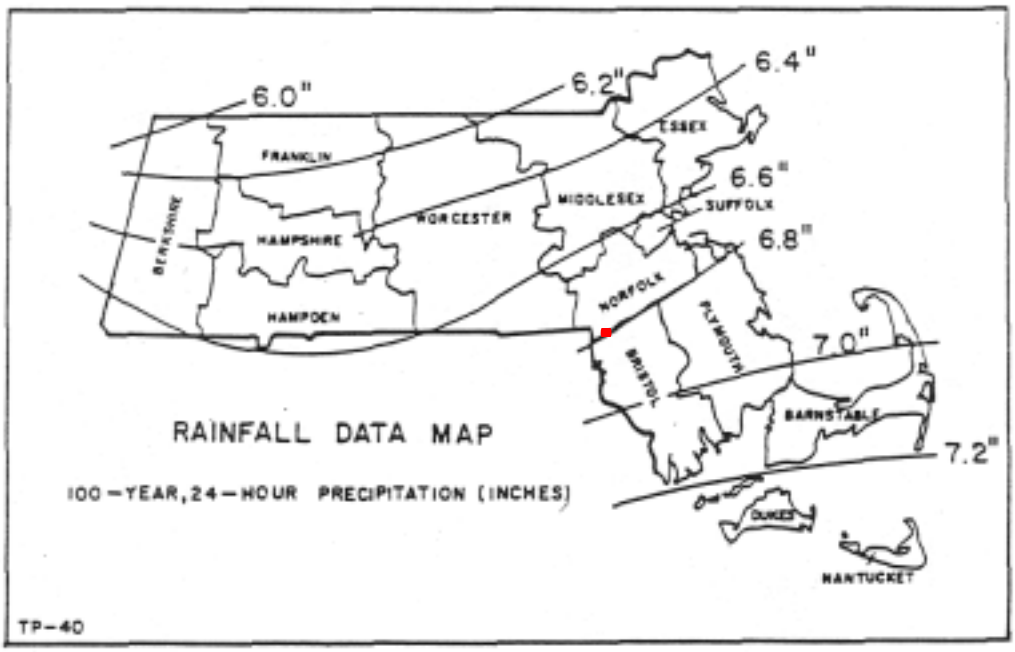
BERKSHIRE
HAMPDEN
NORFOLK
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
50-YEAR, 24 HOUR PRECIPITATION (INCHES)
TP-40


6.0"
6.2"
6.4"
6.6"
6.8"
7.0"
7.2"
FRANKLIN
ESSEX
MIDDLESEX
SUFFOLK
HAMPSHIRE
WORCESTER
BERKSHIRE
HAMPDEN
NORFOLK
PLYMOUTH
BRISTOL
BARNSTABLE
DUKES
NANTUCKET
RAINFALL DATA MAP
100-YEAR, 24-HOUR PRECIPITATION (INCHES)
TP-40

NOAA Atlas 14, Volume 10, Version 3
Location name: Plainville, Massachusetts, USA*
Latitude: 42.0193°, Longitude: -71.3159°
Elevation: 199.23 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

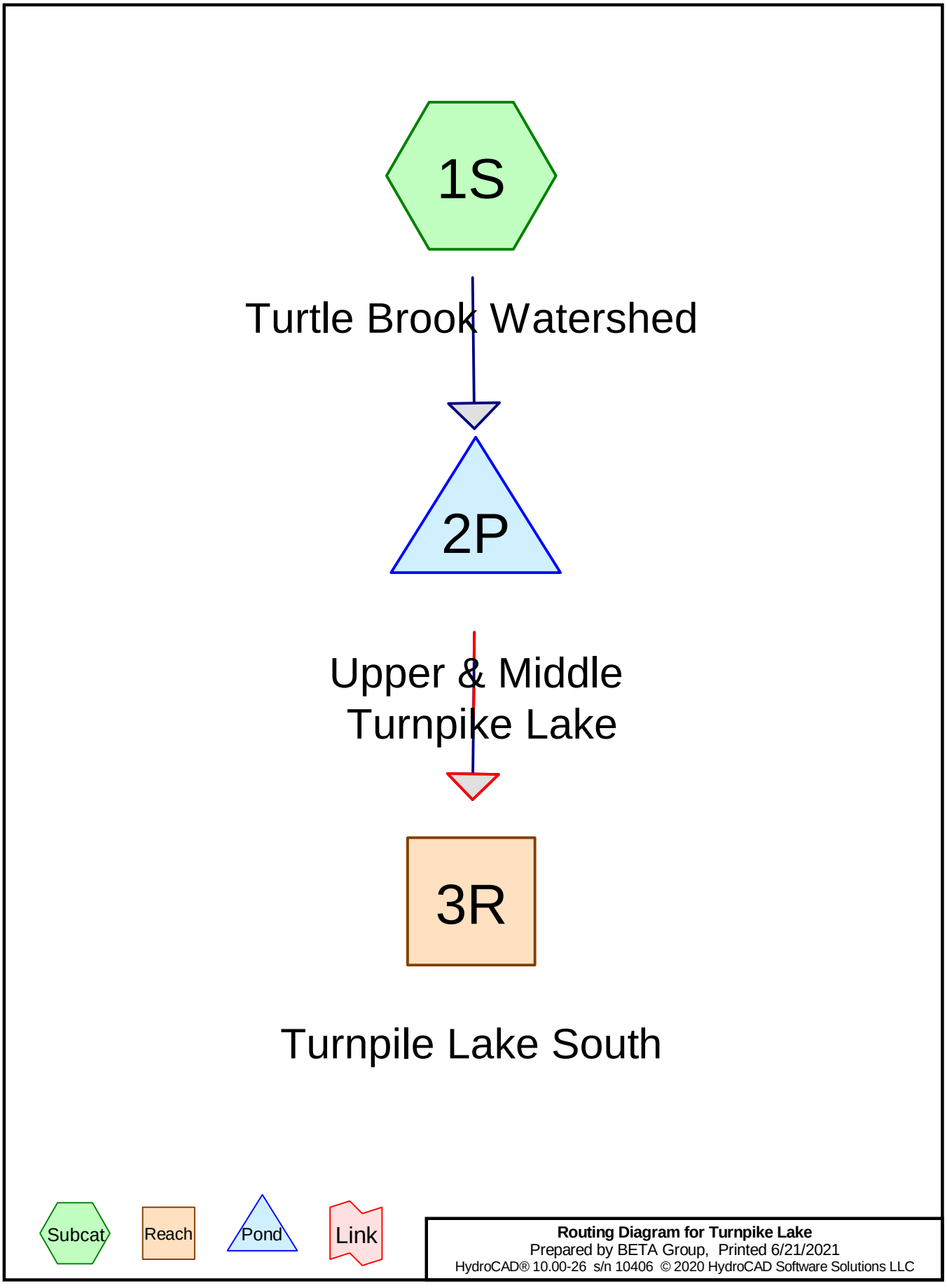
PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.314 (0.249-0.393)	0.386 (0.306-0.483)	0.503 (0.397-0.632)	0.600 (0.471-0.758)	0.734 (0.556-0.970)	0.834 (0.619-1.13)	0.940 (0.677-1.32)	1.06 (0.719-1.52)	1.24 (0.808-1.84)	1.40 (0.884-2.10)
10-min	0.445 (0.353-0.557)	0.547 (0.433-0.684)	0.713 (0.563-0.896)	0.850 (0.667-1.07)	1.04 (0.788-1.38)	1.18 (0.876-1.60)	1.33 (0.959-1.87)	1.51 (1.02-2.15)	1.76 (1.14-2.61)	1.98 (1.25-2.98)
15-min	0.524 (0.415-0.655)	0.643 (0.509-0.805)	0.838 (0.661-1.05)	1.00 (0.784-1.26)	1.22 (0.927-1.62)	1.39 (1.03-1.88)	1.57 (1.13-2.20)	1.77 (1.20-2.53)	2.07 (1.35-3.07)	2.33 (1.47-3.51)
30-min	0.723 (0.574-0.905)	0.891 (0.706-1.12)	1.17 (0.920-1.46)	1.39 (1.09-1.76)	1.71 (1.29-2.26)	1.94 (1.44-2.62)	2.19 (1.58-3.08)	2.48 (1.68-3.54)	2.91 (1.89-4.30)	3.26 (2.07-4.92)
60-min	0.923 (0.732-1.16)	1.14 (0.902-1.43)	1.49 (1.18-1.87)	1.79 (1.40-2.26)	2.19 (1.66-2.90)	2.49 (1.85-3.37)	2.81 (2.03-3.95)	3.19 (2.15-4.55)	3.74 (2.42-5.53)	4.20 (2.66-6.33)
2-hr	1.18 (0.942-1.46)	1.47 (1.18-1.83)	1.96 (1.56-2.44)	2.36 (1.86-2.95)	2.91 (2.22-3.82)	3.31 (2.48-4.46)	3.75 (2.73-5.27)	4.28 (2.91-6.07)	5.09 (3.32-7.46)	5.78 (3.67-8.62)
3-hr	1.37 (1.10-1.69)	1.71 (1.37-2.12)	2.27 (1.82-2.82)	2.74 (2.17-3.42)	3.38 (2.60-4.43)	3.86 (2.90-5.17)	4.37 (3.20-6.11)	5.00 (3.41-7.04)	5.95 (3.89-8.67)	6.77 (4.32-10.1)
6-hr	1.78 (1.44-2.18)	2.21 (1.79-2.71)	2.90 (2.34-3.57)	3.48 (2.78-4.30)	4.27 (3.30-5.54)	4.86 (3.68-6.45)	5.49 (4.04-7.60)	6.26 (4.29-8.74)	7.43 (4.88-10.7)	8.43 (5.40-12.4)
12-hr	2.31 (1.89-2.81)	2.81 (2.29-3.42)	3.63 (2.95-4.43)	4.31 (3.48-5.29)	5.24 (4.08-6.73)	5.94 (4.52-7.79)	6.69 (4.94-9.12)	7.57 (5.22-10.5)	8.89 (5.88-12.7)	10.0 (6.44-14.6)
24-hr	2.80 (2.30-3.37)	3.40 (2.79-4.10)	4.38 (3.59-5.30)	5.20 (4.23-6.32)	6.32 (4.96-8.05)	7.15 (5.49-9.31)	8.05 (5.99-10.9)	9.12 (6.33-12.5)	10.7 (7.12-15.2)	12.1 (7.82-17.4)
2-day	3.16 (2.62-3.77)	3.89 (3.22-4.65)	5.09 (4.20-6.10)	6.09 (4.99-7.33)	7.45 (5.90-9.43)	8.47 (6.56-11.0)	9.57 (7.19-12.9)	10.9 (7.62-14.8)	13.0 (8.68-18.3)	14.8 (9.62-21.2)

APPENDIX F
HydroCAD Calculations



Routing Diagram for Turnpike Lake
Prepared by BETA Group, Printed 6/21/2021

Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Turtle Brook Watershed Runoff Area=1,222.000 ac 0.00% Impervious Runoff Depth>0.72"
Tc=165.0 min CN=50 Runoff=166.10 cfs 73.247 af

Reach 3R: Turnpile Lake South Inflow=32.32 cfs 20.372 af
Outflow=32.32 cfs 20.372 af

Pond 2P: Upper & Middle Turnpike Lake Peak Elev=10.46' Storage=52.934 af Inflow=166.10 cfs 73.247 af
Primary=32.32 cfs 20.372 af Secondary=0.00 cfs 0.000 af Outflow=32.32 cfs 20.372 af

Total Runoff Area = 1,222.000 ac Runoff Volume = 73.247 af Average Runoff Depth = 0.72"
100.00% Pervious = 1,222.000 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Turtle Brook Watershed

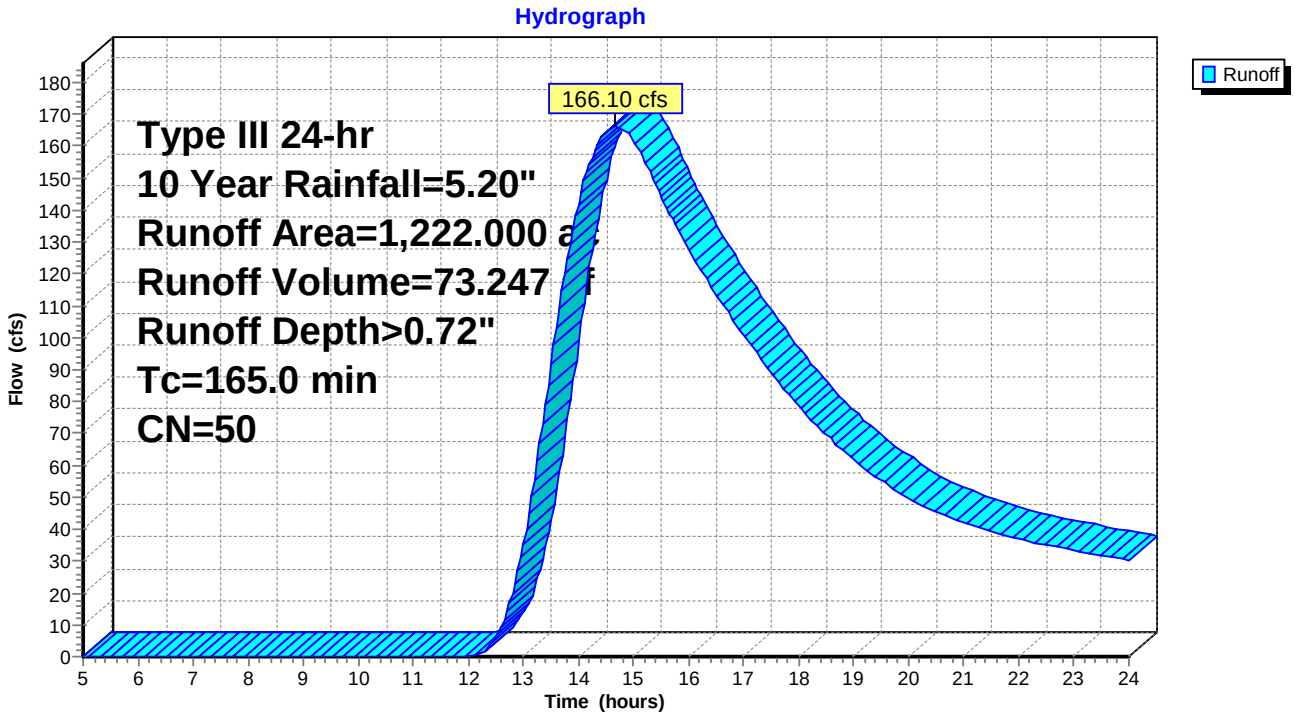
Runoff = 166.10 cfs @ 14.67 hrs, Volume= 73.247 af, Depth> 0.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 Year Rainfall=5.20"

	Area (ac)	CN	Description
*	1,222.000	50	
	1,222.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
165.0					Direct Entry,

Subcatchment 1S: Turtle Brook Watershed



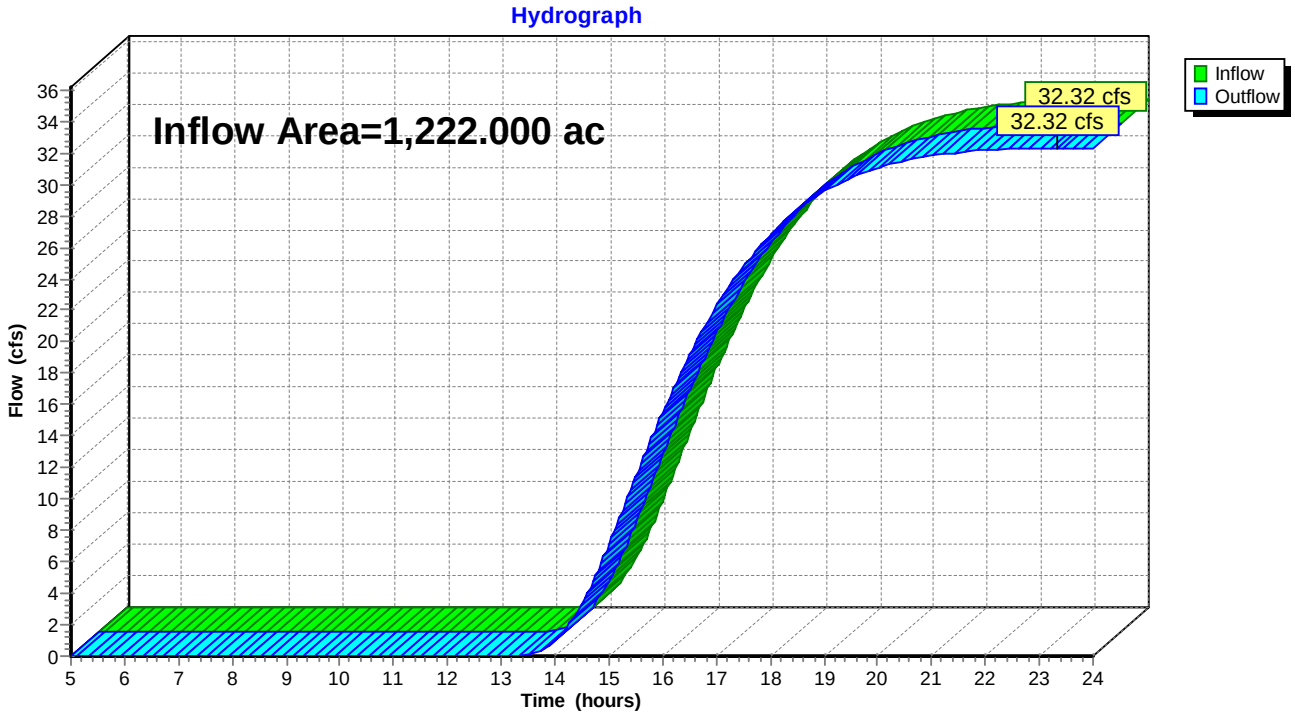
Summary for Reach 3R: Turnpile Lake South

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 1,222.000 ac, 0.00% Impervious, Inflow Depth > 0.20" for 10 Year event
Inflow = 32.32 cfs @ 23.34 hrs, Volume= 20.372 af
Outflow = 32.32 cfs @ 23.34 hrs, Volume= 20.372 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 3R: Turnpile Lake South



Summary for Pond 2P: Upper & Middle Turnpike Lake

[44] Hint: Outlet device #1 is below defined storage

Inflow Area = 1,222.000 ac, 0.00% Impervious, Inflow Depth > 0.72" for 10 Year event
Inflow = 166.10 cfs @ 14.67 hrs, Volume= 73.247 af
Outflow = 32.32 cfs @ 23.34 hrs, Volume= 20.372 af, Atten= 81%, Lag= 519.9 min
Primary = 32.32 cfs @ 23.34 hrs, Volume= 20.372 af
Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 10.46' @ 23.34 hrs Surf.Area= 20.628 ac Storage= 52.934 af

Plug-Flow detention time= 356.2 min calculated for 20.372 af (28% of inflow)
Center-of-Mass det. time= 181.5 min (1,201.2 - 1,019.8)

Volume	Invert	Avail.Storage	Storage Description
#1	7.85'	85.075 af	Custom Stage Data (Prismatic) Listed below (Recalc)

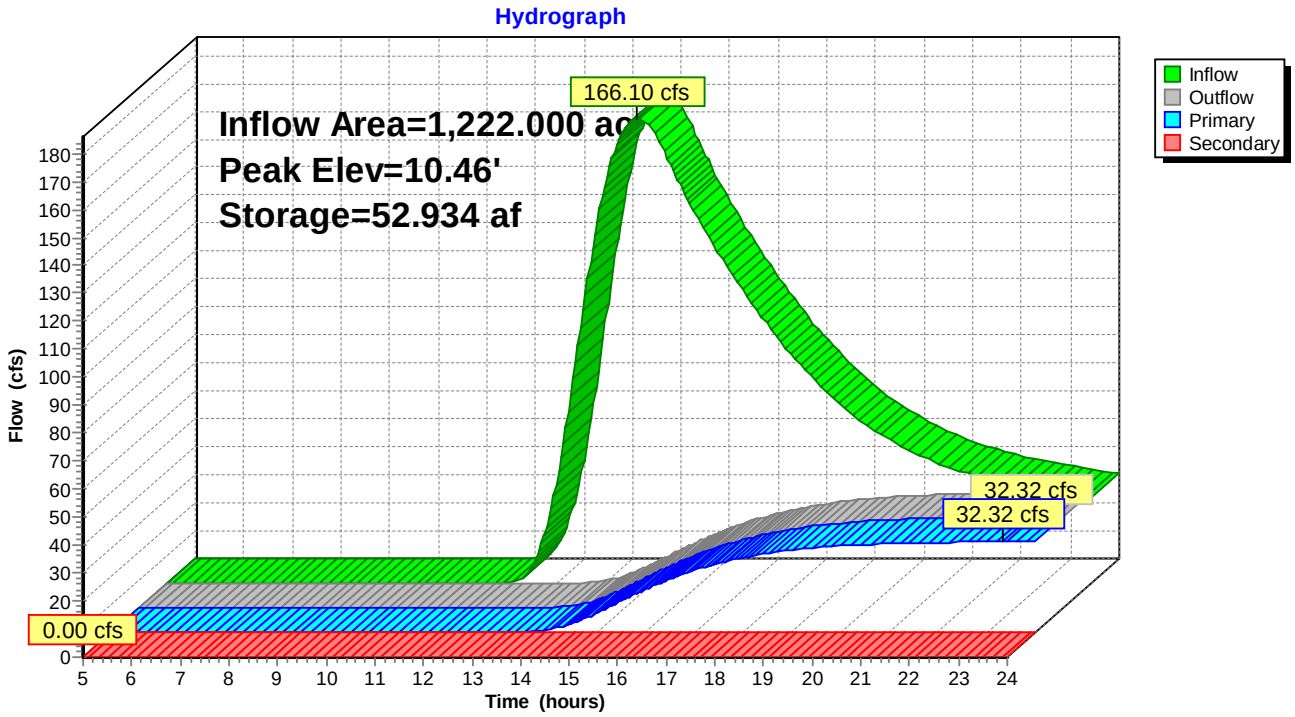
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
7.85	20.000	0.000	0.000
12.00	21.000	85.075	85.075

Device	Routing	Invert	Outlet Devices
#1	Primary	7.85'	24.0" Round Culvert 24"CMP L= 40.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.85' / 7.60' S= 0.0063 '/' Cc= 0.900 n= 0.024, Flow Area= 3.14 sf
#2	Primary	7.95'	30.0" Round Culvert 30"CMP L= 40.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.95' / 7.50' S= 0.0113 '/' Cc= 0.900 n= 0.024, Flow Area= 4.91 sf
#3	Secondary	11.05'	30.0' long x 30.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=32.33 cfs @ 23.34 hrs HW=10.46' (Free Discharge)
└1=Culvert 24"CMP (Barrel Controls 12.91 cfs @ 4.13 fps)
└2=Culvert 30"CMP (Barrel Controls 19.42 cfs @ 4.90 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=7.85' (Free Discharge)
└3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 2P: Upper & Middle Turnpike Lake



APPENDIX G
Order of Magnitude Construction Costs

www.BETA-Inc.com

JOB	Plainville	No.	7624
CALCULATED BY	TMW	DATE	6/25/2021
CHECKED BY		DATE	
DESCRIPTION	Cost Analysis	SHEET NO.	

Shepard Street over Turtle Brook/Turnpike Lake

Repairs:

Masonry Repairs (Replace Stones, Repoint Joints, Fill Voids)

Headwall Repairs =	20.00	sf		
SE Side Wingwall Repairs=	20.00	sf		
SW Side Wingwall Repairs=	20.00	sf		
Approximate Depth of Repairs =	1.00	ft		
Area of Repairs in CY =	2.22	cy		
Stone Masonry Wall in Cement Mortar (Item 685.) =	$900.00	Per CY	Masonry Repairs =	$2,000

Scour Repairs (Fill in Holes)

South Headwall Scour Length =	10.00	ft		
Assumed Height of Scour =	3.70	ft		
Approximate Depth of Scour =	0.50	ft		
Area of Repairs in CF =	18.50	cf		
Conc.Filled Grout Bags for Scour (Item 920.9901.) =	$1,100.00	Per CF	Scour Repairs =	$20,350

Contingency & Misc. Items =	30.00%	of construction cost	Contingency & Misc. Items =	$6,705
Mobilization/Demobilization =	10.00%	of total construction cost	Mobilization/Demobilization =	$2,906
			Cost of Repairs =	$31,960.50
			Call =	**$32,000.00**
			25% Engineering Cost =	**$8,000**
			TOTAL COST =	**$40,000**