Notice of Intent

Walkers Brook Bridge 2 Replacement Project
Track Road East
Reading, Massachusetts

Town of Reading Engineering Department

Project Number: 60700750

April 2026

Quality information

Prepared by	Checked by	Verified by	Approved by
Jessica Marino Senior Wetland Scientist	Thomas J. Keough Project Manager		

Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

# Hard Copies	PDF Required	Association / Company Name
2		Town of Reading Conservation Commission
1		MassDEP – NERO

Prepared for:

Town of Reading
Engineering Department
16 Lowell Street
Reading, MA 01867

Prepared by:

Jessica Marino
Senior Wetland Scientist
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AECOM
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Chelmsford, MA 01824
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Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Reading
City/Town

Important:
When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

Note:
Before completing this form consult your local Conservation Commission regarding any municipal bylaw or ordinance.

A. General Information

1. Project Location (**Note:** electronic filers will click on button to locate project site):

0 Track Road (near 13 Track Road) — a. Street Address
Reading — b. City/Town
01867 — c. Zip Code

Latitude and Longitude:
42.524308 — d. Latitude
-71.085273 — e. Longitude

23 — f. Assessors Map/Plat Number
023.0-0000-0010.0 — g. Parcel /Lot Number

2. Applicant:

Ryan — a. First Name
Percival — b. Last Name
Town of Reading — c. Organization
16 Lowell Street — d. Street Address
Reading — e. City/Town
MA — f. State
01867 — g. Zip Code
781-942-9082 — h. Phone Number
i. Fax Number
rpercival@ci.reading.ma.us — j. Email Address

3. Property owner (required if different from applicant): ☐ Check if more than one owner

a. First Name
b. Last Name
c. Organization
d. Street Address
e. City/Town
f. State
g. Zip Code
h. Phone Number
i. Fax Number
j. Email address

4. Representative (if any):

Heidi — a. First Name
Fisher — b. Last Name
AECOM — c. Company
250 Apollo Drive — d. Street Address
Chelmsford — e. City/Town
MA — f. State
01824 — g. Zip Code
617-371-4467 — h. Phone Number
i. Fax Number
heidi.fisher@aecom.com — j. Email address

5. Total WPA Fee Paid (from NOI Wetland Fee Transmittal Form):

$0.00 (Town is exempt from fee) — a. Total Fee Paid
$0.00 (Exempt from fee) — b. State Fee Paid
$0.00 (Exempt from fee) — c. City/Town Fee Paid

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A. General Information (continued)

6. General Project Description:

The Town of Reading Engineering Department is proposing to replace the existing bridge (Bridge #R-03-006(BW7)) over Walkers Brook on Track Road. Replacement of the existing bridge will include replacing the existing structure with a new precast concrete four-sided box culvert.

7a. Project Type Checklist: (Limited Project Types see Section A. 7b.)

1. ☐ Single Family Home
2. ☐ Residential Subdivision
3. ☐ Commercial/Industrial
4. ☐ Dock/Pier
5. ☐ Utilities
6. ☐ Coastal engineering Structure
7. ☐ Agriculture (e.g., cranberries, forestry)
8. ☒ Transportation
9. ☐ Other

7b. Is any portion of the proposed activity eligible to be treated as a limited project (including Ecological Restoration Limited Project) subject to 310 CMR 10.24 (coastal) or 310 CMR 10.53 (inland)?

1. ☒ Yes ☐ No

If yes, describe which limited project applies to this project. (See 310 CMR 10.24 and 10.53 for a complete list and description of limited project types)

310 CMR 10.53(3)(f) - Maintenance/improvement of existing public roadway.
2. Limited Project Type

If the proposed activity is eligible to be treated as an Ecological Restoration Limited Project (310 CMR10.24(8), 310 CMR 10.53(4)), complete and attach Appendix A: Ecological Restoration Limited Project Checklist and Signed Certification.

8. Property recorded at the Registry of Deeds for:

Middlesex a. County	N/A b. Certificate # (if registered land)
Unknown c. Book	Unknown d. Page Number

B. Buffer Zone & Resource Area Impacts (temporary & permanent)

1. ☐ Buffer Zone Only – Check if the project is located only in the Buffer Zone of a Bordering Vegetated Wetland, Inland Bank, or Coastal Resource Area.
2. ☒ Inland Resource Areas (see 310 CMR 10.54-10.58; if not applicable, go to Section B.3, Coastal Resource Areas).

Check all that apply below. Attach narrative and any supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

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B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

For all projects affecting other Resource Areas, please attach a narrative explaining how the resource area was delineated.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☒ Bank	16 LF (temp), 18 LF (perm) 1. linear feet	 2. linear feet
b. ☐ Bordering Vegetated Wetland	 1. square feet	 2. square feet
c. ☒ Land Under Waterbodies and Waterways	589 SF (temp), 52 SF (perm) 1. square feet 3. cubic yards dredged	 2. square feet

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
d. ☒ Bordering Land Subject to Flooding	589 SF (temp), 52 SF (perm) 1. square feet 102 CF 3. cubic feet of flood storage lost	189 SF 2. square feet 120 CF 4. cubic feet replaced
e. ☐ Isolated Land Subject to Flooding	 1. square feet 2. cubic feet of flood storage lost	 3. cubic feet replaced
f. ☒ Riverfront Area	Walkers Brook (inland) 1. Name of Waterway (if available) - **specify coastal or inland**	

2. Width of Riverfront Area (check one):

☐ 25 ft. - Designated Densely Developed Areas only

☐ 100 ft. - New agricultural projects only

☒ 200 ft. - All other projects

3. Total area of Riverfront Area on the site of the proposed project: 29,579 square feet

4. Proposed alteration of the Riverfront Area:

a. total square feet	b. square feet within 100 ft.	c. square feet between 100 ft. and 200 ft.
4,282 SF	3,214 SF	1,068 SF

5. Has an alternatives analysis been done and is it attached to this NOI? ☐ Yes ☒ No

6. Was the lot where the activity is proposed created prior to August 1, 1996? ☒ Yes ☐ No

3. ☐ Coastal Resource Areas: (See 310 CMR 10.25-10.35)

Note: for coastal riverfront areas, please complete **Section B.2.f**. above.

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B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

Check all that apply below. Attach narrative and supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☐ Designated Port Areas	Indicate size under Land Under the Ocean, below	
b. ☐ Land Under the Ocean	1. square feet 2. cubic yards dredged	
c. ☐ Barrier Beach	Indicate size under Coastal Beaches and/or Coastal Dunes below	
d. ☐ Coastal Beaches	1. square feet	2. cubic yards beach nourishment
e. ☐ Coastal Dunes	1. square feet	2. cubic yards dune nourishment

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
f. ☐ Coastal Banks	1. linear feet	
g. ☐ Rocky Intertidal Shores	1. square feet	
h. ☐ Salt Marshes	1. square feet	2. sq ft restoration, rehab., creation
i. ☐ Land Under Salt Ponds	1. square feet 2. cubic yards dredged	
j. ☐ Land Containing Shellfish	1. square feet	
k. ☐ Fish Runs	Indicate size under Coastal Banks, inland Bank, Land Under the Ocean, and/or inland Land Under Waterbodies and Waterways, above 1. cubic yards dredged	
l. ☐ Land Subject to Coastal Storm Flowage	1. square feet	

4. ☐ Restoration/Enhancement

If the project is for the purpose of restoring or enhancing a wetland resource area in addition to the square footage that has been entered in Section B.2.b or B.3.h above, please enter the additional amount here.

a. square feet of BVW

b. square feet of Salt Marsh

5. ☒ Project Involves Stream Crossings

0 (existing crossing)
a. number of new stream crossings

1
b. number of replacement stream crossings

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C. Other Applicable Standards and Requirements

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section C and complete Appendix A: Ecological Restoration Limited Project Checklists – Required Actions (310 CMR 10.11).

Streamlined Massachusetts Endangered Species Act/Wetlands Protection Act Review

1. Is any portion of the proposed project located in **Estimated Habitat of Rare Wildlife** as indicated on the most recent Estimated Habitat Map of State-Listed Rare Wetland Wildlife published by the Natural Heritage and Endangered Species Program (NHESP)? To view habitat maps, see the *Massachusetts Natural Heritage Atlas* or go to http://maps.massgis.state.ma.us/PRI_EST_HAB/viewer.htm.

   a. ☐ Yes ☒ No

   If yes, include proof of mailing or hand delivery of NOI to:

   Natural Heritage and Endangered Species Program
   Division of Fisheries and Wildlife
   1 Rabbit Hill Road
   Westborough, MA 01581

   August 1, 2021
   b. Date of map

   If *yes*, the project is also subject to Massachusetts Endangered Species Act (MESA) review (321 CMR 10.18). To qualify for a streamlined, 30-day, MESA/Wetlands Protection Act review, please complete Section C.1.c, and include requested materials with this Notice of Intent (NOI); *OR* complete Section C.2.f, if applicable. *If MESA supplemental information is not included with the NOI, by completing Section 1 of this form, the NHESP will require a separate MESA filing which may take up to 90 days to review (unless noted exceptions in Section 2 apply, see below).*

   c. Submit Supplemental Information for Endangered Species Review*

      1. ☐ Percentage/acreage of property to be altered:

         (a) within wetland Resource Area _____ percentage/acreage

         (b) outside Resource Area _____ percentage/acreage

      2. ☐ Assessor's Map or right-of-way plan of site

2. ☐ Project plans for entire project site, including wetland resource areas and areas outside of wetlands jurisdiction, showing existing and proposed conditions, existing and proposed tree/vegetation clearing line, and clearly demarcated limits of work **

   (a) ☐ Project description (including description of impacts outside of wetland resource area & buffer zone)

   (b) ☐ Photographs representative of the site

* Some projects **not** in Estimated Habitat may be located in Priority Habitat, and require NHESP review (see https://www.mass.gov/ma-endangered-species-act-mesa-regulatory-review).
Priority Habitat includes habitat for state-listed plants and strictly upland species not protected by the Wetlands Protection Act.
** MESA projects may not be segmented (321 CMR 10.16). The applicant must disclose full development plans even if such plans are not required as part of the Notice of Intent process.

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C. Other Applicable Standards and Requirements (cont'd)

(c) ☐ MESA filing fee (fee information available at https://www.mass.gov/how-to/how-to-file-for-a-mesa-project-review).
Make check payable to "Commonwealth of Massachusetts - NHESP" and ***mail to NHESP*** at above address

*Projects altering **10 or more acres** of land, also submit:*

(d) ☐ Vegetation cover type map of site

(e) ☐ Project plans showing Priority & Estimated Habitat boundaries

(f) OR Check One of the Following

1. ☐ Project is exempt from MESA review.
Attach applicant letter indicating which MESA exemption applies. (See 321 CMR 10.14, https://www.mass.gov/service-details/exemptions-from-review-for-projectsactivities-in-priority-habitat; the NOI must still be sent to NHESP if the project is within estimated habitat pursuant to 310 CMR 10.37 and 10.59.)

2. ☐ Separate MESA review ongoing. a. NHESP Tracking # b. Date submitted to NHESP

3. ☐ Separate MESA review completed.
Include copy of NHESP "no Take" determination or valid Conservation & Management Permit with approved plan.

3. For coastal projects only, is any portion of the proposed project located below the mean high water line or in a fish run?

a. ☒ Not applicable – project is in inland resource area only b. ☐ Yes ☐ No

If yes, include proof of mailing, hand delivery, or electronic delivery of NOI to either:

South Shore - Bourne to Rhode Island border, and the Cape & Islands:

Division of Marine Fisheries -
Southeast Marine Fisheries Station
Attn: Environmental Reviewer
836 South Rodney French Blvd.
New Bedford, MA 02744
Email: dmf.envreview-south@mass.gov

North Shore - Plymouth to New Hampshire border:

Division of Marine Fisheries -
North Shore Office
Attn: Environmental Reviewer
30 Emerson Avenue
Gloucester, MA 01930
Email: dmf.envreview-north@mass.gov

Also if yes, the project may require a Chapter 91 license. For coastal towns in the Northeast Region, please contact MassDEP's Boston Office. For coastal towns in the Southeast Region, please contact MassDEP's Southeast Regional Office.

c. ☐ Is this an aquaculture project? d. ☐ Yes ☐ No

If yes, include a copy of the Division of Marine Fisheries Certification Letter (M.G.L. c. 130, § 57).

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C. Other Applicable Standards and Requirements (cont'd)

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

4. Is any portion of the proposed project within an Area of Critical Environmental Concern (ACEC)?

   a. ☐ Yes ☒ No If yes, provide name of ACEC (see instructions to WPA Form 3 or MassDEP Website for ACEC locations). **Note:** electronic filers click on Website.

   b. ACEC

5. Is any portion of the proposed project within an area designated as an Outstanding Resource Water (ORW) as designated in the Massachusetts Surface Water Quality Standards, 314 CMR 4.00?

   a. ☐ Yes ☒ No

6. Is any portion of the site subject to a Wetlands Restriction Order under the Inland Wetlands Restriction Act (M.G.L. c. 131, § 40A) or the Coastal Wetlands Restriction Act (M.G.L. c. 130, § 105)?

   a. ☐ Yes ☒ No

7. Is this project subject to provisions of the MassDEP Stormwater Management Standards?

   a. ☒ Yes. Attach a copy of the Stormwater Report as required by the Stormwater Management Standards per 310 CMR 10.05(6)(k)-(q) and check if:

      1. ☐ Applying for Low Impact Development (LID) site design credits (as described in Stormwater Management Handbook Vol. 2, Chapter 3)

      2. ☒ A portion of the site constitutes redevelopment

      3. ☐ Proprietary BMPs are included in the Stormwater Management System.

   b. ☐ No. Check why the project is exempt:

      1. ☐ Single-family house

      2. ☐ Emergency road repair

      3. ☐ Small Residential Subdivision (less than or equal to 4 single-family houses or less than or equal to 4 units in multi-family housing project) with no discharge to Critical Areas.

D. Additional Information

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section D and complete Appendix A: Ecological Restoration Notice of Intent – Minimum Required Documents (310 CMR 10.12).

Applicants must include the following with this Notice of Intent (NOI). See instructions for details.

Online Users: Attach the document transaction number (provided on your receipt page) for any of the following information you submit to the Department.

1. ☒ USGS or other map of the area (along with a narrative description, if necessary) containing sufficient information for the Conservation Commission and the Department to locate the site. (Electronic filers may omit this item.)

2. ☒ Plans identifying the location of proposed activities (including activities proposed to serve as a Bordering Vegetated Wetland [BVW] replication area or other mitigating measure) relative to the boundaries of each affected resource area.

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Reading
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D. Additional Information (cont'd)

3. ☐ Identify the method for BVW and other resource area boundary delineations (MassDEP BVW Field Data Form(s), Determination of Applicability, Order of Resource Area Delineation, etc.), and attach documentation of the methodology.

4. ☒ List the titles and dates for all plans and other materials submitted with this NOI.

Town of Reading Bridge Replacement Track Road East Permitting Plans
a. Plan Title

AECOM
b. Prepared By

c. Signed and Stamped by

November 20, 2025
d. Final Revision Date

Varies
e. Scale

f. Additional Plan or Document Title

g. Date

5. ☐ If there is more than one property owner, please attach a list of these property owners not listed on this form.

6. ☐ Attach proof of mailing for Natural Heritage and Endangered Species Program, if needed.

7. ☐ Attach proof of mailing for Massachusetts Division of Marine Fisheries, if needed.

8. ☒ Attach NOI Wetland Fee Transmittal Form

9. ☒ Attach Stormwater Report, if needed.

E. Fees

1. ☒ Fee Exempt: No filing fee shall be assessed for projects of any city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority, municipal housing authority, or the Massachusetts Bay Transportation Authority.

Applicants must submit the following information (in addition to pages 1 and 2 of the NOI Wetland Fee Transmittal Form) to confirm fee payment:

Town is exempt from filing fee.
2. Municipal Check Number

Town is exempt from filing fee.
3. Check date

Town is exempt from filing fee.
4. State Check Number

Town is exempt from filing fee.
5. Check date

Town is exempt from filing fee.
6. Payor name on check: First Name

Town is exempt from filing fee.
7. Payor name on check: Last Name

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F. Signatures and Submittal Requirements

I hereby certify under the penalties of perjury that the foregoing Notice of Intent and accompanying plans, documents, and supporting data are true and complete to the best of my knowledge. I understand that the Conservation Commission will place notification of this Notice in a local newspaper at the expense of the applicant in accordance with the wetlands regulations, 310 CMR 10.05(5)(a).

I further certify under penalties of perjury that all abutters were notified of this application, pursuant to the requirements of M.G.L. c. 131, § 40. Notice must be made by Certificate of Mailing or in writing by hand delivery or certified mail (return receipt requested) to all abutters within 100 feet of the property line of the project location.

Ryan Percival Ryan Percival (Mar 31, 2026 13:36:06 EDT) 1. Signature of Applicant	2. Date
3. Signature of Property Owner (if different)	4. Date
Heidi Fisher 5. Signature of Representative (if any)	04/01/2026 6. Date

For Conservation Commission:
Two copies of the completed Notice of Intent (Form 3), including supporting plans and documents, two copies of the NOI Wetland Fee Transmittal Form, and the city/town fee payment, to the Conservation Commission by certified mail or hand delivery.

For MassDEP:
One copy of the completed Notice of Intent (Form 3), including supporting plans and documents, one copy of the NOI Wetland Fee Transmittal Form, and a **copy** of the state fee payment to the MassDEP Regional Office (see Instructions) by certified mail or hand delivery.

Other:
If the applicant has checked the “yes” box in any part of Section C, Item 3, above, refer to that section and the Instructions for additional submittal requirements.

The original and copies must be sent simultaneously. Failure by the applicant to send copies in a timely manner may result in dismissal of the Notice of Intent.

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NOI Wetland Fee Transmittal Form

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Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A. Applicant Information

1. Location of Project:

0 Track Road (near 13 Track Road)	Reading
a. Street Address	b. City/Town
Town is exempt from filing fee.	Town is exempt from filing fee.
c. Check number	d. Fee amount

2. Applicant Mailing Address:

Ryan	Percival	
a. First Name	b. Last Name	
Town of Reading		
c. Organization		
16 Lowell Street		
d. Mailing Address		
Reading	MA	01867
e. City/Town	f. State	g. Zip Code
781-942-9082		rpercival@ci.reading.ma.us
h. Phone Number	i. Fax Number	j. Email Address

3. Property Owner (if different):

a. First Name	b. Last Name	
c. Organization		
d. Mailing Address		
e. City/Town	f. State	g. Zip Code
h. Phone Number	i. Fax Number	j. Email Address

B. Fees

To calculate filing fees, refer to the category fee list and examples in the instructions for filling out WPA Form 3 (Notice of Intent).

Fee should be calculated using the following process & worksheet. ***Please see Instructions before filling out worksheet.***

Step 1/Type of Activity: Describe each type of activity that will occur in wetland resource area and buffer zone.

Step 2/Number of Activities: Identify the number of each type of activity.

Step 3/Individual Activity Fee: Identify each activity fee from the six project categories listed in the instructions.

Step 4/Subtotal Activity Fee: Multiply the number of activities (identified in Step 2) times the fee per category (identified in Step 3) to reach a subtotal fee amount. Note: If any of these activities are in a Riverfront Area in addition to another Resource Area or the Buffer Zone, the fee per activity should be multiplied by 1.5 and then added to the subtotal amount.

Step 5/Total Project Fee: Determine the total project fee by adding the subtotal amounts from Step 4.

Step 6/Fee Payments: To calculate the state share of the fee, divide the total fee in half and subtract $12.50. To calculate the city/town share of the fee, divide the total fee in half and add $12.50.

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B. Fees (continued)

Step 1/Type of Activity	Step 2/Number of Activities	Step 3/Individual Activity Fee	Step 4/Subtotal Activity Fee
2e - Limited Project	1	$500 x 1.5	Town is exempt from filing fee.

Step 5/Total Project Fee: $750.00

Step 6/Fee Payments:

Total Project Fee:	$0.00 - exempt a. Total Fee from Step 5
State share of filing Fee:	$0.00 - exempt b. 1/2 Total Fee **less $**12.50
City/Town share of filling Fee:	$0.00 - exempt c. 1/2 Total Fee **plus** $12.50

C. Submittal Requirements

a.) Complete pages 1 and 2 and send with a check or money order for the state share of the fee, payable to the Commonwealth of Massachusetts.

Department of Environmental Protection
Box 4062
Boston, MA 02211

b.) **To the Conservation Commission:** Send the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and the city/town fee payment.

To MassDEP Regional Office (see Instructions): Send a copy of the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and a **copy** of the state fee payment. (E-filers of Notices of Intent may submit these electronically.)

Track Road East WPA Form 3

Final Audit Report 2026-03-31

Created:	2026-03-30
By:	Heidi Fisher (heidi.fisher@aecom.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAzCIhX4vKLPCBbz4Q4JFaRxyG8oVsEI3p

"Track Road East WPA Form 3" History

Document created by Heidi Fisher (heidi.fisher@aecom.com)
2026-03-30 - 3:57:47 PM GMT

Document emailed to Ryan Percival (rpercival@ci.reading.ma.us) for signature
2026-03-30 - 3:58:27 PM GMT

Email viewed by Ryan Percival (rpercival@ci.reading.ma.us)
2026-03-30 - 4:07:33 PM GMT

Document e-signed by Ryan Percival (rpercival@ci.reading.ma.us)
Signature Date: 2026-03-31 - 5:36:06 PM GMT - Time Source: server

Agreement completed.
2026-03-31 - 5:36:06 PM GMT

Project Narrative

1. Introduction

On behalf of the Town of Reading (Town) Engineering Department, AECOM is submitting this Notice of Intent (NOI) application for the replacement and widening of a bridge (culvert) structure on Track Road in Reading, Massachusetts. The bridge (referred to as "Track Road (2) East"), MassDOT Bridge No. R-03-006 (BW7), is an existing culvert that crosses Walkers Brook, a perennial tributary to the Saugus River. This NOI is being submitted to the Reading Conservation Commission and the Massachusetts Department of Environmental Protection (MassDEP), pursuant to the Massachusetts Wetlands Protection Act (WPA) (MGL C. 131, s. 40) and Regulations (310 CMR 10.00) as well as the Town of Reading Wetlands Protection Bylaw (Article 7.1 of the General By-Laws) and Town of Reading Wetlands Protection Regulations.

The proposed work consists of replacing the existing bridge (culvert) structure with a new precast concrete four-sided box culvert at Track Road (2) East (Project). The new MassDOT Bridge No. will be R-03-006-CJR. As a result of the bridge replacement, unavoidable temporary and permanent impacts are proposed to Bank and Land Under Water and Waterways associated with Walkers Brook, Bordering Land Subject to Flooding, and the 200-foot Riverfront Area. A small portion of the 100-year floodplain will be filled as part of the Project, and compensatory flood storage will be provided on an incremental foot-by-foot basis.

The Project qualifies as a "Limited Project" under the WPA regulations 310 CMR 10.53(3)(f): *"maintenance and improvement of existing public roadways, but limited to widening less than a single lane, adding shoulders, correcting substandard intersections, and improving inadequate drainage systems."*

1.1 Project Purpose

The Project is part of the Commonwealth's Municipal Small Bridges Program Chapter 90 apportionment. The existing structure is a single narrow lane spanning Walkers Brook that has been determined to be structurally deficient and has insufficient capacity to carry larger vehicles. Due to the structural deterioration experienced over time, the bridge has been out of use for several years. The purpose of the Project is to replace the current structure to allow for civilian vehicle access, as well as emergency vehicle access in order to serve the adjacent residential area.

2. Existing Conditions

The Walkers Brook Track Road (2) East Bridge is located in a residential neighborhood at the westernmost crossing of Track Road and Walkers Brook, west of Exit 40 off Interstate 95 and south of Salem Street/Route 129 in Reading, Massachusetts. The approximate location of the Project is shown on Figure 1 in Appendix A and is herein referred to as "the Project Area."

The Track Road (2) East Bridge is currently a single narrow lane with a span length of approximately 10 feet across Walkers Brook. The bridge is currently in failing condition and has been closed for several years due to imminent safety concerns. Vertical walls are located beneath the bridge that contains confined flow from Walkers Brook (see Appendix C). Surface water in Walkers Brook flows in a northerly direction and is approximately two to three feet in depth within the work area. The adjacent land area proximate to the bridge contains small narrow areas of trees and shrubs, residential properties, and driveways. Up to two (2) trees located within the Project Area will be removed and either replaced in-kind or replaced with a planting of similar species and size in close proximity to the original planting.

There are two existing drainage pipes (one 6-inch ductile iron (DI) pipe and one 18-inch reinforced concrete pipe (RCP) that currently discharge to the river on each side of the concrete retaining walls underneath the existing bridge. These two drainage pipes are hydrologically connected to manholes loacted on both sides of Track Road beyond the Project Area.

2.1 Regulated Areas under WPA and Regulations

Regulated resource areas located on or near the Project Area and subject to the Massachusetts Wetlands Protection Act (MGL C. 131, s. 40) and Regulations (310 CMR 10.00), and the Reading Wetlands Protection

Regulations (Article 7.1 of the General By-Laws), include Inland Bank, Riverfront Area, Bordering Land Subject to Flooding, and Land Under Water and Waterways.

A wetland resource area delineation was performed by AECOM in May 2023 to delineate the mean annual high water/Bank of Walkers Brook. The following section is a description of the regulated wetlands resource areas that occur within the Project Area. Locations of these resource areas are shown on the Site Plans located in Appendix B.

2.1.1 Inland Bank (310 CMR 10.54)

Inland Bank (Bank) is the portion of the land surface which normally abuts and confines a water body. It occurs between a water body and a vegetated bordering wetland and adjacent flood plain, or, in the absence of these, it occurs between a water body and an upland area. A Bank may be partially or totally vegetated, or it may be comprised of exposed soil, gravel, or stone. The upper boundary of an Inland Bank is the first observable break in the slope or the mean annual flood level, whichever is lower. The lower boundary of a Inland Bank is the mean annual low flow level.

Inland Bank surrounds the perimeter of Walkers Brook within the Project Area and is mainly comprised of vertical concrete retaining walls. The bank was delineated and is demarcated in the field by alphanumerically labeled solid blue flagging and depicted on the Site Plans located in Appendix B.

2.1.2 Land under Waterbodies and Waterways (310 CMR 10.56)

310 CMR 10.56 defines Land Under Waterbodies and Waterways (LUWW) as the lower boundary of Inland Bank. At the time of the wetland delineation, the land beneath Walkers Brook was identified as LUWW under the jurisdiction of the WPA and its' regulations as well as the Town of Reading Wetlands Protection Bylaw and its' regulations. The extent of LUWW within the Project Area is approximately 10 feet wide. The streambed is characterized as silt, sand, and gravel substrate below the mean annual low water mark. Flow is confined by vertical concrete retaining walls underneath the existing bridge. Walkers Brook is depicted on the Site Plans located in Appendix B.

2.1.3 Bordering Land Subject to Flooding (310 CMR 10.57)

310 CMR 10.57 defines Bordering Land Subject to Flooding (BLSF) as the lateral extent of the 100-year floodplain. According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for the Town of Reading (Map Number 25017C0314E) dated June 4, 2010, the Project is located within the 100-year floodplain associated with Walkers Brook, as well as a Regulatory Floodway (see Appendix A, Figure 2). The 100-year floodplain elevation for Track Road (2) East is approximately 83.4 feet North American Vertical Datum 1988 (NAVD 1988).

2.1.4 Riverfront Area (310 CMR 10.58)

As defined in 310 CMR 10.58 (a)(3), the Riverfront Area is "the area of land between a river's mean annual high-water line measured horizontally outward from the river and a parallel line located 200 feet away." The definition of "rivers" includes perennial streams per 310 CMR 10.58(2)(a)1.a. Walkers Brook is designated as a perennial stream per 310 CMR 10.58(2)(a)1.a. according to the current USGS quadrangle map (Appendix A, Figure 1). The Project is located within and adjacent to Walkers Brook, a perennial stream; therefore, portions of the Project are located within the 200-foot Riverfront Area.

The Mean Annual High Water (MAHW) line is located along the bank that forms the boundary of the river. The MAHW is synonymous with the delineated bank (i.e. Bank/MAHW), which was delineated and demarcated in the field by alphanumerically labeled solid blue flagging and depicted in the Site Plans (Appendix B). MAHW was determined using several factors including water marks on bridge abutments, scour marks, topographic breaks along the channel, and other observable field indicators.

2.1.5 Regulated Areas Under the Town of Reading Wetlands Regulations

In addition to the resource areas described above, the Town of Reading establishes a Zone of Natural Vegetation (ZNV) or a No-Disturb Zone, which is defined as a zone which borders any wetland within a

width of 25-feet. The ZNV is established in order to ensure that *"silt, soil, fertilizer in solution, organic chemicals, herbicides, organic manures, oils or petroleum which may be carried by surface run-off shall not reach that wetland, but instead will be trapped by the natural mulch, soil, and roots."* The Project Area coincides with ZNV as it extends from the bank of Walkers Brook to a 25-foot horizontal setback.

3. Project Description

The Town of Reading is proposing to replace the current structure associated with the Track Road (2) East Bridge crossing with a four-sided precast culvert. The inclusion of precast box elements will enable expedited construction in order to reopen to the crossing to the public in a timely fashion. The proposed bridge and adjacent approaches will be widened approximately 12 feet to allow for two way traffic which will constitute as an improvement over the current traffic capabilities afforded by the existing structure. The maximum roadway section is approximately 22 feet to allow for two 9-foot lanes with 2-foot shoulders on each side of the roadway. Concrete parapets and bridgerail along the side of the bridge will provide protection for vehicular traffic. There will be no guardrails at approaches nor will there be provisions for future sidewalks. The roadway width will transition to meet the existing roadway approaches.

Prior to construction, Utility Pole UPL2, which is located in proximity to the Project Area, will be removed and reset by Reading Municipal Light.

The proposed bridge was designed to expedite construction duration within Walkers Brook for the purposes of minimizing the length of time in which flow will be diverted as well as minimization of impacts to the stream. The design will also allow the contractor to plan critical construction activities around forecasted weather conditions.

The proposed Project will involve minor disturbance and permanent fill within the floodplain. The Project will resut in impacts to BLSF associated with the installation of the new wing walls and the placement of associated rockfill. The Town of Reading will offset the addition of new impervious surface within the BLSF resource area by providing compensatory floodplain storage on an incremental basis based on the volume of BLSF impacted by the Project (see Section 4.0 for discussion of impacts).

3.1 Demolition of Bridge

The existing bridge structure will be entirely demolished/removed, and the waste material generated will be removed and disposed of at an off-site landfill facility. Existing wingwalls will be demolished.

It is anticipated that construction within Walkers Brook will occur in dry conditions. Water control structures (i.e. cofferdams) will be installed both upgradient and downgradient of the bridge to divert stream flow and create dry conditions within the work area required to remove footings, install the pre-cast structure, and construct the new wingwalls. Prior to construction and once a contractor is selected and determined, the specific means and methods for the stream bypass plan will be prepared and submitted to the Commission for review and approval.

Water remaining in between the two cofferdams from the dewatering process while installing the cofferdams will be pumped and discharged to an appropriate treatment or containment device (i.e. strawbale corral/sediment filter bag) in accordance with applicable regulations; however, specific means and methods of dewatering to remove remaining surface water in between the two cofferdams shall be at the discretion of the selected contractor. At no point in the dewatering process shall direct discharge be allowed into Walkers Brook.

3.2 Tree Removal

It is anticipated that the Project will involve the removal of a 20" maple tree to be replaced with a 6" maple tree in an adjacent location. One other tree may be replaced as part of this Project, to be confirmed prior to construction. All tree removal will take place in accordance with the Town of Reading Conservation Commission tree replacement policy (see Section 5.0).

3.3 Erosion and Sediment Controls

A turbidity curtain will be installed within Walkers Brook downgradient of the cofferdam and bypass system discharge location to prevent potential sedimentation to Walkers Brook. Stream flow energy dissipation will be temporarily provided during construction within the channel at the outlet of the stream diversion to reduce flow velocity of water to reduce the potential for scour and erosion.

In addition, erosion and sedimentation controls will be implemented to minimize potential temporary impacts to resource areas from work in adjacent uplands during the construction of the Project. It is anticipated that compost filter tubes/straw wattles and/or silt fencing will be utilized along the side slopes (see Appendix B). The program incorporates BMPs specified in guidelines developed by the DEP and presented in the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers, and Municipal Officials (1997).

Non-Structural Practices

Non-structural practices to be used during construction include temporary stabilization, pavement sweeping (if necessary), and dust control. These practices will be initiated as practicable in appropriate areas at the site.

Structural Practices

Structural erosion and sedimentation controls to be used during construction include erosion control barriers consisting of compost filter tubes/straw wattles and/or silt fence along the Walkers Brook. In addition, a turbidity curtain will be used downgradient of the work area.

Erosion Control Barrier Maintenance

If sediment has accumulated to a depth which impairs proper functioning of the erosion control barrier, it will be removed by hand or by machinery operating upslope of the barriers. Any damaged sections of erosion controls will be repaired or replaced immediately upon discovery.

4. Resource Area Impacts and Regulatory Compliance

The following table provides an overall summary of the impacts to wetland resource areas. Project activities which will result in temporary impacts to resource areas will include the replacement of the existing culvert, installation of the turbidity curtain, and the installation of water control structures, as well as sedimentation and erosion controls used during construction. Project activities which will result in permanent impacts to resource areas will include the placement of rock fill associated with the new wingwalls and the reconstruction of the roadway. Discussion of impacts within resource areas, as well as discussion of how the Project will conform to applicable performance standards, are included in Section 4.2 and Section 4.3. Areas of impact upon resource areas by project activity type are detailed in the Site Plans in Appendix B.

Table 1. Summary of Wetland Resource Area Impacts

Resource Area[1]	Temporary Impacts	Permanent Impacts	Total Impacts
Bank	16 LF	18 LF	34 LF
Land Under Waterbodies and Waterways	589 SF	52 SF	641 SF
Bordering Land Subject to Flooding	589 SF	52 SF	641 SF
Riverfront Area	39 SF	4,282 SF	4,321 SF
Zone of Natural Vegetation[2]	670 SF	2,508 SF	3,178 SF

[1]Bank impacts provided in linear feet (LF), other resource area impacts provided in square feet (SF)
[2] Town of Reading Wetlands Protection Regulations resource area

The Project will not result in a loss to flood storage capacity. The Project proposes a compensatory flood storage area with a capacity of 120 CF, which will result in a net increase of 26 CF of storage within the floodplain. See Section 4.2.3 for discussion of impacts to BLSF.

4.1 Limited Project Provision

As afforded pursuant to 310 CMR 10.53(3), it is within the issuing authority's discretion to consider the magnitude of the alteration and the significance of the Project to the interests identified in M.G.L. c. 131 § 40, the availability of reasonable alternatives to the proposed activities, the extent to which disturbances are minimized, and the extent to which mitigation measures, including restoration, are provided to contribute to the protection of the interests identified in M.G.L. c. 131 § 40.

Maintenance and improvement of existing public roadways is included in the list of limited projects at 310 CMR 10.53(3)(f); therefore, the Project qualifies as a Limited Project.

4.2 Wetlands Protection Act Resource Area General Performance Standards

The following sections describe how the Project satisfies the Inland Bank, LUWW, BLSF, and Riverfront Area performance standards as promulgated under the WPA. The standards are provided in *italics*, while the details of compliance with the performance standard follow.

4.2.1 Inland Bank (310 CMR 10.54(4))

The proposed activities will result in temporary and permanent impacts to the Inland Bank of Walkers Brook. The Project activities that coincide with Inland Bank include the removal of the vertical concrete retaining walls and the installation of the side walls of the new culvert, which will act as the re-established limits of Bank to Walkers Brook within the Project Area. Stone riprap will also be placed along a small section of Inland Bank located downgradient from the new culvert to provide scour/erosion protection from flow along the bank.

The general performance standards for Inland Bank are outlined at 310 CMR 10.54(4) and are summarized below.

(a) Where the presumption set forth in 310 CMR 10.54(3) is not overcome, any proposed work on a Bank shall not impair the following:

1. *the physical stability of the Bank;*

The proposed activities will result in temporary and permanent impacts to Inland Bank. Following the installation of the concrete culvert and the stone riprap, impacted areas within the Inland Bank resource area will be restored. The Project will not result in any new long-term impacts to the physical stability of the Inland Bank resource area.

2. *the water carrying capacity of the existing channel within the Bank;*

The flow of Walkers Brook will experience temporary interruption during construction. To mitigate these impacts, a water bypass system will operate during construction activities to maintain water carrying capacity. Once construction is complete, the Inland Bank to Walkers Brook will be restored to its pre-existing capacity. The Project will not result in any long-term, permanent impacts to the water carrying capacity of the existing channel within the Inland Bank.

3. *ground water and surface water quality;*

The Project will not permanently impair ground or surface water quality. Best management practices will be implemented during construction and maintained to prevent erosion and sedimentation of the river during construction.

4. *the capacity of the Bank to provide breeding habitat, escape cover and food for fisheries;*

The majority of the Project Area characterized as bank is existing impervious surface (i.e., vertical concrete walls), and does not provide breeding habitat, escape cover and food for fisheries. Therefore, the Project will not reduce the capacity of Inland Bank to provide breeding habitat, escape cover and food for fisheries.

5. *the capacity of the Bank to provide important wildlife habitat functions. A project or projects on a single lot, for which Notice(s) of Intent is filed on or after November 1, 1987, that (cumulatively) alter(s) up to 10% or 50 feet (whichever is less) of the length of the bank found to be significant to the protection of wildlife habitat, shall not be deemed to impair its capacity to provide important wildlife habitat functions. Additional alterations beyond the above threshold may be permitted if they will have no adverse effects on wildlife habitat, as determined by procedures contained in 310 CMR 10.60;*

Existing wildlife habitat functions of Inland Bank are currently limited (or non-existent) due to the nature of the existing impervious surface within the Inland Bank resource area. The proposed work will have no long-term adverse alterations to important wildlife habitat; therefore, the Project will not reduce the capacity of Inland Bank to provide wildlife habitat functions.

6. *Work on a stream crossing shall be presumed to meet the performance standard set forth in 310 CMR 10.54(4)(a) provided the work is performed in compliance with the Massachusetts Stream Crossing Standards by consisting of a span or embedded culvert in which, at a minimum, the bottom of a span structure or the upper surface of an embedded culvert is above the elevation of the top of the bank, and the structure spans the channel width by a minimum of 1.2 times the bankfull width. This presumption is rebuttable and may be overcome by the submittal of credible evidence from a competent source. Notwithstanding the requirement of 310 CMR 10.54(4)(a)5., the impact on bank caused by the installation of a stream crossing is exempt from the requirement to perform a habitat evaluation in accordance with the procedures contained in 310 CMR 10.60.*

The Project qualifies as a bridge replacement project and will not include the construction of a new bridge crossing. Based on the land area constraints, including the existing elevation of the road, bridge heights, and the adjacent approaches to the bridge, there is not sufficient land area within the existing channel to create a bankfull width of 1.2 to meet the stream crossing standard requirement for bankfull width. The replacement bridge culvert will meet the stream crossing standards for embedment, openness ratio, and substrate as the culvert will be embedded two feet, the proposed openness ratio is 3.71 feet (general standard is 0.82 feet and optimum standard is 1.64 feet), and a natural bottom substrate consisting of two feet of aggregate material consisting of sand, silt, gravel and cobbles will be provided along the bed of the box culvert.

The following equation provides the openness ratio parameters that were used for the Project.

Openness ratio = 86.45 square feet (open area of culvert) / 23.33 feet (culvert length) = 3.71 feet

(b) Notwithstanding the provisions of 310 CMR 10.54(4)(a), structures may be permitted in or on a Bank when required to prevent flood damage to facilities, buildings and roads constructed prior to the effective date of 310 CMR 10.51 through 10.60 or constructed pursuant to a Notice of Intent filed prior to the effective date of 310 CMR 10.51 through 10.60 (April 1, 1983), including the renovation or reconstruction (but not substantial enlargement) of such facilities, buildings and roads, provided that the following requirements are met:

1. *The proposed protective structure, renovation or reconstruction is designed and constructed using best practical measures so as to minimize adverse effects on the characteristics and functions of the resource area;*

2. *The applicant demonstrates that there is no reasonable method of protecting, renovating or rebuilding the facility in question other than the one proposed.*

These standards are not applicable.

(c) Notwithstanding the provisions of 310 CMR 10.54(4)(a) or (b), no project may be permitted which will have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures established under 310 CMR 10.59.

The Project is not located within Estimated Habitat or Priority Habitat of rare species as identified in the 14th Edition (2017) of the Massachusetts Natural Heritage Atlas published by the Natural Heritage and Endangered Species Program (NHESP). Therefore, this standard does not apply.

4.2.2 Land Under Waterbodies and Waterways (310 CMR 10.56(4))

(a) Where the presumption set forth in 310 CMR 10.56(3) is not overcome, any proposed work within Land Under Water Bodies and Waterway shall not impair the following:

1. The water carrying capacity within the defined channel, which is provided by said land in conjunction with the banks;

As stated previously, the water carrying capacity of Walkers Brook may experience temporary interruption as a result of the replacement of the culvert. Installation of a water bypass system will allow for construction to take place in the dry, temporarily diverting flow within the channel. In addition, a small portion of the LUWW resource area will coincide with the placement of stone riprap at the inlet and outlet of the culvert. While the placement of the riprap may be considered a permanent impact to LUWW, it will have no long-term impacts on the water carrying capacity of Walkers Brook, as the area will be restored to previously-existing grades and conditions following construction.

2. Ground and surface water quality;

As stated previously, the Project will not permanently impair ground or surface water quality. Best management practices will be implemented and maintained to prevent sedimentation of the watercourse during construction.

3. The capacity of said land to provide breeding habitat, escape cover and food for fisheries;

There will be no significant long-term impacts to LUWW to provide breeding habitat, escape cover and food for fisheries.

4. The capacity of said land to provide important wildlife habitat functions. A project or projects on a single lot, for which Notice(s) of intent is filed on or after November 1, 1987, that (cumulatively) alter(s) up to 10% or 5,000 square feet (whichever is less) of land in this resource area found to be significant to the protection of wildlife habitat, shall not be deemed to impair its capacity to provide important wildlife habitat functions. Additional alterations beyond the above threshold may be permitted if they will have no adverse effects on wildlife habitat, as determined by procedures established under 310 CMR 10.60.

The Project Area was not found to be significant to the protection of wildlife habitat. As work will be conducted within the riverbed, disturbances to LUWW will be unavoidable and will temporarily affect the potential capacity of said land to provide important wildlife functions. However, most areas will be restored, and no significant long-term adverse alterations will occur. In addition, the area of permanent impact to LUWW is less than 5,000 square feet (SF).

(b) Notwithstanding the provisions of 310 CMR 10.56(4)(a), the issuing authority may issue an Order in accordance with M.G.L. c. 131 § 40 to maintain or improve boat channels within Land Under Water Bodies and Waterways when said work is designed and carried out using the best practical measures so as to minimize adverse effects such as the suspension or transport of pollutants, increases in turbidity, the smothering of bottom organisms, the accumulation of pollutants by organisms or the destruction of fisheries habitat or nutrient source areas.

This standard is not applicable.

(c) Notwithstanding the provisions of 310 CMR 10.56(4)(a) or (b), no project may be permitted which will have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures established under 310 CMR 10.59

Not applicable (see previous).

4.2.3 Bordering Land Subject to Flooding (310 CMR 10.57(4))

The proposed activities will include minor disturbance and fill within BLSF and will result in permanent fill within the floodplain. Project activities which will result in impacts to BLSF include the installation of the new wing walls, associated grading around the wing walls, and installation of rock fill to increase scour protection.

Site work will be completed to the extent practicable in compliance with the performance standards referenced in the WPA (310 CMR 10.57 (4)) for work within BLSF as described below.

> *1. Compensatory storage shall be provided for all flood storage volume that will be lost as the result of a proposed project within Bordering Land Subject to Flooding, when in the judgment of the issuing authority said loss will cause an increase or will contribute incrementally to an increase in the horizontal extent and level of flood waters during peak flows.*

Proposed work within BLSF is minimal and will not cause a significant increase or contribute to a significant increase in the horizontal extent and level of flood waters during peak flows or significant loss of flood storage volume. A Hydraulic Report (No-Rise Floodway Encroachment Review) was prepared by AECOM which indicates there is a “no-rise” impact on the floodplain in the Project Area (Appendix E).

Compensatory flood storage (120 CF) will be provided for any permanent fill occurring below elevation 83.4 feet (See Appendix B). The following table provides a summary of the BLSF impacts and incremental floodplain compensation.

Table 2. Impacts to 100-year Floodplain

Elevation (NAVD 88)	Cut (ft^3)	Fill (ft^3)	Proposed Compensatory Flood Storage (ft^3)	Net Loss (-)/Gain (+) to Floodplain (ft^3)
EL 80 – EL 81	8	0	0	+8
EL 81 – EL 82	0	7	11	+4
EL 82 – EL 83	0	35	40	+5
EL 83 – EL 83.4	0	60	69	+9
TOTAL:	**8**	**102**	**120**	**+26**

> *2. Work within Bordering Land Subject to Flooding, including that work required to provide the above-specified compensatory storage, shall not restrict flows so as to cause an increase in flood stage or velocity.*

Work in BLSF will not result in a significant loss of flood storage volume as floodplain compensation will be provided on an incremental basis, as required. Therefore, these activities will not restrict flows causing a significant increase in flood stage or velocity. A Hydraulic Report (No-Rise Floodway Encroachment Review) for the Project was prepared by AECOM that indicates there is a “no-rise” impact on the floodplain in the area from the proposed project (Appendix E).

> *3. Work in those portions of bordering land subject to flooding found to be significant to the protection of wildlife habitat shall not impair its capacity to provide important wildlife habitat functions. Except for work which would adversely affect vernal pool habitat, a project or projects on a single lot, for which Notice(s) of Intent is filed on or after November 1, 1987, that (cumulatively) alter(s) up to 10% or 5,000 square feet (whichever is less) of land in this resource area found to be significant to the protection of wildlife habitat, shall not be deemed to impair its capacity to provide important wildlife habitat functions. Additional alterations beyond the above threshold, or altering vernal pool habitat, may be permitted if they will have no adverse effects on wildlife habitat, as determined by procedures contained in 310 CMR 10.60.*

Not applicable. See previous.

4.2.4 Riverfront Area (310 CMR 10.58(4))

The Project Area coincides with approximately 29,579 SF of Riverfront Area. The Project proposes approximately 4,282 SF of permanent impacts to the Riverfront Area due to full-depth reconstruction of the roadway (including the addition of 371 SF of new impervious area) to widen the roadway approach to the bridge and grading of side slopes. The Project will also result in approximately 39 SF of temporary impacts associated with vegetation cutting and the installation of the temporary bypass pipe. It is anticipated that all disturbed areas within the Riverfront Area will be restored following construction (see Section 5.0).

As described in 310 CMR 10.58 4(d)1, the issuing authority may allow the alteration of up to 5,000 square feet or 10% of the Riverfront Area within a lot (whichever is greater); however, per 310 CMR 10.58 4.(d)(1)(d), the calculation of square footage of alteration "*shall exclude areas use for structural stormwater management measures, provided there is not practicable alternative to siting these structures within the riverfront area and provided a wildlife corridor is maintained."* It was determined that there are no practicable alternatives for siting the bridge in an alternative location, as the existing bridge structure and roadway currently serve a function specific to this location.

> *(a) Protection of Other Resource Areas. The work shall meet the performance standards for all other resource areas within the riverfront area, as identified in 310 CMR 10.30 (coastal bank), 10.32 (salt marsh), 10.55 (Bordering Vegetated Wetland), and 10.57 (Land Subject to Flooding). When work in the riverfront area is also within the buffer zone to another resource area, the performance standards for the riverfront area shall contribute to the protection of the interests of M.G.L. c. 131 § 40 in lieu of any additional requirements that might otherwise be imposed on work in the buffer zone within the riverfront area.*

See above for a discussion of performance standard compliance related to other resource areas.

> *(b) Protection of Rare Species. No project may be permitted within the riverfront area which will have any adverse effect on specified habitat sites of rare wetland or upland, vertebrate or invertebrate species, as identified by the procedures established under 310 CMR 10.59 or 10.37, or which will have any adverse effect on vernal pool habitat certified prior to the filing of the Notice of Intent.*

Not applicable. See previous.

> *(c) Practicable and Substantially Equivalent Economic Alternatives. There must be no practicable and substantially equivalent economic alternative to the proposed project with less adverse effects on the interests identified in M.G.L. c. 131 § 40.*

There are no practicable alternatives to the proposed Project with less adverse effects to resource areas and the interests of M.G.L. c. 131 § 40.

> *(d)* No Significant Adverse Impact. *The work, including proposed mitigation measures, must have no significant adverse impact on the riverfront area to protect the interests identified in M.G.L. c. 131, § 40.*

A Project is presumed to have no significant adverse impacts to the interests identified in M.G.L. c. 131, § 40 if the Project will result in no more than 5,000 square feet of permanent impacts to the Riverfront Area or will result in permanent impacts to no more than 10% of the Riverfront Area within "the lot", whichever is greater. The Project proposes to restore disturbed areas within the Riverfront Area upon the completion of the Project. It is anticipated that Project activities will not adversely impact the ability of the Riverfront Area to protect the interests identified in M.G.L. c. 131, § 40.

4.3 Compliance with Town of Reading Wetlands Regulations

In addition to conforming with the performance standards as described in 310 CMR 10.00 for work occurring within jurisdictional wetlands resource areas, the Project will conform with the performance standards as described in the Town of Reading Wetlands Protection Regulations as they pertain to Banks, Land Subject to Flooding, Land Under Water, and the Riverfront Area.

In addition to these resource areas, the Town of Reading also promulgates a Zone of Natural Vegetation (see Section 4.3.2). Descriptions of how the Project will conform to these performance standards is described below.

4.3.1 Banks (Section 3(b))

The general performance standards for Banks are outlined in Section 3(b) of the Town of Reading Wetlands Protection Regulations and are summarized below.

(1) Proposed work that may alter a bank shall not adversely affect the following:

a. The stability of the bank;

See Section 4.2.1.

b. The capacity of the channel to convey water;

See Section 4.2.1.

c. Ground water and surface water quality;

See Section 4.2.1.

d. The capacity of the bank to provide important fisheries, wildlife habitat, food, shelter, migratory, breeding, and overwintering areas; or

See Section 4.2.1.

e. The function of the bank to recharge or discharge groundwater.

It is anticipated that Project activities within the Bank resource area will not have any long-term impacts on the function of the bank to recharge or discharge groundwater. The Project includes a replacement of the existing culvert structure, including the removal of the existing retaining walls with the new side walls of the new culvert. This development within the Inland Bank resource area may therefore constitute as an in-kind replacement, and will therefore have no new impacts to the function of the bank to recharge or discharge groundwater. In addition, the placement of riprap along the bank will ensure the stability of the bank by protecting against erosion and sedimentation. By protecting the stability of the bank, it may be assumed that the function of the bank, including the ability to recharge or discharge groundwater, is protected.

4.3.2 Zone of Natural Vegetation (ZNV) (Section 3(d))

Project activities which will result in impacts to ZNV include the installation of the new wing walls, associated grading around the wing walls, installation of rock fill to increase scour protection, as well as restoration of the roadway, including the addition of 371 SF impervious surface associated with the lengthening of the existing bridge.

The general performance standards for ZNV are outlined in Section 3(d) of the Town of Reading Wetlands Protection Regulations and are summarized below.

(1) Bordering any wetland, the Commission shall require a Zone of Natural Vegetation (ZNV) or No-Disturb Zone of sufficient width and vegetative community type to assure that silt, products which may be carried by surface run-off shall not reach that wetland, but instead will be trapped by the natural mulch, soil and roots; and that light levels and temperature shall be moderated; and that dispersal of seeds of exotic or otherwise disruptive plant species, such as phragmites reed and purple loosestrife (Lythrum salicaria) shall be avoided; and that other alterations shall be avoided or mitigated within the wetland.

The Project has been designed in consideration of the values inherent to this zone and will be carried out in such a manner to minimize impacts to this zone as is practicable.

(2) Under most conditions, a zone width of a minimum of twenty-five feet would be considered sufficient to accomplish this purpose. A wider ZNV may be required, depending on specific site conditions, such as grades, soil permeability or other impact potential, including but not limited to potential vernal pools, as defined in Section 3J2 of these regulations. A previously developed or disturbed ZNV shall be restored to a naturally vegetated state to the maximum extent feasible within the ZNV, as determined by the Commission, including but not limited to requiring that a buffer strip be created where none currently exists.

A 25-foot strip has been designated in association with the Inland Bank to Walkers Brook (see Appendix B). As this area has been previously disturbed and is within a residential area, it is anticipated that this width will be considered appropriate for the maintenance and protection of nearby wetlands. Following Project activities, site conditions will be restored.

(3) Excavations for proposed structures extend beyond the finished limits of the structures. The extent of excavation varies depending on: the nature of the structure; the soil; depth of excavation; type of equipment used; construction techniques; slope; incidence of precipitation; groundwater flow; soil saturation and freeze/thaw cycles; existing vegetative cover; or other ground cover. An area of curtilage is developed around structures as a result of access for finish work, maintenance, foot traffic, and machine travel such as lawnmowers; and to provide a clear area for security; and to prevent moisture damage and physical damage from shading and plant structures such as tree limbs.

Not applicable. The Project does not propose any excavation.

(4) To protect the integrity of the Zone of Natural Vegetation or No-Disturb Zone, including the associated root system and canopy, no new structures or fixtures that may not require a building permit, including, but not limited to, foundations, footings, frost walls, retaining walls, pools and pool equipment, fences, patios, sports courts, driveways, sheds, or other in-ground fixtures, shall be permitted within ten feet of the ZNV. Depending on special site conditions, a greater distance may be required. The ZNV as otherwise defined in this Section 3D, plus this "ten feet" or "greater distance," may be referred to as the "No- Structure Zone." Associated structures, including but not limited to the following: cantilevered structures, bay windows, eaves, and, garrisons, or other overhangs, may protrude to no closer than seven feet from the ZNV.

Not applicable. The replacement of the culvert will have no impact on the root system or canopy, nor will the replacement constitute as new impacts in proximity to the ZNV.

(5) Notwithstanding the standards of the preceding paragraph, the Commission may grant a reduced setback distance of structures from the ZNV as a consideration of specific site conditions, such as limited vegetative cover or an existing developed condition, and provided that a permanent physical delineation, such as a solid hedge or an appropriate permanent fence or wall, of sufficient height, shall be provided and shall be maintained between the structure and the ZNV.

No response.

(6) Permanent markers shall be installed and maintained in convenient locations along the limits of the ZNV, such as at any corners or along a radius, no more than fifty feet apart. Markers may be stone or concrete bounds, metal pipes or rods, trees, shrubs or other structures as approved.

A contractor will ensure that permanent markers are placed to mark the ZNV.

4.3.3 Land Subject to Flooding (Section 3(e))

The general performance standards for Land Subject to Flooding are outlined in Section 3(e) of the Town of Reading Wetlands Protection Regulations and are summarized below.

(1) Proposed work that may alter land subject to flooding shall not adversely affect the interests protected under the Bylaw, including the flood control capacity of said area.

The Project will result in both temporary and permanent impacts within Land Subject to Flooding, however it is anticipated that Project activities will not result in any new, long-term impacts to the values inherent to Land Subject to Flooding, including flood control capacity. See Section 4.2.3 for discussion of compensatory flood storage.

(2) Additional alterations beyond the above threshold, or altering vernal pool habitat, may be permitted if they will have no adverse effects on important wildlife habitat, food, shelter, migratory, breeding or overwintering areas.

Not applicable. See previous discussion.

(3) Construction of the compensatory storage area shall be completed prior to any alteration of the existing storage area.

The contractor selected to complete all proposed work will complete construction of the compensatory storage area before altering the existing storage area so long as it is practical to do so. Contractors may use discretion during construction to mitigate impacts to nearby wetlands to the greatest extent practicable.

(4) Compensatory storage shall be provided for all flood storage volume that will be lost as the result of a proposed project within land subject to flooding, when in the judgment of the issuing authority said loss will cause an increase or will contribute incrementally to an increase in the horizontal extent and level of flood waters during peak flows. Compensatory storage shall mean a volume not previously used for flood storage and shall be incrementally equal to the theoretical volume of flood water at each elevation, up to and including the 100-year flood elevation, which would be displaced by the proposed project. Such compensatory volume shall have an unrestricted hydraulic connection to the same waterway or water body. Further, with respect to waterways, such compensatory volume shall be provided within the same reach of the river, stream, or creek.

See discussion in Section 4.2.3.

(5) Work within land subject to flooding, including that work required to provide the above specified compensatory storage, shall not restrict flows so as to cause an increase in flood stage or velocity.

See discussion in Section 4.2.3.

(6) Work in those portions of land subject to flooding found to be significant to the protection of wildlife habitat shall not impair its capacity to provide important wildlife habitat functions. Except for work that would adversely affect vernal pool habitat, a project or projects on a single lot, for which Notice(s) of Intent is filed on or after November 1, 1987, that (cumulatively) alter(s) up to 10% or 5,000 square feet (whichever is less) of land in this resource area found to be significant to the protection of wildlife habitat, shall not be deemed to impair its capacity to provide important wildlife habitat functions. Additional alterations beyond the above threshold, or altering vernal pool habitat, may be permitted if they will have no adverse effect on wildlife habitat, as determined by procedures contained in 310 CMR l0.60.

Not applicable. See previous.

4.3.4 Land Under Water (Section 3(f))

The performance standards included in Section 3(f) of the Town of Reading Wetlands Protection Regulations reflect those included in 310 CMR 10.56(4). See Section 4.2.2.

4.3.5 Riverfront Area (Section 3(g))

The Town of Reading Wetlands Protection Regulations do not promulgate additional performance standards for the Riverfront Area, but rather refer project proponents to 310 CMR 10.58. See Section 4.2.4 of this narrative.

4.4 Compliance with Massachusetts Stormwater Policy

In 1996, MassDEP issued the Stormwater Policy that established Stormwater Management Standards aimed at encouraging recharge and preventing stormwater discharges from causing or contributing to the pollution of the surface waters and groundwaters of the Commonwealth. In 1997, MassDEP published the Massachusetts Stormwater Handbook as guidance on the Stormwater Policy. MassDEP has revised the Stormwater Management Standards and Massachusetts Stormwater Handbook to promote increased stormwater recharge, the treatment of more runoff from polluting land uses, low impact development (LID) techniques, pollution prevention, the removal of illicit discharges to stormwater management systems, and improved operation and maintenance of stormwater best management practices (BMPs). MassDEP applies the Stormwater Management Standards pursuant to its authority under the WPA and the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53. The revised Stormwater Management Standards have been incorporated in the WPA Regulations, 310 CMR 10.05(6)(k) and the Water Quality Certification Regulations, 314 CMR 9.06(6)(a).

The Project will result in approximately 371 SF of new impervious surface associated with the lengthening of the existing bridge. Since the Project Area is constrained by the Track Road ROW, there are very limited opportunities to provide stormwater improvements that will satisfy the requirements of the DEP Stormwater Management Standards. The proposed bridge replacement does not include any new untreated discharges. All runoff from the proposed bridge structure will follow the existing overland flow paths towards Walkers Brook, running overland to the vegetated areas along Walkers Brook. Due to site constraints, no stormwater management structures have been proposed.

As stated in Standard 7 of the MassDEP Checklist for Stormwater Report, Limited Projects are only required to meet Stormwater Management Standards 1, 8, 9, and 10. Standards 2, 3, 4, 5, and 6 are to be met to the maximum extent practicable. The following section describes how the Project will meet each stormwater standard included in Volume 1 of the Massachusetts Stormwater Handbook.

Standard 1: No New Untreated Discharges or Erosion to Wetlands

Not applicable. The Project does not include the construction of any new stormwater conveyances.

Standard 2: Peak Rate Attenuation

This standard has been met to the extent practicable. Due to site constraints, no stormwater management structures have been designed to manage peak flow attenuation.

Standard 3: Stormwater Recharge

Due to site constraints, no stormwater management structures have been designed to provide recharge.

Standard 4: Water Quality

Not applicable. The Project will have no impact on existing stormwater management systems. No changes to TSS removal are proposed.

Standard 5: Land Uses with Higher Potential Pollutant Loads

Not applicable.

Standard 6: Critical Areas

Not applicable. The Project is not located within Zone II or Interim Wellhead Protection Area of a public water supply.

Standard 7: Redevelopment Projects

The Project qualifies as a redevelopment project. The Project will comply to the applicable Stormwater Management Standards to the greatest extent practicable.

Standard 8: Construction Period Pollution Prevention, Erosion/Sedimentation Controls

Soil and erosion controls have been developed for this Project and will be in practice during the duration of Project activities. See Appendix F for more details.

Standard 9: Operation and Maintenance Plan

Not applicable. The Project does not include the addition or alteration of any permanent stormwater management systems pertaining to the standards that would require an operation and maintenance plan.

Standard 10: Prohibition of Illicit Discharges

Not applicable. No illicit discharges are proposed as part of the Project.

4.5 Compliance with Town of Reading Stormwater Regulations

No new stormwater management system is proposed for this Project. As such, the Project will be in compliance with the Reading Stormwater Regulations, which prohibits illegal discharges, illicit connections to storm sewer systems, and obstruction or interference with normal stormwater flow in sewer systems without prior approval from the Conservation Commission. As required by the Stormwater Regulations, in the event of a release of oil or hazardous materials, the fire and police departments, highway department, Commission and Board of Health will be immediately notified. This notification shall be followed by written notification to said departments within 24 hours. In the event of a release of non-hazardous material, the Conservation Commission shall be notified no later than the next business day.

5. Mitigation

Restoration areas are proposed within the Riverfront Area in each of the four corners of the bridge crossing. These restoration areas will be loamed and seeded using a combination of New England Conservation/Wildlife Seed Mix (restoration seed mix) and an annual rye grass (annual rye grass to provide temporary vegetative stabilization while the conservation seed mix germinates and grows).

One (1) replacement tree will be planted within the restoration area of the bridge crossing to mitigate for the existing tree that that will be directly lost from the bridge replacement and creation of the compensatory flood storage area (see Appendix B). Additionally, six shrubs will also be planted in the restoration areas including three arrowwood (*Viburnum dentatum*) and three highbush blueberry (*Vaccinium corymbosum*).

6. Conclusion

The Project will improve the functionality and safety of the bridge and associated roadway. Permanent impacts to regulated wetland resources have been minimized to the maximum extent practicable and are limited to 18 SF of Inland Bank, 4,282 SF of Riverfront Area, 52 SF of LUWW, and 52 SF of BLSF. The Town of Reading Engineering Department respectfully requests that the Reading Conservation Commission find that these measures adequately protect the interests identified in the WPA and issue an Order of Conditions approving the work shown on the accompanying Site Plans (Appendix B).

7. References

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MassGIS. Areas of Critical Environmental Concern datalayer, April 2009. Available online: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-ofgeographic-information-massgis/datalayers/acecs.html. Accessed January 27, 2024.

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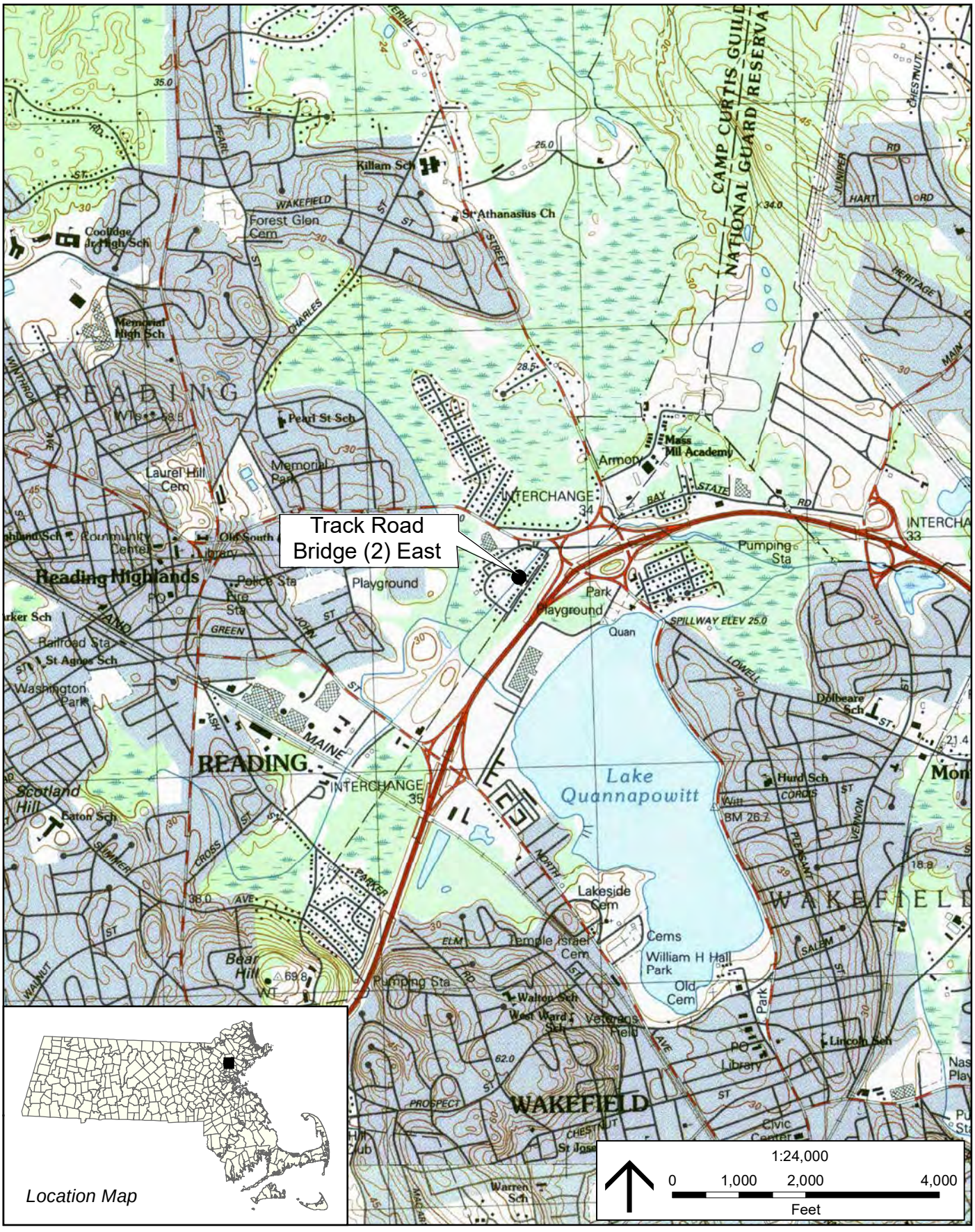
MassGIS. OLIVER: MassGIS's Online Mapping Tool. http://maps.massgis.state.ma.us/map_ol/oliver.php. Accessed January 27, 2024.

MassGIS. Outstanding Resource Waters datalayer, March 2010. Available online: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-ofgeographic-information-massgis/datalayers/orw.html. Accessed January 27, 2024.

Natural Heritage and Endangered Species Program – Massachusetts Division of Fisheries & Wildlife. NHESP Atlas – 2017 Priority and Estimated Habitat. http://maps.massgis.state.ma.us/PRI_EST_HAB/viewer.htm. Accessed January 27, 2024.

U.S. Environmental Protection Agency. *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites* (Office of Water Report EPA 833-B-09-002). February 2009.

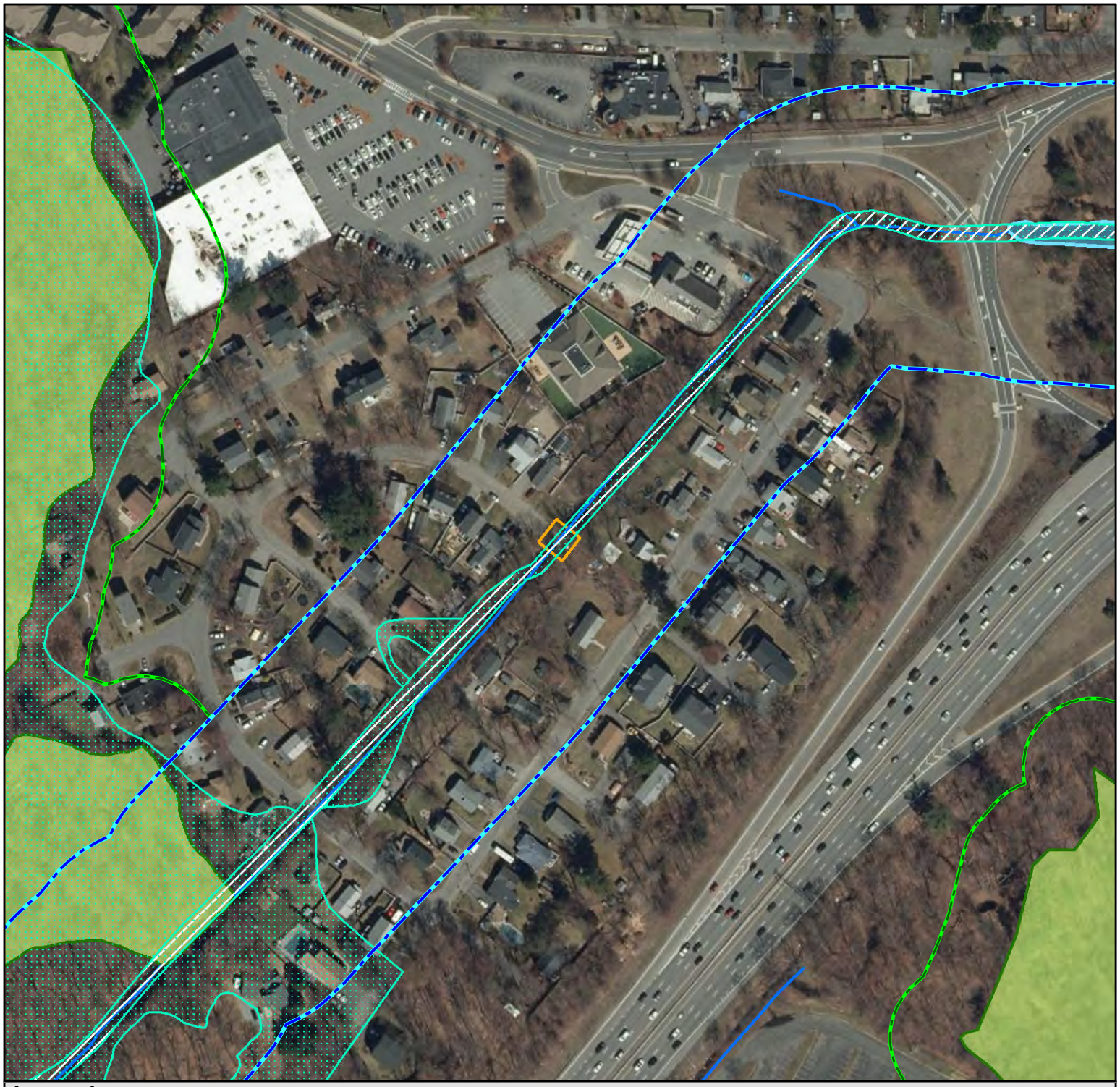
Appendix A – Figures



M:\work\Site_Maps\TrackRdBridge.mxd 2/26/2020 10:03:39 AM

Portion of Reading and Boston North
7.5' USGS quadrangles.
Scanned quadrangles supplied by MassGIS.

Site Locus
Track Road/Walker's Brook
Bridge Replacement Project
READING, MASSACHUSETTS



Legend

- Project Boundary
- Apparent Wetland Limit
- Hydrologic Connection
- Shoreline
- Open Water
- Wetland Area
- 100-ft Wetland Buffer
- 200-ft Riverfront Area
- 1% Annual Chance Flood Hazard Area
- FEMA Floodway

Locus Map
1 in = 100 miles

Environmental Constraints Map
Track Road Bridge East Project

Reading, MA

Data Source: MassGIS 2021 Orthoimagery

Projection: MA State Plane (ft) NAD 1983

N

0 100 200 Feet

AECOM

Date: 3/13/2024

Project #: 60700750

National Flood Hazard Layer FIRMette

FEMA

71°5'26"W 42°31'41"N

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

1:6,000

71°4'48"W 42°31'14"N

Basemap Imagery Source: USGS National Map 2023

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 Cross Sections with 1% Annual Chance
- 17.5 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 3/30/2026 at 3:04 PM 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.

Appendix B – Site Plans

TOWN OF READING

BRIDGE REPLACEMENT

TRACK ROAD EAST PERMITTING PLANS

IN THE TOWN OF

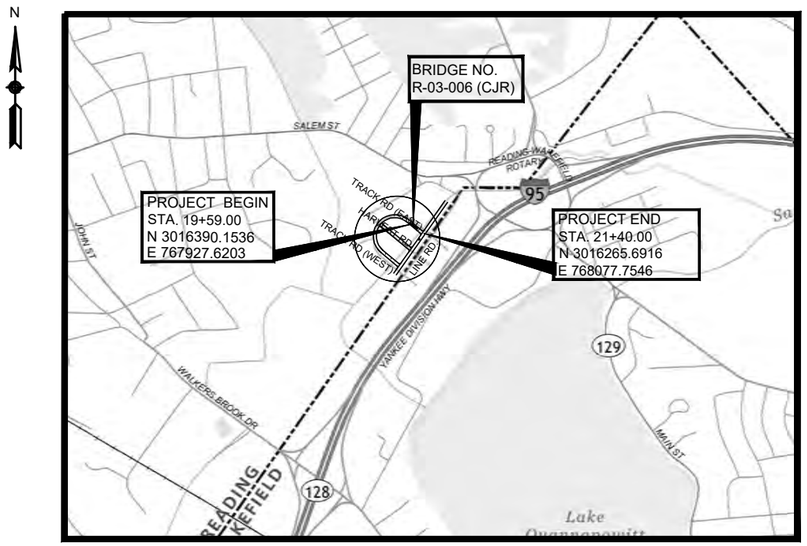
READING

MIDDLESEX COUNTY

FOR PERMITTING USE

THESE PLANS ARE SUPPLEMENTED BY THE JANUARY 2025 CONSTRUCTION STANDARD DETAILS, THE 2015 OVERHEAD SIGNAL STRUCTURE AND FOUNDATION STANDARD DRAWINGS, MASSDOT TRAFFIC MANAGEMENT PLANS AND DETAIL DRAWINGS, THE 1990 STANDARD DRAWINGS FOR SIGNS AND SUPPORTS, THE 1968 STANDARD DRAWINGS FOR TRAFFIC SIGNALS AND HIGHWAY LIGHTING, AND THE LATEST EDITION OF THE AMERICAN STANDARD FOR NURSERY STOCK.

INDEX



SCALE: 1" = 2000'

LENGTH OF PROJECT = 195 FT = 0.037 MILES

DESIGN DESIGNATION TRACK RD (WEST AND EAST)

DESIGN SPEED	25 MPH
ADT (2019)	< 100 VPD
ADT (2040)	< 100 VPD
K	...
D	--
T (PEAK HOUR)	N/A
T (AVERAGE DAY)	UNAVAILABLE
DHV	UNAVAILABLE
DDHV	UNAVAILABLE
FUNCTIONAL CLASSIFICATION	LOCAL ROAD

COMMONWEALTH OF MASSACHUSETTS
JEFFREY A. DiNINDCENTIS
CIVIL
No. 48723
REGISTERED PROFESSIONAL ENGINEER
1/6/26

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	1	9
PROJECT FILE NO.	60609390		

TITLE SHEET & INDEX

DATE	DESCRIPTION	REV #
NOV. 20, 2025	25% SUBMISSION	0

AECOM
AECOM TECHNICAL SERVICES, INC.
250 APOLLO DRIVE · CHELMSFORD · MA · 01824

TOWN OF READING
ENGINEERING DIVISION
16 LOWELL STREET READING, MASS

60609390_HWY02TITLE1.DWG Plotted on 12-Dec-2025 12:59 PM

BLSF AND LUW TEMPORARY IMPACTS:
TOTAL = 590 SF

BSLF AND RIVERFRONT TEMPORARY IMPACTS:
TOTAL = 81 SF

BANK TEMPORARY IMPACTS:
TOTAL = 16 LF

NOTE:
THE 200 FOOT FLOODPLAIN / RIVERBANK BUFFER IS OUTSIDE OF THE LIMITS OR WORK AND OUTSIDE THIS VIEW.

023.0–0000–0010.0
TOWN OF READING
TRACK ROAD
READING, MA 01867

023.0–0000–0011.0
HOLLAND PHILIP W
KATHRYN L HOLLAND
13 TRACK ROAD
READING, MA 01867

023.0–0000–0012.0
WANG JIA JUN
WU JIAJING
15 TRACK ROAD
READING, MA 01867

023.0–0000–0008.0
WOOD KENNETH
WOOD SILVA
27 LINE ROAD
READING, MA 01867

023.0–0000–0026.0
BARMOY JOHN P
CARNEY SHANA E
16 TRACK ROAD
READING, MA 01867

023.0–0000–0025.0
MANLEY CELESTE D
12 TRACK ROAD
READING, MA 01867

023.0–0000–0024.0
TOWN OF READING
TRACK ROAD
READING, MA 01867

023.0–0000–0023.0
GUEVARA ELADIO S
7 HARVEST ROAD
READING, MA 01867

023.0–0000–0022.0
RAO VARUN B
SIVAKUMAR SMRUTHY K TE
33 LINE ROAD
READING, MA 01867

WALKERS BROOK
FLOW
N 41°39'55" E
S 50°20'28" E
TRACK ROAD EAST
SMH
RIM=84.82'
INV=79.8'
UPL
84.59
18"RCP
8"AC
20"RCP
12"RCP
8"CI
18"M
10"M
8"E
4"E
12"M

WF#405
WF#305
WF#404
WF#304
WF#403
WF#303
WF#402
WF#302
WF#401
WF#301
WF#201
WF#101
WF#102
WF#103
WF#203
WF#104
WF#204
WF#105

ZONE OF NATURAL VEGETATION (ZNV)
℄ WALKERS BROOK/ ℄ PRECAST FRAME
BLSF & RIVERFRONT TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 5± SF
REMOVE 12" MAPLE
LIMITS OF ROCK FILL (TYP.)
EXISTING EP (TYP.)
BANK TEMPORARY IMPACT = 3± LF
PROPOSED EP (TYP.) LIMITS OF OVERLAY
APPROX. LIMITS OF EXIST. STRUCTURE (TO BE REMOVED)
TEMPORARY IMPACTS TO LUW = 589± SF
LIMITS OF SLOPE IMPACTS
PROP EROSION AND SEDIMENTATION CONTROL BARRIER (TYP.)
TOE OF SLOPE
BLSF & LUW TEMPORARY IMPACT AREA DUE TO TURBIDITY CURTAIN = 13± SF
TURBIDITY CURTAIN
COFFERDAM FOR WATER DIVERSION
BLSF & LUW TEMPORARY IMPACT AREA DUE TO TEMP WATER CONTROL = 98± SF
BLSF & LUW TEMPORARY IMPACT AREA DUE TO COFFERDAM = 34± SF
BLSF & RIVERFRONT TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 1± SF
BANK TEMPORARY IMPACT = 6± LF
℄ CONSTRUCTION TRACK ROAD (2) EAST
PROP. PRECAST CULVERT
BLSF & RIVERFRONT TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 71± SF
PROP. WINGWALL (TYP.)
BLSF & RIVERFRONT TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 2± SF
BANK TEMPORARY IMPACT = 2± LF
BLSF & LUW TEMPORARY IMPACT AREA DUE TO COFFERDAM = 39± SF
BLSF & RIVERFRONT TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 2± SF
BANK TEMPORARY IMPACT = 4± LF
TEMP PIPE FOR WATER DIVERSION
BLSF & LUW TEMPORARY IMPACT AREA DUE TO CULVERT REPLACEMENT = 406± SF
ZONE OF NATURAL VEGETATION (ZNV)
APPROXIMATE 40' DRAINAGE EASEMENT
APPROXIMATE 40' DRAINAGE EASEMENT

NAD 83
N

LEGEND:

- WF#XXX
- BORDERING LAND SUBJECT TO FLOODING (ELEVATION 83' NAVD 88)
- BANK (WF#XXX)
- BANK IMPACT (TEMPORARY IMPACT)
- BANK IMPACT (PERMANENT IMPACT)
- EROSION AND SEDIMENTATION BARRIER
- NEW IMPERVIOUS AREA
- RECLAIMED EXISTING IMPERVIOUS AREA
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) PERMANENT IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) PERMANENT IMPACT

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	2	9
PROJECT FILE NO. 60609390			

RESOURCE AREA IMPACT PLAN
TEMPORARY AREA IMPACTS

GRAPHIC SCALE
20 0 20
SCALE: 1" = 20'

60609390_BR_02 (ENV AREA PLAN)_ENV.DWG Plotted on 16-Dec-2025 3:30 PM

READING, MA 01867

BLSF AND LUW PERMANENT IMPACTS:
TOTAL = 54 SF

BSLF AND RIVERFRONT PERMANENT IMPACTS:
TOTAL = 4,517 SF

BANK PERMANENT IMPACTS:
TOTAL = 40 LF

NOTE:
THE 200 FOOT FLOODPLAIN / RIVERBANK BUFFER IS OUTSIDE OF THE LIMITS OR WORK AND OUTSIDE THIS VIEW.

ZONE OF NATURAL VEGETATION (ZNV)

℄ WALKERS BROOK/ ℄ PRECAST FRAME

WALKERS BRO

FLOW

N 41°39'35" E

WF#404

WF#304

WF#403

PERMANENT IMPACT TO BLSF AND LUW DUE TO ROCK FILL AREA = 1± SF

REMOVE 12" MAPLE

LIMITS OF ROCK FILL (TYP.)

TOE OF SLOPE

TURBIDITY CURTAIN

COFFERDAM FOR WATER DIVERSION

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROCK FILL AND ROADWAY RECONSTRUCTION AREA = 22± SF

EXISTING EP (TYP.)

WF#303

PERMANENT IMPACT TO BLSF AND LUW DUE TO ROCK FILL AREA = 19± SF

PERMANENT BANK IMPACT = 9± LF

WF#402

WF#301

WF#302

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROCK FILL AND ROADWAY RECONSTRUCTION AREA = 77± SF

PERMANENT BANK IMPACT = 12± LF

WF#401

WF#300

PROPOSED EP (TYP.) LIMITS OF OVERLAY

APPROX. LIMITS OF EXIST. STRUCTURE (TO BE REMOVED)

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROADWAY RECONSTRUCTION AREA = 3,476± SF

℄ CONSTRUCTION TRACK ROAD (2) EAST

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROADWAY RECONSTRUCTION AREA = 807± SF

TRACK ROAD EAST

TEMPORARY IMPACTS TO LUW = 589± SF

WF#200

WF#100

PROP. PRECAST CULVERT

S 50°20'28" E

LIMITS OF SLOPE IMPACTS

PROP EROSION AND SEDIMENTATION CONTROL BARRIER (TYP.)

WF#201

PROP. WINGWALL (TYP.)

PERMANENT BANK IMPACT = 8± LF

PERMANENT BANK IMPACT = 11± LF

WF#202

WF#102

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROCK FILL AND ROADWAY RECONSTRUCTION AREA = 77± SF

PERMANENT BLSF AND RIVERFRONT IMPACT DUE TO ROCK FILL AND ROADWAY RECONSTRUCTION AREA = 60± SF

WF#103

PERMANENT IMPACT TO BLSF AND LUW DUE TO ROCK FILL AREA = 13± SF

PERMANENT IMPACT TO BSLF AND LUW DUE TO ROCK FILL AREA = 21± SF

FLOW

TEMP PIPE FOR WATER DIVERSION

WF#203

ZONE OF NATURAL VEGETATION (ZNV)

WF#104

WF#204

WF#105

℄

℄

APPROXIMATE 40' DRAINAGE EASEMENT

APPROXIMATE 40' DRAINAGE EASEMENT

023.0-0000-0008.0
WOOD KENNETH
WOOD SILVA
27 LINE ROAD
READING, MA 01867

023.0-0000-0025.0
MANLEY CELESTE D
12 TRACK ROAD
READING, MA 01867

023.0-0000-0024.0
TOWN OF READING
TRACK ROAD
READING, MA 01867

023.0-0000-0023.0
GUEVARA ELADIO S
7 HARVEST ROAD
READING, MA 01867

023.0-0000-0022.0
RAO VARUN B
SIVAKUMAR SMRUTHY K TE
33 LINE ROAD
READING, MA 01867

BENCHMARK:
EL=86.92'
HYD; BOMO

SMH
RIM=84.82'

SMH
RIM=84.28'

NAD 83

LINE ROAD

LEGEND:

- WF#XXX
- BORDERING LAND SUBJECT TO FLOODING (ELEVATION 83' NAVD 88)
- BANK (WF#XXX)
- BANK IMPACT (TEMPORARY IMPACT)
- BANK IMPACT (PERMANENT IMPACT)
- EROSION AND SEDIMENTATION BARRIER
- NEW IMPERVIOUS AREA
- RECLAIMED EXISTING IMPERVIOUS AREA
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) PERMANENT IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) PERMANENT IMPACT

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	3	9
PROJECT FILE NO. 60609390			

RESOURCE AREA IMPACT PLAN
PERMANENT AREA IMPACTS

GRAPHIC SCALE
20 0 20
SCALE: 1" = 20'

60609390_BR_02 (ENV AREA PLAN)_ENV.DWG Plotted on 16-Dec-2025 3:30 PM

IMPERVIOUS AREAS:
- NEW IMPERVIOUS AREAS = 404 SF
- RECLAIMED IMPERVIOUS AREA = 33 SF

TOTAL NEW IMPERVIOUS AREA = 371 SF

NOTE:
THE 200 FOOT FLOODPLAIN / RIVERBANK BUFFER IS OUTSIDE OF THE LIMITS OR WORK AND OUTSIDE THIS VIEW.

N

NAD 83

023.0–0000–0010.0
TOWN OF READING
TRACK ROAD
READING, MA 01867

023.0–0000–0011.0
HOLLAND PHILIP W
KATHRYN L HOLLAND
13 TRACK ROAD
READING, MA 01867

023.0–0000–0012.0
WANG JIA JUN
WU JIAJING
15 TRACK ROAD
READING, MA 01867

023.0–0000–0008.0
WOOD KENNETH
WOOD SILVA
27 LINE ROAD
READING, MA 01867

023.0–0000–0026.0

023.0–0000–0025.0
MANLEY CELESTE D
12 TRACK ROAD
READING, MA 01867

023.0–0000–0024.0
TOWN OF READING

023.0–0000–0023.0
GUEVARA ELADIO S
7 HARVEST ROAD
READING, MA 01867

023.0–0000–0022.0
RAO VARUN B
SIVAKUMAR SMRUTHY K TE
33 LINE ROAD
READING, MA 01867

WF#405
WF#305
WF#404
WF#304
WF#403
WF#303
WF#402
WF#302
WF#401
WF#301
WF#400
WF#300
WF#200
WF#100
WF#201
WF#101
WF#102
WF#103
WF#203
WF#104
WF#204
WF#105

WALKERS BROOK
FLOW
N 41°39'32" E
℄ WALKERS BROOK/
℄ PRECAST FRAME
ZONE OF NATURAL VEGETATION (ZNV)
REMOVE 12" MAPLE
LIMITS OF ROCK FILL (TYP.)
TOE OF SLOPE
TURBIDITY CURTAIN
COFFERDAM FOR WATER DIVERSION
EXISTING EP (TYP.)
RECLAIMED IMPERVIOUS AREA = 33± SF
PROPOSED EP (TYP.) LIMITS OF OVERLAY
APPROX. LIMITS OF EXIST. STRUCTURE (TO BE REMOVED)
℄ CONSTRUCTION TRACK ROAD (2) EAST
PROP. PRECAST CULVERT
S 50°20'28" E
TEMPORARY IMPACTS TO LUW = 589± SF
LIMITS OF SLOPE IMPACTS
PROP EROSION AND SEDIMENTATION CONTROL BARRIER (TYP.)
PROP. WINGWALL (TYP.)
PROP NEW IMPERVIOUS AREA = 404± SF
TEMP PIPE FOR WATER DIVERSION
ZONE OF NATURAL VEGETATION (ZNV)
40' DRAINAGE EASEMENT
UPL 3
UPL 2
SMH
RIM=84.82'
INV=79.8'
TRACK ROAD EAST
84.59
18" RCP
8"AC
8"CI
8"PVC
8"DI
12"W
18"M
10"M
14"M
6"M
12"M
20"D
8"E
20"DEC

LEGEND:

- WF#XXX
- BORDERING LAND SUBJECT TO FLOODING (ELEVATION 83' NAVD 88)
- BANK (WF#XXX)
- BANK IMPACT (TEMPORARY IMPACT)
- BANK IMPACT (PERMANENT IMPACT)
- EROSION AND SEDIMENTATION BARRIER
- NEW IMPERVIOUS AREA
- RECLAIMED EXISTING IMPERVIOUS AREA
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) PERMANENT IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) PERMANENT IMPACT

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	4	9
PROJECT FILE NO.	60609390		

RESOURCE AREA IMPACT PLAN
IMPERVIOUS AREA

GRAPHIC SCALE
20 0 20
SCALE: 1" = 20'

60609390_BR_02 (ENV AREA PLAN)_ENV.DWG Plotted on 16-Dec-2025 3:30 PM

PROPOSED EROSION AND SEDIMENTATION BARRIER:
– TOTAL LENGTH = 137± LF

NOTE:
THE 200 FOOT FLOODPLAIN / RIVERBANK BUFFER IS OUTSIDE OF THE LIMITS OR WORK AND OUTSIDE THIS VIEW.

REFER TO PLAN SET FOR SEDIMENTATION / EROSION CONTROL DETAILS.

023.0–0000–0010.0
TOWN OF READING
TRACK ROAD
READING, MA 01867

023.0–0000–0011.0
HOLLAND PHILIP W
KATHRYN L HOLLAND
13 TRACK ROAD
READING, MA 01867

023.0–0000–0012.0
WANG JIA JUN
WU JIAJING
15 TRACK ROAD
READING, MA 01867

023.0–0000–0008.0
WOOD KENNETH
WOOD SILVA
27 LINE ROAD
READING, MA 01867

023.0–0000–0026.0
BARMOY JOHN P

023.0–0000–0025.0
MANLEY CELESTE D
12 TRACK ROAD
READING, MA 01867

023.0–0000–0022.0
RAO VARUN B
SIVAKUMAR SMRUTHY K TE
33 LINE ROAD
READING, MA 01867

023.0–0000–0024.0
TOWN OF READING
TRACK ROAD

023.0–0000–0023.0
GUEVARA ELADIO S
7 HARVEST ROAD
READING, MA 01867

WF#405
WF#305
WF#404
WF#304
WF#403
WF#303
WF#402
WF#302
WF#401
WF#301
WF#400
WF#300
WF#200
WF#100
WF#201
WF#101
WF#202
WF#102
WF#203
WF#103
WF#204
WF#104
WF#105

WALKERS BROOK
FLOW
N 41°39'35" E
ZONE OF NATURAL VEGETATION (ZNV)
℄ WALKERS BROOK/ ℄ PRECAST FRAME
REMOVE 12" MAPLE
LIMITS OF ROCK FILL (TYP.)
PROP LOAM AND RESTORATION (CONSERVATION) SEED MIX
EXISTING EP (TYP.)
TURBIDITY CURTAIN
TOE OF SLOPE
COFFERDAM FOR WATER DIVERSION
PROP LOAM AND RESTORATION (CONSERVATION) SEED MIX
PROPOSED EP (TYP.) LIMITS OF OVERLAY
APPROX. LIMITS OF EXIST. STRUCTURE (TO BE REMOVED)
℄ CONSTRUCTION TRACK ROAD (2) EAST
PROP. PRECAST CULVERT
TEMPORARY IMPACTS TO LUW = 589± SF
LIMITS OF SLOPE IMPACTS
PROP EROSION AND SEDIMENTATION CONTROL BARRIER (TYP.)
PROP. WINGWALL (TYP.)
PROP LOAM AND RESTORATION (CONSERVATION) SEED MIX
TEMP PIPE FOR WATER DIVERSION
ZONE OF NATURAL VEGETATION (ZNV)
40' DRAINAGE EASEMENT
40' DRAINAGE EASEMENT
TRACK ROAD EAST
SMH
RIM=84.82'
INV=79.8'
UPL 3
S 50°20'28" E
84.59

N
NAD 83

LEGEND:

- WF#XXX
- BORDERING LAND SUBJECT TO FLOODING (ELEVATION 83' NAVD 88)
- BANK (WF#XXX)
- BANK IMPACT (TEMPORARY IMPACT)
- BANK IMPACT (PERMANENT IMPACT)
- EROSION AND SEDIMENTATION BARRIER
- NEW IMPERVIOUS AREA
- RECLAIMED EXISTING IMPERVIOUS AREA
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND LAND UNDER WATER (LUW) PERMANENT IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) TEMPORARY IMPACT
- BOARDERING LAND SUBJECT TO FLOODING (BLSF) AND RIVERFRONT AREA (LUW) PERMANENT IMPACT

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	5	9
PROJECT FILE NO.	60609390		

MITIGATION, RESTORATION AND EROSION AND SEDIMENT CONTROL PLAN

GRAPHIC SCALE
20 0 20
SCALE: 1" = 20'

60609390_BR_02 (ENV AREA PLAN)_ENV.DWG Plotted on 16-Dec-2025 3:30 PM

N

NAD 83

℄ WALKERS BROOK/
℄ PRECAST FRAME

IP 2" FENCE

WF#403

WF#402

WF#401

WF#303

WF#302

WF#301

WF#300

WF#203

WF#202

WF#201

WF#200

WF#103

WF#102

WF#101

WF#100

WF#104

TOP OF HYDRAULIC OPENING
EL=84.23

INV 18" RCP
EL=77.77'

3'CLF

UPL 2

WG

6"DI

STA. 19+59.00
LIMIT OF WORK

STA. 19+93.92
LT. 0.21'

STA. 20+00.00 ℄ CONST. TRACK RD
STA. 5+00.00 ℄ WALKERS BROOK

STA. 20+06.08
RT. 0.21'

℄ CONSTRUCTION TRACK ROAD

S 50°20'28" E

TOP OF HYDRAULIC OPENING
EL=84.33

TRACK RD
EAST BRIDGE

RET 20" DEC

DRAINAGE EASEMENT

PROPOSED AREA
FOR COMPENSATORY
STORAGE 120 CF

RET 10" MAPLE

R&R 6" ELM
IN PLACE

REM 20" MAPLE
PLANT 6" MAPLE

RET 10" MAPLE

DRAINAGE EASEMENT

ELADIO & AMY GUEVARA
DEED BOOK 59147, PAGE 356
PLAN 314 OF 2003
PLAN BOOK 295, PLAN 46
#7 HARVEST ROAD
(MAP 23, LOT 23)

LEGEND:

- PROPOSED BORDERING LAND SUBJECT TO FLOODING COMPENSATORY AREA
- REMOVE AND REPLACE TREE (R&R) (PROPOSED)
- PROPOSED SHRUB (MIXTURE OF 6 ARROWWOOD AND 6 HIGHBUSH BLUEBERRY)
- EROSION AND SEDIMENTATION BARRIER

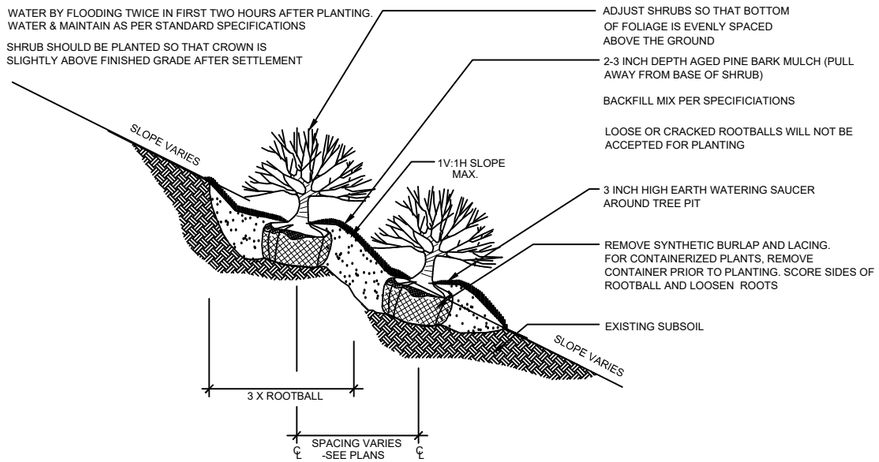
READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	6	9
PROJECT FILE NO. 60609390			

PROPOSED COMPENSATORY FLOODPLAIN PLAN

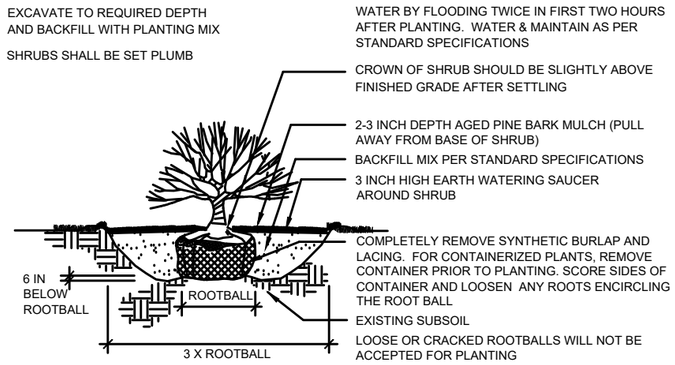
GRAPHIC SCALE
10 0 10
SCALE: 1" = 10'

60609390_BR_02 (COMP PLAN) NEW.DWG Plotted on 12-Dec-2025 10:47 AM



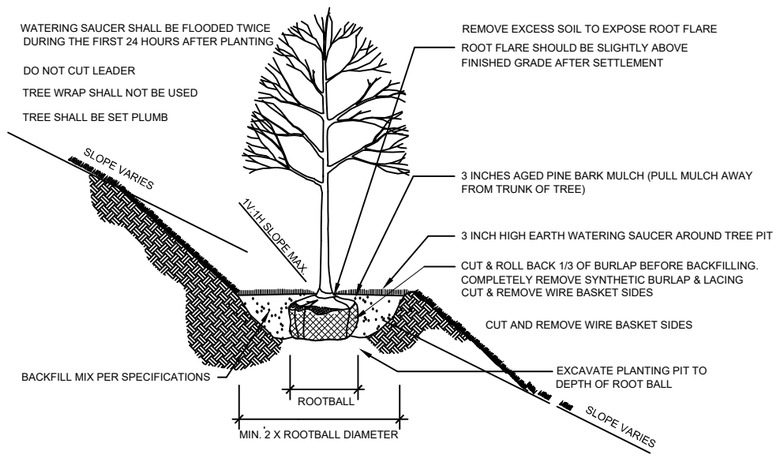
SHRUB PLANTING (SLOPE)

NOT TO SCALE



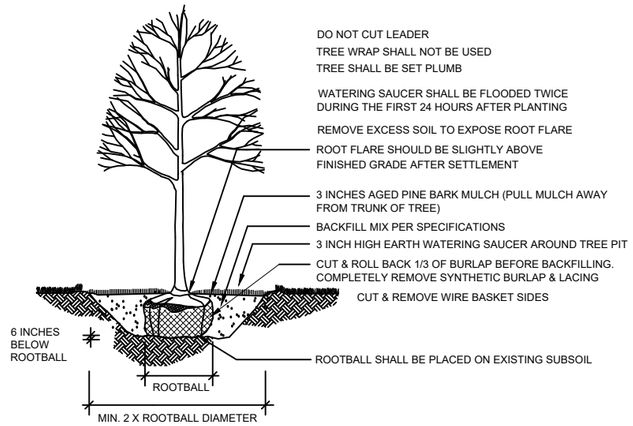
SHRUB PLANTING

NOT TO SCALE



DECIDUOUS TREE PLANTING (SLOPE)

NOT TO SCALE



DECIDUOUS TREE PLANTING

NOT TO SCALE

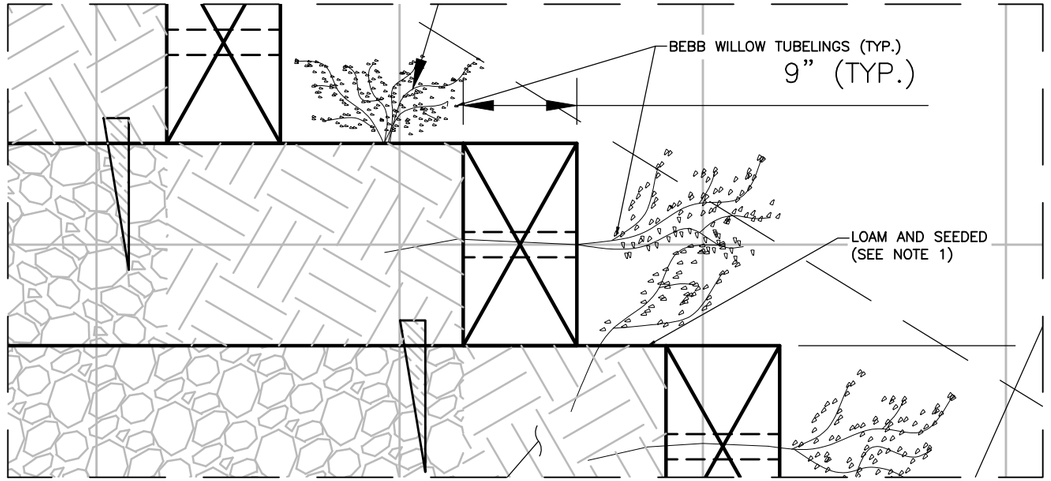
READING MA
TRACK ROAD EAST PERMITTING PLANS

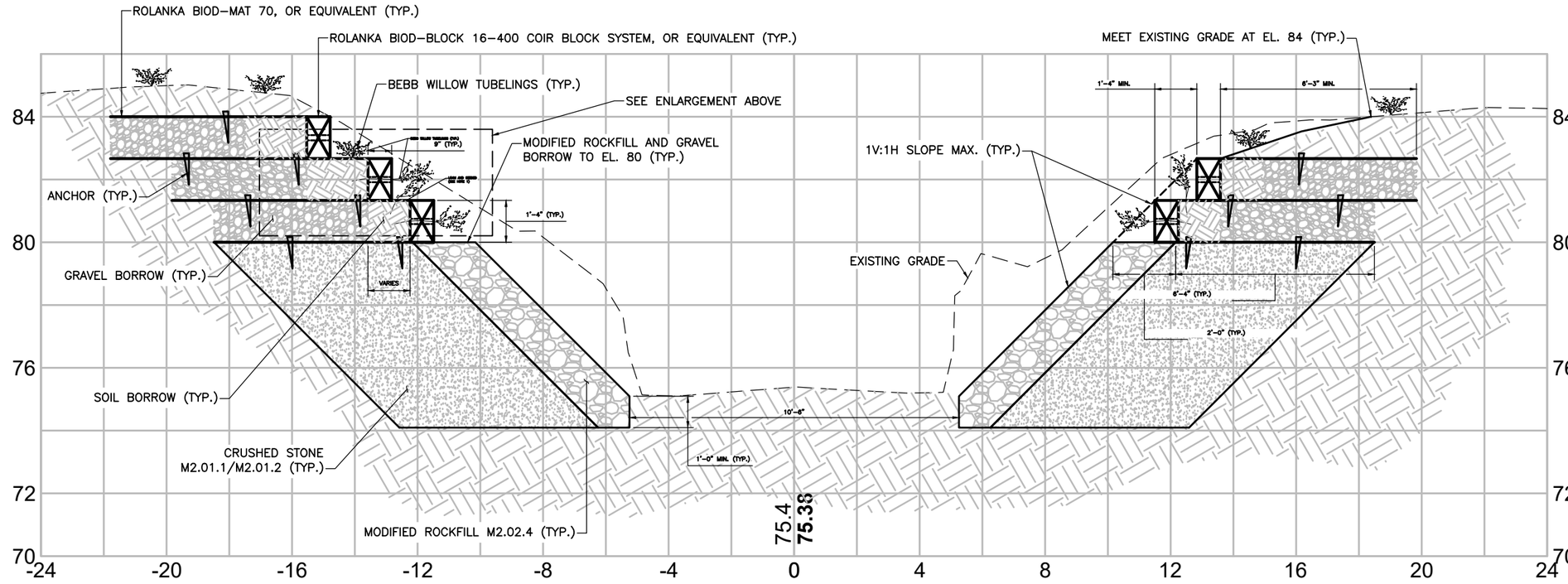
STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	7	9
PROJECT FILE NO.	60609390		

ENVIRONMENTAL AND PLANTING DETAILS

NOTES:

1. THE LEVEL AREAS (SHELVES) IN-BETWEEN EACH BIOD-BLOCK AND THE FINAL GRADES ON THE TOP OF THE SLOPES CONTAINING THE BIOD-MAT WILL BE LOAMED AND SEEDED USING A COMBINATION OF THE NEW ENGLAND CONSERVATION / WILDLIFE SEED MIX AND AN ANNUAL RYE GRASS.
2. 9 BEBB WILLOW (SALIX BEBBIANA) TUBELINGS WILL BE PLANTED ON THE SLOPE WITHIN THE NORTHEASTERN CORNER OF BRIDGE AND 15 BEBB WILLOW TUBELINGS WILL BE PLANTED ON THE SLOPE WITHIN THE NORTHWEST CORNER OF THE BRIDGE.
3. THE TOP PORTIONS OF EACH SLOPE WILL BE PLANTED WITH A MIXTURE OF 3 SHRUBS OF ARROWWOOD (VIBURNUM DENTATUM) AND 3 SHRUBS OF HIGHBUSH BLUEBERRY (VACCINIUM CORYMBOSUM). THE TOP OF EACH CORNER (NORTHEASTERN AND NORTHWESTERN CORNERS) OF THE BRIDGE WILL HAVE A TOTAL OF 3 SHRUBS PLANTED.





TYPICAL REINFORCED SLOPE SECTION

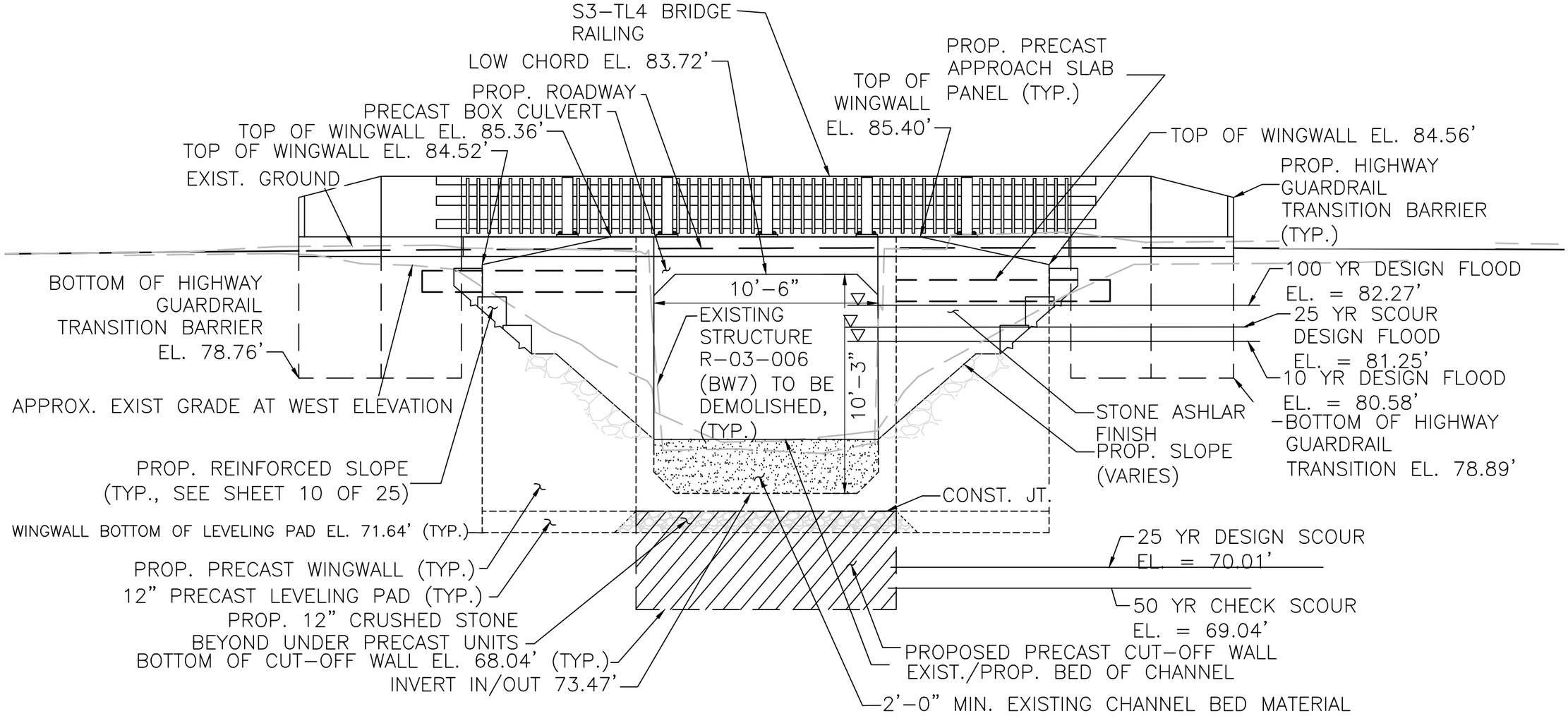
GRAPHIC SCALE

SCALE: 1" = 4'

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	8	9
PROJECT FILE NO. 60609390			

REINFORCED SLOPE SECTION



WEST ELEVATION

READING MA
TRACK ROAD EAST PERMITTING PLANS

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	9	9
PROJECT FILE NO. 60609390			

ELEVATION AT CULVERT

GRAPHIC SCALE
5 0 5
SCALE: 1" = 5'

Appendix C – Photolog

PHOTOGRAPH LOG: 06/22/23
Walkers Brook Bridge

Site Location:
Track Road (east) bridge, Reading, MA 01867

Project # 60700750

Photo No. 1	**Date:** 06/22/23

Photo Location:

East of 12 Track Road

Description:

View of Track Road (east) bridge looking north. Bridge seems to be in poor condition and not regularly maintained.

Photo No. 2	**Date:** 06/22/23

Photo Location:

East of 12 Track Road

Description:

View of Walkers Brook looking south from the center of the bridge. Moderate bank erosion is present on the eastern bank.

PHOTOGRAPH LOG: 06/22/23
Walkers Brook Bridge

Site Location:
Track Road (east) bridge, Reading, MA 01867

Project # 60700750

Photo No. 3	**Date:** 06/22/23

Photo Location:

East of 12 Track Road

Description:

A lower elevation view of Walkers Brook looking north. Compost filter tubes and silt fences are present on the western bank of the brook.

Photo No. 4	**Date:** 06/22/23

Photo Location:

East of 12 Track Road

Description:

View of Track Road (east) bridge looking south.

PHOTOGRAPH LOG: 06/22/23
Walkers Brook Bridge

Site Location:
Track Road (east) bridge, Reading, MA 01867

Project # 60700750

Photo No.	**Date:**
5	06/22/23

Photo Location:

Northeast of 12 Track Road

Description:

View of roadway conditions west of Track Road (east) bridge. Google image was taken in October of 2022.

Appendix D – Certified Abutters List and Abutter Notification


23-62
5,898
23-61
7,006
23-60
7,980
23-59
7,980
23-18
11,952
23-19
33,880
23-21
32,830
23-20
12,520
23-2
8,005
23-3
5,876
23-4
7,649
23-5
8,222
23-6
9,396
23-7
15,205
23-8
14,110
23-15
8,400
23-14
6,450
23-13
9,200
23-12
9,060
23-11
9,740
23-16
8,315
23-17
8,910
23-28
5923
23-27
6248
23-26
4,590
23-25
5,595
23-24
5,594
23-29
12,539
23-30
9,345
23-31
11,189
23-23
11,189
23-22
10,090
23-219
5,594
23-32
5,714
23-33
5,838
23-39
8,700
23-38
12,442
23-40
7,235
23-41
6,035
23-37
8,391
23-36
5,594
23-35
11,188
23-42
12,614
23-34
TRACK RD
HARVEST RD
23

Patriot Properties

Reading

01/07/2026

9:01:04AM

Abutters List

Filter Used: DataProperty.AccountNumber in (4626,4637,4629,4613,4621,4636,4619,4616,4623,4615,4620,4635,4639,4612,4632,4618,4627,4611,4631,4630,4640,4641,4633,4617,4634,4614,4622,4628,4638)

Reading
Abutters List

Subject Parcel ID: ***0 TRACK ROAD REPORT***

Subject Property Location:

ParcelID	Location	Owner	Co-Owner	Mailing Address	City	State	Zip
023.0-0000-0002.0	1 LINE RD	FARNAM LYDIA		1 LINE RD	READING	MA	01867
023.0-0000-0003.0	3 LINE RD	MODUGNO DEBRA A		3 LINE RD	READING	MA	01867
023.0-0000-0004.0	7 LINE RD	DRISCOLL PATRICK A	DRISCOLL JESSICA P	7 LINE RD	READING	MA	01867
023.0-0000-0005.0	11 LINE RD	VAQUERANO LUIS	ROXIANNE CAIRNS	11 LINE RD	READING	MA	01867
023.0-0000-0006.0	15 LINE RD	SINGH JORAWAR	KAUR HARPREET TE	15 LINE RD	READING	MA	01867
023.0-0000-0007.0	21 LINE RD	MAYFIELD EMILY	MCCLEARY PATRICK JTRS	21 LINE RD	READING	MA	01867
023.0-0000-0008.0	27 LINE RD	WOOD KENNETH	WOOD SILVIA	27 LINE ROAD	READING	MA	01867
023.0-0000-0010.0	TRACK RD	TOWN OF READING		16 LOWELL ST	READING	MA	01867
023.0-0000-0011.0	13 TRACK RD	HOLLAND PHILIP W	KATHRYN L HOLLAND	13 TRACK RD	READING	MA	01867
023.0-0000-0012.0	15 TRACK RD	WANG JIA JUN	WU JIAJING	15 TRACK RD	READING	MA	01867
023.0-0000-0013.0	19 TRACK RD	ANTONELLI KARA	MOREIRA NICHOLAS TE	19 TRACK RD	READING	MA	01867
023.0-0000-0014.0	21 TRACK RD	MANSILLA MARISA	RAVIDA GUISEPPE A	21 TRACK RD	READING	MA	01867
023.0-0000-0015.0	26 TORRE ST	TRUEIRA JULIE A		26 TORRE STREET	READING	MA	10867
023.0-0000-0018.0	20 TORRE ST	POON JONATHAN SUI	AVAYUET HUA YEE	20 TORRE ST	READING	MA	01867
023.0-0000-0019.0	10 TORRE ST	TORRE STREET REALTY LLC		106 MAIN ST	STONEHAM	MA	02180
023.0-0000-0020.0	8 TORRE ST	FAIRHAVEN REALTY ASSOCIATES	C/O CUMBERLAND FARMS I	165 FLANDERS ROAD	WESTBOROUGH	MA	01581
023.0-0000-0021.0	303 SALEM ST	FAIRHAVEN REALTY ASSOC LLC	C/O CUMBERLAND FARMS	165 FLANDERS RD	WESTBOROUGH	MA	01581-1000
023.0-0000-0022.0	33 LINE RD	RAO VARUN B	SIVAKUMAR SMRUTHY K TE	33 LINE RD	READING	MA	01867
023.0-0000-0023.0	7 HARVEST RD	GUEVARA ELADIO S		7 HARVEST RD	READING	MA	01867
023.0-0000-0024.0	TRACK RD	TOWN OF READING		16 LOWELL ST	READING	MA	01867
023.0-0000-0025.0	12 TRACK RD	MANLEY CELESTE D TRUSTEE	CELESTE D MANLEY REVOC	12 TRACK RD	READING	MA	01867
023.0-0000-0026.0	16 TRACK RD	BARMOY JOHN P	CARNEY SHANA E	16 TRACK RD	READING	MA	01867
023.0-0000-0027.0	20 TRACK RD	GRAVALLESE LENORE TRUSTEE	FILOSA REALTY TRUST	20 TRACK RD	READING	MA	01867
023.0-0000-0028.0	24 TRACK RD	MENENELLO ALBERT F JR	SUZANNE MENENELLO	24 TRACK RD	READING	MA	01867
023.0-0000-0029.0	25 HARVEST RD	CAPOMACCIO CAMILLE		25 HARVEST RD	READING	MA	01867
023.0-0000-0030.0	19 HARVEST RD	MARCUS ALANNA	GONZALEZ MIGUEL JTRS	216 PLEASANT HILL RD	FLANDERS	NJ	07836
023.0-0000-0031.0	13 HARVEST RD	SCIMEMI PETER	HADRI JIHAN	13 HARVEST RD	READING	MA	01867
023.0-0000-0032.0	39 LINE RD	MACDONALD PAUL W		39 LINE ROAD	READING	MA	01867
023.0-0000-0033.0	43 LINE RD	QUIGLEY BERNADETTE		43 LINE RD	READING	MA	01867

Parcel Count: **29**

End of Report

Notification to Abutters

By Hand Delivery, Certified Mail (return receipt requested), or Certificates of Mailing

This is a notification required by law. You are receiving this notification because you have been identified as the owner of land abutting another parcel of land for which certain activities are proposed. Those activities require a permit under the Massachusetts Wetlands Protection Act (M.G.L. c. 131, § 40).

In accordance with the second paragraph of the Massachusetts Wetlands Protection Act, and 310 CMR 10.05(4)(a) of the Wetlands Regulations, you are hereby notified that:

A. A Notice of Intent was filed with the Reading Conservation Commission on April 1, 2026, seeking permission to remove, fill, dredge, or alter an area subject to protection under M.G.L. c. 131 §40. The following is a description of the proposed activity/activities:

The Town of Reading Engineering Department is proposing to replace the existing Track Road bridge (Bridge #R-03-006(BW7)) over Walkers Brook on Track Road. Minor temporary and permanent impacts are proposed to Inland Bank, Land Under Water and Waterways, Bordering Land Subject to Flooding, and the 200-foot Riverfront Area associated with Walkers Brook.

B. The name of the applicant is: Town of Reading Engineering Department.

C. The address of the land where the activity is proposed is: 0 Track Road (near 13 Track Road).

D. Copies of the Notice of Intent may be examined or obtained at the office of the Reading Conservation Commission, located at 16 Lowell St, Reading, MA 01867. The regular business hours of the Commission are Monday, Wednesday, and Thursday 7:30am to 5:30pm and Tuesday 7:30am to 7:00pm, and the Commission may be reached at (781) 942-6616.

E. Copies of the Notice of Intent may be obtained from the applicant's representative by calling Heidi Fisher at (617) 371-4467 or by e-mailing at Heidi.fisher@aecom.com. An administrative fee may be applied for providing copies of the NOI and plans.

F. Information regarding the date, time, and location of the public hearing regarding the Notice of Intent may be obtained from the Reading Conservation Commission. Notice of the public hearing will be published at least five business days in advance, in the Reading Daily Times Chronicle.

Notification provided pursuant to the above requirement does not automatically confer standing to the recipient to request Departmental Action for the underlying matter. See 310 CMR 10.05(7)(a)4.

AFFIDAVIT OF SERVICE

Under the Massachusetts Wetlands Protection Act, M.G.L., c.131, s.40 and Reading General Bylaws, Section 7.1

(To be submitted to the Conservation Commission when filing a Notice of Intent or Abbreviated Notice of Resource Area Delineation or Request for Determination of Applicability)

I, Heidi Fisher (Name), hereby certify under the pains and penalties of perjury that on TBD (Date), I gave notification to abutters in compliance with the second paragraph of Massachusetts General Laws, c.131, s.40, and the **DEP Guide to Abutter Notification** dated April 8, 1994, and Reading General Bylaws, Section 7.1 in connection with the following matter:

(Check the applicable form.)

- ☑ Notice of Intent
- ☐ Abbreviated Notice of Resource Area Delineation
- ☐ Request for Determination of Applicability

filed under M.G.L., c.131, s.40 and R.G.B., s.7.1 by Reading Engineering Dept (Applicant) with the Town of Reading Conservation Commission on April 1, 2026 (Date) for property located at Walkers Brook (Track Road, Reading, MA) (Location).

The form of the notification and list of abutters to whom it was given and their addresses are attached to this Affidavit of Service.

Heidi Fisher
Name

04/01/2026
Date

Appendix E – FEMA No-Rise Hydraulic Report

AECOM

Submitted to
Town of Reading
Engineering Division
16 Lowell Street
Reading, MA 01867

Submitted by
AECOM
250 Apollo Drive
Chelmsford, MA
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Hydraulic Report

Bridge R-03-006 (CJR) Replacement
Track Road 2 (East) over Walkers Brook
Reading, Massachusetts

April 24, 2024

REV: August 15, 2025

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1.0 EXECUTIVE SUMMARY

In 2019, the Town of Reading requested AECOM to design and prepare construction documents and permit applications to replace the two Bridges R-03-005 (BW6) and R-03-006 (BW7) over Walkers Brook, identified as Track Road Bridge 1 (West) and Track Road Bridge 2 (East) respectively. The first of these bridges was replaced in 2020. The second R-03-006 (CJR) is currently under design. It will be widened to provide a maximum 22-ft 0-in roadway section and a maximum 25-ft 3-in out-to-out bridge safety barriers. The bridge span over Walkers Brook will be 10-ft 6-in. The replacement bridge will consist of a four-sided precast structure with the riverbed consisting of two feet thick channel bed material placed on the top of the concrete slab to satisfy the Massachusetts Stream Crossing Standards (MSCS).

This report summarizes the results of the hydrologic and hydraulic studies and the scour evaluation of the bridge along with the proposed scour remedial measures.

At the location of the bridge, Walkers Brook has floodway delineations regulated by the National Flood Insurance Program (NFIP). A hydraulic model of the existing conditions, using the cross sections surveyed in 2019 in the immediate vicinity of the bridges was developed using the US Army Corps of Engineers program HEC-RAS Version 6.6. A Proposed Conditions Model was then developed by modifying the Existing Conditions Model to reflect the replacement bridge and wider roadway section. The comparison of the two models shows that the proposed bridges have a minimal impact on the Existing Conditions profile by slightly lowering the water surface elevation during the 100-year Flood event, along the Walkers Brook reach upstream of the replacement Bridge.

For the purpose of the bridge scour evaluation, AECOM reviewed the hydrology of the watershed drained by the Walkers Brook. The watershed drainage area is 2.6 square miles in mainly suburban area in Reading, MA. Previous studies performed for FEMA (1978) and by AECOM for the Town of Reading (2013) were reviewed and compared to the results of the Regional Regression Equations developed by the United States Geological Survey (USGS) (2016). The larger flows resulting from the Regional Regression Equations were selected to provide a slightly more conservative design.

The hydraulic parameters under design flow conditions were extracted from the Proposed Conditions HEC-RAS Model. Scour depths were evaluated in accordance with FHWA HEC-18 Evaluation Scour at Bridges, Fifth Edition (2013), including the NCHRP 24-20 Abutment Scour Approach to estimate abutment depth as required by MassDOT in MassDOT LRFD Bridge Manual (January 2020 Revision).

In conformance with MassDOT Municipal Bridge Projects Chapter 85 requirements for Urban Local Road, the scour depths have been calculated for the Scour Design Flood Frequency (25-Year) and the Check Scour Flood Frequency (50-Year). The HEC-RAS simulation indicates that under the Hydraulic Design Flood (10-year) conditions, with a flow rate of 140 cfs the freeboard height under the Bridge is 3.4 feet, with a design elevation of 80.3 feet in the North American Vertical Datum of 1988 (NAVD88). The results of the scour calculations are summarized in Table 1.

All elevations are reported in NAVD88.

Table 1 - Summary of Scour Depths at Bridge R-03-006 (CJR)

Flood Event	Discharge (cfs)	Elements	Contraction Scour (ft.)	Local Scour (ft.)	Total Scour (ft.)	Scour Bottom Elev. (ft.-NAVD88)
25-Year Scour Design	222	L. Abutment	-	5.46	5.46	70.01
		R. Abutment	-	5.46	5.46	70.01
50-Year Scour Check	269	L. Abutment	-	6.43	6.43	69.04
		R. Abutment	-	6.43	6.43	69.04

Total scour depth for Track Road Bridge 2, R-03-006 (CJR) under the Scour Design Flood has been estimated to be 5.46 feet. The bridge stability will also be checked under the Scour Check Flood when the total scour depth is 6.43 feet. As a countermeasure, the culvert is provided with a concrete cut-off wall extending to elevation 68.0.

2.0 PROJECT DESCRIPTION

2.1 Existing Bridge

The bridge is a single span, consisting of 9-in thick reinforced concrete slab with a 2-in thick wearing surface, approximately 14-ft in total width with 12-in high reinforced concrete curbs and wooden guardrails. The bridge has a clear span of approximately 10-ft 4-in. Both abutments consist of 10-in thick reinforced concrete walls that support the bridge superstructure and function as a retaining wall and channel lining for the flowing water. According to the proposed design drawing dated 1943, the wall footings and concrete lining are buried 1.5 feet below the bottom of the channel. The estimated age of the structure is approximately 75 years. The typical bridge design drawing, dated April 1943, is included in Appendix A; the construction date is unknown.

2.1.1 Crossed Waterway

The bridge is located on Track Road in the Town of Reading, Middlesex County, and crosses over Walkers Brook (Lat. 42 deg 31 min 28 sec N, 71 deg 5 min 7 sec W). At the bridge location, the drainage area of the watershed is estimated to be 2.6 square miles. The watershed generally consists of suburban neighborhoods with single family houses on small to medium size lots. Previous studies have determined the watershed included approximately 34% of impervious area.

Figure 1 – Bridge Location - Aerial View, 2022 Google Maps

Upstream of the Bridge, Walkers Brook consists of a series of straight reaches with slow moving water. The hydraulic profile of Walkers Brook shown in the Flood Insurance Study (FIS) (Federal Emergency Management Agency, FIS No. 25017CV001C, Middlesex County, Massachusetts, dated July 6, 2016) indicates a longitudinal slope of the approach channel of approximately 0.17 feet per mile. The bed material consists of very fine material with D_{50} smaller than 0.2 millimeters. There are signs of bank erosion upstream and adjacent to the bridge wingwalls.

2.1.2 Highway Conveyed

The bridge carries Track Road, a local street with a Functional Class of Urban Local Road. Track Road Bridge is currently closed to vehicular traffic by the installation of concrete barrier.

2.1.3 Land Use in the Vicinity of the Bridge

Near the bridge, the land use is essentially residential, with small patches of wooded area located immediately west of the most upstream bridge. The neighborhood is located approximately 600 feet north of Interstate I-95.

2.1.4 Special Consideration

At the location of the bridge, Walkers Brook has floodway delineations regulated by the National Flood Insurance Program (NFIP): the bridge shall be designed to convey the waterway's base (100-year) flood discharge without causing any increase in waterway's base flood elevation (BFE) profile. Walkers Brook flood profiles are presented in the current Countywide Flood Insurance Study (FIS), dated July 6, 2016, for Middlesex County, Massachusetts. FIS Information can be found in Appendix 7.1.

2.2 Proposed Action

The replacement bridge will be widened to provide a maximum 22-ft 0-in roadway section and a maximum 25-ft 3-in out-to-out bridge safety barriers. The bridge spans over the Walkers Brook will be 10-ft 6-in. The replacement bridge will consist of a four-sided precast unit with the riverbed consisting of two feet thick channel bed material placed on the top of the concrete slab to satisfy the Massachusetts Stream Crossing Standards.

2.3 Temporary Condition

Dewatering will be performed during construction of the proposed structure. The recommended approach is to install a 36-inch High-Density Polyethylene (HDPE) pipe to divert the flow. The pipe will be installed on the east side of the proposed opening. The bypass would be needed for a time period of up to two weeks.

3.0 DATA COLLECTION

3.1 Data Sources

Primary references and data sources are listed in Table 2.

Table 2 - Hydraulic Study Data Sources

Data Category	Considerations	Data Sources
Watershed	Drainage area, Mean Basin Elevation, etc.	USGS: http://water.usgs.gov/osw/streamstats.html
	Land use	http://www.mass.gov/mgis/lus.htm
	Hydrology	Aberjona and Saugus River Drainage Study (October 2013) for the Town of Reading, MA, by AECOM
Approach Waterways	Channel bank sinuosity, Channel bed slope	USGS StreamStats: http://water.usgs.gov/osw/streamstats.html
	River Bed Material	Geotechnical Investigation (October 2019); Particle size analysis
Existing Structure	Superstructure Geometry and Condition	MassDOT, Structures Inspection Field Report. R03005-BW6 Routine Inspection dated Feb. 5, 2019 R03006-BW7 Closed / Rehabilitation Inspection dated Mar 29, 2018 Proposed Drainage System for Lake Quannapowitt; Design Plan (April 1943)
	Substructure Geometry and Condition	Geotechnical Investigation (October 2019): Boring Logs Proposed Drainage System for Lake Quannapowitt; Design Plan (April 1943)
	Structure geometry and Water Passage	Topographic Survey, November 2019
Regulatory Issues	National Flood Insurance Program; Zone and Regulatory Floodway Delineation	Flood Insurance Study, Middlesex County, MA Volume 1 of 8, Revised July 6, 2016 Volume 8 of 8, Revised July 6, 2016, Flood Profiles

4.0 ENGINEERING METHODS

4.1 Hydrologic analyses

At the bridge location, the drainage area of the watershed is estimated to be 2.6 square miles. There is no USGS gaging station on the Walkers Brook. The flood flows for several return periods have been estimated using several methodologies in previous hydrologic studies: the approaches are briefly described below and summarized in Table 3.

According to the Flood Insurance Study Flood Insurance Study (Federal Emergency Management Agency, FIS No. 25017CV001C, Middlesex County, Massachusetts, dated July 6, 2016), the discharges for the Walkers Brook were determined using the Wandle Method developed by the USGS specifically for Massachusetts: USGS Water Supply Paper 2214 (1983). The calculated regional equation flows were adjusted for impervious surface area resulting from urbanization. Extract of the FIS are presented in Appendix 7.1 – FEMA Documents. The resulting flood event discharges are shown in Table 3.

A more recent hydrology study entitled 'Aberjona and Saugus River Drainage Study' completed in October 2013 for the Town of Reading, MA, by AECOM, takes a different approach to estimate the flood flows at the bridge location. For the area of interest, AECOM developed a rainfall-runoff model using the USEPA SWMMS program. The model includes 34 sub-areas covering the Walkers Brook watershed; the extent of the model is shown on Figure 2. Extract of the hydrology study is presented in Appendix 7.5.

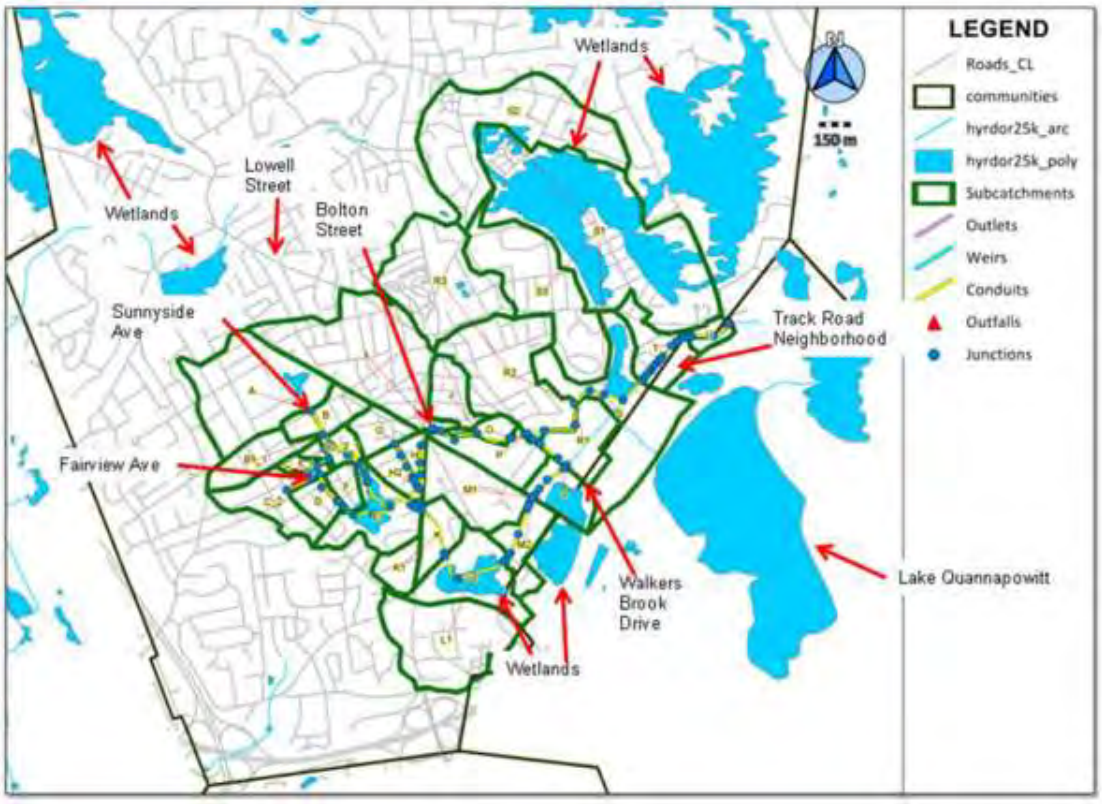


Figure 2 - Areal Extent of the SWMMS model.

The model was configured to simulate a 62-year rainfall period (1949 to 2010) using hourly precipitation data from Logan Airport. The 62-year simulation period resulted in a series of annual peak discharges

which were statistically analyzed using the USGS Bulletin 17B methodology. The resulting flows for various return period are shown in Table 4.

A third approach to estimate the flood flows at the Track Road Bridges was used to check the previous study. The Scientific Investigations Report 2016-5156 – Magnitude of Flood Flows at Selected Annual Exceedance Probabilities for Stream in Massachusetts, prepared by the USGS in cooperation with MassDOT developed a series of regional regression equations based on peak flow records at 220 stream gages in Massachusetts and adjacent States. Regression parameters obtained for the USGS website 'StreamStats' are:

- Drainage Area 2.6 square miles
- Average elevation 113 feet
- Total storage 8.65%

The resulting flood flows are also shown in Table 4.

Table 3 - Track Road Bridges - Flood Flow Selection

Approach	Flood Flow (cfs)				
	10-yr	25-yr	50-yr	100-yr	500-yr
Flood Insurance Study (FIS)	140	-	230	280	420
Aberjona and Saugus River Drainage Study	190	226	254	283	356
USGS Regional Regression Equations	166	222	269	319	447

The three approaches provide similar results. For the purpose of the 'No-Rise' Floodway Review the flows listed in the FIS will be used for consistency. The flows calculated using the USGS Regional Regression Equations will be used for the Scour Analysis, because they are slightly larger than those used in the FIS and therefore more conservative, and they correspond to a regression analysis completed with an additional 35 years of flow records.

4.2 Hydraulic Analyses

4.2.1 No-Rise Hydraulic Analysis

Walkers Brook is located in FEMA Zone AE with a regulated floodway. Because of the requirements of the National Flood Insurance Program, the proposed bridge for Track Road (2) East must be investigated for its hydraulic impact on the BFEs, the regulated floodplain, and the regulated floodway. This No-Rise Section of the report demonstrates that the 100-year water surface elevation will not increase under proposed conditions. Both unencroached and encroached conditions were examined. The unencroached scenario refers to modeling the regular profile of the FEMA 100-year floodplain. The encroached scenario refers to modeling the width of the floodway based on regulatory encroached widths. The floodway encroachment analysis is performed to evaluate the impact of the proposed project on the FEMA regulated floodway. This analysis is required per "Guidance for Flood Risk Analysis and Mapping (7) because the segment of Walkers Brook is located in FEMA Zone AE.

For the purposes of evaluating no-rise, the river flows reported in the FEMA FIS (July 2016) were used. LiDAR from USGS was used to supplement the overland topography for the existing and proposed conditions.

4.2.1.1 *Effective Flood Insurance Study*

The effective FEMA FIS for Middlesex County, MA (25017CV001C) is dated July 6, 2016. The FIS Effective Model was obtained in HEC-2 format from the FEMA Engineering Library and was completed in August 1978. The Walkers Brook FIS was performed using detailed hydraulic methods. The Effective Model for Walkers Brook begins approximately 565 feet downstream of the State Route 129 Eastbound culvert. Several structures are included in the study: Line Road, Track Road 1, Harvest Road, Track Road 2, Landfill Road, John Street, a railroad, a footbridge, and Ash Street. Ash Street is the upstream limit of the study. The studied limit comprises 7,800 feet. The project bridge, Track Road Bridge 2 (East), R-03-006 (CJR) is bound by FEMA lettered cross sections B and C. The relevant FIS information is included in Appendix 7.1.

4.2.1.2 *Duplicate Effective Model*

FEMA's effective HEC-2 model was re-constructed to develop the Duplicate Effective Model using the USACE's HEC-RAS model (Version 6.6). The Effective model was truncated from its full extent. The extent adopted for the Duplicate Effective model began at the upstream cross section FEMA Letter E, and continued to the downstream end of the effective model. This cross section is station 0.006 in HEC-2, which is approximately 500 feet downstream of the Route 129 Eastbound bridge. The FIS flow rates were adopted for the no-rise analysis, and are shown in Table 4.

Table 4 - FIS Flow Rates

Location	Flood Flow (cfs)			
Station	**10-yr**	**50-yr**	**100-yr**	**500-yr**
Downstream Reading Corporate Limits	140	230	280	420

Comparison of the BFEs between the Duplicate Effective Model (HEC-RAS) and the current Effective Model (HEC-2) is presented in Table 5. The Duplicate Effective Model appeared to yield BFEs that are reasonably close to the FIS. The profile deviated somewhat from the HEC-2 results, particularly near bridge and culvert crossings. These differences continued to propagate upstream. This is likely attributed to the difference in the bridge/culvert modeling methods used between HEC-2 and HEC-RAS.

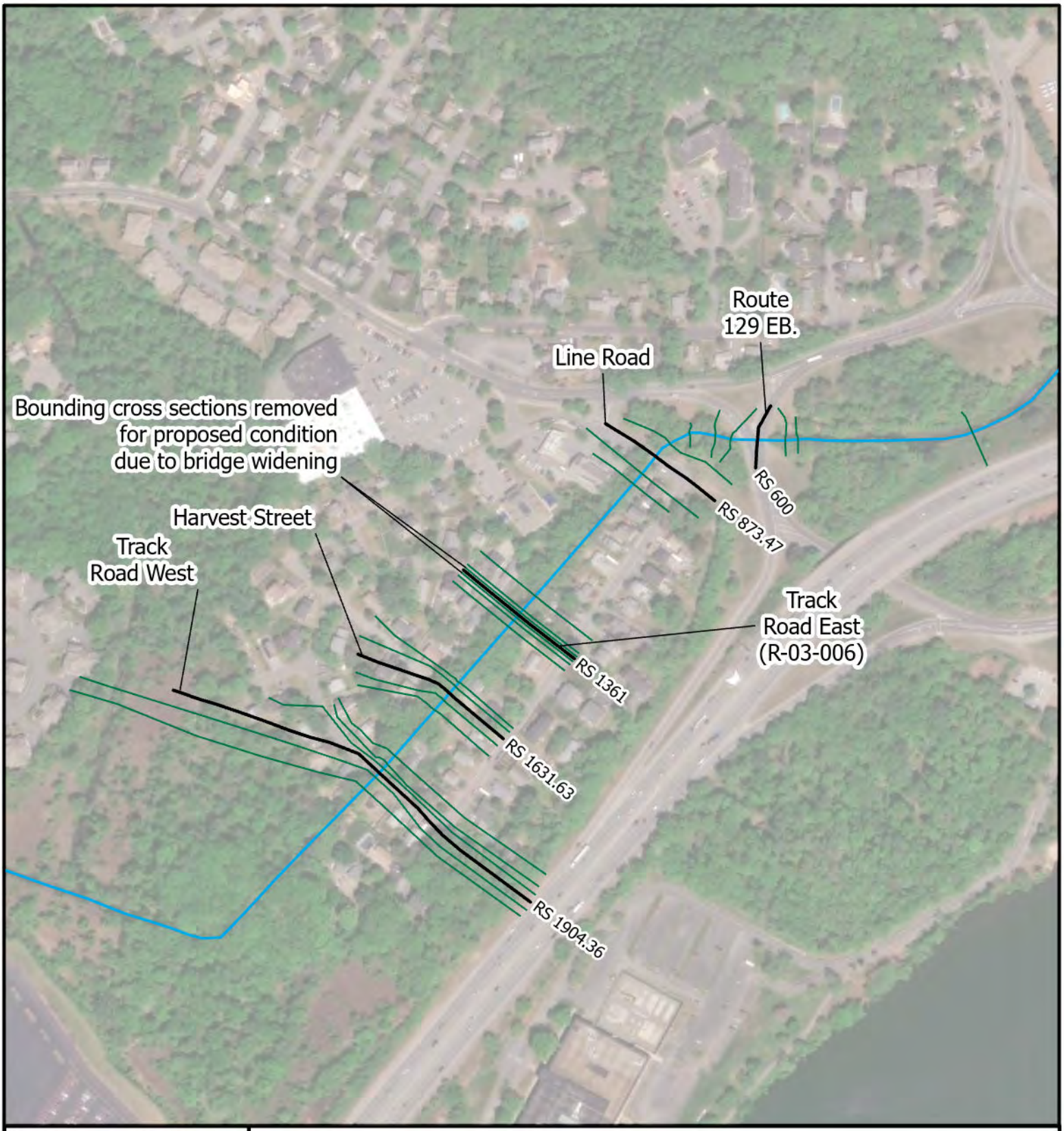
Table 5 - FIS Effective Model vs Duplicate Effective Model BFE Results

XS ID	FIS Lettered XS	BFE (ft)		Difference (FIS Effective - DE)
		FIS Effective	Dup. Effective	
0		78.54	78.54	0.00
438		79.31	79.29	0.02
488		79.42	79.39	0.03
591	Route 129 EB			
592		79.61	79.58	0.03
641	A	79.70	79.63	0.07
715	B	79.60	79.26	0.34
765		80.65	80.69	-0.04
847	Line Road			
848		80.98	81.08	-0.10
897		81.36	81.33	0.03
1267		82.51	82.35	0.16
1317		83.14	83.03	0.11
1331	Track Road East (R-03-006)			
1332		83.18	83.06	0.12
1381	C	83.36	83.27	0.09
1529		83.39	83.3	0.09
1579		83.40	83.26	0.14
1593	Harvest Road			
1594		83.34	83.28	0.06
1643	D	83.49	83.38	0.11
1786		83.50	83.39	0.11
1836		83.46	83.35	0.11
1850	Track Road West			
1851		83.48	83.38	0.10
1900	E	83.72	83.6	0.12

4.2.1.3 *Corrected Effective/Existing Condition Model*

AECOM developed the Corrected Effective Model/Existing Condition Model from the Duplicate Effective Model by incorporating project survey and LiDAR topographic data, when available. Upstream the FIS flows were used for the purpose of the no-rise study. The downstream limit of the Corrected Effective/Existing Condition Model was kept the same as the Effective Model. Therefore, the known water surface elevations from the Effective Model were used. The HEC-RAS schematic for this no-rise study is shown in Figure 3. The latest aerial imagery (Google Maps) and topographic data (USGS) supplemented with the 2019 field survey was used in the Corrected Effective/Existing Conditions model. The Duplicate Effective model was truncated to the study area of the Track Road 2 (East). This covered FEMA lettered cross sections A through E.

Survey was not available for most of the structures. AECOM engineers visited the accessible stream crossings in November 2024. The structure geometry was verified to match the HEC-2 data or bridge plans if available. The structures were updated based on bridge plans or survey if available. The structures within the truncated study extent included Route 129 Eastbound, Line Road, Track Road 1 (West), Harvest Road, and Track Road 2 (East).



AECOM

Figure: 3
HEC-RAS Model Schematic

Track Road 2 (East) over
Walkers Brook
60700750

Drawn: DF
Date: 4/21/2025

N

0 75 150 300
Feet
Scale: 1,000

Legend

- Existing Cross Section
- Walkers Brook
- Bridge Crossing

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

4.2.1.4 *Proposed Condition Model*

The proposed conditions model was developed by modifying the existing condition model geometry to represent the proposed design for Track Road 2 (East). Results of the Corrected Effective/Existing Conditions model in comparison to the Proposed Condition model for the unencroached scenario are presented in Table 6. Results for the encroached scenario are presented in Table 7.

Table 6. Summary of Base Flood Water Surface Elevations (BFEs) for Existing Conditions and Proposed Conditions Models; Unencroached Scenario (NAVD88)

XS ID	FIS Lettered XS	EX 100 Yr (ft. NAVD88)	PR 100 Yr (ft. NAVD88)	Difference (PR-EX)
1947	E	83.14	82.84	-0.30
1907		83.02	82.71	-0.31
1876		82.96	82.64	-0.32
1862		83.01	82.69	-0.32
1833		82.98	82.66	-0.32
1680	D	82.84	82.47	-0.37
1646		82.80	82.43	-0.37
1600		82.77	82.39	-0.38
1587		82.78	82.40	-0.38
1399	C	82.61	82.27	-0.34
1379*		**82.55**	**82.27**	**-0.28**
1313*		**82.42**	**82.09**	**-0.33**
919		81.46	81.46	0.00
885		81.30	81.30	0.00
780		80.67	80.67	0.00
725	B	80.66	80.66	0.00
659	A	80.56	80.56	0.00
618		80.52	80.52	0.00
480		80.00	80.00	0.00
448		79.95	79.95	0.00
4		78.54	78.54	0.00

*adjacent to project bridge (R-03-006)

Table 7. Summary of Base Flood Water Surface Elevations (BFEs) for Existing Conditions and Proposed Conditions Models; Encroached Scenario (NAVD88)

XS ID	FIS Lettered XS	EX 100 Yr (ft. NAVD88)	PR 100 Yr (ft. NAVD88)	Difference (PR-EX)
1947	E	83.80	83.52	-0.28
1907		83.71	83.42	-0.29
1904.36		0.00	0.00	0.00
1876		83.67	83.37	-0.30
1862		83.71	83.42	-0.29
1833		83.69	83.39	-0.30
1680	D	83.60	83.28	-0.32
1646		83.57	83.25	-0.32
1600		83.55	83.23	-0.32
1587		83.56	83.24	-0.32
1399	C	83.42	83.13	-0.29
1379*		**83.39**	**83.14**	**-0.25**
1313*		**83.27**	**82.98**	**-0.29**
919		82.49	82.49	0.00
885		82.40	82.40	0.00
780		81.73	81.73	0.00
725	B	81.74	81.74	0.00
659	A	81.61	81.61	0.00
618		81.64	81.64	0.00
480		81.44	81.44	0.00
448		81.42	81.42	0.00
4		81.00	81.00	0.00

*adjacent to project bridge (R-03-006)

The result of the modeling indicates that the proposed condition achieves no-rise in the regulatory FEMA floodplain and floodway. The complete water surface elevation output for the entire Walkers Brook reach model can be found in Appendix 7.4.

4.2.2 HEC-RAS Model

A design model was also prepared for Walkers Brook reach in the vicinity of the Track Road Bridges using HEC-RAS. The model extends 1,200 feet from approximately 200 feet upstream of Track Road Bridge 1 R-03-005 (CIR) to approximately 50 feet downstream of the culvert under Line Road. The reach is essentially straight with slow moving water under normal flow condition. The bed material consists of very fine material with organic deposits and small vegetative debris. The banks are steeper than 1.5H on 1.0V, with large trees and brush rooted at about 3 feet above the toe of the bank. At normal flow the stream is one to two feet deep and 12 to 18 feet wide. The model includes four crossing structures (from upstream to downstream): Track Road Bridge 1 R-03-005 (CIR), Harvest Road Bridge, Track Road Bridge 2 R-03-006 (BW7) and Line Road Culvert.

The hydraulic vertical clearances for the four structures are shown on Table 8. The simulation results for the proposed conditions are presented in Table 9.

Table 8 - River Crossing Hydraulic Opening

Crossing	Width (ft.)	Existing Low Chord Elev. (ft.-NAVD88)	Upstream Invert Elev. (ft.-NAVD88)	Hydraulic Clearance (ft.)
Track Road Bridge 1 (West)	10.33	83.76	75.05	8.71
Harvest Road Bridge	10.33	84.06	76.65	7.41
Track Road Bridge 2 (East) (R-03-006)	10.33	84.23	75.47	8.76
Line Road Culvert	10.33	80.14	75.99	4.14

Table 9 - Walkers Brook 10-Year Hydraulic Design Flood Results Upstream of Bridge No. R-03-006

River Station	WS Elev. Proposed Conditions HEC-RAS Model (ft.-NAVD88)	Velocity Proposed Conditions HEC-RAS Model (ft/s)
1390	80.69	2.13

The temporary condition during construction was modeled in HEC-RAS. The 36-inch flow diversion HDPE pipe was modified as a culvert crossing with a 3-ft diameter barrel on the right side of the channel. The estimated construction period is approximately two weeks. Therefore, the 2-year Flood is applicable because the duration is one year or less, according to the MassDOT LRFD Manual 2020, Section 2.72. Table 10 presents the result of the 2-year Flood during the temporary condition. The HEC-RAS results for the Temporary Conditions during this construction are found in Appendix 7.2.

Table 10 – Temporary Water Control Design Data

Design Flood Discharge	77 cfs
Design Flood Frequency	2 – year
Design Flood Velocity	0.72 ft/sec
Design Flood Elevation	82.33 ft, NAVD88

4.3 Scour Safety / Stability Analyses

Based on the latest FHWA HEC-18 and the MassDOT Design for Full Municipal Bridge Replacement Projects requirements relating hydraulic design floods to scour design and design check, and bridge functional classification, the hydraulic modeling was performed for the following Flood events:

Table 11 - Track Road Bridge 2 - Flood Flows

Flood Event	Flood Flows (cfs)
25-year - Scour Design Flood	222
50-year – Scour Check Flood	269

The river bed material is estimated to be similar to the soil sample collected at the two borings performed in October 2019. Four samples were collected and tested for particle size: the results are shown in Table 11.

Table 12 - Walkers Brook Soil Sample Particle Size

Sample	D_{85} (mm)	D_{50} (mm)
Boring B-1, depth 10-12 ft.	0.128	0.072
Boring B-1, depth 25-27 ft.	0.087	0.046
Boring B-2, depth 6-8 ft.	0.296	0.173
Boring B-2, depth 15-17 ft.	0.200	0.070

Total scour depth is calculated as the sum of the long-term aggradation/degradation of the stream (if any), the contraction scour and/or the local abutment scour.

Regarding aggradation/degradation, the river bed level surveyed for the purpose of this study was compared to the level shown on the design drawings (1943): the current hydraulic clearance (at the time of the survey) appears to be slightly greater than on the design drawings. It should be noted that the river bed material is very fine, and significantly affect by the river flow; at the time of the survey, the discharge was noted to be greater than average. It is therefore concluded that there is no indication that any aggradation / degradation has occurred along the brook in the vicinity of the bridge.

Scour depths were evaluated in accordance with FHWA HEC-18 Evaluation Scour at Bridges, Fifth Edition (2013). Based on the river bed material size estimated for this study, and the hydraulic simulation of the evaluated flood events, it was determined that live-bed conditions occur during all floods. Contraction scour depths were calculated accordingly.

The abutment scour was calculated using the NCHRP 24-20 Abutment Scour Approach to estimate local abutment scour depth as required by MassDOT in MassDOT LRFD Bridge Manual (January 2020 Revision). Detailed calculations are presented in Appendix 7.4 Scour Calculations, and are summarized in Tables 13-14.

Table 13 – Hydraulic Data for Scour Analysis – Bridge 2 R-03-006 (CJR)

HYDRAULIC DATA		
Drainage Area = 2.6 sq. mi.	**Scour Design Flood**	**Scour Check Flood**
Recurrence Interval (years)	25	50
Peak discharge (ft^3/s)	222	269
Water Surface Elevation (ft.-NAVD88)	81.25	81.93
Approach Velocity (ft./s)	3.75	4.06
Scour Analysis: Yes	Channel Elev. 75.47 ft.-NAVD88	

Table 14 - Total Scour Depths and Scour Elevations – Bridge 2 R-03-006 (CJR)

	Q_{25} Scour Depth (ft.)	Q_{25} Scour Elev. (ft.)	Q_{50} Scour Depth (ft.)	Q_{50} Scour Elev. (ft.)
Left Abutment	5.46	70.01	6.43	69.04
Right Abutment	5.46	70.01	6.43	69.04

4.4 Stream Crossing Standards

In accordance with the Massachusetts Stream Crossings Handbook (June 2012), and, the MassDOT's updated Stream Crossing Handbook (September 2018), all new and, where feasible, replacement crossings shall adhere to stream crossing guideline presented in the Handbook. The crossings shall provide for fish passage, stream continuity and some wildlife passage. The standards are based on the six variables listed below. In the case of the replacement of Track Road Bridge 2 (East) most of the standards are being met as explained below.

- *Type of Crossing* – The invert of the four-sided precast concrete culvert will be filled with a 2-foot-deep layer of existing channel bed material.
- *Embedment* – top of footing of the wing wall is planned to be 6.5 feet below the stream bed for the purpose of scour countermeasure: in excess of the minimum of 2 feet requirement.
- *Crossing Span* – the bridge span will be replaced in kind to meet the existing channel structure and to match existing conditions, approximately equal to the bankfull width, with headroom to provide passage for wildlife met to practical extent possible for given site conditions. The crossing span could not meet the 1.2 times bankfull width criteria due to right-of-way and utilities limitations at the location of the bridge and the adjacent properties.
- *Openness* – the openness ratio (cross-sectional area / crossing length) for the bridge is approximately 3.35 feet, and the height is 8.25 feet, both values in excess of the required 2.46 feet and 8.0 feet, respectively, for stream steep embankments.
- *Substrate* – the natural material is planned to be used for the crossing bottom; a coarser gravel base material may be substituted to resist displacements during flood events.
- *Water depth and velocity* – both parameters remain comparable to those found in the natural channel upstream and downstream of the bridges.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A hydrologic and hydraulic study was performed to evaluate the impact of the bridge replacement over Walkers Brook in Reading, MA. The comparison of the simulation results from the no-rise study shows that the replacement of the Bridge R-03-006 (CJR) would not increase water surface elevation in Walkers Brook during the 100-year Flood event.

Total scour depth for Track Road Bridge 2, R-03-006 (CJR) under the Scour Design Flood (25-year Flood event) has been estimated to be 5.5 feet. The bridge stability will also be checked under the Scour Check Flood (50-year Flood event) when the total scour depth is 6.4 feet.

5.2 Recommendations

As a countermeasure, the culvert will be provided with a concrete cut-off wall extending to elevation 68.0 feet.

5.3 Hydraulic Data Tables

BRIDGE R-03-006 (CJR)
HYDRAULIC DESIGN DATA

DRAINAGE AREA	2.6 SQUARE MILES
DESIGN FLOOD DISCHARGE	166 CUBIC FEET PER SECOND
DESIGN FLOOD ANNUAL CHANCE (RETURN FREQUENCY)	10% (10 YEARS)
DESIGN FLOOD VELOCITY	2.1 FEET PER SECOND
DESIGN FLOOD ELEVATION	80.7 FEET, NAVD88

BASE (100-YEAR) FLOOD DATA

BASE FLOOD DISCHARGE	280 CUBIC FEET PER SECOND
BASE FLOOD ELEVATION	82.27 FEET, NAVD88

SCOUR DESIGN (SDF) AND SCOUR CHECK (SCF) FLOOD DATA

SDF ANNUAL CHANCE (RETURN FREQUENCY)	4% (25 YEARS)
SDF ABUTMENT SCOUR DEPTH	5.5 FEET
SCF ANNUAL CHANCE (RETURN FREQUENCY)	2% (50 YEARS)
SCF ABUTMENT SCOUR DEPTH	6.4 FEET

FLOOD OF RECORD
UNKNOWN

6.0 REFERENCES

1. Massachusetts Department of Transportation, Highway Division, LRFD Bridge Manual, January 2020 Revision.
2. Federal Emergency Management Agency (FEMA), Guidelines and Specifications for Flood Hazard Mapping Partners, April 2003.
3. Federal Highway Administration (FHWA), Hydraulic Engineering Circular Number 18, Evaluating Scour at Bridges, HEC-18, April 2012.
4. US Army Corps of Engineers (USACOE), Hydrologic Research Center, HEC-RAS, River Analysis System.
5. US Geologic Survey (USGS), The National Streamflow Statistics Program: A Computer Program for Estimating Streamflow Statistics for Ungaged Sites – StreamStats: www.usgs.gov/streamstats/
6. US Geologic Survey (USGS), in cooperation with Massachusetts Department of Transportation: Magnitude of Flood Flows at Selected Annual Exceedance Probabilities for Streams in Massachusetts. Scientific Investigations Report SIR-2016-5156.
7. Federal Emergency management Agency (FEMA), Guidance for Flood Risk Analysis Mapping, November 2023.

7.0 APPENDICES

7.1 FEMA Documents

- 7.1.1 Flood Insurance Study – Summary of Discharges
- 7.1.2 Flood Insurance Study – Flood Profiles
- 7.1.3 Flood Insurance Rate Map

7.2 Design Model Hydraulic Analyses

- 7.2.1 HEC-RAS Input Parameters
- 7.2.2 HEC-RAS Simulation Output

7.3 Scour Calculations

- 7.3.1 Original Design Drawing (1943)
- 7.3.2 Proposed Design Drawings (2024)
- 7.3.3 Scour Analysis Results

7.4 No-Rise Study Hydraulic Analyses

- 7.4.1 FEMA HEC-2 Model
- 7.4.2 HEC-RAS Model Report
- 7.4.3 HEC-RAS Profiles
- 7.4.4 HEC-RAS Cross Sections
- 7.4.5 HEC-RAS Simulation Output

7.5 Hydrologic Analyses

- 7.5.1 Aberjona River and Saugus River Drainage Study (H&H Extract)

APPENDIX 7.1

FEMA DOCUMENTS:

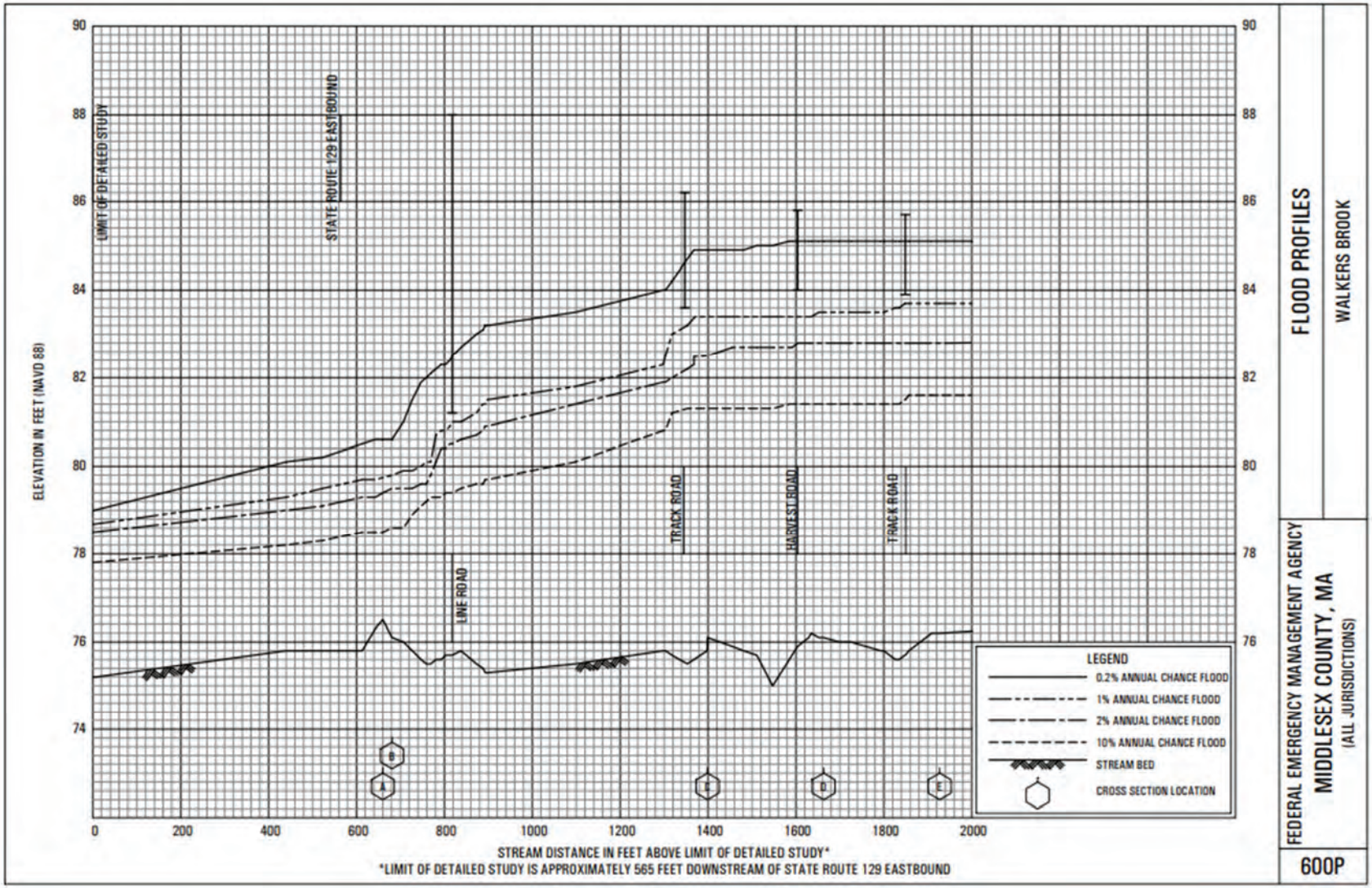
Flood Insurance Study – Summary of Discharge

TABLE 8 - SUMMARY OF DISCHARGES – continued

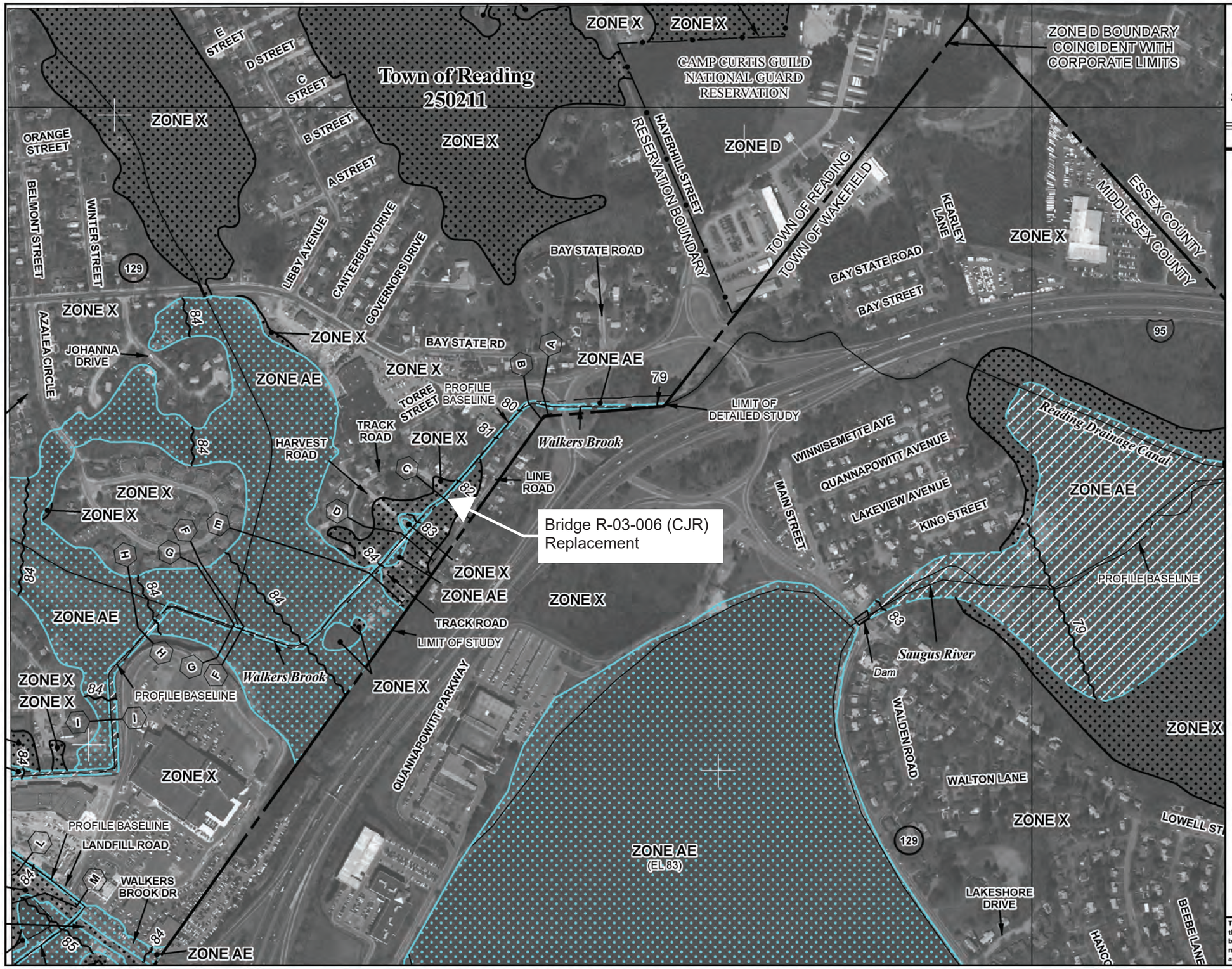
FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
WALKERS BROOK					
Downstream Reading corporate limits	2.6	140	230	280	420
Approximately 2,900 feet downstream of John Street	1.7	120	200	240	350
Approximately 900 feet downstream of John Street	1.2	96	150	180	280
WELLINGTON BROOK					
At Boston and Maine Railroad	1.7	70	130	180	320
WEST CHESTER BROOK					
At its confluence with Chester Brook	1.1	120	160	200	290
WHITEHALL BROOK					
At confluence with Sudbury River	7.2	660	990	1,130	1,470
WILLARD BROOK					
At confluence with Walker Brook No. 2	26.9	1,330	2,360	2,920	4,440
WINTHROP CANAL					
Upstream of Linden Pond	2.5	175	235	310	460
Upstream of Arch Street	1.8	60	80	100	150
WITCH BROOK					
At confluence with the Squannacook River	3.5	150	240	280	380

The stillwater elevations have been determined for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods for the flooding sources studied by detailed methods and are summarized in Table 9, "Summary of Stillwater Elevations."

Flood Insurance Study – Flood Profiles



FIS Flood Insurance Rate Map



MAP SCALE 1" = 500'

250 0 500 1000 FEET

0 150 300 METE

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0314E

FIRM

FLOOD INSURANCE RATE MAP

MIDDLESEX COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 314 OF 656
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
READING, TOWN OF	250211	0314	E
STONEHAM, TOWN OF	250215	0314	E
WAKEFIELD, TOWN OF	250221	0314	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25017C0314E

EFFECTIVE DATE
JUNE 4, 2010

Federal Emergency Management Agency

APPENDIX 7.2

DESIGN MODEL HYDRAULIC ANALYSES

HEC-RAS Input Data

Existing Conditions Model

Edit Downstream Reach Lengths

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	LOB	Channel	ROB
1	2130	50	50	50
2	2080	50	50	50
3	2030	50	50	50
4	1980	50	50	50
5	1930	14	14	14
6	1916	29	29	29
7	1902	Bridge		
8	1887	7	7	7
9	1880	50	50	50
10	1830	50	50	50
11	1780	50	50	50
12	1730	50	50	50
13	1680	26	26	26
14	1654	35	35	35
15	1637	Bridge		
16	1619	39	39	39
17	1580	50	50	50
18	1530	50	50	50
19	1480	50	50	50
20	1430	45	45	45
21	1385	27	27	27
22	1372	Bridge		
23	1358	28	28	28
24	1330	50	50	50
25	1280	50	50	50
26	1230	50	50	50
27	1180	50	50	50
28	1130	50	50	50
29	1080	50	50	50
30	1030	50	50	50
31	980	50	50	50
32	930	42	42	42
33	888	75	75	75
34	851	Bridge		
35	813	33	33	33
36	780			

OK | Cancel | Help

Edit Contraction/Expansion Coefficients (Steady Flow)

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Contraction	Expansion
1	2130	0.3	0.5
2	2080	0.3	0.5
3	2030	0.3	0.5
4	1980	0.3	0.5
5	1930	0.3	0.5
6	1916	0.3	0.5
7	1902	Bridge	
8	1887	0.3	0.5
9	1880	0.3	0.5
10	1830	0.3	0.5
11	1780	0.3	0.5
12	1730	0.3	0.5
13	1680	0.3	0.5
14	1654	0.3	0.5
15	1637	Bridge	
16	1619	0.3	0.5
17	1580	0.3	0.5
18	1530	0.3	0.5
19	1480	0.3	0.5
20	1430	0.3	0.5
21	1385	0.3	0.5
22	1372	Bridge	
23	1358	0.3	0.5
24	1330	0.3	0.5
25	1280	0.3	0.5
26	1230	0.3	0.5
27	1180	0.3	0.5
28	1130	0.3	0.5
29	1080	0.3	0.5
30	1030	0.3	0.5
31	980	0.3	0.5
32	930	0.3	0.5
33	888	0.3	0.5
34	851	Bridge	
35	813	0.3	0.5
36	780	0.3	0.5

OK | Cancel | Help

Bank Stations Table

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Left Bank Sta	Right Bank Sta
1	2130	285.35	345.45
2	2080	288.76	309.81
3	2030	288.31	314.14
4	1980	285.44	309.74
5	1930	293.76	304.27
6	1916	294.845	305.155
7	1902	Bridge	
8	1887	294.834	305.131
9	1880	293	307.41
10	1830	288.34	308.33
11	1780	288.35	315.2
12	1730	285.8	310.88
13	1680	286.3	313.67
14	1654	294.843	305.157
15	1637	Bridge	
16	1619	294.843	305.158
17	1580	291.54	308.65
18	1530	286.31	312.57
19	1480	289.7	312.56
20	1430	289.55	309.57
21	1385	294.845	305.155
22	1372	Bridge	
23	1358	294.845	305.155
24	1330	289.58	303.34
25	1280	289.07	305.25
26	1230	286.7	303.73
27	1180	287.55	303.03
28	1130	289.54	310.5
29	1080	290.66	307.89
30	1030	287.79	307.21
31	980	287.48	308.65
32	930	288	309.06
33	888	293.72	303.72
34	851	Bridge	
35	813	291.78	301.76
36	780	296.55	306.65

OK | Cancel | Help

Cross Section Ineffective Flow Area's Table

River: Walker Brook Show All River Stations

Reach: Walker Brook Cen

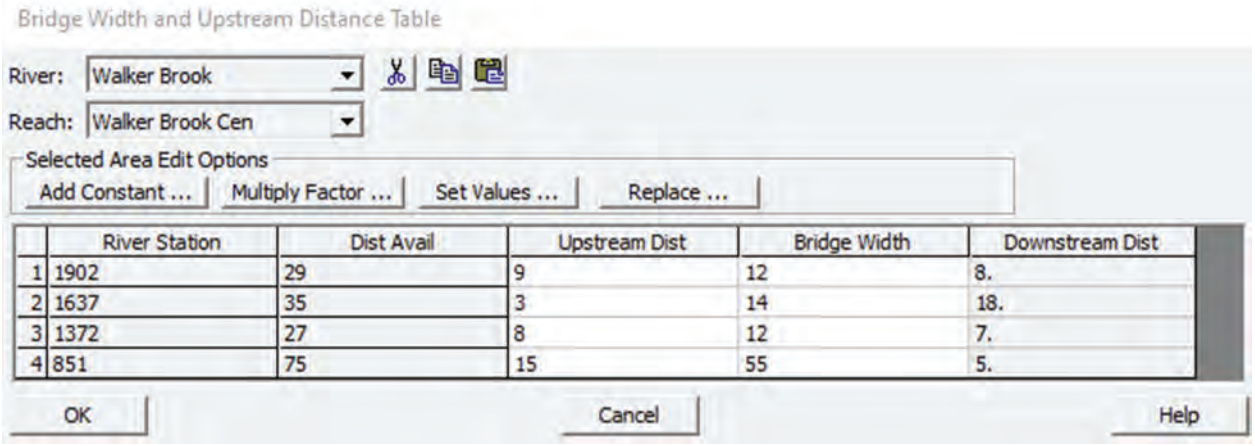
Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace Values ...

Cross Section with Ineffective Regions

	RS	Left	Right	Elev	Left	Right	Elev	Left
1	2130	-41.99	263.26	83.05	430.9	698.78	84.94	
2	2080	-39.86	279.51	84.1	399.71	628.9	83.96	
3	2030	70.68	279.73	83.69	30.62	48.65	85.03	456.44
4	1980	55.44	256.31	84.06	555.76	629.31	84.76	498.02
5	1930	123.25	256.04	84.68	552.41	621.2	84.96	501.91
6	1916				113.56	285.01	84.6	325.42
7	1887	59.28	274.49	84.69	319.13	642.29	84.45	
8	1880	40.67	279.77	84.98	354.7	633.07	84.33	279.77
9	1830	103.4	231.71	86.37	0	68.97	86.54	322.47
10	1780	0	119.97	86.13	477.21	553.43	84.73	558.21
11	1730	61.36	251.36	84.95	452.64	619.3	84.41	0
12	1680	0	158.04	86.55	191.2	236.34	85.32	435.59
13	1654	-17.87	185.12	85.39	191.85	230.18	84.72	561.37
14	1619	-15.83	238.91	85.74	347.77	627.23	84.88	
15	1580	-9.01	255.17	85.6	330.93	438.65	84.48	442.34
16	1530	95.11	277.26	84.88	346.76	515.81	84.56	520.26
17	1480	0	98.07	85.89	357.11	400.85	84.65	408.07
18	1430				434.2	600	85.77	190.5
19	1385	334.97	780	85.14				
20	1358				120.2	177.92	85.47	
21	1330	404.61	504.05	85.63	538.98	600	86.78	229.91
22	1280	411.96	486.03	85.93	515.36	600	87.66	
23	1230	538.04	600	85.76	380.42	482	85.9	
24	1180	494.36	600	86.26				
25	1130	466.99	600	87.91				
26	1080	376.86	600	87.51				
27	1030	320.01	600	89				
28	980	460.11	600	88.59				
29	930	348.12	600	87.86				
30	888	348.23	600	87.87				
31	813	433.16	600	88.05				
32	780	410.86	600	88.26	242.06	278.94	84.53	

OK Cancel



Bridge Width and Upstream Distance Table

River: Walker Brook

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Dist Avail	Upstream Dist	Bridge Width	Downstream Dist
1	1902	29	9	12	8.
2	1637	35	3	14	18.
3	1372	27	8	12	7.
4	851	75	15	55	5.

OK | Cancel | Help

Proposed Conditions Model

Proposed Conditions Model

Edit Manning's n or k Values

River: Walker Brook | Edit Interpolated XS's | Channel n Values have a light green background

Reach: Walker Brook Cen | All Regions

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ... | Reduce to L Ch R ...

	River Station	Frctn (n/K)	n #1	n #2	n #3
1	2130	n	0.16	0.05	0.16
2	2080	n	0.16	0.05	0.16
3	2030	n	0.16	0.05	0.16
4	1980	n	0.16	0.05	0.16
5	1930	n	0.16	0.025	0.16
6	1916	n	0.1	0.02	0.1
7	1898	Bridge			
8	1880	n	0.1	0.02	0.1
9	1865	n	0.16	0.05	0.16
10	1830	n	0.16	0.05	0.16
11	1780	n	0.16	0.05	0.16
12	1730	n	0.16	0.05	0.16
13	1680	n	0.16	0.05	0.16
14	1654	n	0.1	0.02	0.1
15	1637	Bridge			
16	1619	n	0.16	0.05	0.16
17	1580	n	0.16	0.05	0.16
18	1530	n	0.16	0.05	0.16
19	1480	n	0.16	0.05	0.16
20	1430	n	0.16	0.05	0.16
21	1390	n	0.1	0.02	0.1
22	1372	Bridge			
23	1354	n	0.1	0.02	0.1
24	1330	n	0.16	0.05	0.16
25	1280	n	0.16	0.05	0.16
26	1230	n	0.16	0.05	0.16
27	1180	n	0.16	0.05	0.16
28	1130	n	0.16	0.05	0.16
29	1080	n	0.16	0.05	0.16
30	1030	n	0.16	0.05	0.16
31	980	n	0.16	0.05	0.16
32	930	n	0.16	0.05	0.16
33	888	n	0.1	0.02	0.1
34	851	Bridge			
35	813	n	0.1	0.02	0.1
36	780	n	0.1	0.02	0.1

OK | Cancel | Help

Edit Downstream Reach Lengths

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	LOB	Channel	ROB
1	2130	50	50	50
2	2080	50	50	50
3	2030	50	50	50
4	1980	50	50	50
5	1930	14	14	14
6	1916	36	36	36
7	1898	Bridge		
8	1880	15	15	15
9	1865	35	35	35
10	1830	50	50	50
11	1780	50	50	50
12	1730	50	50	50
13	1680	26	26	26
14	1654	35	35	35
15	1637	Bridge		
16	1619	39	39	39
17	1580	50	50	50
18	1530	50	50	50
19	1480	50	50	50
20	1430	40	40	40
21	1390	36	36	36
22	1372	Bridge		
23	1354	24	24	24
24	1330	50	50	50
25	1280	50	50	50
26	1230	50	50	50
27	1180	50	50	50
28	1130	50	50	50
29	1080	50	50	50
30	1030	50	50	50
31	980	50	50	50
32	930	42	42	42
33	888	75	75	75
34	851	Bridge		
35	813	33	33	33
36	780			

OK Cancel Help

Bank Stations Table

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Left Bank Sta	Right Bank Sta
1	2130	285.35	345.45
2	2080	288.76	309.81
3	2030	288.31	314.14
4	1980	285.44	309.74
5	1930	294.2	304.62
6	1916	294.84	305.11
7	1898	Bridge	
8	1880	295.11	305.38
9	1865	293	307.41
10	1830	288.34	308.33
11	1780	288.35	315.2
12	1730	285.8	310.88
13	1680	286.3	313.67
14	1654	294.843	305.157
15	1637	Bridge	
16	1619	294.843	305.158
17	1580	291.54	308.65
18	1530	286.31	312.57
19	1480	289.7	312.56
20	1430	289.55	309.57
21	1390	291.32	308.63
22	1372	Bridge	
23	1354	291.32	308.63
24	1330	289.58	303.34
25	1280	289.07	305.25
26	1230	286.7	303.73
27	1180	287.55	303.03
28	1130	289.54	310.5
29	1080	290.66	307.89
30	1030	287.79	307.21
31	980	287.48	308.65
32	930	288	309.06
33	888	293.72	303.72
34	851	Bridge	
35	813	291.78	301.76
36	780	296.55	306.65

OK | Cancel | Help

Edit Contraction/Expansion Coefficients (Steady Flow)

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Contraction	Expansion
1	2130	0.3	0.5
2	2080	0.3	0.5
3	2030	0.3	0.5
4	1980	0.3	0.5
5	1930	0.3	0.5
6	1916	0.3	0.5
7	1898	Bridge	
8	1880	0.3	0.5
9	1865	0.3	0.5
10	1830	0.3	0.5
11	1780	0.3	0.5
12	1730	0.3	0.5
13	1680	0.3	0.5
14	1654	0.3	0.5
15	1637	Bridge	
16	1619	0.3	0.5
17	1580	0.3	0.5
18	1530	0.3	0.5
19	1480	0.3	0.5
20	1430	0.3	0.5
21	1390	0.3	0.5
22	1372	Bridge	
23	1354	0.3	0.5
24	1330	0.3	0.5
25	1280	0.3	0.5
26	1230	0.3	0.5
27	1180	0.3	0.5
28	1130	0.3	0.5
29	1080	0.3	0.5
30	1030	0.3	0.5
31	980	0.3	0.5
32	930	0.3	0.5
33	888	0.3	0.5
34	851	Bridge	
35	813	0.3	0.5
36	780	0.3	0.5

OK | Cancel | Help

Cross Section Ineffective Flow Area's Table

River: Walker Brook Show All River Stations

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace Values ...

Cross Section with Ineffective Regions

	RS	Left	Right	Elev	Left	Right	Elev	Left
1	2130	-41.99	263.26	83.05	430.9	698.78	84.94	
2	2080	-39.86	279.51	84.1	399.71	628.9	83.96	
3	2030	70.68	279.73	83.69	30.62	48.65	85.03	456.44
4	1980	55.44	256.31	84.06	555.76	629.31	84.76	498.02
5	1930	123.25	256.04	84.68	552.41	621.2	84.96	501.91
6	1916				113.56	285.01	84.6	325.42
7	1880	59.28	274.49	84.69	319.13	642.29	84.45	
8	1865	40.67	279.77	84.98	354.7	633.07	84.33	279.77
9	1830	103.4	231.71	86.37	0	68.97	86.54	322.47
10	1780	0	119.97	86.13	477.21	553.43	84.73	558.21
11	1730	61.36	251.36	84.95	452.64	619.3	84.41	0
12	1680	0	158.04	86.55	191.2	236.34	85.32	435.59
13	1654	-17.87	185.12	85.39	191.85	230.18	84.72	561.37
14	1619	-15.83	238.91	85.74	347.77	627.23	84.88	
15	1580	-9.01	255.17	85.6	330.93	438.65	84.48	442.34
16	1530	95.11	277.26	84.88	346.76	515.81	84.56	520.26
17	1480	0	98.07	85.89	357.11	400.85	84.65	408.07
18	1430				434.2	600	85.77	190.5
19	1390	334.97	780	85.14				
20	1354				120.2	177.92	85.47	
21	1330	404.61	504.05	85.63	538.98	600	86.78	229.91
22	1280	411.96	486.03	85.93	515.36	600	87.66	
23	1230	538.04	600	85.76	380.42	482	85.9	
24	1180	494.36	600	86.26				
25	1130	466.99	600	87.91				
26	1080	376.86	600	87.51				
27	1030	320.01	600	89				
28	980	460.11	600	88.59				
29	930	348.12	600	87.86				
30	888	348.23	600	87.87				
31	813	433.16	600	88.05				
32	780	410.86	600	88.26	242.06	278.94	84.53	

OK Cancel

Bridge Width and Upstream Distance Table

River: Walker Brook

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Dist Avail	Upstream Dist	Bridge Width	Downstream Dist
1	1898	36	3	24	9.
2	1637	35	3	14	18.
3	1372	36	5	25.25	5.75
4	851	75	15	55	5.

OK | Cancel | Help

Temporary Conditions Model

Edit Manning's n or k Values

River: Walker Brook | Edit Interpolated XS's | Channel n Values have a light green background

Reach: Walker Brook Cen | All Regions

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ... | Reduce to L Ch R ...

	River Station	Frctn (n/K)	n #1	n #2	n #3
1	2130	n	0.16	0.05	0.16
2	2080	n	0.16	0.05	0.16
3	2030	n	0.16	0.05	0.16
4	1980	n	0.16	0.05	0.16
5	1930	n	0.16	0.025	0.16
6	1916	n	0.1	0.02	0.1
7	1898	Bridge			
8	1880	n	0.1	0.02	0.1
9	1865	n	0.16	0.05	0.16
10	1830	n	0.16	0.05	0.16
11	1780	n	0.16	0.05	0.16
12	1730	n	0.16	0.05	0.16
13	1680	n	0.16	0.05	0.16
14	1654	n	0.1	0.02	0.1
15	1637	Bridge			
16	1619	n	0.16	0.05	0.16
17	1580	n	0.16	0.05	0.16
18	1530	n	0.16	0.05	0.16
19	1480	n	0.16	0.05	0.16
20	1430	n	0.16	0.05	0.16
21	1390	n	0.1	0.02	0.1
22	1372	Culvert			
23	1354	n	0.1	0.02	0.1
24	1330	n	0.16	0.05	0.16
25	1280	n	0.16	0.05	0.16
26	1230	n	0.16	0.05	0.16
27	1180	n	0.16	0.05	0.16
28	1130	n	0.16	0.05	0.16
29	1080	n	0.16	0.05	0.16
30	1030	n	0.16	0.05	0.16
31	980	n	0.16	0.05	0.16
32	930	n	0.16	0.05	0.16
33	888	n	0.1	0.02	0.1
34	851	Bridge			
35	813	n	0.1	0.02	0.1

OK | Cancel | Help

Edit Downstream Reach Lengths

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	LOB	Channel	ROB
1	2130	50	50	50
2	2080	50	50	50
3	2030	50	50	50
4	1980	50	50	50
5	1930	14	14	14
6	1916	36	36	36
7	1898	Bridge		
8	1880	15	15	15
9	1865	35	35	35
10	1830	50	50	50
11	1780	50	50	50
12	1730	50	50	50
13	1680	26	26	26
14	1654	35	35	35
15	1637	Bridge		
16	1619	39	39	39
17	1580	50	50	50
18	1530	50	50	50
19	1480	50	50	50
20	1430	40	40	40
21	1390	36	36	36
22	1372	Culvert		
23	1354	24	24	24
24	1330	50	50	50
25	1280	50	50	50
26	1230	50	50	50
27	1180	50	50	50
28	1130	50	50	50
29	1080	50	50	50
30	1030	50	50	50
31	980	50	50	50
32	930	42	42	42
33	888	75	75	75
34	851	Bridge		
35	813	33	33	33
36	780			

OK | Cancel | Help

Edit Contraction/Expansion Coefficients (Steady Flow)

iver: Walker Brook Edit Interpolated XS's

each: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Contraction	Expansion
1	2130	0.3	0.5
2	2080	0.3	0.5
3	2030	0.3	0.5
4	1980	0.3	0.5
5	1930	0.3	0.5
6	1916	0.3	0.5
7	1898	Bridge	
8	1880	0.3	0.5
9	1865	0.3	0.5
10	1830	0.3	0.5
11	1780	0.3	0.5
12	1730	0.3	0.5
13	1680	0.3	0.5
14	1654	0.3	0.5
15	1637	Bridge	
16	1619	0.3	0.5
17	1580	0.3	0.5
18	1530	0.3	0.5
19	1480	0.3	0.5
20	1430	0.3	0.5
21	1390	0.3	0.5
22	1372	Culvert	
23	1354	0.3	0.5
24	1330	0.3	0.5
25	1280	0.3	0.5
26	1230	0.3	0.5
27	1180	0.3	0.5
28	1130	0.3	0.5
29	1080	0.3	0.5
30	1030	0.3	0.5
31	980	0.3	0.5
32	930	0.3	0.5
33	888	0.3	0.5
34	851	Bridge	
35	813	0.3	0.5
36	780	0.3	0.5

OK Cancel Help

Bank Stations Table

River: Walker Brook Edit Interpolated XS's

Reach: Walker Brook Cen

Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace ...

	River Station	Left Bank Sta	Right Bank Sta
1	2130	285.35	345.45
2	2080	288.76	309.81
3	2030	288.31	314.14
4	1980	285.44	309.74
5	1930	294.2	304.62
6	1916	294.84	305.11
7	1898	Bridge	
8	1880	295.11	305.38
9	1865	293	307.41
10	1830	288.34	308.33
11	1780	288.35	315.2
12	1730	285.8	310.88
13	1680	286.3	313.67
14	1654	294.843	305.157
15	1637	Bridge	
16	1619	294.843	305.158
17	1580	291.54	308.65
18	1530	286.31	312.57
19	1480	289.7	312.56
20	1430	289.55	309.57
21	1390	291.32	308.63
22	1372	Culvert	
23	1354	291.32	308.63
24	1330	289.58	303.34
25	1280	289.07	305.25
26	1230	286.7	303.73
27	1180	287.55	303.03
28	1130	289.54	310.5
29	1080	290.66	307.89
30	1030	287.79	307.21
31	980	287.48	308.65
32	930	288	309.06
33	888	293.72	303.72
34	851	Bridge	
35	813	291.78	301.76
36	780	296.55	306.65

OK | Cancel | Help

Cross Section Ineffective Flow Area's Table

River: Walker Brook Show All River Stations

Reach: Walker Brook Cen

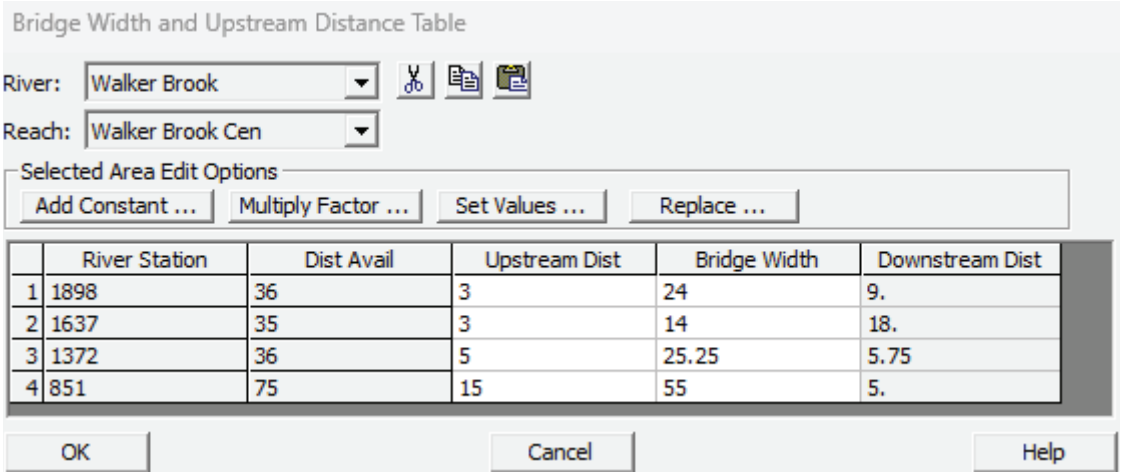
Selected Area Edit Options

Add Constant ... | Multiply Factor ... | Set Values ... | Replace Values ...

Cross Section with Ineffective Regions

	RS	Left	Right	Elev	Left	Right	Elev
1	2130	-41.99	263.26	83.05	430.9	698.78	84.94
2	2080	-39.86	279.51	84.1	399.71	628.9	83.96
3	2030	70.68	279.73	83.69	30.62	48.65	85.03
4	1980	55.44	256.31	84.06	555.76	629.31	84.76
5	1930	123.25	256.04	84.68	552.41	621.2	84.96
6	1916				113.56	285.01	84.6
7	1880	59.28	274.49	84.69	319.13	642.29	84.45
8	1865	40.67	279.77	84.98	354.7	633.07	84.33
9	1830	103.4	231.71	86.37	0	68.97	86.54
10	1780	0	119.97	86.13	477.21	553.43	84.73
11	1730	61.36	251.36	84.95	452.64	619.3	84.41
12	1680	0	158.04	86.55	191.2	236.34	85.32
13	1654	-17.87	185.12	85.39	191.85	230.18	84.72
14	1619	-15.83	238.91	85.74	347.77	627.23	84.88
15	1580	-9.01	255.17	85.6	330.93	438.65	84.48
16	1530	95.11	277.26	84.88	346.76	515.81	84.56
17	1480	0	98.07	85.89	357.11	400.85	84.65
18	1430				434.2	600	85.77
19	1390	334.97	780	85.14			
20	1354				120.2	177.92	85.47
21	1330	404.61	504.05	85.63	538.98	600	86.78
22	1280	411.96	486.03	85.93	515.36	600	87.66
23	1230	538.04	600	85.76	380.42	482	85.9
24	1180	494.36	600	86.26			
25	1130	466.99	600	87.91			
26	1080	376.86	600	87.51			
27	1030	320.01	600	89			
28	980	460.11	600	88.59			
29	930	348.12	600	87.86			
30	888	348.23	600	87.87			
31	813	433.16	600	88.05			
32	780	410.86	600	88.26	242.06	278.94	84.53

OK | Cancel



	River Station	Dist Avail	Upstream Dist	Bridge Width	Downstream Dist
1	1898	36	3	24	9.
2	1637	35	3	14	18.
3	1372	36	5	25.25	5.75
4	851	75	15	55	5.

HEC-RAS Simulation Output

Walkers Brook - 10-year Proposed Condition Design Model (Hydraulic Design Flood)

Reach	River Sta.	Profile	Q Total (cfs)	Min Ch. Elev. (ft.)	W.S. Elev. (ft.)	Crit. W.S. (ft.)	E.G. Elev. (ft.)	E.G. Slope (ft./ft.)	Vel. Channel (fps)	Flow Area (sq. ft.)	Top Width (ft.)	Froude # Channel
Walker Brook	2130	10-Year	166	76.48	81.47	77.62	81.48	0.00006	0.63	292	363	0.05
Walker Brook	2080	10-Year	166	76.05	81.43	77.69	81.46	0.00036	1.58	120	266	0.13
Walker Brook	2030	10-Year	166	75.80	81.42	77.32	81.44	0.00023	1.26	150	100	0.10
Walker Brook	1980	10-Year	166	75.57	81.41	77.17	81.43	0.00022	1.28	136	29	0.10
Walker Brook	1930	10-Year	166	75.29	81.28	77.29	81.39	0.00038	2.66	66	17	0.19
Walker Brook	1916	10-Year	166	75.29	81.28	77.30	81.39	0.00025	2.68	67	15	0.19
Walker Brook	1898	Track Road West Bridge										
Walker Brook	1880	10-Year	166	75.29	81.27	77.30	81.38	0.00025	2.69	66	15	0.19
Walker Brook	1865	10-Year	166	75.61	81.28	77.59	81.35	0.00072	2.17	86	22	0.17
Walker Brook	1830	10-Year	166	75.82	81.28	77.58	81.32	0.00042	1.67	112	29	0.13
Walker Brook	1780	10-Year	166	76.03	81.26	77.76	81.29	0.00032	1.39	127	33	0.12
Walker Brook	1730	10-Year	166	76.23	81.24	77.78	81.27	0.00037	1.48	122	36	0.12
Walker Brook	1680	10-Year	166	76.44	81.23	77.83	81.26	0.00035	1.41	126	39	0.12
Walker Brook	1654	10-Year	166	76.65	80.97	78.66	81.19	0.00062	3.73	45	10	0.32
Walker Brook	1637	Harvest Road Bridge										
Walker Brook	1619	10-Year	166	76.78	80.82	78.82	81.07	0.00499	4.02	41	10	0.35
Walker Brook	1580	10-Year	166	76.33	80.80	78.48	80.90	0.00136	2.55	73	25	0.23
Walker Brook	1530	10-Year	166	76.11	80.80	77.58	80.84	0.00041	1.50	116	33	0.13
Walker Brook	1480	10-Year	166	75.90	80.76	77.79	80.81	0.00056	1.76	104	32	0.15
Walker Brook	1430	10-Year	166	75.68	80.72	77.59	80.78	0.00064	1.89	94	26	0.16
Walker Brook	1390	10-Year	166	75.47	80.69	77.36	80.76	0.00014	2.13	80	20	0.18
Walker Brook	1372	Track Road East Bridge (R-03-006)										
Walker Brook	1354	10-Year	166	75.47	80.61	77.36	80.68	0.00015	2.17	79	20	0.18
Walker Brook	1330	10-Year	166	75.76	80.51	78.16	80.65	0.00203	3.03	57	17	0.27
Walker Brook	1280	10-Year	166	75.76	80.44	78.03	80.55	0.00139	2.61	70	24	0.23
Walker Brook	1230	10-Year	166	75.75	80.38	77.92	80.48	0.00133	2.52	70	23	0.23
Walker Brook	1180	10-Year	166	75.74	80.27	77.94	80.39	0.00169	2.79	63	19	0.25
Walker Brook	1130	10-Year	166	75.89	80.23	77.84	80.30	0.00113	2.23	77	25	0.21
Walker Brook	1080	10-Year	166	75.73	80.11	77.96	80.22	0.00174	2.73	65	23	0.26
Walker Brook	1030	10-Year	166	75.73	80.05	77.76	80.14	0.00130	2.40	73	25	0.22
Walker Brook	980	10-Year	166	75.71	80.00	77.42	80.07	0.00092	2.09	82	25	0.19
Walker Brook	930	10-Year	166	75.71	79.95	77.46	80.02	0.00102	2.16	82	28	0.20
Walker Brook	888	10-Year	166	75.99	79.56	78.04	79.89	0.00126	4.66	36	10	0.43
Walker Brook	851	Line Road Bridge										
Walker Brook	813	10-Year	166	75.52	79.50	77.57	79.77	0.00092	4.18	40	10	0.37
Walker Brook	780	10-Year	166	75.40	79.50	77.44	79.72	0.00074	3.87	58	39	0.34

Walkers Brook - 25-year Proposed Condition Design Model (Scour Design Flood)

Reach	River Sta.	Profile	Q Total (cfs)	Min Ch. Elev. (ft.)	W.S. Elev. (ft.)	Crit. W.S. (ft.)	E.G. Elev. (ft.)	E.G. Slope (ft./ft.)	Vel. Channel (fps)	Flow Area (sq. ft.)	Top Width (ft.)	Froude # Channel
Walker Brook	2130	25-Year	222	76.48	82.32	77.80	82.33	0.00006	0.69	385	502	0.05
Walker Brook	2080	25-Year	222	76.05	82.26	77.99	82.31	0.00036	1.76	178	343	0.13
Walker Brook	2030	25-Year	222	75.80	82.26	77.58	82.29	0.00023	1.41	201	195	0.10
Walker Brook	1980	25-Year	222	75.57	82.24	77.42	82.28	0.00025	1.47	161	34	0.10
Walker Brook	1930	25-Year	222	75.29	82.07	77.72	82.22	0.00044	3.13	81	22	0.21
Walker Brook	1916	25-Year	222	75.29	82.07	77.73	82.22	0.00029	3.16	79	16	0.21
Walker Brook	1898	Track Road West Bridge										
Walker Brook	1880	25-Year	222	75.29	82.05	77.73	82.20	0.00029	3.17	78	16	0.21
Walker Brook	1865	25-Year	222	75.61	82.07	77.99	82.17	0.00079	2.49	104	24	0.18
Walker Brook	1830	25-Year	222	75.82	82.07	77.91	82.13	0.00045	1.90	135	30	0.14
Walker Brook	1780	25-Year	222	76.03	82.06	78.05	82.10	0.00033	1.57	154	34	0.12
Walker Brook	1730	25-Year	222	76.23	82.04	78.06	82.08	0.00037	1.66	151	37	0.13
Walker Brook	1680	25-Year	222	76.44	82.02	78.09	82.06	0.00034	1.57	155	42	0.12
Walker Brook	1654	25-Year	222	76.65	81.69	79.09	81.97	0.00066	4.28	52	10	0.34
Walker Brook	1637	Harvest Road Bridge										
Walker Brook	1619	25-Year	222	76.78	81.53	79.25	81.85	0.00519	4.57	49	10	0.37
Walker Brook	1580	25-Year	222	76.33	81.54	78.81	81.66	0.00132	2.82	92	28	0.24
Walker Brook	1530	25-Year	222	76.11	81.54	77.84	81.58	0.00042	1.70	141	35	0.13
Walker Brook	1480	25-Year	222	75.90	81.50	78.09	81.56	0.00057	1.97	128	35	0.16
Walker Brook	1430	25-Year	222	75.68	81.45	77.90	81.52	0.00068	2.15	114	27	0.17
Walker Brook	1390	25-Year	222	75.47	81.41	77.73	81.50	0.00015	2.45	95	22	0.19
Walker Brook	1372	Track Road East Bridge (R-03-006)										
Walker Brook	1354	25-Year	222	75.47	81.29	77.73	81.38	0.00016	2.51	93	22	0.20
Walker Brook	1330	25-Year	222	75.76	81.17	78.54	81.35	0.00216	3.46	69	20	0.28
Walker Brook	1280	25-Year	222	75.76	81.10	78.38	81.24	0.00145	2.96	87	27	0.25
Walker Brook	1230	25-Year	222	75.75	81.04	78.28	81.16	0.00139	2.86	86	25	0.24
Walker Brook	1180	25-Year	222	75.74	80.92	78.31	81.07	0.00178	3.18	76	21	0.27
Walker Brook	1130	25-Year	222	75.89	80.88	78.15	80.97	0.00114	2.51	94	27	0.22
Walker Brook	1080	25-Year	222	75.73	80.75	78.32	80.89	0.00176	3.07	80	25	0.27
Walker Brook	1030	25-Year	222	75.73	80.69	78.09	80.80	0.00132	2.70	90	26	0.23
Walker Brook	980	25-Year	222	75.71	80.64	77.72	80.73	0.00097	2.38	98	26	0.20
Walker Brook	930	25-Year	222	75.71	80.59	77.78	80.68	0.00105	2.44	101	34	0.21
Walker Brook	888	25-Year	222	75.99	80.05	78.48	80.51	0.00147	5.47	41	11	0.48
Walker Brook	851	Line Road Bridge										
Walker Brook	813	25-Year	222	75.52	79.99	78.01	80.37	0.00112	4.98	45	10	0.42
Walker Brook	780	25-Year	222	75.40	80.00	77.88	80.29	0.00086	4.50	73	43	0.37

Walkers Brook - Scour Analysis Proposed Condition Design Model – 50-year (Scour Check Flood)

Reach	River Sta.	Profile	Q Total (cfs)	Min Ch. Elev. (ft.)	W.S. Elev. (ft.)	Crit. W.S. (ft.)	E.G. Elev. (ft.)	E.G. Slope (ft./ft.)	Vel. Channel (fps)	Flow Area (sq. ft.)	Top Width (ft.)	Froude # Channel
Walker Brook	2130	50-year	269	76.48	83.08	77.92	83.08	0.00003	0.49	1382	595	0.04
Walker Brook	2080	50-year	269	76.05	83.02	78.22	83.06	0.00032	1.80	246	452	0.12
Walker Brook	2030	50-year	269	75.80	83.01	77.78	83.04	0.00022	1.49	266	347	0.10
Walker Brook	1980	50-year	269	75.57	82.99	77.62	83.03	0.00024	1.59	189	210	0.11
Walker Brook	1930	50-year	269	75.29	82.80	78.05	82.97	0.00045	3.39	98	26	0.22
Walker Brook	1916	50-year	269	75.29	82.79	78.07	82.97	0.00030	3.44	91	44	0.22
Walker Brook	1898	Track Road West Bridge										
Walker Brook	1880	50-year	269	75.29	82.76	78.07	82.95	0.00030	3.45	91	31	0.22
Walker Brook	1865	50-year	269	75.61	82.80	78.27	82.90	0.00078	2.67	121	34	0.18
Walker Brook	1830	50-year	269	75.82	82.80	78.16	82.86	0.00043	2.03	158	32	0.14
Walker Brook	1780	50-year	269	76.03	82.79	78.26	82.83	0.00031	1.67	180	41	0.12
Walker Brook	1730	50-year	269	76.23	82.77	78.28	82.81	0.00035	1.75	178	38	0.13
Walker Brook	1680	50-year	269	76.44	82.75	78.29	82.80	0.00032	1.65	181	43	0.12
Walker Brook	1654	50-year	269	76.65	82.38	79.42	82.70	0.00063	4.56	59	10	0.34
Walker Brook	1637	Harvest Road Bridge										
Walker Brook	1619	50-year	269	76.78	82.22	79.58	82.58	0.00482	4.83	56	10	0.37
Walker Brook	1580	50-year	269	76.33	82.26	79.05	82.38	0.00115	2.91	112	29	0.23
Walker Brook	1530	50-year	269	76.11	82.27	78.04	82.31	0.00038	1.78	167	36	0.13
Walker Brook	1480	50-year	269	75.90	82.22	78.30	82.29	0.00051	2.06	154	36	0.15
Walker Brook	1430	50-year	269	75.68	82.18	78.13	82.26	0.00063	2.27	134	29	0.17
Walker Brook	1390	50-year	269	75.47	82.13	78.01	82.24	0.00014	2.60	111	23	0.19
Walker Brook	1372	Track Road East Bridge (R-03-006)										
Walker Brook	1354	50-year	269	75.47	81.99	78.01	82.10	0.00015	2.66	109	23	0.20
Walker Brook	1330	50-year	269	75.76	81.86	78.83	82.06	0.00196	3.61	84	23	0.28
Walker Brook	1280	50-year	269	75.76	81.81	78.63	81.95	0.00128	3.06	108	30	0.24
Walker Brook	1230	50-year	269	75.75	81.75	78.53	81.89	0.00123	2.97	104	27	0.23
Walker Brook	1180	50-year	269	75.74	81.64	78.57	81.81	0.00157	3.30	91	23	0.26
Walker Brook	1130	50-year	269	75.89	81.61	78.38	81.71	0.00097	2.57	114	28	0.20
Walker Brook	1080	50-year	269	75.73	81.49	78.58	81.64	0.00146	3.12	99	27	0.25
Walker Brook	1030	50-year	269	75.73	81.45	78.32	81.56	0.00109	2.75	111	28	0.22
Walker Brook	980	50-year	269	75.71	81.41	77.95	81.50	0.00082	2.44	119	27	0.19
Walker Brook	930	50-year	269	75.71	81.37	78.02	81.46	0.00086	2.47	128	50	0.19
Walker Brook	888	50-year	269	75.99	80.82	78.81	81.30	0.00121	5.57	49	11	0.45
Walker Brook	851	Line Road Bridge										
Walker Brook	813	50-year	269	75.52	80.47	78.35	80.93	0.00117	5.45	49	10	0.43
Walker Brook	780	50-year	269	75.40	80.50	78.22	80.83	0.00085	4.80	88	46	0.38

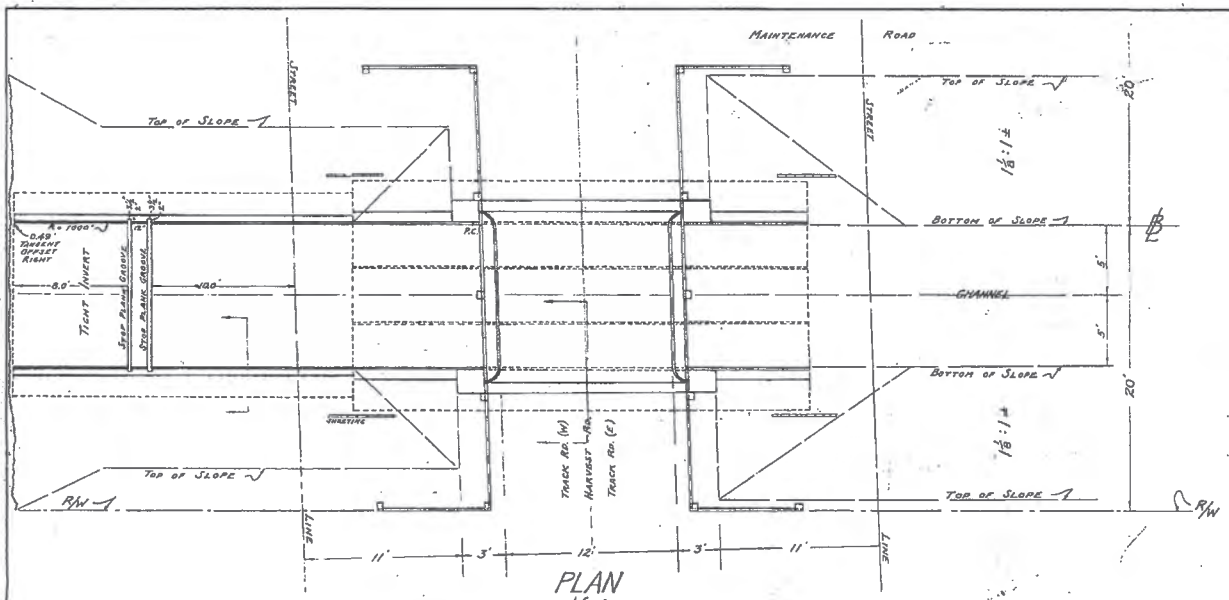
Walkers Brook Temporary Construction Condition - 2-Year Flood

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
Walker Brook	2130	2-Year	76.9	76.48	82.41	77.27	82.41	0.000007	0.24	395.46	521.05	0.02
Walker Brook	2080	2-Year	76.9	76.05	82.41	77.09	82.41	0.00004	0.59	190.25	351.52	0.04
Walker Brook	2030	2-Year	76.9	75.8	82.41	76.79	82.41	0.000026	0.48	212.37	208.64	0.03
Walker Brook	1980	2-Year	76.9	75.57	82.4	76.59	82.41	0.000027	0.5	165.94	38.55	0.03
Walker Brook	1930	2-Year	76.9	75.29	82.39	76.49	82.4	0.000045	1.03	88.22	23.83	0.07
Walker Brook	1916	2-Year	76.9	75.29	82.38	76.49	82.4	0.00003	1.04	84.28	17.04	0.07
Walker Brook	1898	Track Road West Bridge										
Walker Brook	1880	2-Year	76.9	75.29	82.38	76.49	82.4	0.00003	1.04	83.93	16.85	0.07
Walker Brook	1865	2-Year	76.9	75.61	82.39	76.86	82.4	0.000079	0.82	111.11	24.65	0.06
Walker Brook	1830	2-Year	76.9	75.82	82.39	76.97	82.39	0.000045	0.62	144.97	30.78	0.04
Walker Brook	1780	2-Year	76.9	76.03	82.38	77.17	82.39	0.000032	0.51	164.88	35.58	0.04
Walker Brook	1730	2-Year	76.9	76.23	82.38	77.23	82.39	0.000036	0.54	163.74	37.4	0.04
Walker Brook	1680	2-Year	76.9	76.44	82.38	77.31	82.38	0.000033	0.51	167.52	42.21	0.04
Walker Brook	1654	2-Year	76.9	76.65	82.35	77.86	82.38	0.000053	1.31	58.76	10.33	0.1
Walker Brook	1637	Harvest Road Bridge										
Walker Brook	1619	2-Year	76.9	76.78	82.34	78.01	82.37	0.000366	1.35	56.99	10.33	0.1
Walker Brook	1580	2-Year	76.9	76.33	82.34	77.78	82.35	0.000088	0.82	114.69	29.01	0.06
Walker Brook	1530	2-Year	76.9	76.11	82.34	77.08	82.35	0.00003	0.5	170.26	36.56	0.04
Walker Brook	1480	2-Year	76.9	75.9	82.34	77.2	82.35	0.000039	0.58	158.48	36.57	0.04
Walker Brook	1430	2-Year	76.9	75.68	82.34	77.01	82.34	0.000047	0.63	138.64	29.34	0.05
Walker Brook	1390	2-Year	76.9	75.47	82.33	76.63	82.34	0.00001	0.72	116.11	23.17	0.05
Walker Brook	1372	Track Road East Bridge (R-03-006)										
Walker Brook	1354	2-Year	76.9	75.47	79.05	76.63	79.09	0.000132	1.55	49.53	17.41	0.16
Walker Brook	1330	2-Year	76.9	75.76	78.99	77.43	79.07	0.002207	2.29	33.73	14.25	0.26
Walker Brook	1280	2-Year	76.9	75.76	78.9	77.3	78.96	0.001682	2.05	38.31	18.46	0.24
Walker Brook	1230	2-Year	76.9	75.75	78.82	77.21	78.88	0.001674	1.99	38.82	18.18	0.23
Walker Brook	1180	2-Year	76.9	75.74	78.7	77.23	78.78	0.002156	2.21	34.82	16.13	0.26
Walker Brook	1130	2-Year	76.9	75.89	78.61	77.22	78.67	0.001847	1.9	40.4	20.88	0.24
Walker Brook	1080	2-Year	76.9	75.73	78.45	77.22	78.54	0.003247	2.43	31.64	17.21	0.32
Walker Brook	1030	2-Year	76.9	75.73	78.31	77.07	78.38	0.002689	2.2	34.98	19.6	0.29
Walker Brook	980	2-Year	76.9	75.71	78.21	76.83	78.27	0.001725	1.86	41.31	21.05	0.23
Walker Brook	930	2-Year	76.9	75.71	78.1	76.83	78.16	0.002328	2.06	37.26	20.49	0.27
Walker Brook	888	2-Year	76.9	75.99	77.62	77.22	77.97	0.003081	4.73	16.26	9.99	0.65
Walker Brook	851	Line Road Bridge										
Walker Brook	813	2-Year	76.9	75.52	77.36	76.75	77.63	0.002159	4.2	18.3	9.97	0.55
Walker Brook	780	2-Year	76.9	75.4	77.3	76.62	77.55	0.001916	4.03	19.06	10.07	0.52

APPENDIX 7.3

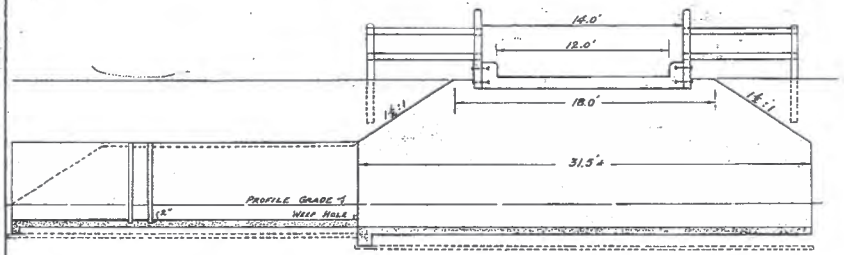
SCOUR ANALYSES

Original Design Drawing (1943)

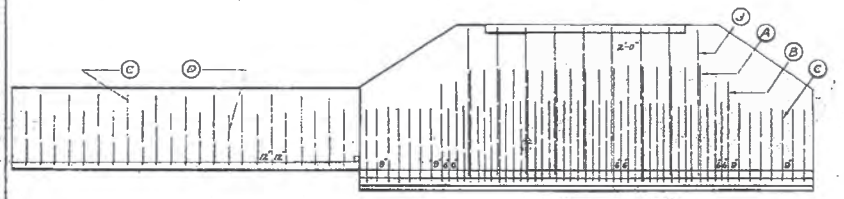


PLAN
1/4"=1'.

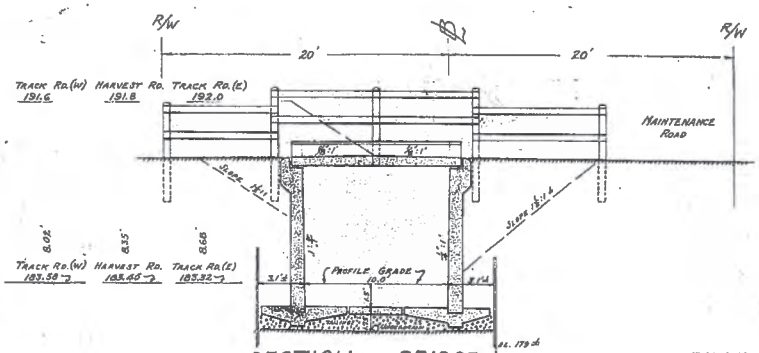
PROPOSED STOP No.3
WEST OF TRACK RD. (W)
REFER TO ACC. 02140-Y



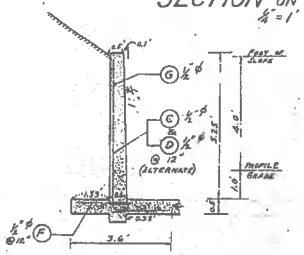
SECTION ON CHANNEL ℄
1/4"=1'



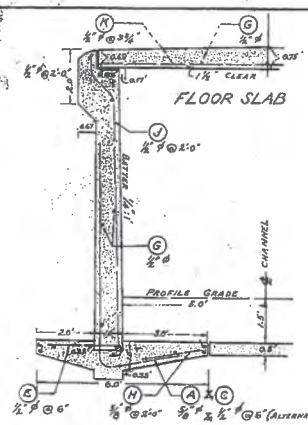
STEM ROD LAYOUT

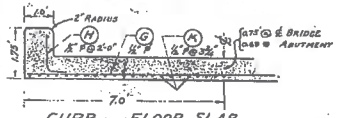


SECTION ON BRIDGE ℄
1/4"=1'



CHANNEL WALL SECTION
1/2"=1'





CURB AND FLOOR SLAB
1/2"=1'

ROD SCHEDULE

MARK	SIZE	UNBENT LENGTH	No. PCS.	SKETCH
A	⅝"ϕ	10'-6"	102	7'-6"
B	⅝"ϕ	9'-3"	24	8'-6"
C	½"ϕ	6'-9"	166	4'-5"
D	½"ϕ	4'-6"	24	2'-5"
E	½"ϕ	2'-8"	344	2'-0" HOOK 6"
F	½"ϕ	2'-2"	46	1'-6" HOOK 6"
G	½"ϕ	14'-0"		STRAIGHT
H	⅝"ϕ	2'-0"	66	STRAIGHT
J	½"ϕ	10'-7"	54	8'-10" CUT FROM 20'-0"
K	½"ϕ	11'-10"	135	STRAIGHT CUT FROM 14'-0"

BRIDGES AND CHANNEL STOP FOR PROPOSED DRAINAGE SYSTEM FOR THE LAKE QUANNAPOWITT DRAINAGE AREA OF THE TOWN OF READING

IN ACCORDANCE WITH

CHAPTER 458 ACTS OF 1939

DEPARTMENT OF PUBLIC WORKS OF MASSACHUSETTS
DIVISION OF WATERWAYS —

APRIL - 1943

SCALES NOTED

ASSOCIATE CIVIL ENGINEER

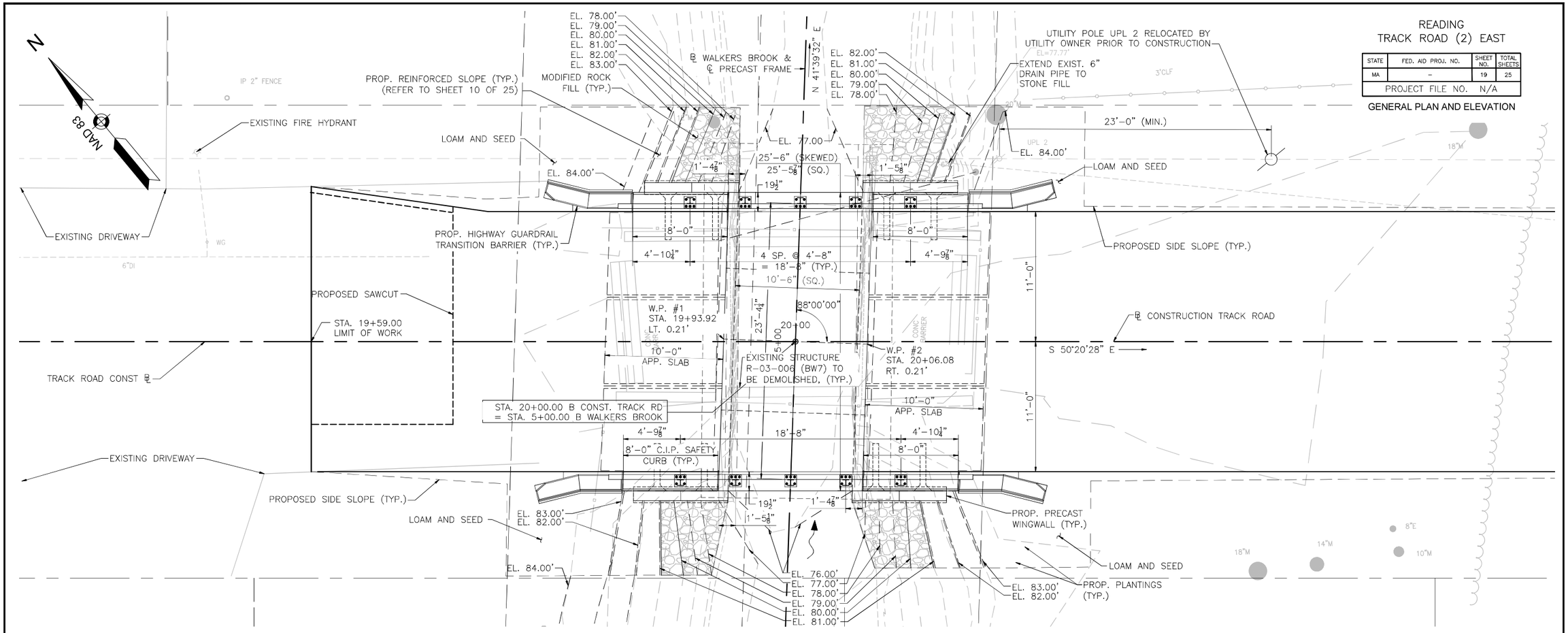
ACC. 02140-Z

Proposed Design Drawings (2025)

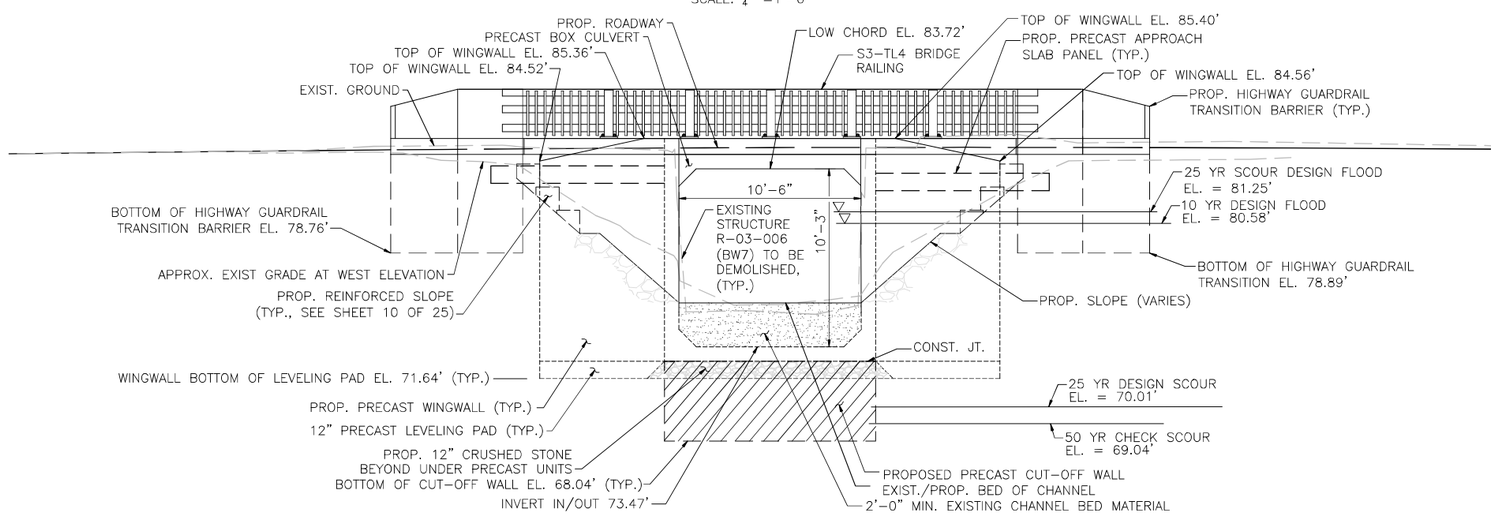
READING
TRACK ROAD (2) EAST

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	–	19	25
PROJECT FILE NO. N/A			

GENERAL PLAN AND ELEVATION



GENERAL PLAN
SCALE: ¼" =1'-0"



WEST ELEVATION
SCALE: ¼" =1'-0"

COMMONWEALTH OF MASSACHUSETTS
MassDOT, Highway Division
CONCEPTUAL DESIGN IS ACCEPTABLE TO MASSDOT FOR CONTRACTING

DISTRICT 4 BRIDGE ENGINEER _____ DATE _____

DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

Scour Calculations

TRACK ROAD BRIDGE R-03-006 (BW7)

TOWN OF READING, MA

SCOUR ANALYSIS RESULTS

SUMMARY

Table 1 – Hydraulic Data for Scour Analysis – Bridge R-03-006-BW7

HYDRAULIC DATA			
Drainage Area = 2.6 sq. mi.	Hydraulic Design Flood	Scour Design Flood	Scour Check Flood
Recurrence Interval (years)	10	25	50
Peak discharge (ft^3/s)	166	222	269
Water Surface Elevation (ft.-NAVD88)	80.58	81.25	81.93
Avg. Velocity Through Structure (ft./s)	3.17	3.75	4.06
Scour Analysis Completed: Yes	Channel Elev. 75.47 ft.-NAVD88		

Table 2 - Total Scour Depths and Scour Elevations – Bridge R-03-006-BW7

	Q_{10} Scour Depth (ft.)	Q_{10} Scour Elev. (ft.)	Q_{25} Scour Depth (ft.)	Q_{25} Scour Elev. (ft.)	Q_{50} Scour Depth (ft.)	Q_{50} Scour Elev. (ft.)
Left Abutment	4.54	70.93	5.46	70.01	6.43	69.04
Centerline	1.85	73.62	2.39	73.08	2.91	72.56
Right Abutment	4.54	70.93	5.46	70.01	6.43	69.04

10-Year Flood Event (Hydraulic Design)

HEC-RAS Simulation Results

River: Walker Brook Profile: 10-yearUpdated
Reach: Walker Brook Cen RS: 1430 Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1430 Profile: 10-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	80.78	Wt. n-Val.	0.160	0.050	0.160
Vel Head (ft)	0.05	Reach Len. (ft)	40.00	40.00	40.00
W.S. Elev (ft)	80.72	Flow Area (sq ft)	3.10	87.03	4.19
Crit W.S. (ft)	77.59	Area (sq ft)	3.10	87.03	4.19
E.G. Slope (ft/ft)	0.000643	Flow (cfs)	0.70	164.36	0.94
Q Total (cfs)	166.00	Top Width (ft)	2.28	20.02	3.53
Top Width (ft)	25.83	Avg. Vel. (ft/s)	0.23	1.89	0.22
Vel Total (ft/s)	1.76	Hydr. Depth (ft)	1.36	4.35	1.19
Max Chl Dpth (ft)	5.04	Conv. (cfs)	27.8	6482.1	37.1
Conv. Total (cfs)	6546.9	Wetted Per. (ft)	3.28	21.94	4.51
Length Wtd. (ft)	40.00	Shear (lb/sq ft)	0.04	0.16	0.04
Min Ch El (ft)	75.68	Stream Power (lb/ft s)	0.01	0.30	0.01
Alpha	1.14	Cum Volume (acre-ft)	0.03	0.92	0.03
Frctn Loss (ft)	0.01	Cum SA (acres)	0.04	0.24	0.03
C & E Loss (ft)	0.00				

River: Walker Brook Profile: 10-yearUpdated
Reach: Walker Brook Cen RS: 1372 BR U Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1372 BR U Profile: 10-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	80.73	Wt. n-Val.		0.020	
Vel Head (ft)	0.16	Reach Len. (ft)	25.25	25.25	25.25
W.S. Elev (ft)	80.58	Flow Area (sq ft)		52.36	
Crit W.S. (ft)	77.48	Area (sq ft)		52.36	
E.G. Slope (ft/ft)	0.000520	Flow (cfs)		166.00	
Q Total (cfs)	166.00	Top Width (ft)		10.25	
Top Width (ft)	10.25	Avg. Vel. (ft/s)		3.17	
Vel Total (ft/s)	3.17	Hydr. Depth (ft)		5.11	
Max Chl Dpth (ft)	5.11	Conv. (cfs)		7277.0	
Conv. Total (cfs)	7277.0	Wetted Per. (ft)		20.47	
Length Wtd. (ft)	25.25	Shear (lb/sq ft)		0.08	
Min Ch El (ft)	75.47	Stream Power (lb/ft s)		0.26	
Alpha	1.00	Cum Volume (acre-ft)	0.03	0.84	0.02
Frctn Loss (ft)	0.01	Cum SA (acres)	0.03	0.22	0.03
C & E Loss (ft)	0.00				

Contraction Scour: ***Determining Clear-water or Live-bed Conditions.***

V_c : Critical velocity above which bed material of size D will be transported

$$V_c = K_u y^{1/6} {D_{50}}^{1/3} \qquad \textbf{(HEC-18 Equation 6.1)}$$

Y: Average depth of flow upstream of the bridge

Based on the HEC-RAS output table, the channel average depth at Sta. 1430 is:

$$y = 4.35\ ft$$

D_{50}: Particle size in a mixture of which 50 percent are smaller.

Based on the subsurface investigation, the material in the vicinity of the bridge has a median grain size, D_{50} value of 0.2 mm or 0.00066 ft.

$$D_{50} = 0.00066\ ft$$

K_u: 11.17 English units (From HEC-18)

$$V_c = K_u y^{1/6} {D_{50}}^{1/3}$$

$$V_c = (11.17)(4.35\ ft)^{1/6}(0.00066\ ft)^{1/3}$$

$$V_c = 1.24\ fps$$

If the critical velocity is smaller than the mean velocity (V_c<V), live-bed contraction scour will exist

V_{Avg}: Average velocity upstream of the bridge, ft/s

Based the HEC-RAS output table, the channel average velocity at Sta. 1430 is:

$$V_{Avg} = 1.89\ fps$$

$$V_{Avg} > V_c$$

Because the average velocity is larger than the critical velocity **live-bed contraction scour exists.**

Live-Bed Contraction Scour

$y_2/ y_1 = (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$ (**HEC-18 Equation 6.2)**

y_1: Average depth in the upstream main channel
y_2: Average equilibrium depth in the contracted section after contraction scour
W_1: Channel width at the upstream main channel
W_2: Channel width in the contracted section
Q_1: Flow in the upstream channel transporting sediment
Q_2: Flow in the contracted section
K: Exponent based on mode of bed material transport, including shear velocity and fall velocity of bed material (**HEC-18 Figure 6.8).**

The flow is confined to the main channel (no overbank flow), the normal river channel width becomes narrower due the bridge: HEC-18 Case 2.

The hydraulic width of the upstream channel calculated as the total flow area divided by hydraulic depth (width transporting bed material) is 20.02 ft., and the contracted width of the bridge is 10.25 ft. (HEC-RAS table above).

Based on the shear stress provided in the HEC-RAS output table (0.16 lb./sq. ft.), the shear velocity in the upstream section is equal to 0.287 fps. Based on the bed material D_{50}, the fall velocity of the bed material is estimated to be 0.082 fps indicating that the bed material discharge is mostly suspended. The exponent K to be used in HEC-18 equation 6.2 is 0.69.

The average depth at the contracted section is:

$y_2 = y_1 * (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$

$y_2 = 4.35 * (166/164.36)^{6/7} * (20.02/10.25)^{0.69}$

$y_2 = 6.96$ ft.

y_s: Average contraction scour depth:

$y_s = y_2 - y_0$ **(HEC-18 Equation 6.3)**

y_0: Average existing depth in the contracted section (HEC-RAS table above):

$y_0 = 5.11$ ft.

$y_S = 6.96 - 5.11$

$y_s = 1.85$ ft. for live-bed contraction scour

Scour depths with live-bed contraction may be limited by coarser sediments in the bed material armoring the bed. In the case of Walkers Brook, given the small size of the sediment, it is expected that some armoring will take place. In this situation HEC-18 recommends that scour depth be calculated using the clear-water equation in addition to the live-bed equation, and that the smaller calculated scour depth be used.

Clear-water contraction scour

y_2=Average equilibrium depth in the contracted section after contraction scour, ft.

$$y_2 = \left[\frac{K_u * Q^2}{D_m{}^{2/3} * W^2}\right]^{3/7}$$ **(HEC-18 Equation 6.4)**

K_u=0.0077 English Units (From HEC-18)

Q: Discharge through the bridge associated with the width W, cfs

$$Q = 166\ cfs$$

D_m: Diameter of the smallest non-transportable particle in the bed material ($1.25 * D_{50}$) in the contracted section, ft.

$$D_m = D_{50} * 1.25$$
$$D_m = 0.00066\ ft * 1.25$$
$$D_m = 0.00083\ ft$$

W: Bottom width of the contracted section, ft.

$$W = 10.25\ ft$$

$$y_2 = \left[\frac{(0.0077) * (166\ cfs)^2}{(0.00083\ ft)^{2/3} * (\ 10.25\ ft)^2}\right]^{3/7}$$

$$y_2 = 10.26\ ft$$

y_s: average contraction scour depth:

$$y_s = y_2 - y_0$$ **(HEC-18 Equation 6.5)**

y_0: Average existing depth in the contracted section

$y_0 = 5.11 ft$

$y_s = 10.26\ ft - 5.11\ ft$

$y_s = 5.15 ft$ for clear water contraction scour

The smaller calculated scour depth was given by the live-bed equation, and should be used for the purpose of this design:

Contraction Scour: y_s = 1.85 ft.

Local Scour: Abutment

NCHRP Method

Using *Live-Bed* equations and charts

y_{max}: Maximum flow depth resulting from abutment scour.

$$y_{max} = \alpha_A * y_c$$ **(HEC-18 Equation 8.3)**

y_c: Flow depth including live-bed contraction scour

$$y_c = y_1(\frac{q_{2c}}{q_1})^{6/7}$$ **(HEC-18 Equation 8.5)**

y_1: Upstream flow depth

q_1: Upstream unit discharge

$q_1 = Q_1 / W_1$ or $y_1 * V_1$

$q_1 = 4.35 * 1.89 = 8.22$ cfs/ft

q_{2c}: Unit discharge in the constricted opening

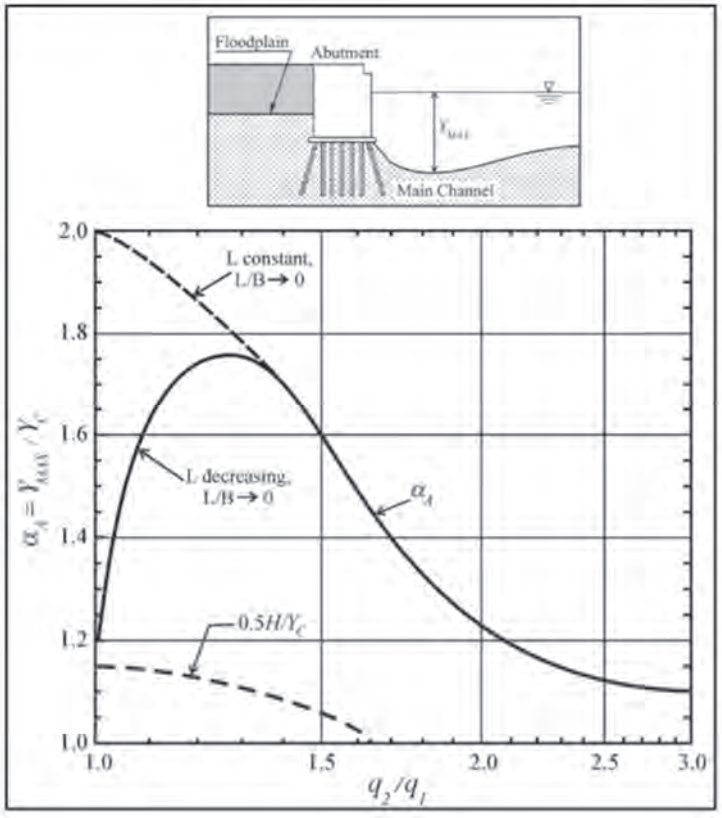
$q_{2c} = Q_2 / W_2$

$q_{2c} = 166 / 10.25 = 16.20$ cfs/ft

$y_c = y_1 * (q_{2c} / q_1)^{6/7}$

$y_c = 4.35 * (16.20 / 8.22)^{6/7} = 7.78$ ft.

α_A: Amplification factor for live-bed conditions



From HEC-18 Figure 8.10 (NCHRP 2010b)

From HEC-18 Figure 8.10, at $q_{2c} / q_1 = 1.97$ **$\alpha_A = 1.24$**

$y_{max} = \alpha_A * y_c = 1.24 * 7.78 = 9.65$ ft.

y_s: Abutment scour depth, ft.

$y_s = y_{max} - y_0$ **(HEC-18 Equation 8.3)**

y_0: Flow depth prior to scour

$y_s = 9.65 - 5.11 = 4.54$ ft.

This equation predicts total scour at the abutment, including the abutment scour component and the contraction scour.

Table 3 – 10-Year Flood – Bridge R-03-006-BW7
Scour Calculation Summary

	Left Abutment	Center of Channel	Right Abutment
W.S. Elev.	80.58	80.58	80.58
Depth (ft.)	5.11	5.11	5.11
Riverbed Elev.	75.47	75.47	75.47
Contraction Scour (ft.)	-	1.85	-
Abutment Scour (ft.)	4.54	-	4.54
Total Scour (ft.)	4.54	1.85	4.54
Scour Elev.	70.93	73.62	70.93

25-Year Flood Event (Design Scour)

HEC-RAS Simulation Results

River: Walker Brook Profile: 25-yearUpdated
Reach: Walker Brook Cen RS: 1430 Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1430 Profile: 25-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	81.52	Wt. n-Val.	0.160	0.050	0.160
Vel Head (ft)	0.07	Reach Len. (ft)	40.00	40.00	40.00
W.S. Elev (ft)	81.45	Flow Area (sq ft)	4.91	101.62	7.13
Crit W.S. (ft)	77.90	Area (sq ft)	4.91	101.62	7.13
E.G. Slope (ft/ft)	0.000679	Flow (cfs)	1.34	218.67	1.99
Q Total (cfs)	222.00	Top Width (ft)	2.69	20.02	4.53
Top Width (ft)	27.24	Avg. Vel. (ft/s)	0.27	2.15	0.28
Vel Total (ft/s)	1.95	Hydr. Depth (ft)	1.83	5.08	1.57
Max Chl Dpth (ft)	5.77	Conv. (cfs)	51.3	8393.1	76.4
Conv. Total (cfs)	8520.8	Wetted Per. (ft)	4.11	21.94	5.75
Length Wtd. (ft)	40.00	Shear (lb/sq ft)	0.05	0.20	0.05
Min Ch El (ft)	75.68	Stream Power (lb/ft s)	0.01	0.42	0.01
Alpha	1.20	Cum Volume (acre-ft)	0.06	1.07	0.05
Frctn Loss (ft)	0.01	Cum SA (acres)	0.05	0.24	0.05
C & E Loss (ft)	0.01				

River: Walker Brook Profile: 25-yearUpdated
Reach: Walker Brook Cen RS: 1372 BR U Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1372 BR U Profile: 25-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	81.46	Wt. n-Val.		0.020	
Vel Head (ft)	0.22	Reach Len. (ft)	25.25	25.25	25.25
W.S. Elev (ft)	81.25	Flow Area (sq ft)		59.21	
Crit W.S. (ft)	77.91	Area (sq ft)		59.21	
E.G. Slope (ft/ft)	0.000672	Flow (cfs)		222.00	
Q Total (cfs)	222.00	Top Width (ft)		10.25	
Top Width (ft)	10.25	Avg. Vel. (ft/s)		3.75	
Vel Total (ft/s)	3.75	Hydr. Depth (ft)		5.78	
Max Chl Dpth (ft)	5.78	Conv. (cfs)		8562.0	
Conv. Total (cfs)	8562.0	Wetted Per. (ft)		21.80	
Length Wtd. (ft)	25.25	Shear (lb/sq ft)		0.11	
Min Ch El (ft)	75.47	Stream Power (lb/ft s)		0.43	
Alpha	1.00	Cum Volume (acre-ft)	0.05	0.98	0.05
Frctn Loss (ft)	0.02	Cum SA (acres)	0.05	0.22	0.04
C & E Loss (ft)	0.00				

Contraction Scour: ***Determining Clear-water or Live-bed Conditions.***

V_c : Critical velocity above which bed material of size D will be transported

$$V_c = K_u y^{1/6} {D_{50}}^{1/3} \qquad \textbf{(HEC-18 Equation 6.1)}$$

Y: Average depth of flow upstream of the bridge

Based on the HEC-RAS output table, the channel average depth at Sta. 1430 is:

$$y = 5.08\ ft$$

D_{50}: Particle size in a mixture of which 50 percent are smaller.

Based on the subsurface investigation, the material in the vicinity of the bridge has a median grain size, D_{50} value of 0.2 mm or 0.00066 ft.

$$D_{50} = 0.00066\ ft$$

K_u: 11.17 English units (From HEC-18)

$$V_c = K_u y^{1/6} {D_{50}}^{1/3}$$

$$V_c = (11.17)(5.08\ ft)^{1/6}(0.00066\ ft)^{1/3}$$

$$V_c = 1.28\ fps$$

If the critical velocity is smaller than the mean velocity (V_c<V), live-bed contraction scour will exist

V_{Avg}: Average velocity upstream of the bridge, ft/s

Based the HEC-RAS output table, the channel average velocity at Sta. 1430 is:

$$V_{Avg} = 2.15\ fps$$

$$V_{Avg} > V_c$$

Because the average velocity is larger than the critical velocity **live-bed contraction scour exists.**

Live-Bed contraction scour

$y_2/ y_1 = (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$ (**HEC-18 Equation 6.2)**

y_1: Average depth in the upstream main channel
y_2: Average equilibrium depth in the contracted section after contraction scour
W_1: Channel width at the upstream main channel
W_2: Channel width in the contracted section
Q_1: Flow in the upstream channel transporting sediment
Q_2: Flow in the contracted section
K: Exponent based on mode of bed material transport, including shear velocity and fall velocity of bed material (**HEC-18 Figure 6.8).**

The flow is confined to the main channel (no overbank flow), the normal river channel width becomes narrower due the bridge: HEC-18 Case 2.

The hydraulic width of the upstream channel calculated as the total flow area divided by hydraulic depth (width transporting bed material) is 20.02 ft., and the contracted width of the bridge is 10.25 ft. (HEC-RAS table above).

Based on the shear stress provided in the HEC-RAS output table (0.20 lb./sq. ft.), the shear velocity in the upstream section is equal to 0.321 fps. Based on the bed material D_{50}, the fall velocity of the bed material is estimated to be 0.082 fps indicating that the bed material discharge is mostly suspended. The exponent K to be used in HEC-18 equation 6.2 is 0.69.

The average depth at the contracted section is:

$y_2 = y_1 * (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$

$y_2 = 5.08 * (222 / 218.67)^{6/7} * (20.02/10.25)^{0.69}$

$y_2 = 8.17$ ft.

y_s: Average contraction scour depth:

$y_s = y_2 – y_0$ **(HEC-18 Equation 6.3)**

y_0: Average existing depth in the contracted section (HEC-RAS table above):

$y_0 = 5.68$ ft.

$y_S = 8.17 – 5.78$

$y_s = 2.39$ ft.

Scour depths with live-bed contraction may be limited by coarser sediments in the bed material armoring the bed. In the case of Walkers Brook, given the small size of the sediment, it is expected that some armoring with take place. In this situation HEC-18 recommends that scour depth be calculated using the clear-water equation in addition to the live-bed equation, and that the smaller calculated scour depth be used.

Clear-water contraction scour

y_2=Average equilibrium depth in the contracted section after contraction scour, ft.

$$y_2 = \left[\frac{K_u * Q^2}{D_m{}^{2/3} * W^2}\right]^{3/7}$$ **(HEC-18 Equation 6.4)**

K_u=0.0077 English Units (From HEC-18)

Q: Discharge through the bridge associated with the width W, cfs

$$Q = 222\ cfs$$

D_m: Diameter of the smallest non-transportable particle in the bed material ($1.25 * D_{50}$) in the contracted section, ft.

$$D_m = D_{50} * 1.25$$
$$D_m = 0.00066\ ft * 1.25$$
$$D_m = 0.00083\ ft$$

W: Bottom width of the contracted section, ft.

$$W = 10.25\ ft$$

$$y_2 = \left[\frac{(0.0077) * (222\ cfs)^2}{(0.00083\ ft)^{2/3} * (\ 10.25\ ft)^2}\right]^{3/7}$$

$$y_2 = 13.16\ ft$$

y_s=average contraction scour depth:

$$y_s = y_2 - y_0$$ **(HEC-18 Equation 6.5)**

y_0: Average existing depth in the contracted section

$y_0 = 5.68 ft$

$y_s = 13.16\ ft - 5.68\ ft$

$y_s = 7.48\ ft$ for clear water contraction scour

The smaller calculated scour depth was given by the live-bed equation, and should be used for the purpose of this design:

Contraction Scour: y_s = 2.39 ft.

Local Scour: Abutment

NCHRP Method

Using *Live-Bed* equations and charts

y_{max}: Maximum flow depth resulting from abutment scour.

$$y_{max} = \alpha_A * y_c$$ **(HEC-18 Equation 8.3)**

y_c: Flow depth including live-bed contraction scour

$$y_c = y_1(\frac{q_{2c}}{q_1})^{6/7}$$ **(HEC-18 Equation 8.5)**

y_1: Upstream flow depth

q_1: Upstream unit discharge

$q_1 = Q_1 / W_1$ or $y_1 * V_1$

$q_1 = 5.08 * 2.15 = 10.92$ cfs/ft

q_{2c}: Unit discharge in the constricted opening

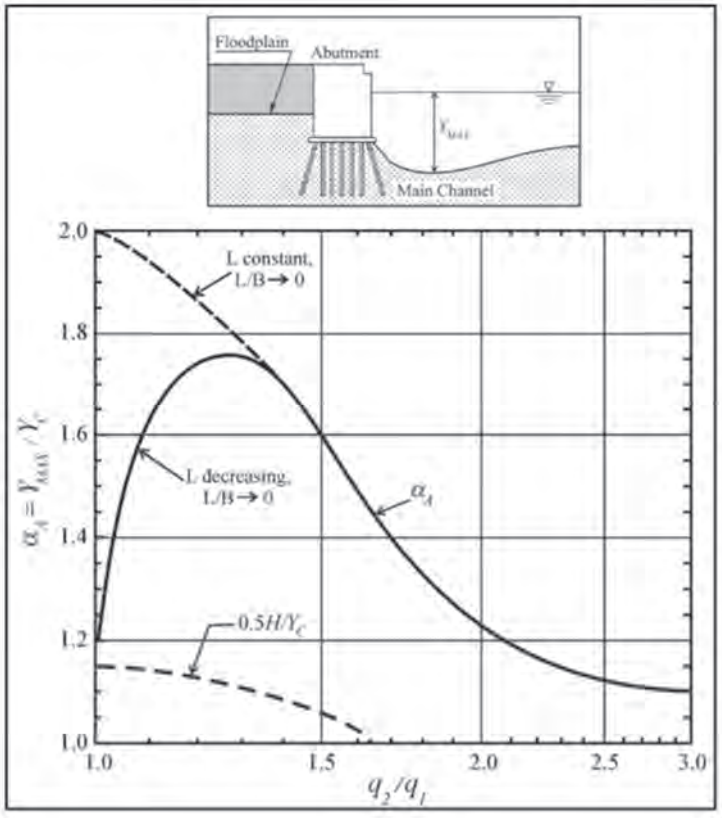
$q_{2c} = Q_2 / W_2$

$q_{2c} = 222 / 10.25 = 21.66$ cfs/ft

$y_c = y_1 * (q_{2c} / q_1)^{6/7}$

$y_c = 5.08 * (21.66 / 10.92)^{6/7} = 9.14$ ft.

α_A: Amplification factor for live-bed conditions



From HEC-18 Figure 8.10 (NCHRP 2010b)

From HEC-18 Figure 8.10, at $q_{2c} / q_1 = 1.98$ **$\alpha_A = 1.23$**

$y_{max} = \alpha_A * y_c = 1.23 * 9.14 = 11.24$ ft.

y_s: Abutment scour depth, ft.

$y_s = y_{max} - y_0$ **(HEC-18 Equation 8.3)**

y_0: Flow depth prior to scour

$y_s = 11.24 - 5.78 = 5.46$ ft.

This equation predicts total scour at the abutment, including the abutment scour component and the contraction scour.

Table 4 – 25-Year Flood – Bridge R-03-006-BW7
Scour Calculation Summary

	Left Abutment	Center of Channel	Right Abutment
W.S. Elev.	81.25	81.25	81.25
Depth (ft.)	5.78	5.78	5.78
Riverbed Elev.	75.47	75.47	75.47
Contraction Scour (ft.)	-	2.39	-
Local Scour (ft.)	5.46	-	5.46
Total Scour (ft.)	5.46	2.39	5.46
Scour Elev.	70.01	73.08	70.01

50-Year Flood Event (Check Scour)

HEC-RAS Simulation Results

River: Walker Brook Profile: 50-yearUpdated
Reach: Walker Brook Cen RS: 1430 Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1430 Profile: 50-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	82.26	Wt. n-Val.	0.160	0.050	0.160
Vel Head (ft)	0.08	Reach Len. (ft)	40.00	40.00	40.00
W.S. Elev (ft)	82.18	Flow Area (sq ft)	7.04	116.16	10.79
Crit W.S. (ft)	78.13	Area (sq ft)	7.04	116.16	10.79
E.G. Slope (ft/ft)	0.000632	Flow (cfs)	2.03	263.60	3.36
Q Total (cfs)	269.00	Top Width (ft)	3.32	20.02	5.53
Top Width (ft)	28.87	Avg. Vel. (ft/s)	0.29	2.27	0.31
Vel Total (ft/s)	2.01	Hydr. Depth (ft)	2.12	5.80	1.95
Max Chl Dpth (ft)	6.50	Conv. (cfs)	81.0	10487.9	133.8
Conv. Total (cfs)	10702.7	Wetted Per. (ft)	5.11	21.94	6.98
Length Wtd. (ft)	40.00	Shear (lb/sq ft)	0.05	0.21	0.06
Min Ch El (ft)	75.68	Stream Power (lb/ft s)	0.02	0.47	0.02
Alpha	1.25	Cum Volume (acre-ft)	0.10	1.24	0.09
Frctn Loss (ft)	0.01	Cum SA (acres)	0.06	0.23	0.07
C & E Loss (ft)	0.01				

River: Walker Brook Profile: 50-yearUpdated
Reach: Walker Brook Cen RS: 1372 BR U Plan: 2

Plan: 2 Walker Brook Walker Brook Cen RS: 1372 BR U Profile: 50-yearUpdated

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	82.19	Wt. n-Val.		0.020	
Vel Head (ft)	0.26	Reach Len. (ft)	25.25	25.25	25.25
W.S. Elev (ft)	81.93	Flow Area (sq ft)		66.25	
Crit W.S. (ft)	78.25	Area (sq ft)		66.25	
E.G. Slope (ft/ft)	0.000736	Flow (cfs)		269.00	
Q Total (cfs)	269.00	Top Width (ft)		10.25	
Top Width (ft)	10.25	Avg. Vel. (ft/s)		4.06	
Vel Total (ft/s)	4.06	Hydr. Depth (ft)		6.46	
Max Chl Dpth (ft)	6.46	Conv. (cfs)		9914.5	
Conv. Total (cfs)	9914.5	Wetted Per. (ft)		23.18	
Length Wtd. (ft)	25.25	Shear (lb/sq ft)		0.13	
Min Ch El (ft)	75.47	Stream Power (lb/ft s)		0.53	
Alpha	1.00	Cum Volume (acre-ft)	0.09	1.13	0.09
Frctn Loss (ft)	0.02	Cum SA (acres)	0.06	0.21	0.07
C & E Loss (ft)	0.00				

Contraction Scour: ***Determining Clear-water or Live-bed Conditions.***

V_c : Critical velocity above which bed material of size D will be transported

$$V_c = K_u y^{1/6} {D_{50}}^{1/3} \qquad \textbf{(HEC-18 Equation 6.1)}$$

Y: Average depth of flow upstream of the bridge

Based on the HEC-RAS output table, the channel average depth at Sta. 1430 is:

$$y = 5.80\ ft$$

D_{50}: Particle size in a mixture of which 50 percent are smaller.

Based on the subsurface investigation, the material in the vicinity of the bridge has a median grain size, D_{50} value of 0.2 mm or 0.00066 ft.

$$D_{50} = 0.00066\ ft$$

K_u: 11.17 English units (From HEC-18)

$$V_c = K_u y^{1/6} {D_{50}}^{1/3}$$

$$V_c = (11.17)(5.80\ ft)^{1/6}(0.00066\ ft)^{1/3}$$

$$V_c = 1.30\ fps$$

If the critical velocity is smaller than the mean velocity (V_c<V), live-bed contraction scour will exist.

V_{Avg}: Average velocity upstream of the bridge, ft/s

Based the HEC-RAS output table, the channel average velocity at Sta. 1430 is:

$$V_{Avg} = 2.27\ fps$$

$$V_{Avg} > V_c$$

Because the average velocity is larger than the critical velocity **live-bed contraction scour exists.**

Live-Bed contraction scour

$y_2/ y_1 = (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$ (**HEC-18 Equation 6.2)**

y_1: Average depth in the upstream main channel
y_2: Average equilibrium depth in the contracted section after contraction scour
W_1: Channel width at the upstream main channel
W_2: Channel width in the contracted section
Q_1: Flow in the upstream channel transporting sediment
Q_2: Flow in the contracted section
K: Exponent based on mode of bed material transport, including shear velocity and fall velocity of bed material (**HEC-18 Figure 6.8).**

The flow is confined to the main channel (no overbank flow), the normal river channel width becomes narrower due the bridge: HEC-18 Case 2.

The hydraulic width of the upstream channel calculated as the total flow area divided by hydraulic depth (width transporting bed material) is 20.02 ft., and the contracted width of the bridge is 10.25 ft. (HEC-RAS table above).

Based on the shear stress provided in the HEC-RAS output table (0.21 lb./sq. ft.), the shear velocity in the upstream section is equal to 0.329 fps. Based on the bed material D_{50}, the fall velocity of the bed material is estimated to be 0.082 fps indicating that the bed material discharge is mostly suspended. The exponent K to be used in HEC-18 equation 6.2 is 0.69.

The average depth at the contracted section is:

$y_2 = y_1 * (Q_2/Q_1)^{6/7} * (W_1/W_2)^K$

$y_2 = 5.80 * (269/263.6)^{6/7}*(20.02/10.25)^{0.69}$

y_2 = 9.37 ft.

y_s: Average contraction scour depth:

$y_s = y_2 – y_0$ **(HEC-18 Equation 6.3)**

y_0: Average existing depth in the contracted section (HEC-RAS table above):

y_0 = 6.46 ft.

$y_S = 9.37 – 6.46$

y_s = 2.91 ft. for live-bed contraction scour

Scour depths with live-bed contraction may be limited by coarser sediments in the bed material armoring the bed. In the case of Walkers Brook, given the small size of the sediment, it is expected that some armoring with take place. In this situation HEC-18 recommends that scour depth be calculated using the clear-water equation in addition to the live-bed equation, and that the smaller calculated scour depth be used.

Clear-water contraction scour

y_2=Average equilibrium depth in the contracted section after contraction scour, ft.

$$y_2 = \left[\frac{K_u * Q^2}{{D_m}^{2/3} * W^2}\right]^{3/7}$$ **(HEC-18 Equation 6.4)**

K_u=0.0077 English Units (From HEC-18)

Q: Discharge through the bridge associated with the width W, cfs

$$Q = 269\ cfs$$

D_m: Diameter of the smallest non-transportable particle in the bed material (1.25*D_{50}) in the contracted section, ft.

$$D_m = D_{50} * 1.25$$
$$D_m = 0.00066\ ft * 1.25$$
$$D_m = 0.00083\ ft$$

W: Bottom width of the contracted section, ft.

$$W = 10.25\ ft$$

$$y_2 = \left[\frac{(0.0077) * (269\ cfs)^2}{(0.00083\ ft)^{2/3} * (\ 10.25\ ft)^2}\right]^{3/7}$$

$$y_2 = 15.52\ ft$$

y_s: Average contraction scour depth:

$$y_s = y_2 - y_0$$ **(HEC-18 Equation 6.5)**

y_0: Average existing depth in the contracted section:

$y_0 = 6.46ft$

$y_s = 15.52\ ft - 6.46\ ft$

$y_s = 9.06\ ft$ for clear water contraction scour

The smaller calculated scour depth was given by the live-bed equation, and should be used for the purpose of this design:

Contraction Scour: y_s = 2.91 ft.

Local Scour: Abutment

NCHRP Method

Using *Live-Bed* equations and charts

y_{max}: Maximum flow depth resulting from abutment scour.

$$y_{max} = \alpha_A * y_c$$ **(HEC-18 Equation 8.3)**

y_c: Flow depth including live-bed contraction scour

$$y_c = y_1(\frac{q_{2c}}{q_1})^{6/7}$$ **(HEC-18 Equation 8.5)**

y_1: Upstream flow depth

q_1: Upstream unit discharge

$q_1 = Q_1 / W_1$ or $y_1 * V_1$

$q_1 = 5.80 * 2.27 = 13.17$ cfs/ft

q_{2c}: Unit discharge in the constricted opening

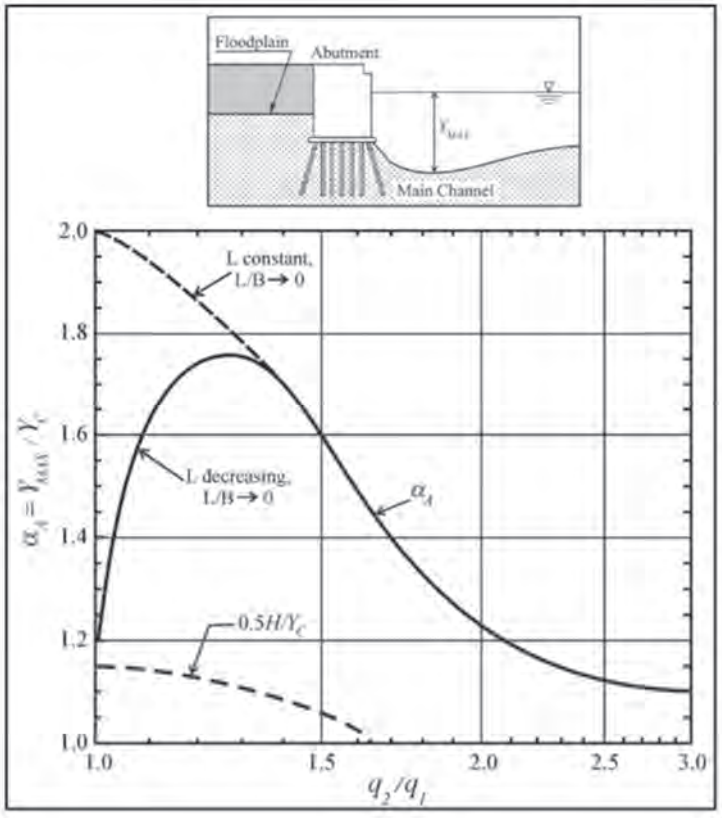
$q_{2c} = Q_2 / W_2$

$q_{2c} = 269 / 10.25 = 26.24$ cfs/ft

$y_c = y_1 * (q_{2c} / q_1)^{6/7}$

$y_c = 5.80 * (26.24 / 13.17)^{6/7} = 10.48$ ft.

α_A: Amplification factor for live-bed conditions



From HEC-18 Figure 8.10 (NCHRP 2010b)

From HEC-18 Figure 8.10, at $q_{2c} / q_1 = 1.99$ **$\alpha_A = 1.23$**

$y_{max} = \alpha_A * y_c = 1.23 * 10.48 = 12.89$ ft.

y_s: Abutment scour depth, ft.

$y_s = y_{max} - y_0$ **(HEC-18 Equation 8.3)**

y_0: Flow depth prior to scour

$y_s = 12.89 - 6.46 = 6.43$ ft.

This equation predicts total scour at the abutment, including the abutment scour component and the contraction scour.

Table 5 – 50-Year Flood – Bridge R-03-006-BW7
Scour Calculation Summary

	Left Abutment	Center of Channel	Right Abutment
W.S. Elev.	81.93	81.93	81.93
Depth (ft.)	6.46	6.46	6.46
Riverbed Elev.	75.47	75.47	75.47
Contraction Scour (ft.)	-	2.91	-
Local Scour (ft.)	6.43	-	6.43
Total Scour (ft.)	6.43	2.91	6.43
Scour Elev.	69.04	72.56	69.04

APPENDIX 7.4

NO-RISE STUDY HYDRAULIC ANALYSES

FEMA HEC-2 Model

THIS RUN EXECUTED 07/11/78 17.25.51

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************

T1      FLOOD INSURANCE STUDY   READING,MASS                              PLOT
T2      WALKERS BROOK
T3      10 YEAR MULTIPLE
J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        2.        0.        0.  0.0         0.0       0.0       0.     78.340     0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
      1.000     0.0      -1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
J3  VARIABLE CODES FOR SUMMARY PRINTOUT
     38.000    39.000    40.000    41.000    42.000    43.000     1.000     2.000     3.000    34.000

     21.000    22.000    26.000     0.0      38.000     1.000    50.000    61.000    51.000    53.000

     27.000     4.000    28.000    54.000    13.000    14.000    15.000     0.0       0.0       0.0
J6  IHLEQ     ICOPY
      1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0

NC      0.040     0.040     0.030     0.100     0.300     0.0       0.0       0.0       0.0       0.0
QT      8.000   140.000   230.000   280.000   420.000   280.000   280.000   280.000   280.000     0.0

X1      0.006    14.000   988.000  1012.000     0.0       0.0       0.0       0.0       0.0       0.0
GR     90.000   760.000    88.000   800.000    88.000   945.000    86.000   965.000    84.000   972.000
GR     82.000   980.000    78.000   988.000    76.500   989.000    76.000  1000.000    76.500  1011.000
GR     78.000  1012.000    88.000  1035.000    88.000  1040.000    90.000  1055.000     0.0       0.0

X1      0.087    13.000   990.000  1010.000   438.000   438.000   438.000     0.0       0.0       0.0
GR     90.000   880.000    88.000   910.000    86.000   950.000    84.000   975.000    80.000   990.000
GR     77.000   991.000    76.600  1000.000    77.000  1009.000    80.000  1010.000    84.000  1022.000
GR     86.000  1041.000    88.000  1266.000    90.000  1270.000     0.0       0.0       0.0       0.0
NC      0.0       0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0

X1      0.096    13.000   990.700  1009.400    50.000    50.000    50.000     0.0       0.0       0.0
X3     10.000     0.0       0.0       0.0       0.0       0.0       0.0      89.900    87.600     0.0
GR     92.000   830.000    91.200   975.000    85.000   985.000    78.000   990.600    77.000   990.700
GR     76.600  1000.000    77.000  1009.400    78.000  1009.500    86.000  1030.000    88.200  1050.000
GR     87.600  1100.000    90.000  1345.000   100.000  1375.000     0.0       0.0       0.0       0.0
SB      0.0       1.560     2.800     0.0      18.700     0.0     130.900     0.0      76.600    76.600

X1      0.116     0.0       0.0       0.0     103.000   103.000   103.000     0.0       0.0       0.0
X2      0.0       0.0       1.000     0.0      83.500    87.600     0.0       0.0       0.0       0.0
BT    800.000    86.000
```

X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	89.900	87.600	0.0
BT	13.000	830.000	92.000	0.0	975.000	91.200	0.0	98.000	90.500	0.0
BT	990.600	89.900	0.0	990.700	89.900	83.500	1000.000	89.900	83.500	1009.400
BT	89.900	83.500	1009.500	89.900	0.0	1030.000	89.000	0.0	1050.000	88.200
BT	0.0	1100.000	87.600	0.0	1345.000	90.000	0.0	1375.000	100.000	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	0.125	15.000	990.000	1010.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	92.000	820.000	90.000	835.000	90.000	925.000	88.000	960.000	85.600	978.000
GR	78.100	990.000	77.600	995.000	77.500	1000.000	77.500	1005.000	78.100	1010.000
GR	78.700	1015.000	88.200	1030.000	88.200	1400.000	90.000	1410.000	100.000	1430.000
NC	0.070	0.070	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.139	14.000	995.000	1005.000	74.000	74.000	74.000	0.0	0.0	0.0
GR	92.000	840.000	90.000	850.000	90.000	925.000	88.100	974.000	84.600	988.000
GR	81.100	995.000	76.900	995.100	77.200	1004.900	81.600	1005.000	85.300	1012.000
GR	87.700	1020.000	88.000	1430.000	90.000	1440.000	100.000	1460.000	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	0.148	15.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	88.800	88.500	0.0
GR	91.000	760.000	90.000	850.000	89.300	950.000	88.000	988.000	81.100	995.000
GR	76.900	995.100	76.300	1000.000	77.000	1004.900	81.600	1005.000	88.000	1020.000
GR	88.700	1050.000	88.500	1100.000	88.500	1390.000	90.000	1445.000	100.000	1465.000
SB	0.0	1.560	3.000	0.0	10.000	0.0	54.000	0.0	76.700	76.300
X1	0.164	0.0	0.0	0.0	82.000	82.000	82.000	0.0	0.400	0.0
X2	0.0	0.0	1.000	82.000	88.500	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	88.800	88.500	0.0
BT	15.000	760.000	91.000	0.0	850.000	90.000	0.0	950.000	89.300	0.0
BT	988.000	89.000	0.0	995.000	88.800	0.0	995.100	88.800	82.000	1000.000
BT	88.800	82.000	1004.900	88.800	82.000	1005.000	88.800	0.0	102.000	88.800
BT	0.0	1050.000	88.700	0.0	1100.000	88.500	0.0	1390.000	88.500	0.0
BT	1445.000	90.000	0.0	1465.000	100.000	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	0.173	11.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	91.000	730.000	90.000	800.000	88.000	985.000	82.000	995.000	76.100	995.100
GR	76.100	1004.900	82.000	1005.000	86.000	1020.000	88.000	1160.000	90.000	1400.000
GR	100.000	1420.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.243	13.000	995.000	1005.000	370.000	370.000	370.000	0.0	0.0	0.0
GR	91.000	220.000	90.000	500.000	88.000	800.000	86.000	970.000	84.000	995.000
GR	80.000	996.000	76.500	1000.000	80.000	1004.000	84.000	1005.000	86.000	1180.000
GR	86.000	1420.000	90.000	1430.000	96.000	1490.000	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	0.252	19.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.300	85.100	0.0
GR	91.000	200.000	90.000	510.000	88.000	740.000	86.000	800.000	85.300	900.000
GR	85.300	950.000	85.000	980.000	80.000	995.000	77.000	995.100	76.600	1000.000
GR	77.000	1004.900	80.000	1005.000	85.000	1020.000	85.000	1050.000	85.000	1100.000
GR	86.000	1110.000	86.000	1430.000	90.000	1440.000	94.000	1490.000	0.0	0.0
SB	0.0	1.560	3.000	0.0	10.000	0.0	82.000	0.0	76.300	76.600
X1	0.255	0.0	0.0	0.0	14.000	14.000	14.000	0.0	-0.300	0.0
X2	0.0	0.0	1.000	84.500	85.100	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.300	85.100	0.0
BT	19.000	200.000	91.000	0.0	510.000	90.000	0.0	740.000	88.000	0.0

BT	85.700	0.0	995.000	86.000	0.0	995.100	87.000	84.500	1000.000	87.000
BT	84.500	1004.900	87.000	84.500	1005.000	86.000	0.0	1020.000	85.800	0.0
BT	1050.000	85.400	0.0	1100.000	85.100	0.0	1110.000	86.000	0.0	1430.000
BT	86.000	0.0	1440.000	90.000	0.0	1490.000	94.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	0.265	19.000	992.000	1008.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	92.000	380.000	90.000	540.000	88.000	710.000	86.000	800.000	86.000	900.000
GR	84.800	972.000	83.700	977.000	82.000	982.000	78.400	992.000	77.100	995.000
GR	77.400	1006.000	78.400	1008.000	80.700	1011.000	84.100	1018.000	84.500	1020.000
GR	86.000	1165.000	86.000	1440.000	90.000	1455.000	94.000	1500.000	0.0	0.0
X1	0.293	14.000	992.000	1008.000	148.000	148.000	148.000	0.0	0.0	0.0
GR	92.000	250.000	90.000	370.000	88.000	500.000	86.000	790.000	85.000	972.000
GR	79.000	992.000	77.200	994.000	76.500	1000.000	77.200	1006.000	79.000	1008.000
GR	85.000	1018.000	86.000	1460.000	90.000	1475.000	92.000	1485.000	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	0.302	18.000	1994.800	2003.200	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.100	84.700	0.0
GR	92.000	1000.000	90.000	1250.000	88.000	1410.000	86.000	1580.000	84.100	1900.000
GR	84.000	1946.000	84.000	1950.000	79.000	1994.800	76.000	1994.900	75.700	2000.000
GR	76.000	2005.100	79.000	2005.200	84.000	2019.000	84.500	2050.000	84.700	2100.000
GR	85.300	2450.000	86.000	2460.000	92.000	2480.000	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.800	0.0	10.400	0.0	93.600	0.0	76.400	75.700
X1	0.305	0.0	0.0	0.0	14.000	14.000	14.000	0.0	0.700	0.0
X2	0.0	0.0	1.000	84.800	84.100	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.100	84.700	0.0
BT	18.000	1000.000	92.000	0.0	1250.000	90.000	0.0	1410.000	88.000	0.0
BT	1580.000	86.000	0.0	1900.000	84.100	0.0	1950.000	84.700	0.0	1980.000
BT	85.000	0.0	1994.800	85.600	0.0	1994.900	86.600	84.800	2000.000	86.600
BT	84.800	2005.100	86.600	84.800	2005.200	85.600	0.0	2019.000	85.500	0.0
BT	2050.000	85.300	0.0	2100.000	84.700	0.0	2450.000	85.000	0.0	2460.000
BT	86.000	0.0	2480.000	92.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	0.315	17.000	1993.000	2007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	94.000	980.000	92.000	1080.000	88.000	1105.000	86.000	1125.000	86.000	1465.000
GR	86.000	1805.000	84.300	1946.000	84.100	1971.000	81.600	1988.000	78.600	1993.000
GR	77.200	1995.000	77.000	2005.000	78.600	2007.000	81.700	2013.000	84.600	2019.000
GR	84.600	2455.000	92.000	2480.000	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.342	16.000	993.000	1007.000	143.000	143.000	143.000	0.0	0.0	0.0
GR	94.000	50.000	92.000	155.000	90.000	165.000	86.000	235.000	86.000	585.000
GR	86.000	625.000	86.000	775.000	85.000	990.000	79.000	993.000	76.700	1000.000
GR	79.000	1007.000	84.000	1010.000	84.000	1380.000	86.000	1470.000	90.000	1485.000
GR	91.000	1555.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	0.352	19.000	994.800	1005.200	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.600	84.500	0.0
GR	94.000	80.000	92.000	190.000	90.000	205.000	86.000	250.000	86.000	705.000
GR	84.600	900.000	84.900	950.000	84.000	990.000	82.000	994.800	79.000	994.900
GR	76.300	1000.000	79.000	1005.100	82.000	1005.200	84.000	1010.000	84.900	1050.000
GR	84.500	1100.000	84.500	1420.000	90.000	1445.000	91.000	1500.000	0.0	0.0
SB	0.0	1.560	3.000	0.0	10.400	0.0	87.400	0.0	76.500	76.300
X1	0.355	0.0	0.0	0.0	14.000	14.000	14.000	0.0	0.200	0.0

X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.600	84.500	0.0
BT	19.000	80.000	94.000	0.0	190.000	92.000	0.0	205.000	90.000	0.0
BT	250.000	86.000	0.0	705.000	86.000	0.0	900.000	84.600	0.0	950.000
BT	84.900	0.0	990.000	85.500	0.0	994.800	85.500	0.0	994.900	86.500
BT	84.700	1000.000	86.500	84.700	1005.100	86.500	84.700	1005.200	85.500	0.0
BT	1010.000	85.400	0.0	1050.000	84.900	0.0	1100.000	84.500	0.0	1420.000
BT	84.500	0.0	1445.000	90.000	0.0	1500.000	91.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	0.365	16.000	993.000	1007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	94.000	130.000	92.000	210.000	90.000	240.000	84.700	260.000	84.700	973.000
GR	83.600	991.000	78.600	993.000	77.000	995.000	77.100	1005.000	78.600	1007.000
GR	82.600	1011.000	83.900	1012.000	84.100	1022.000	84.100	1460.000	90.000	1485.000
GR	91.000	1545.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.526	15.000	994.000	1006.000	600.000	1000.000	850.000	0.0	0.0	0.0
GR	100.000	450.000	90.000	560.000	88.000	570.000	86.000	610.000	82.000	635.000
GR	80.000	725.000	80.000	850.000	78.000	994.000	77.500	995.000	77.500	1005.000
GR	78.000	1006.000	80.000	1150.000	86.000	1190.000	96.000	1210.000	106.000	1245.000
QT	8.000	120.000	200.000	240.000	350.000	240.000	240.000	240.000	240.000	0.0
X1	0.534	10.000	982.000	1016.000	40.000	40.000	40.000	0.0	0.0	0.0
GR	100.000	485.000	90.000	595.000	82.000	670.000	82.000	982.000	77.000	992.000
GR	77.000	1008.000	82.000	1016.000	82.000	1140.000	86.000	1170.000	96.000	1190.000
X1	0.595	10.000	982.000	1016.000	320.000	320.000	320.000	0.0	0.0	0.0
GR	96.000	710.000	90.000	760.000	82.000	820.000	82.000	982.000	77.200	992.000
GR	77.200	1008.000	82.000	1016.000	82.000	1160.000	86.000	1185.000	96.000	1255.000
QT	8.000	110.000	170.000	200.000	300.000	200.000	200.000	200.000	200.000	0.0
NC	0.0	0.040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.638	10.000	982.000	1018.000	230.000	230.000	230.000	0.0	0.0	0.0
GR	92.000	585.000	82.000	705.000	82.000	925.000	82.000	982.000	77.300	992.000
GR	77.300	1008.000	82.300	1018.000	86.000	1026.000	86.400	1046.000	96.000	1076.000
X1	0.732	11.000	979.000	1018.000	490.000	490.000	490.000	0.0	0.0	0.0
GR	92.000	865.000	90.000	905.000	88.000	910.000	84.000	950.000	84.000	979.000
GR	77.600	992.000	77.600	1008.000	82.600	1018.000	86.000	1026.000	86.400	1046.000
GR	96.000	1076.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
X1	0.891	12.000	980.000	1018.000	550.000	850.000	840.000	0.0	0.0	0.0
GR	100.000	440.000	90.000	530.000	88.000	630.000	86.000	770.000	86.000	974.000
GR	83.000	980.000	78.000	992.000	78.000	1008.000	83.000	1018.000	86.000	1026.000
GR	86.400	1046.000	96.000	1076.000	0.0	0.0	0.0	0.0	0.0	0.0
QT	8.000	90.000	150.000	180.000	280.000	180.000	180.000	180.000	180.000	0.0
X1	0.901	14.000	1986.000	2014.000	53.000	53.000	53.000	0.0	0.0	0.0
GR	92.000	910.000	90.000	1000.000	88.000	1060.000	86.000	1410.000	86.000	1580.000
GR	86.000	1810.000	86.000	1984.000	83.000	1986.000	78.000	1996.000	78.000	2004.000
GR	83.000	2014.000	86.000	2020.000	86.400	2040.000	96.000	2070.000	0.0	0.0
X1	0.997	11.000	986.000	1014.000	800.000	260.000	507.000	0.0	0.0	0.0
GR	90.000	400.000	88.000	530.000	86.000	730.000	86.000	980.000	83.200	986.000
GR	78.200	996.000	78.200	1004.000	83.200	1014.000	86.000	1020.000	86.400	1040.000
GR	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0

X1	1.008	17.000	990.000	1004.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.000	86.300	0.0
GR	90.000	340.000	88.000	530.000	86.000	690.000	86.000	980.000	84.000	984.000
GR	83.000	986.000	79.000	994.900	79.000	995.000	78.300	995.900	78.300	996.000
GR	78.300	1004.000	78.300	1004.100	79.000	1005.000	79.000	1005.100	86.000	1020.000
GR	86.400	1040.000	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.800	0.0	8.000	0.0	40.000	0.0	78.300	78.300
X1	1.018	0.0	0.0	0.0	62.000	62.000	62.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	83.300	86.000	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.000	86.300	0.0
BT	17.000	340.000	90.000	0.0	530.000	88.000	0.0	690.000	86.000	0.0
BT	980.000	86.000	0.0	984.000	86.000	0.0	986.000	86.000	0.0	994.900
BT	86.300	0.0	995.000	87.300	0.0	995.900	87.300	0.0	996.000	87.300
BT	83.300	1004.000	87.300	83.300	1004.100	87.300	0.0	1005.000	87.300	0.0
BT	1005.100	86.300	0.0	1020.000	86.300	0.0	1040.000	86.400	0.0	1070.000
BT	96.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	1.028	12.000	986.000	1014.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	90.000	290.000	88.000	510.000	86.000	630.000	86.000	970.000	86.000	980.000
GR	83.300	986.000	78.300	996.000	78.300	1004.000	83.300	1014.000	86.000	1020.000
GR	86.400	1040.000	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0
X1	1.062	13.000	986.000	1014.000	180.000	180.000	180.000	0.0	0.0	0.0
GR	90.000	150.000	88.000	370.000	86.000	460.000	86.000	780.000	86.000	978.000
GR	86.000	980.000	83.400	986.000	78.400	996.000	78.400	1004.000	83.400	1014.000
GR	86.000	1020.000	86.400	1040.000	96.000	1070.000	0.0	0.0	0.0	0.0
NC	0.060	0.060	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	1.071	17.000	2997.000	3003.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	82.400	82.400	0.0
GR	90.000	1140.000	88.000	1360.000	86.000	1450.000	86.000	1780.000	86.000	2950.000
GR	85.500	2980.000	80.000	2997.000	79.000	2997.100	78.400	3000.000	79.000	3002.900
GR	80.000	3003.000	85.500	3015.000	86.100	3050.000	85.900	3100.000	86.000	3470.000
GR	86.000	3890.000	100.000	3920.000	0.0	0.0	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.800	0.0	6.000	0.0	27.600	0.0	78.300	78.300
X1	1.084	0.0	0.0	0.0	65.000	65.000	65.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	82.400	85.900	0.0	0.0	0.0	0.0	0.0
X3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.000	85.900	0.0
BT	17.000	1140.000	90.000	0.0	1360.000	88.000	0.0	1450.000	86.000	0.0
BT	1780.000	86.000	0.0	2950.000	86.000	0.0	2980.000	86.100	0.0	2997.000
BT	86.100	0.0	2997.100	86.100	82.400	3000.000	86.100	82.400	3002.900	86.100
BT	82.400	3003.000	86.100	0.0	3015.000	86.100	0.0	3050.000	86.100	0.0
BT	3100.000	85.900	0.0	3470.000	86.000	0.0	3890.000	86.000	0.0	3920.000
BT	100.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	1.094	19.000	993.000	1007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	96.000	180.000	90.000	200.000	88.000	460.000	86.000	590.000	86.000	860.000
GR	82.000	880.000	82.000	985.000	80.000	990.000	79.500	993.000	78.500	995.000
GR	78.300	1000.000	78.500	1005.000	79.500	1007.000	80.000	1015.000	82.000	1050.000
GR	84.000	1140.000	86.000	1240.000	86.000	1930.000	100.000	1950.000	0.0	0.0
X1	1.249	17.000	995.000	1005.000	818.000	818.000	818.000	0.0	0.0	0.0
GR	94.000	360.000	88.000	380.000	86.000	530.000	84.000	780.000	84.000	960.000
GR	82.000	985.000	81.000	990.000	80.000	995.000	79.600	998.000	79.500	1000.000
GR	79.600	1004.000	80.000	1005.000	82.000	1011.000	82.000	1160.000	84.000	1180.000
GR	86.000	1240.000	110.000	1290.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0

X1	1.258	19.000	1998.000	2002.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.300	83.500	0.0
GR	94.000	730.000	92.000	1140.000	90.000	1650.000	87.900	1900.000	87.700	1950.000
GR	83.000	1980.000	81.100	1998.000	80.000	1998.300	79.400	1999.000	79.100	2000.000
GR	79.400	2001.000	80.000	2001.700	81.100	2002.000	83.000	2015.000	87.000	2050.000
GR	87.000	2100.000	87.000	2360.000	87.000	3280.000	110.000	3330.000	0.0	0.0
SB	0.0	1.560	2.800	0.0	4.000	0.0	12.600	0.0	79.700	79.100
X1	1.269	0.0	0.0	0.0	56.000	56.000	56.000	0.0	0.600	0.0
X2	0.0	0.0	1.000	83.100	86.000	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.300	86.000	0.0
BT	19.000	730.000	94.000	0.0	1140.000	92.000	0.0	1650.000	90.000	0.0
BT	1900.000	87.900	0.0	1950.000	87.700	0.0	1980.000	87.500	0.0	1998.000
BT	87.300	81.100	1998.300	87.300	82.200	1999.000	87.300	82.800	2000.000	87.300
BT	83.100	2001.000	87.300	82.800	2001.700	87.300	82.200	2002.000	87.300	81.100
BT	2015.000	87.200	0.0	2050.000	87.000	0.0	2100.000	86.700	0.0	2360.000
BT	86.000	0.0	3280.000	86.700	0.0	3330.000	110.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	1.279	16.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	100.000	150.000	90.000	350.000	86.000	430.000	84.000	950.000	82.200	973.000
GR	82.700	983.000	80.900	994.800	80.000	995.000	79.600	995.100	79.600	1000.000
GR	80.100	1005.000	83.000	1007.000	83.700	1012.000	83.700	1210.000	86.000	1280.000
GR	100.000	1315.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	1.297	18.000	997.500	1002.500	95.000	95.000	95.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.000	85.000	0.0
GR	100.000	70.000	92.000	160.000	90.000	250.000	86.000	420.000	86.000	709.500
GR	100.000	710.000	100.000	949.500	85.900	950.000	83.000	990.000	80.000	997.500
GR	79.700	998.000	79.700	1002.000	80.000	1002.500	85.000	1015.000	85.000	1050.000
GR	86.000	1060.000	86.000	2270.000	106.000	2310.000	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.800	0.0	5.000	0.0	11.300	0.0	79.100	79.700
X1	1.304	21.000	997.500	1002.500	37.000	37.000	37.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	83.100	85.900	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.900	85.900	0.0
BT	21.000	70.000	100.000	0.0	160.000	92.000	0.0	250.000	90.000	0.0
BT	420.000	86.000	0.0	709.500	86.000	0.0	710.000	100.000	0.0	949.500
BT	100.000	0.0	950.000	86.900	0.0	990.000	85.900	0.0	997.500	85.900
BT	80.600	998.000	85.900	82.100	999.000	85.900	82.900	1000.000	85.900	83.100
BT	1001.000	85.900	82.900	1002.000	85.900	82.100	1002.500	85.900	80.600	1015.000
BT	85.900	0.0	1050.000	85.900	0.0	1060.000	86.000	0.0	2270.000	86.000
BT	0.0	2310.000	106.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GR	100.000	70.000	92.000	160.000	90.000	250.000	86.000	420.000	86.000	709.500
GR	100.000	710.000	100.000	949.500	85.900	950.000	83.000	990.000	80.600	997.500
GR	79.100	998.000	79.100	999.000	79.100	1000.000	79.100	1001.000	79.100	1002.000
GR	80.600	1002.500	85.000	1015.000	85.900	1050.000	86.000	1060.000	86.000	2270.000
GR	106.000	2310.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	1.313	20.000	994.000	1006.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	100.000	130.000	96.000	170.000	94.000	250.000	92.000	255.000	90.000	325.000
GR	86.000	530.000	84.000	930.000	82.500	955.000	82.400	991.000	80.300	994.000
GR	79.400	996.000	79.100	1000.000	79.300	1004.000	80.300	1006.000	83.400	1010.000
GR	85.000	1015.000	85.100	1020.000	86.000	1035.000	86.000	2290.000	106.000	2335.000
X1	1.487	17.000	995.000	1005.000	918.000	918.000	918.000	0.0	0.0	0.0
GR	100.000	140.000	90.000	375.000	90.000	775.000	88.000	845.000	86.000	975.000
GR	84.000	980.000	82.000	995.000	81.000	996.000	80.700	1000.000	81.000	1004.000
GR	82.000	1005.000	88.000	1020.000	88.000	1140.000	90.000	1180.000	90.000	1320.000

GR	92.000	1330.000	96.000	1410.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
X1	1.496	17.000	994.100	1005.900	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.500	86.500	0.0
GR	100.000	280.000	92.000	530.000	90.000	830.000	86.700	900.000	88.100	950.000
GR	84.000	985.000	82.000	994.100	81.200	994.200	81.000	1000.000	81.200	1005.800
GR	82.000	1005.900	84.000	1010.000	87.600	1050.000	88.400	1100.000	90.000	1220.000
GR	92.000	1270.000	94.000	1305.000	0.0	0.0	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.600	0.0	11.800	0.0	36.600	0.0	81.000	81.000
X1	1.505	0.0	0.0	0.0	51.000	51.000	51.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	84.000	87.600	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.700	87.600	0.0
BT	17.000	280.000	100.000	0.0	530.000	92.000	0.0	830.000	90.000	0.0
BT	900.000	88.700	0.0	950.000	86.100	0.0	985.000	87.800	0.0	994.100
BT	87.700	0.0	994.200	87.700	84.008	1000.000	87.700	94.000	1005.800	87.700
BT	84.000	1005.900	87.700	0.0	1010.000	87.700	0.0	1050.000	87.600	0.0
BT	1100.000	88.400	0.0	1220.000	90.000	0.0	1270.000	92.000	0.0	1305.000
BT	94.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
X1	1.515	17.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	100.000	385.000	92.000	500.000	90.000	865.000	88.000	870.000	86.000	930.000
GR	85.100	982.000	84.400	991.000	81.500	995.000	81.200	997.000	81.300	1000.000
GR	81.000	1003.000	81.300	1005.000	84.000	1009.000	84.200	1019.000	86.000	1055.000
GR	90.000	1170.000	94.000	1270.000	0.0	0.0	0.0	0.0	0.0	0.0
EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THIS RUN EXECUTED 07/11/78 17.26.28

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************

T1      FLOOD INSURANCE STUDY   READING,MASS                    PLOT
T2      WALKERS BROOK
T3      50 YEAR MULTIPLE

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        3.        0.        0.  0.0           0.0       0.0       0.    79.020    0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLOC     IBW       CHNIM     ITRACE
    2.000     0.0       -1.000    0.0       0.0       0.0       0.0       0.0       0.0       0.0
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THIS RUN EXECUTED 07/11/78 17.26.38

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************

T1      FLOOD INSURANCE STUDY   READING,MASS
T2      WALKERS BROOK
T3      100 YEAR MULTIPLE

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        4.        0.        0.  0.0           0.0       0.0       0.    79.340    0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
    3.000     0.0      -1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0
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THIS RUN EXECUTED 07/11/78 17.26.56

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************

T1      FLOOD INSURANCE STUDY   READING,MASS
T2      WALKERS BROOK
T3      500 YEAR MULTIPLE
J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        5.        0.        0.  0.0           0.0       0.0       0.    80.130    0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
    15.000    0.0       -1.000    0.0       0.0       0.0       0.0       0.0       0.0       0.0
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THIS RUN EXECUTED 07/11/78 17.27.20

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**********************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**********************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

10 YEAR MULTIPLE

SUMMARY PRINTOUT

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
	0.006	0.0	0.0	0.0	76.00	140.00	78.34	0.0	78.47	36.35	988.00	1012.00	2.90
	0.006	0.0	0.0	0.0	76.00	230.00	79.02	0.0	79.21	59.58	988.00	1012.00	3.54
	0.006	0.0	0.0	0.0	76.00	280.00	79.34	0.0	79.56	72.30	988.00	1012.00	3.83
	0.006	0.0	0.0	0.0	76.00	420.00	80.13	0.0	80.43	108.69	988.00	1012.00	4.46
	0.087	438.00	0.0	0.0	76.60	140.00	79.06	0.0	79.23	31.79	990.00	1010.00	3.33
	0.087	438.00	0.0	0.0	76.60	230.00	79.78	0.0	80.04	49.19	990.00	1010.00	4.10
	0.087	438.00	0.0	0.0	76.60	280.00	80.11	0.0	80.42	58.51	990.00	1010.00	4.46
	0.087	438.00	0.0	0.0	76.60	420.00	80.89	0.0	81.33	85.30	990.00	1010.00	5.32
	0.096	50.00	0.0	0.0	76.60	140.00	79.16	0.0	79.32	36.07	990.70	1009.40	3.18
	0.096	50.00	0.0	0.0	76.60	230.00	79.88	0.0	80.13	59.07	990.70	1009.40	4.00
	0.096	50.00	0.0	0.0	76.60	280.00	80.22	0.0	80.52	69.90	990.70	1009.40	4.39
	0.096	50.00	0.0	0.0	76.60	420.00	80.99	0.0	81.44	97.45	990.70	1009.40	5.36
	0.116	103.00	87.60	83.50	76.60	140.00	79.31	0.0	79.45	42.33	990.70	1009.40	2.98
	0.116	103.00	87.60	83.50	76.60	230.00	80.06	0.0	80.28	64.98	990.70	1009.40	3.77
	0.116	103.00	87.60	83.50	76.60	280.00	80.41	0.0	80.68	76.67	990.70	1009.40	4.15
	0.116	103.00	87.60	83.50	76.60	420.00	81.23	0.0	81.63	106.58	990.70	1009.40	5.07
A	0.125	50.00	0.0	0.0	77.50	140.00	79.36	0.0	79.57	25.80	990.00	1010.00	3.80
	0.125	50.00	0.0	0.0	77.50	230.00	80.13	0.0	80.37	50.29	990.00	1010.00	4.11
	0.125	50.00	0.0	0.0	77.50	280.00	80.50	0.0	80.76	64.34	990.00	1010.00	4.29
	0.125	50.00	0.0	0.0	77.50	420.00	81.42	0.0	81.71	107.37	990.0	1010.00	4.66
B	0.139	74.00	0.0	0.0	76.90	140.00	79.51	0.0	80.03	16.73	995.00	1005.00	5.78
	0.139	74.00	0.0	0.0	76.90	230.00	80.12	0.0	81.01	22.01	995.00	1005.00	7.59
	0.139	74.00	0.0	0.0	76.90	280.00	80.40	0.0	81.51	26.06	995.00	1005.00	8.46
	0.139	74.00	0.0	0.0	76.90	420.00	81.04	0.0	82.80	33.33	995.00	1005.00	10.63
	0.148	50.00	0.0	0.0	76.30	140.00	80.03	0.0	80.30	27.21	995.00	1005.00	4.17
	0.148	50.00	0.0	0.0	76.30	230.00	80.97	0.0	81.42	38.09	995.00	1005.00	5.36
	0.148	50.00	0.0	0.0	76.30	280.00	81.45	0.0	81.99	43.89	995.00	1005.00	5.86
	0.148	50.00	0.0	0.0	76.30	420.00	82.70	0.0	83.45	61.50	995.00	1005.00	6.98
	0.164	82.00	88.50	82.00	76.70	140.00	80.25	0.0	80.55	25.17	995.00	1005.00	4.41
	0.164	82.00	88.50	82.00	76.70	230.00	81.27	0.0	81.74	36.88	995.00	1005.00	5.48
	0.164	82.00	88.50	82.00	76.70	280.00	81.78	0.0	82.33	43.08	995.00	1005.00	5.95
	0.164	82.00	88.50	82.00	76.70	420.00	83.50	0.0	84.16	67.91	995.00	1005.00	6.53

SECNC	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
0.173	50.00	0.0	0.0	76.10	140.00	80.49	0.0	80.66	37.83	995.00	1005.00	3.23
0.173	50.00	0.0	0.0	76.10	230.00	81.61	0.0	81.89	51.31	995.00	1005.00	4.22
0.173	50.00	0.0	0.0	76.10	280.00	82.16	0.0	82.50	58.82	995.00	1005.00	4.66
0.173	50.00	0.0	0.0	76.10	420.00	83.89	0.0	84.32	91.52	995.00	1005.00	5.32
0.243	370.00	0.0	0.0	76.50	140.00	81.46	0.0	81.90	20.02	995.00	1005.00	5.35
0.243	370.00	0.0	0.0	76.50	230.00	82.70	0.0	83.28	39.42	995.00	1005.00	6.14
0.243	370.00	0.0	0.0	76.50	280.00	83.31	0.0	83.96	59.17	995.00	1005.00	6.48
0.243	370.00	0.0	0.0	76.50	420.00	84.87	82.63	85.51	66.53	995.00	1005.00	6.66
0.252	50.00	0.0	0.0	76.60	140.00	81.95	0.0	82.06	51.22	995.00	1005.00	2.74
0.252	50.00	0.0	0.0	76.60	230.00	83.29	0.0	83.48	71.94	995.00	1005.00	3.56
0.252	50.00	0.0	0.0	76.60	280.00	83.94	0.0	84.18	82.55	995.00	1005.00	3.94
0.252	50.00	0.0	0.0	76.60	420.00	85.57	0.0	85.71	184.92	995.00	1005.00	3.51
0.255	14.00	85.10	84.50	76.30	140.00	81.97	0.0	82.08	55.90	995.00	1005.00	2.58
0.255	14.00	85.10	84.50	76.30	230.00	83.32	0.0	83.50	77.04	995.00	1005.00	3.40
0.255	14.00	85.10	84.50	76.30	280.00	83.98	0.0	84.20	87.81	995.00	1005.00	3.77
0.255	14.00	85.10	84.50	76.30	420.00	85.71	0.0	85.80	229.88	995.00	1005.00	2.92
0.265	50.00	0.0	0.0	77.10	140.00	82.05	0.0	82.10	108.23	992.00	1008.00	1.74
0.265	50.00	0.0	0.0	77.10	230.00	83.47	0.0	83.53	178.20	992.00	1008.00	2.08
0.265	50.00	0.0	0.0	77.10	280.00	84.16	0.0	84.23	219.02	992.00	1008.00	2.21
0.265	50.00	0.0	0.0	77.10	420.00	85.74	0.0	85.81	345.18	992.00	1008.00	2.42
0.293	148.00	0.0	0.0	76.50	140.00	82.08	0.0	82.12	112.63	992.00	1008.00	1.68
0.293	148.00	0.0	0.0	76.50	230.00	83.49	0.0	83.55	179.50	992.00	1008.00	2.05
0.293	148.00	0.0	0.0	76.50	280.00	84.19	0.0	84.25	218.18	992.00	1008.00	2.20
0.293	148.00	0.0	0.0	76.50	420.00	85.77	0.0	85.83	346.50	992.00	1008.00	2.38
0.302	50.00	0.0	0.0	75.70	140.00	82.08	0.0	82.15	71.37	1994.80	2005.20	2.17
0.302	50.00	0.0	0.0	75.70	230.00	83.48	0.0	83.61	95.56	1994.80	2005.20	2.91
0.302	50.00	0.0	0.0	75.70	280.00	84.20	0.0	84.26	180.58	1994.80	2005.20	2.34
0.302	50.00	0.0	0.0	75.70	420.00	85.84	0.0	85.86	482.00	1994.80	2005.20	1.49
0.305	14.00	84.10	84.80	76.40	140.00	82.07	0.0	82.17	59.57	1994.80	2005.20	2.46
0.305	14.00	84.10	84.80	76.40	230.00	83.47	0.0	83.63	82.82	1994.80	2005.20	3.22
0.305	14.00	84.10	84.80	76.40	280.00	84.14	0.0	84.34	110.39	1994.80	2005.20	3.58
0.305	14.00	84.10	84.80	76.40	420.00	85.78	0.0	85.93	125.37	1994.80	2005.20	3.61
0.315	50.00	0.0	0.0	77.00	140.00	82.13	0.0	82.18	97.86	1993.00	2007.00	1.93
0.315	50.00	0.0	0.0	77.00	230.00	83.59	0.0	83.66	161.42	1993.00	2007.00	2.29
0.315	50.00	0.0	0.0	77.00	280.00	84.29	0.0	84.37	199.00	1993.00	2007.00	2.43
0.315	50.00	0.0	0.0	77.00	420.00	85.93	0.0	85.95	489.90	1993.00	2007.00	1.70
0.342	143.00	0.0	0.0	76.70	140.00	82.15	0.0	82.23	77.18	993.00	1007.00	2.30
0.342	143.00	0.0	0.0	76.70	230.00	83.59	0.0	83.71	125.99	993.00	1007.00	2.80
0.342	143.00	0.0	0.0	76.70	280.00	84.30	0.0	84.41	164.24	993.00	1007.00	2.83
0.342	143.00	0.0	0.0	76.70	420.00	85.94	0.0	85.96	495.55	993.00	1007.00	1.64
0.352	50.00	0.0	0.0	76.30	140.00	82.15	0.0	82.30	43.64	994.80	1005.20	3.02
0.352	50.00	0.0	0.0	76.30	230.00	83.58	0.0	83.80	65.65	994.80	1005.20	3.76
0.352	50.00	0.0	0.0	76.30	280.00	84.26	0.0	84.53	77.07	994.80	1005.20	4.10
0.352	50.00	0.0	0.0	76.30	420.00	85.95	0.0	85.97	344.05	994.80	1005.20	1.74

	SECNC	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
	0.355	14.00	84.50	84.70	76.50	140.00	82.16	0.0	82.32	40.78	994.80	1005.20	3.16
	0.355	14.00	84.50	84.70	76.50	230.00	83.59	0.0	83.83	62.45	994.80	1005.20	3.89
	0.355	14.00	84.50	84.70	76.50	280.00	84.28	0.0	84.55	73.68	994.80	1005.20	4.23
	0.355	14.00	84.50	84.70	76.50	420.00	85.95	0.0	85.97	210.06	994.80	1005.20	1.84
	0.365	50.00	0.0	0.0	77.00	140.00	82.29	0.0	82.34	99.23	993.00	1007.00	1.95
E	0.365	50.00	0.0	0.0	77.00	230.00	83.77	0.0	83.86	155.30	993.00	1007.00	2.43
	0.365	50.00	0.0	0.0	77.00	280.00	84.52	0.0	84.59	211.04	993.00	1007.00	2.34
	0.365	50.00	0.0	0.0	77.00	420.00	85.97	0.0	85.98	764.87	993.00	1007.00	1.10
	0.526	850.00	0.0	0.0	77.50	140.00	82.36	0.0	82.36	687.32	994.00	1006.00	0.28
F	0.526	850.00	0.0	0.0	77.50	230.00	83.87	0.0	83.87	1365.82	994.00	1006.00	0.28
	0.526	850.00	0.0	0.0	77.50	280.00	84.60	0.0	84.60	1762.85	994.00	1006.00	0.29
	0.526	850.00	0.0	0.0	77.50	420.00	85.98	0.0	85.98	2633.01	994.00	1006.00	0.32
	0.534	40.00	0.0	0.0	77.00	120.00	82.35	0.0	82.36	181.06	982.00	1016.00	0.79
	0.534	40.00	0.0	0.0	77.00	200.00	83.87	0.0	83.87	549.38	982.00	1016.00	0.54
G	0.534	40.00	0.0	0.0	77.00	240.00	84.60	0.0	84.60	813.51	982.00	1016.00	0.47
	0.534	40.00	0.0	0.0	77.00	350.00	85.98	0.0	85.98	1447.22	982.00	1016.00	0.44
	0.595	320.00	0.0	0.0	77.20	120.00	82.37	0.0	82.38	166.54	982.00	1014.00	0.84
	0.595	320.00	0.0	0.0	77.20	200.00	83.88	0.0	83.88	457.42	982.00	1016.00	0.64
	0.595	320.00	0.0	0.0	77.20	240.00	84.60	0.0	84.61	661.87	982.00	1016.00	0.57
	0.595	320.00	0.0	0.0	77.20	350.00	85.98	0.0	85.98	1149.43	982.00	1016.00	0.55
	0.638	230.00	0.0	0.0	77.30	110.00	82.38	0.0	82.39	165.29	982.00	1018.00	0.76
H	0.638	230.00	0.0	0.0	77.30	170.00	83.88	0.0	83.88	443.41	982.00	1018.00	0.55
	0.638	230.00	0.0	0.0	77.30	200.00	84.61	0.0	84.61	638.06	982.00	1018.00	0.49
	0.638	230.00	0.0	0.0	77.30	300.00	85.98	0.0	85.99	1102.78	982.00	1018.00	0.49
	0.732	490.00	0.0	0.0	77.60	110.00	82.40	0.0	82.42	134.83	979.00	1018.00	0.89
I	0.732	490.00	0.0	0.0	77.60	170.00	83.89	0.0	83.90	235.00	979.00	1018.00	0.95
	0.732	490.00	0.0	0.0	77.60	200.00	84.61	0.0	84.62	302.76	979.00	1018.00	0.95
	0.732	490.00	0.0	0.0	77.60	300.00	85.99	0.0	86.00	468.27	979.00	1018.00	1.08
	0.891	840.00	0.0	0.0	78.00	110.00	82.46	0.0	82.48	120.56	980.00	1018.00	0.95
J	0.891	840.00	0.0	0.0	78.00	170.00	83.93	0.0	83.95	221.71	980.00	1018.00	1.00
	0.891	840.00	0.0	0.0	78.00	200.00	84.65	0.0	84.66	283.97	980.00	1018.00	1.01
	0.891	840.00	0.0	0.0	78.00	300.00	86.02	0.0	86.04	425.43	980.00	1018.00	1.18
	0.901	53.00	0.0	0.0	78.00	96.00	82.46	0.0	82.49	72.79	1986.00	2014.00	1.27
K	0.901	53.00	0.0	0.0	78.00	150.00	83.93	0.0	83.96	141.12	1986.00	2014.00	1.29
	0.901	53.00	0.0	0.0	78.00	180.00	84.64	0.0	84.67	184.54	1986.00	2014.00	1.31
	0.901	53.00	0.0	0.0	78.00	280.00	86.01	0.0	86.05	282.18	1986.00	2014.00	1.58
	0.997	507.00	0.0	0.0	78.20	96.00	82.56	0.0	82.58	69.03	986.00	1014.00	1.32
	0.997	507.00	0.0	0.0	78.20	150.00	83.99	0.0	84.02	132.54	986.00	1014.00	1.34
L	0.997	507.00	0.0	0.0	78.20	180.00	84.69	0.0	84.72	174.55	986.00	1014.00	1.36
	0.997	507.00	0.0	0.0	78.20	290.00	86.06	0.0	86.10	272.12	986.00	1014.00	1.61
	1.006	50.00	0.0	0.0	78.30	96.00	82.53	0.0	82.65	40.32	996.00	1004.00	2.84
	1.006	50.00	0.0	0.0	78.30	150.00	83.94	0.0	84.11	81.86	996.00	1004.00	3.33
	1.006	50.00	0.0	0.0	78.30	180.00	84.63	0.0	84.82	72.97	996.00	1004.00	3.56
	1.006	50.00	0.0	0.0	78.30	280.00	86.02	0.0	86.17	154.02	996.00	1004.00	3.52

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
	1.018	62.00	86.00	83.30	78.30	96.00	82.56	0.0	82.69	40.87	996.00	1004.00	2.81
	1.018	62.00	86.00	83.30	78.30	150.00	84.12	0.0	84.28	64.72	996.00	1004.00	3.22
	1.018	62.00	86.00	83.30	78.30	180.00	84.94	0.0	85.12	78.08	996.00	1004.00	3.39
	1.018	62.00	86.00	83.30	78.30	280.00	86.17	0.0	86.30	162.84	996.00	1004.00	3.37
	1.028	50.00	0.0	0.0	78.30	96.00	82.68	0.0	82.71	69.94	986.00	1014.00	1.31
	1.028	50.00	0.0	0.0	78.30	150.00	84.28	0.0	84.30	143.43	986.00	1014.00	1.28
	1.028	50.00	0.0	0.0	78.30	180.00	85.12	0.0	85.14	196.04	986.00	1014.00	1.27
	1.028	50.00	0.0	0.0	78.30	280.00	86.29	0.0	86.32	291.95	986.00	1014.00	1.52
M	1.062	180.00	0.0	0.0	78.40	96.00	82.72	0.0	82.75	67.79	986.00	1014.00	1.34
	1.062	180.00	0.0	0.0	78.40	150.00	84.29	0.0	84.32	138.83	986.00	1014.00	1.30
	1.062	180.00	0.0	0.0	78.40	180.00	85.13	0.0	85.16	190.44	986.00	1014.00	1.29
	1.062	180.00	0.0	0.0	78.40	280.00	86.30	0.0	86.34	293.12	986.00	1014.00	1.50
	1.071	50.00	0.0	0.0	78.40	96.00	82.69	0.0	82.83	30.02	2997.00	3003.00	3.29
	1.071	50.00	0.0	0.0	78.40	150.00	84.27	0.0	84.38	61.71	2997.00	3003.00	3.13
	1.071	50.00	0.0	0.0	78.40	180.00	85.11	0.0	85.21	84.67	2997.00	3003.00	3.01
	1.071	50.00	0.0	0.0	78.40	280.00	86.33	0.0	86.35	224.09	2997.00	3003.00	1.98
	1.084	65.00	85.90	82.40	78.40	96.00	82.86	0.0	82.99	32.79	2997.00	3003.00	3.10
	1.084	65.00	85.90	82.40	78.40	150.00	84.91	0.0	84.99	78.82	2997.00	3003.00	2.64
	1.084	65.00	85.90	82.40	78.40	180.00	85.95	0.0	86.00	115.30	2997.00	3003.00	2.40
	1.084	65.00	85.90	82.40	78.40	280.00	86.33	0.0	86.35	233.46	2997.00	3003.00	1.91
	1.094	50.00	0.0	0.0	78.30	96.00	83.00	0.0	83.00	160.89	993.00	1007.00	0.78
	1.094	50.00	0.0	0.0	78.30	150.00	84.99	0.0	84.99	535.22	993.00	1007.00	0.47
	1.094	50.00	0.0	0.0	78.30	180.00	86.01	0.0	86.01	837.11	993.00	1007.00	0.40
	1.094	50.00	0.0	0.0	78.30	280.00	86.35	0.0	86.35	997.31	993.00	1007.00	0.53
	1.249	818.00	0.0	0.0	79.50	96.00	83.05	0.0	83.06	92.70	995.00	1005.00	1.15
	1.249	818.00	0.0	0.0	79.50	150.00	85.00	0.0	85.00	442.32	995.00	1005.00	0.51
	1.249	818.00	0.0	0.0	79.50	180.00	86.01	0.0	86.01	829.01	995.00	1005.00	0.37
	1.249	818.00	0.0	0.0	79.50	280.00	86.35	0.0	86.35	1006.06	995.00	1005.00	0.49
	1.258	50.00	0.0	0.0	79.10	96.00	82.92	0.0	83.73	9.22	1998.00	2002.00	7.23
	1.258	50.00	0.0	0.0	79.10	150.00	84.99	0.0	85.07	41.51	1998.00	2002.00	2.97
	1.258	50.00	0.0	0.0	79.10	180.00	86.01	0.0	86.05	66.76	1998.00	2002.00	2.33
	1.258	50.00	0.0	0.0	79.10	280.00	86.34	0.0	86.43	77.27	1998.00	2002.00	3.18
	1.269	56.00	86.00	83.10	79.70	96.00	84.28	82.72	85.67	4.38	1998.00	2002.00	9.46
	1.269	56.00	86.00	83.10	79.70	150.00	86.22	0.0	86.26	55.94	1998.00	2002.00	2.28
	1.269	56.00	86.00	83.10	79.70	180.00	86.30	0.0	86.36	58.17	1998.00	2002.00	2.64
	1.269	56.00	86.00	83.10	79.70	280.00	86.33	0.0	86.47	58.99	1998.00	2002.00	4.06
N	1.279	50.00	0.0	0.0	79.60	96.00	85.81	0.0	85.81	472.27	995.00	1005.00	0.33
	1.279	50.00	0.0	0.0	79.60	150.00	86.27	0.0	86.27	678.91	995.00	1005.00	0.37
	1.279	50.00	0.0	0.0	79.60	180.00	86.37	0.0	86.37	732.05	995.00	1005.00	0.42
	1.279	50.00	0.0	0.0	79.60	280.00	86.49	0.0	86.49	797.85	995.00	1005.00	0.61
	1.297	95.00	0.0	0.0	79.70	96.00	85.81	0.0	85.82	109.60	997.50	1002.50	1.41
	1.297	95.00	0.0	0.0	79.70	150.00	86.27	0.0	86.28	180.32	997.50	1002.50	1.41
	1.297	95.00	0.0	0.0	79.70	180.00	86.37	0.0	86.38	217.57	997.50	1002.50	1.42
	1.297	95.00	0.0	0.0	79.70	280.00	86.49	0.0	86.50	269.47	997.50	1002.50	1.80

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	[illegible]	STCHL	STCHR	VCH
1.304	37.00	85.90	83.10	79.10	96.00	86.04	0.0	86.05	116.15	997.50	1002.50	1.15
1.304	37.00	85.90	83.10	79.10	150.00	86.27	0.0	86.28	172.11	997.50	1002.50	1.24
1.304	37.00	85.90	83.10	79.10	180.00	86.37	0.0	86.38	209.67	997.50	1002.50	1.24
1.304	37.00	85.90	83.10	79.10	280.00	86.49	0.0	86.50	263.26	997.50	1002.50	1.55
1.313	50.00	0.0	0.0	79.10	96.00	86.05	0.0	86.05	375.[illegible]	994.00	1006.00	0.44
1.313	50.00	0.0	0.0	79.10	150.00	86.28	0.0	86.28	475.44	994.00	1006.00	0.55
1.313	50.00	0.0	0.0	79.10	180.00	86.38	0.0	86.38	533.23	994.00	1006.00	0.59
1.313	50.00	0.0	0.0	79.10	280.00	86.50	0.0	86.50	610.14	994.00	1006.00	0.82
1.487	918.00	0.0	0.0	80.70	96.00	86.08	0.0	86.10	104.39	995.00	1005.00	1.28
1.487	918.00	0.0	0.0	80.70	150.00	86.33	0.0	86.37	115.32	995.00	1005.00	1.87
1.487	918.00	0.0	0.0	80.70	180.00	86.45	0.0	86.50	121.44	995.00	1005.00	2.16
1.487	918.00	0.0	0.0	80.70	280.00	86.64	0.0	86.75	131.75	995.00	1005.00	3.17
1.496	50.00	0.0	0.0	81.00	96.00	86.07	0.0	86.12	65.61	994.10	1005.90	1.64
1.496	50.00	0.0	0.0	81.00	150.00	86.32	0.0	86.41	70.50	994.10	1005.90	2.43
1.496	50.00	0.0	0.0	81.00	180.00	86.43	0.0	86.56	72.53	994.10	1005.90	2.87
1.496	50.00	0.0	0.0	81.00	280.00	86.69	0.0	86.78	144.66	994.10	1005.90	2.80
1.505	51.00	87.60	84.00	81.00	96.00	86.20	0.0	86.24	67.96	994.10	1005.90	1.60
1.505	51.00	87.60	84.00	81.00	150.00	86.65	0.0	86.73	76.85	994.10	1005.90	2.30
1.505	51.00	87.60	84.00	81.00	180.00	86.91	0.0	87.02	82.24	994.10	1005.90	2.63
1.505	51.00	87.60	84.00	81.00	280.00	87.87	0.0	87.90	232.74	994.10	1005.90	1.97
1.515	50.00	0.0	0.0	81.00	96.00	86.23	0.0	86.25	117.02	995.00	1005.00	1.19
1.515	50.00	0.0	0.0	81.00	150.00	86.72	0.0	86.74	159.57	995.00	1005.00	1.45
1.515	50.00	0.0	0.0	81.00	180.00	87.02	0.0	87.03	190.21	995.00	1005.00	1.51
1.515	50.00	0.0	0.0	81.00	280.00	87.89	0.0	87.91	307.26	995.00	1005.00	1.59

10 YEAR MULTIPLE
SUMMARY PRINTOUT

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
0.006	78.34	0.0	0.0	0.0	987.32	0.0	25.46	0.0	1012.78	0.05	139.90	0.06
0.006	79.02	0.68	0.74	0.0	985.96	0.0	28.39	0.0	1014.35	0.89	270.08	1.03
0.006	79.34	0.32	1.09	0.0	985.32	0.0	29.76	0.0	1015.08	1.84	276.02	2.15
0.006	80.13	0.79	1.96	0.0	983.74	0.0	33.16	0.0	1016.90	6.31	406.32	7.37
0.087	79.06	0.0	0.0	0.72	990.31	0.0	19.37	0.0	1009.69	0.0	140.00	0.0
0.087	79.78	0.72	0.81	0.76	990.07	0.0	19.85	0.0	1009.93	0.0	230.00	0.0
0.087	80.11	0.33	1.19	0.77	989.59	0.0	20.74	0.0	1010.33	0.00	280.00	0.00
0.087	80.89	0.78	2.10	0.76	986.56	0.0	26.02	0.0	1012.67	1.55	417.22	1.23
0.096	79.16	0.0	0.0	0.10	990.70	0.0	18.70	0.0	1009.40	0.0	140.00	0.0
0.096	79.88	0.72	0.81	0.11	990.70	0.0	18.70	0.0	1009.40	0.0	230.00	0.0
0.096	80.22	0.33	1.20	0.11	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.096	80.99	0.77	2.12	0.10	990.70	0.0	18.70	0.0	1009.40	0.0	420.00	0.0
0.116	79.31	0.0	0.0	0.15	990.70	0.0	18.70	0.0	1009.40	0.0	140.00	0.0
0.116	80.06	0.75	0.83	0.18	990.70	0.0	18.70	0.0	1009.40	0.0	230.00	0.0
0.116	80.41	0.35	1.23	0.19	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.116	81.23	0.82	2.18	0.24	990.70	0.0	18.70	0.0	1009.40	0.0	420.00	0.0
0.125	79.36	0.0	0.0	0.05	987.98	0.0	28.07	0.0	1016.05	1.70	128.55	5.74
0.125	80.13	0.77	0.80	0.07	986.75	0.0	30.50	0.0	1017.25	5.06	201.91	23.02
0.125	80.50	0.37	1.19	0.09	986.17	0.0	31.65	0.0	1017.83	7.46	241.63	30.91
0.125	81.42	0.92	2.14	0.19	984.69	0.0	34.60	0.0	1019.29	16.08	349.04	54.89
0.139	79.51	0.0	0.0	0.15	995.04	0.0	9.91	0.0	1004.95	0.0	140.00	0.0
0.139	80.12	0.61	0.98	-0.01	995.02	0.0	9.94	0.0	1004.97	0.0	230.00	0.0
0.139	80.40	0.28	1.48	-0.10	995.02	0.0	9.96	0.0	1004.97	0.0	280.00	0.0
0.139	81.04	0.64	2.77	-0.38	995.00	0.0	9.99	0.0	1004.99	0.0	420.00	0.0
0.148	80.03	0.0	0.0	0.51	995.03	0.0	9.94	0.0	1004.97	0.0	140.00	0.0
0.148	80.97	0.94	1.12	0.85	995.00	0.0	9.98	0.0	1004.99	0.0	230.00	0.0
0.148	81.45	0.48	1.69	1.05	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.148	82.70	1.25	3.16	1.66	995.00	0.0	10.00	0.0	1005.00	0.0	420.00	0.0
0.164	80.25	0.0	0.0	0.22	995.03	0.0	9.93	0.0	1004.96	0.0	140.00	0.0
0.164	81.27	1.02	1.19	0.30	995.01	0.0	9.98	0.0	1004.98	0.0	230.00	0.0
0.164	81.78	0.52	1.75	0.33	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.164	83.50	1.72	3.62	0.80	995.00	0.0	10.00	0.0	1005.00	0.0	420.00	0.0
0.173	80.49	0.0	0.0	0.25	995.03	0.0	9.95	0.0	1004.97	0.0	140.00	0.0
0.173	81.61	1.12	1.23	0.34	995.01	0.0	9.99	0.0	1004.99	0.0	230.00	0.0
0.173	82.16	0.55	1.85	0.38	994.72	0.0	10.89	0.0	1005.62	0.00	280.00	0.00
0.173	83.89	1.73	3.67	0.39	991.85	0.0	20.25	0.0	1012.09	2.53	411.32	6.15
0.243	81.45	0.0	0.0	0.96	995.64	0.0	8.73	0.0	1004.36	0.0	140.00	0.0
0.243	82.70	1.24	1.38	1.09	995.32	0.0	9.35	0.0	1004.68	0.0	230.00	0.0
0.243	83.31	0.61	2.06	1.14	995.17	0.0	9.65	0.0	1004.83	0.0	280.00	0.0
0.243	84.87	1.56	3.61	0.98	984.13	0.0	96.92	0.0	1081.06	3.62	390.56	25.41
0.252	81.95	0.0	0.0	0.49	995.00	0.0	10.00	0.0	1005.00	0.0	140.00	0.0
0.252	83.29	1.34	1.42	0.58	995.00	0.0	10.00	0.0	1005.00	0.0	230.00	0.0
0.252	83.54	0.65	2.11	0.63	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.252	85.57	1.63	3.64	0.70	861.18	0.0	244.53	0.0	1105.72	52.18	306.97	60.86

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
0.255	81.97	0.0	0.0	0.03	995.00	0.0	10.00	0.0	1005.00	0.0	140.00	0.0
0.255	83.32	1.35	1.43	0.04	995.00	0.0	10.00	0.0	1005.00	0.0	230.00	0.0
0.255	83.98	0.65	2.12	0.04	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.255	85.71	1.74	3.72	0.15	799.56	0.0	630.47	0.0	1430.04	73.06	268.13	78.81
0.265	82.05	0.0	0.0	0.08	981.85	0.0	31.94	0.0	1013.78	7.37	129.01	3.63
0.265	83.47	1.42	1.43	0.10	977.68	0.0	39.03	0.0	1016.70	19.64	200.98	9.37
0.265	84.16	0.69	2.13	0.19	974.89	0.0	43.42	0.0	1018.32	27.98	238.54	13.48
0.265	85.74	1.58	3.72	0.03	915.85	0.0	223.61	0.0	1139.46	56.80	322.04	41.16
0.293	82.08	0.0	0.0	0.03	981.74	0.0	31.39	0.0	1013.13	5.40	132.09	2.51
0.293	83.49	1.42	1.43	0.02	977.02	0.0	38.47	0.0	1015.49	15.27	207.64	7.09
0.293	84.19	0.69	2.13	0.02	974.71	0.0	41.93	0.0	1016.64	22.40	247.19	10.40
0.293	85.77	1.58	3.71	0.02	831.57	0.0	527.49	0.0	1359.05	53.09	327.74	39.17
0.302	82.08	0.0	0.0	-0.00	1994.80	0.0	10.40	0.0	2005.20	0.0	140.00	0.0
0.302	83.48	1.40	1.46	-0.02	1994.80	0.0	10.40	0.0	2005.20	0.0	230.00	0.0
0.302	84.20	0.72	2.12	0.01	1884.01	0.0	121.19	0.0	2005.20	77.37	202.63	0.0
0.302	85.84	1.64	3.71	0.08	1606.46	0.0	851.30	0.0	2457.76	163.15	153.92	102.93
0.305	82.07	0.0	0.0	-0.00	1994.80	0.0	10.40	0.0	2005.20	0.0	140.00	0.0
0.305	83.47	1.40	1.47	-0.01	1994.80	0.0	10.40	0.0	2005.20	0.0	230.00	0.0
0.305	84.14	0.67	2.17	-0.06	1955.04	0.0	50.16	0.0	2005.20	0.0	280.00	0.0
0.305	85.78	1.64	3.77	-0.06	1734.69	0.0	590.53	0.0	2324.62	89.03	306.49	24.47
0.315	82.13	0.0	0.0	0.06	1984.66	0.0	29.23	0.0	2013.89	4.57	130.14	5.28
0.315	83.59	1.45	1.47	0.11	1975.50	0.0	41.40	0.0	2016.90	14.65	201.24	14.12
0.315	84.29	0.70	2.18	0.15	1971.08	0.0	47.28	0.0	2018.35	22.87	237.17	19.96
0.315	85.93	1.64	3.77	0.15	1810.87	0.0	648.62	0.0	2459.49	62.17	205.54	152.29
0.342	82.15	0.0	0.0	0.02	991.42	0.0	17.47	0.0	1008.89	0.76	138.25	1.00
0.342	83.59	1.44	1.48	0.01	990.70	0.0	19.05	0.0	1009.75	2.08	225.18	2.74
0.342	84.30	0.71	2.18	0.01	990.35	0.0	403.07	0.0	1393.42	2.84	255.24	21.91
0.342	85.94	1.65	3.73	0.01	787.18	0.0	680.28	0.0	1467.45	13.55	185.55	220.90
0.352	82.15	0.0	0.0	0.00	994.80	0.0	10.40	0.0	1005.20	0.0	140.00	0.0
0.352	83.58	1.43	1.50	-0.01	994.80	0.0	10.40	0.0	1005.20	0.0	230.00	0.0
0.352	84.26	0.68	2.23	-0.03	994.80	0.0	10.40	0.0	1005.20	0.0	280.00	0.0
0.352	85.95	1.69	3.67	0.01	712.38	0.0	714.19	0.0	1426.58	70.09	149.25	200.66
0.355	82.16	0.0	0.0	0.01	994.80	0.0	10.40	0.0	1005.20	0.0	140.00	0.0
0.355	83.59	1.43	1.51	0.01	994.80	0.0	10.40	0.0	1005.20	0.0	230.00	0.0
0.355	84.28	0.69	2.24	0.01	994.80	0.0	10.40	0.0	1005.20	0.0	280.00	0.0
0.355	85.95	1.68	3.65	0.00	739.12	0.0	686.59	0.0	1425.70	57.66	129.60	232.74
0.365	82.29	0.0	0.0	0.12	991.53	0.0	19.16	0.0	1010.69	0.63	136.94	2.43
0.365	83.77	1.48	1.51	0.18	988.21	0.0	23.69	0.0	1011.90	1.68	221.40	6.91
0.365	84.52	0.75	2.25	0.24	975.98	0.0	485.79	0.0	1461.77	3.41	237.80	38.74
0.365	85.97	1.45	3.63	0.02	255.22	0.0	1212.70	0.0	1467.91	131.04	133.39	155.58
0.526	82.36	0.0	0.0	0.07	632.77	0.0	532.93	0.0	1165.71	75.86	16.41	47.73
0.526	83.87	1.52	1.52	0.10	623.30	0.0	552.51	0.0	1175.81	133.77	21.40	74.83
0.526	84.60	0.73	2.24	0.08	618.75	0.0	561.93	0.0	1180.67	165.91	24.21	89.88
0.526	85.98	1.38	3.62	0.01	610.12	0.0	579.75	0.0	1189.87	254.62	32.74	132.64

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	GLOB	QCH	QROB
0.534	82.35	0.0	0.0	-0.01	666.62	0.0	476.09	0.0	1142.70	8.05	108.74	3.21
0.534	83.87	1.52	1.51	-0.00	652.41	0.0	501.67	0.0	1154.07	70.05	101.62	28.33
0.534	84.60	0.73	2.24	-0.00	645.58	0.0	513.95	0.0	1159.53	98.70	101.12	40.18
0.534	85.98	1.38	3.62	-0.00	632.68	0.0	537.18	0.0	1169.86	166.20	115.34	68.46
0.595	82.37	0.0	0.0	0.01	817.31	0.0	344.94	0.0	1162.24	4.52	111.46	4.02
0.595	83.88	1.51	1.50	0.00	805.95	0.0	365.76	0.0	1171.71	43.97	117.01	23.02
0.595	84.60	0.73	2.23	0.00	800.49	0.0	375.78	0.0	1176.26	63.70	119.81	33.49
0.595	85.98	1.38	3.61	0.00	790.14	0.0	394.74	0.0	1184.88	110.78	141.10	98.12
0.638	82.38	0.0	0.0	0.01	700.48	0.0	317.69	0.0	1018.17	7.73	102.27	0.00
0.638	83.88	1.50	1.50	0.00	682.46	0.0	338.96	0.0	1021.41	66.14	103.56	0.31
0.638	84.61	0.73	2.22	0.00	673.74	0.0	349.25	0.0	1022.98	94.15	105.16	0.69
0.638	85.98	1.38	3.60	0.00	657.20	0.0	368.77	0.0	1025.96	168.82	129.10	2.09
0.732	82.40	0.0	0.0	0.02	982.24	0.0	35.36	0.0	1017.60	0.0	110.00	0.0
0.732	83.89	1.49	1.49	0.01	979.23	0.0	41.80	0.0	1021.03	0.0	169.63	0.37
0.732	84.61	0.72	2.21	0.00	943.88	0.0	78.85	0.0	1022.73	1.91	196.98	1.11
0.732	85.99	1.37	3.59	0.00	930.12	0.0	95.85	0.0	1025.97	15.07	280.61	4.32
0.891	82.46	0.0	0.0	0.06	981.28	0.0	35.65	0.0	1016.93	0.0	110.00	0.0
0.891	83.93	1.47	1.47	0.05	978.13	0.0	42.36	0.0	1020.49	0.08	169.73	0.19
0.891	84.65	0.71	2.19	0.04	976.72	0.0	45.65	0.0	1022.37	0.33	198.89	0.79
0.891	86.02	1.37	3.56	0.03	769.18	0.0	257.40	0.0	1026.58	1.68	294.33	3.99
0.901	82.46	0.0	0.0	-0.00	1987.06	0.0	25.88	0.0	2012.94	0.0	96.00	0.0
0.901	83.93	1.47	1.47	-0.00	1985.38	0.0	30.50	0.0	2015.87	0.03	149.78	0.19
0.901	84.64	0.71	2.18	-0.00	1984.90	0.0	32.40	0.0	2017.30	0.11	179.08	0.81
0.901	86.01	1.37	3.56	-0.01	1406.97	0.0	613.90	0.0	2020.87	0.71	275.18	4.11
0.997	82.55	0.0	0.0	0.09	987.29	0.0	25.42	0.0	1012.71	0.0	96.00	0.0
0.997	83.99	1.44	1.44	0.06	984.32	0.0	31.36	0.0	1015.68	0.08	149.78	0.14
0.997	84.69	0.70	2.14	0.05	982.81	0.0	34.38	0.0	1017.19	0.40	178.90	0.70
0.997	86.06	1.37	3.52	0.05	724.31	0.0	298.54	0.0	1022.85	2.76	273.22	4.02
1.006	82.63	0.0	0.0	-0.03	996.00	0.0	8.00	0.0	1004.00	0.0	96.00	0.0
1.006	83.94	1.41	1.46	-0.05	996.00	0.0	8.00	0.0	1004.00	0.0	150.00	0.0
1.006	84.63	0.69	2.17	-0.07	996.00	0.0	8.00	0.0	1004.00	0.0	180.00	0.0
1.006	86.02	1.39	3.52	-0.05	688.61	0.0	315.39	0.0	1004.00	62.88	217.12	0.0
1.018	82.56	0.0	0.0	0.04	996.00	0.0	8.00	0.0	1004.00	0.0	96.00	0.0
1.018	84.12	1.55	1.59	0.18	996.00	0.0	8.00	0.0	1004.00	0.0	150.00	0.0
1.018	84.94	0.82	2.43	0.31	996.00	0.0	8.00	0.0	1004.00	0.0	180.00	0.0
1.018	86.17	1.23	3.62	0.15	676.71	0.0	327.29	0.0	1004.00	67.99	212.01	0.0
1.028	82.68	0.0	0.0	0.12	987.23	0.0	25.53	0.0	1012.77	0.0	96.00	0.0
1.028	84.28	1.59	1.59	0.16	983.83	0.0	32.33	0.0	1016.17	0.14	149.62	0.24
1.028	85.12	0.84	2.43	0.18	981.96	0.0	36.08	0.0	1018.04	0.63	178.26	1.10
1.028	86.29	1.17	3.61	0.12	612.83	0.0	421.38	0.0	1034.26	11.55	263.69	4.76
1.062	82.72	0.0	0.0	0.03	987.36	0.0	25.27	0.0	1012.64	0.0	96.00	0.0
1.062	84.29	1.58	1.58	0.02	983.94	0.0	32.13	0.0	1016.06	0.12	149.68	0.20
1.062	85.13	0.84	2.41	0.01	982.00	0.0	35.99	0.0	1018.00	0.60	178.36	1.04
1.062	86.30	1.17	3.59	0.02	445.96	0.0	589.64	0.0	1035.60	17.81	257.49	4.71

SECNO	GWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
1.071	82.69	0.0	0.0	-0.03	2988.68	0.0	20.19	0.0	3008.87	10.46	78.38	7.16
1.071	84.27	1.58	1.55	-0.02	2983.80	0.0	28.52	0.0	3012.32	27.22	104.15	18.64
1.071	85.11	0.84	2.37	-0.01	2981.20	0.0	32.95	0.0	3014.15	38.44	115.25	26.32
1.071	86.33	1.21	3.51	0.02	1435.78	0.0	2454.90	0.0	3890.68	114.24	40.36	75.40
1.084	82.86	0.0	0.0	0.17	2988.15	0.0	21.10	0.0	3009.25	11.29	76.98	7.73
1.084	84.91	2.05	2.00	0.64	2981.82	0.0	31.90	0.0	3013.72	30.95	97.86	21.19
1.084	85.95	1.04	3.02	0.84	2953.21	0.0	271.67	0.0	3272.19	44.96	103.88	31.16
1.084	86.33	0.38	3.76	0.00	1434.97	0.0	2455.74	0.0	3890.72	116.47	87.07	76.46
1.094	83.00	0.0	0.0	0.13	875.02	0.0	219.76	0.0	1094.78	20.97	48.23	26.80
1.094	84.99	2.00	1.99	0.08	865.04	0.0	324.61	0.0	1189.64	53.89	42.16	53.95
1.094	86.01	1.01	3.01	0.06	589.56	0.0	1340.45	0.0	1930.01	66.96	41.30	71.74
1.094	86.35	0.34	3.35	0.02	567.84	0.0	1362.64	0.0	1930.49	103.40	58.02	118.58
1.249	83.05	0.0	0.0	0.06	971.90	0.0	198.57	0.0	1170.48	9.78	39.11	47.11
1.249	85.00	1.95	1.94	0.01	654.89	0.0	555.14	0.0	1210.03	33.54	27.30	89.15
1.249	86.01	1.01	2.95	0.00	529.18	0.0	710.85	0.0	1240.02	60.96	23.32	95.72
1.249	86.35	0.34	3.29	0.01	503.48	0.0	737.26	0.0	1240.74	104.44	32.62	142.94
1.258	82.92	0.0	0.0	-0.13	1998.00	0.0	4.00	0.0	2002.00	0.0	96.00	0.0
1.258	84.99	2.07	1.84	-0.01	1998.00	0.0	34.91	0.0	2032.91	0.0	64.22	85.77
1.258	86.01	1.01	2.32	-0.00	1998.00	0.0	43.35	0.0	2041.35	0.0	59.82	120.14
1.258	86.34	0.34	2.69	-0.01	1998.00	0.0	46.35	0.0	2044.35	0.0	85.98	194.02
1.269	84.28	0.0	0.0	1.36	1998.00	0.0	4.00	0.0	2002.00	0.0	96.00	0.0
1.269	86.22	1.94	0.59	1.22	1998.00	0.0	39.91	0.0	2037.91	0.0	54.86	95.14
1.269	86.30	0.09	0.69	0.30	1998.00	0.0	40.65	0.0	2038.65	0.0	64.47	115.53
1.269	86.33	0.03	0.80	-0.01	1998.00	0.0	40.92	0.0	2038.92	0.0	99.54	180.46
1.279	85.81	0.0	0.0	1.53	479.26	0.0	794.97	0.0	1274.23	35.99	19.97	40.05
1.279	86.27	0.46	0.46	0.05	424.63	0.0	856.04	0.0	1280.67	63.84	24.49	61.47
1.279	86.37	0.10	0.56	0.07	422.62	0.0	858.30	0.0	1280.92	78.51	27.96	73.53
1.279	86.49	0.12	0.68	0.16	420.24	0.0	860.98	0.0	1281.22	125.38	41.11	113.52
1.297	85.81	0.0	0.0	-0.00	951.23	0.0	95.32	0.0	1046.54	32.49	43.00	20.50
1.297	86.27	0.46	0.45	-0.00	408.69	0.0	1621.36	0.0	2270.53	48.73	46.06	55.21
1.297	86.37	0.10	0.55	-0.00	404.34	0.0	1625.92	0.0	2270.74	56.11	47.01	76.88
1.297	86.49	0.12	0.68	0.00	399.23	0.0	1631.28	0.0	2270.98	83.53	60.84	135.63
1.304	86.04	0.0	0.0	0.23	417.97	0.0	1611.63	0.0	2270.10	34.69	39.20	22.11
1.304	86.27	0.23	0.23	0.00	408.37	0.0	1621.70	0.0	2270.55	49.74	43.71	56.55
1.304	86.37	0.10	0.33	0.00	404.00	0.0	1626.28	0.0	2270.75	57.03	44.12	78.85
1.304	86.49	0.12	0.45	0.00	398.78	0.0	1631.76	0.0	2271.00	84.52	56.29	139.19
1.313	86.05	0.0	0.0	0.0	527.83	0.0	1762.26	0.0	2290.09	57.23	34.56	4.22
1.313	86.28	0.23	0.23	0.01	516.06	0.0	1774.55	0.0	2290.61	88.06	45.10	16.85
1.313	86.38	0.10	0.33	0.01	510.82	0.0	1780.02	0.0	2290.84	103.46	49.56	26.98
1.313	86.50	0.12	0.45	0.01	504.51	0.0	1786.61	0.0	2291.12	156.24	69.38	54.39
1.487	86.08	0.0	0.0	0.03	969.66	0.0	45.55	0.0	1015.21	23.43	65.29	7.27
1.487	86.33	0.25	0.27	0.06	953.94	0.0	61.88	0.0	1015.81	38.34	99.68	11.98
1.487	86.45	0.12	0.40	0.07	945.82	0.0	70.30	0.0	1016.12	47.23	118.04	14.73
1.487	86.64	0.20	0.65	0.15	933.09	0.0	83.52	0.0	1016.61	76.84	179.47	23.69

SECNO	CWSEL	DIFWSP	DIFSG	DIFWSX	SSTA	STENCL	TOPMID	STENCR	ENDST	QLOB	QCH	QROB
1.496	86.07	0.0	0.0	-0.00	994.10	0.0	11.80	0.0	1005.90	0.0	96.00	0.0
1.496	86.32	0.25	0.30	-0.01	994.10	0.0	11.80	0.0	1005.90	0.0	150.00	0.0
1.496	86.43	0.11	0.44	-0.02	994.10	0.0	11.80	0.0	1005.90	0.0	180.00	0.0
1.496	86.69	0.26	0.66	0.05	962.01	0.0	77.92	0.0	1039.93	55.93	184.41	39.66
1.505	86.20	0.0	0.0	0.13	994.10	0.0	11.80	0.0	1005.90	0.0	96.00	0.0
1.505	86.65	0.45	0.49	0.33	994.10	0.0	11.80	0.0	1005.90	0.0	150.00	0.0
1.505	86.91	0.26	0.78	0.48	994.10	0.0	11.80	0.0	1005.90	0.0	180.00	0.0
1.505	87.87	0.96	1.66	1.17	952.00	0.0	114.61	0.0	1066.61	66.65	157.45	55.90
1.515	86.23	0.0	0.0	0.03	922.98	0.0	138.75	0.0	1061.73	14.30	59.45	22.26
1.515	86.72	0.49	0.49	0.08	908.30	0.0	167.50	0.0	1075.80	30.62	79.56	39.82
1.515	87.02	0.29	0.79	0.11	899.54	0.0	184.65	0.0	1084.19	42.00	87.30	50.70
1.515	87.89	0.88	1.66	0.03	873.43	0.0	235.79	0.0	1109.21	84.66	106.14	89.19

SUMMARY OF ERRORS

PLOT DECK PRINTOUT FOLLOWS

0.006	76.000	78.340	79.020	79.340	80.130	0.0	07/11/78
0.087	76.600	79.061	79.778	80.111	80.892	0.0	07/11/78
0.096	76.600	79.159	79.883	80.218	80.992	0.0	07/11/78
0.116	76.600	79.309	80.060	80.409	81.228	83.5000	07/11/78
0.125	77.500	79.359	80.131	80.501	81.418	0.0	07/11/78
0.139	76.900	79.511	80.118	80.400	81.042	0.0	07/11/78
0.148	76.300	80.026	80.971	81.452	82.627	0.0	07/11/78
0.164	76.700	80.246	81.269	81.784	83.501	82.0000	07/11/78
0.173	76.100	80.495	81.611	82.164	83.891	0.2	07/11/78
0.243	76.500	81.455	82.697	83.309	84.870	0.0	07/11/78
0.252	76.600	81.947	83.287	83.937	85.566	0.0	07/11/78
0.255	76.300	81.973	83.324	83.978	85.715	84.5000	07/11/78
0.265	77.100	82.052	83.470	84.163	85.742	0.0	07/11/78
0.293	76.500	82.078	83.495	84.187	85.765	0.0	07/11/78
0.302	75.700	82.076	83.477	84.201	85.843	0.0	07/11/78
0.305	76.400	82.072	83.472	84.140	85.784	84.8000	07/11/78
0.315	77.000	82.131	83.586	84.288	85.929	0.0	07/11/78
0.342	76.700	82.150	83.591	84.298	85.943	0.0	07/11/78
0.352	76.300	82.154	83.579	84.264	85.951	0.0	07/11/78
0.355	76.500	82.163	83.590	84.275	85.954	84.7000	07/11/78
0.365	77.000	82.287	83.770	84.517	85.970	0.0	07/11/78
0.526	77.500	82.357	83.872	84.601	85.980	0.0	07/11/78
0.534	77.000	82.351	83.871	84.600	85.980	0.0	07/11/78
0.595	77.200	82.366	83.875	84.603	85.982	0.0	07/11/78
0.638	77.300	82.379	83.880	84.606	85.984	0.0	07/11/78
0.732	77.150	82.403	83.888	84.611	85.985	0.0	07/11/78
0.891	78.000	82.465	83.934	84.649	86.020	0.0	07/11/78
0.901	78.000	82.464	83.931	84.645	86.012	0.0	07/11/78
0.997	78.200	82.556	83.991	84.695	86.063	0.0	07/11/78
1.006	78.300	82.526	83.937	84.629	86.017	0.0	07/11/78
1.018	78.300	82.563	84.116	84.941	86.167	83.3000	07/11/78
1.028	78.300	82.683	84.275	85.117	86.285	0.0	07/11/78
1.062	78.400	82.718	84.295	85.132	86.304	0.0	07/11/78
1.071	78.400	82.692	84.271	85.111	86.325	0.0	07/11/78
1.084	78.400	82.863	84.912	85.947	86.327	82.4000	07/11/78
1.094	78.300	82.995	84.993	86.007	86.347	0.0	07/11/78
1.249	79.500	83.051	85.001	86.011	86.354	0.0	07/11/78
1.258	79.100	82.924	84.995	86.006	86.345	0.0	07/11/78
1.269	79.700	84.282	86.218	86.303	86.333	83.1000	07/11/78
1.279	79.600	85.811	86.267	86.369	86.488	0.0	07/11/78
1.297	79.700	85.807	86.266	86.368	86.488	0.0	07/11/78
1.304	79.100	86.039	86.268	86.371	86.492	83.1000	07/11/78
1.313	79.100	86.048	86.276	86.377	86.500	0.0	07/11/78
1.487	80.700	86.078	86.333	86.449	86.645	0.0	07/11/78
1.496	81.000	86.074	86.321	86.431	86.694	0.0	07/11/78
1.505	81.000	86.201	86.646	86.910	87.860	84.0000	07/11/78
1.515	81.000	86.234	86.723	87.015	87.893	0.0	07/11/78

THIS RUN EXECUTED 07/12/78 09.29.18

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
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T1      FLOOD INSURANCE STUDY   READING,MASS
T2      WALKERS BROOK
T3      100 YEAR NATURAL

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        4.        0.        0.  0.0           0.0         0         0.    79.340    0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
    1.000     0.0       -1.000    0.0       0.0       0.0       0.0       0.0       0.0       0.0
J3  VARIABLE CODES FOR SUMMARY PRINTOUT
    38.000    39.000    40.000    41.000    42.000    43.000    1.000     2.000     3.000     34.000
    21.000    22.000    26.000    0.0       38.000    1.000     50.000    61.000    51.000    53.000
    27.000    4.000     28.000    54.000    13.000    14.000    15.000    0.0       0.0       0.0
J6  IHLEQ     ICOPY
        1.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0

NC      0.040     0.040     0.030     0.100     0.300     0.0       0.0       0.0       0.0       0.0
QT      8.000     140.000   230.000   280.000   420.000   280.000   280.000   280.000   280.000   0.0
ET      0.0       988.000   1012.000  0.0       0.0       0.0       0.0       0.0       2.100     0.0
ET      0.0       0.0       0.0       0.0       0.0       7.600     10.600    13.600    0.0       0.0

X1      0.006     14.000    988.000   1012.000  0.0       0.0       0.0       0.0       0.0       0.0
GR      90.000    760.000   88.000    800.000   88.000    945.000   86.000    965.000   84.000    972.000
GR      82.000    980.000   78.000    988.000   76.500    989.000   76.000    1000.000  76.500    1011.000
GR      78.000    1012.000  88.000    1035.000  88.000    1040.000  90.000    1055.000  0.0       0.0
ET      0.0       990.000   1010.000  0.0       0.0       0.0       0.0       0.0       2.100     0.0

X1      0.087     13.000    990.000   1010.000  438.000   438.000   438.000   0.0       0.0       0.0
GR      90.000    880.000   88.000    910.000   86.000    950.000   84.000    975.000   80.000    990.000
GR      77.000    991.000   76.600    1000.000  77.000    1009.000  80.000    1010.000  84.000    1022.000
GR      86.000    1041.000  88.000    1066.000  90.000    1270.000  0.0       0.0       0.0       0.0
NC      0.0       0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0
ET      0.0       990.700   1009.400  0.0       0.0       0.0       0.0       0.0       2.100     0.0

X1      0.096     13.000    990.700   1009.400  50.000    50.000    50.000    0.0       0.0       0.0
X3      10.000    0.0       0.0       0.0       0.0       0.0       0.0       89.900    87.600    0.0
GR      92.000    830.000   91.200    975.000   85.000    985.000   78.000    990.600   77.000    990.700
GR      76.600    1000.000  77.000    1009.400  78.000    1009.500  86.000    1030.000  88.200    1050.000
GR      87.600    1100.000  90.000    1345.000  100.000   1375.000  0.0       0.0       0.0       0.0
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	SB	0.0	1.500	2.800	0.0	18.700	0.0	130.900	0.0	76.600	76.600
	X1	0.116	0.0	0.0	0.0	103.000	103.000	103.000	0.0	0.0	0.0
	X2	0.0	0.0	1.000	83.500	1.600	0.0	0.0	0.0	0.0	0.0
	X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	89.900	87.600	0.0
	BT	13.000	830.000	92.000	0.0	975.000	91.200	0.0	985.000	90.500	0.0
	BT	990.600	89.900	0.0	990.700	89.900	83.500	1000.000	89.900	83.500	1009.400
	BT	89.900	83.500	1009.500	89.900	0.0	1030.000	89.000	0.0	1050.000	88.200
	BT	0.0	1100.000	87.600	0.0	1345.000	90.000	0.0	1375.000	100.000	0.0
	NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
	ET	0.0	990.000	1010.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.125	15.000	990.000	1010.000	50.000	50.000	50.000	0.0	0.0	0.0
	SB	92.000	820.000	90.000	835.000	90.000	925.000	88.000	960.000	85.600	978.000
	GR	78.100	990.000	77.600	995.000	77.500	1000.000	77.500	1005.000	78.100	1010.000
	GR	78.700	1015.000	88.200	1030.000	88.200	1400.000	90.000	1410.000	100.000	1430.000
	NC	0.070	0.070	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.139	14.000	995.000	1005.000	74.000	74.000	74.000	0.0	0.0	0.0
	GR	92.000	840.000	90.000	850.000	90.000	925.000	88.100	974.000	84.600	988.000
	GR	81.100	995.000	76.900	995.100	77.200	1004.900	81.600	1005.000	85.300	1012.000
	GR	87.700	1020.000	88.000	1430.000	90.000	1440.000	100.000	1460.000	0.0	0.0
	NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.148	15.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
	X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	88.800	88.500	0.0
	GR	91.000	760.000	90.000	850.000	89.300	950.000	88.000	988.000	81.100	995.000
	GR	76.900	995.100	76.300	1000.000	77.000	1004.900	81.600	1005.000	88.000	1020.000
	GR	88.700	1050.000	88.500	1100.000	88.500	1390.000	90.000	1445.000	100.000	1465.000
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	SB	0.0	1.560	3.000	0.0	10.000	0.0	54.000	0.0	76.700	76.300
	X1	0.164	0.0	0.0	0.0	82.000	82.000	82.000	0.0	0.400	0.0
	X2	0.0	0.0	1.000	82.000	88.500	0.0	0.0	0.0	0.0	0.0
	X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	88.800	88.500	0.0
	BT	13.000	760.000	91.000	0.0	850.000	90.000	0.0	950.000	89.300	0.0
	BT	988.000	89.000	0.0	995.000	88.800	0.0	995.100	88.800	82.000	1000.000
	BT	88.800	82.000	1004.900	88.800	82.000	1005.000	88.800	0.0	1020.000	88.800
	BT	0.0	1050.000	88.700	0.0	1100.000	88.500	0.0	1390.000	88.500	0.0
	BT	1445.000	90.000	0.0	1465.000	100.000	0.0	0.0	0.0	0.0	0.0
	NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.173	11.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
	GR	91.000	730.000	90.000	800.000	88.000	985.000	82.000	995.000	76.100	995.100
	GR	76.100	1004.900	82.000	1005.000	86.000	1020.000	88.000	1160.000	90.000	1400.000
	GR	100.000	1420.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.243	13.000	995.000	1005.000	370.000	370.000	370.000	0.0	0.0	0.0
	GR	91.000	220.000	90.000	500.000	88.000	800.000	86.000	970.000	84.000	995.000
	GR	80.000	996.000	76.500	1000.000	80.000	1004.000	84.000	1005.000	86.000	1180.000
	GR	86.000	1420.000	90.000	1430.000	96.000	1490.000	0.0	0.0	0.0	0.0
	NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
	ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
	X1	0.252	19.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0

GR	91.000	200.000	90.000	510.000	88.000	740.000	86.000	800.000	85.300	900.000
GR	85.300	950.000	85.000	980.000	80.000	995.000	77.000	995.100	76.600	1000.000
GR	77.000	1004.900	80.000	1005.000	85.000	1020.000	85.000	1050.000	85.000	1100.000
GR	86.000	1110.000	86.000	1430.000	90.000	1440.000	94.000	1490.000	0.0	0.0
ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	3.000	0.0	10.000	0.0	82.000	0.0	76.300	76.600
X1	0.255	0.0	0.0	0.0	14.000	14.000	14.000	0.0	-0.300	0.0
X2	0.0	0.0	1.000	84.500	85.100	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.300	85.100	0.0
BT	19.000	200.000	91.000	0.0	510.000	90.000	0.0	740.000	88.000	0.0
BT	800.000	86.000	0.0	900.000	85.300	0.0	950.000	85.300	0.0	980.000
BT	85.700	0.0	995.000	86.000	0.0	995.100	87.000	84.500	1000.000	87.000
BT	84.500	1004.900	87.000	84.500	1005.000	86.000	0.0	1020.000	85.800	0.0
BT	1050.000	85.400	0.0	1100.000	85.100	0.0	1110.000	86.000	0.0	1430.000
BT	86.000	0.0	1440.000	90.000	0.0	1490.000	94.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	992.000	1008.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.265	19.000	992.000	1008.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	92.000	380.000	90.000	540.000	88.000	710.000	86.000	800.000	86.000	900.000
GR	84.800	972.000	83.700	977.000	82.000	982.000	78.400	992.000	77.100	995.000
GR	77.400	1006.000	78.400	1008.000	80.700	1011.000	84.100	1018.000	84.500	1020.000
GR	86.000	1165.000	86.000	1440.000	90.000	1455.000	94.000	1500.000	0.0	0.0
ET	0.0	992.000	1008.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.293	14.000	992.000	1008.000	148.000	148.000	148.000	0.0	0.0	0.0
GR	92.000	250.000	90.000	370.000	88.000	500.000	86.000	790.000	86.000	972.000
GR	79.000	992.000	77.200	994.000	76.500	1000.000	77.200	1006.000	79.000	1008.000
GR	85.000	1018.000	86.000	1460.000	90.000	1475.000	92.000	1485.000	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	1884.000	2005.200	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.302	18.000	1994.800	2005.200	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.100	84.700	0.0
GR	92.000	1000.300	90.000	1250.000	88.000	1410.000	86.000	1580.000	84.100	1900.000
GR	84.000	1946.000	84.000	1950.000	79.000	1994.800	76.000	1994.900	75.700	2000.000
GR	76.000	2005.100	79.000	2005.300	84.000	2019.000	84.500	2050.000	84.700	2100.000
GR	85.300	2450.000	86.000	2460.000	92.000	2480.000	0.0	0.0	0.0	0.0
ET	0.0	1955.000	2005.200	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	2.800	0.0	10.400	0.0	93.600	0.0	76.400	75.700
X1	0.305	0.0	0.0	0.0	14.000	14.000	14.000	0.0	0.700	0.0
X2	0.0	0.0	1.000	84.800	84.100	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.100	84.700	0.0
BT	18.000	1000.000	92.000	0.0	1250.000	90.000	0.0	1410.000	88.000	0.0
BT	1580.000	36.000	0.0	1900.000	84.100	0.0	1950.000	84.700	0.0	1980.000
BT	85.000	0.0	1994.800	85.600	0.0	1994.900	86.600	84.800	2000.000	86.600
BT	84.800	2005.100	86.600	84.800	2005.200	85.600	0.0	2019.000	85.500	0.0
BT	2050.000	85.300	0.0	2100.000	84.700	0.0	2450.000	85.000	0.0	2460.000
BT	86.000	0.0	2480.000	92.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	1993.000	2007.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.315	17.000	1993.000	2007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	94.000	980.000	92.000	1080.000	88.000	1105.000	86.000	1125.000	86.000	1465.000
GR	86.000	1805.000	84.300	1946.000	84.300	1971.000	81.600	1988.000	78.600	1993.000
GR	77.200	1995.000	77.000	2005.000	78.600	2007.000	81.700	2013.000	84.600	2019.000
GR	84.600	2455.000	92.000	2480.000	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	993.000	1007.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0

X1	0.342	16.000	993.000	1007.000	143.000	143.000	143.000	0.0	0.0	0.0
GR	94.000	50.000	92.000	155.000	90.000	165.000	86.000	235.000	86.000	585.000
GR	86.000	625.000	86.000	775.000	85.000	990.000	79.000	993.000	76.700	1000.000
GR	79.000	1007.000	84.000	1010.000	84.000	1380.000	86.000	1470.000	90.000	1485.000
GR	91.000	1555.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	994.800	1005.200	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.352	19.000	994.800	1005.200	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.600	84.500	0.0
GR	94.000	80.000	92.000	150.000	90.000	205.000	86.000	250.000	86.000	705.000
GR	84.600	900.000	84.900	950.000	84.000	990.000	82.000	994.800	79.000	994.900
GR	76.300	1000.000	79.000	1005.100	82.000	1005.200	84.000	1010.000	84.900	1050.000
GR	84.500	1100.000	84.500	1420.000	90.000	1445.000	91.000	1500.000	0.0	0.0
ET	0.0	994.800	1005.200	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	3.000	0.0	10.400	0.0	87.400	0.0	76.500	76.300
X1	0.355	0.0	0.0	0.0	14.000	14.000	14.000	0.0	0.200	0.0
X2	0.0	0.0	1.000	84.700	84.500	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	84.600	84.500	0.0
BT	19.000	80.000	94.000	0.0	190.000	92.000	0.0	205.000	90.000	0.0
BT	250.000	86.000	0.0	705.000	86.000	0.0	900.000	84.600	0.0	950.000
BT	84.900	0.0	990.000	85.500	0.0	994.800	85.500	0.0	994.900	86.500
BT	84.700	1000.000	86.500	84.700	1005.100	86.500	84.700	1005.200	85.500	0.0
BT	1010.000	83.400	0.0	1050.000	84.900	0.0	1100.000	84.500	0.0	1420.000
BT	84.500	0.0	1445.000	90.000	0.0	1500.000	91.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	993.000	1007.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.365	16.000	993.000	1007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	94.000	130.000	92.000	210.000	90.000	240.000	84.700	260.000	84.700	973.000
GR	83.600	991.000	78.600	993.000	77.000	995.000	77.100	1005.000	78.600	1007.000
GR	82.600	1011.000	83.900	1012.000	84.100	1022.000	84.100	1460.000	90.000	1485.000
GR	91.000	1545.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	994.000	1006.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.526	15.000	994.000	1006.000	600.000	1000.000	850.000	0.0	0.0	0.0
GR	100.000	450.000	90.000	560.000	98.000	570.000	86.000	610.000	82.000	635.000
GR	80.000	725.000	80.000	850.000	78.000	994.000	77.500	995.000	77.500	1005.000
GR	78.000	1006.000	80.000	1150.000	86.000	1190.000	96.000	1210.000	106.000	1245.000
QT	8.000	120.000	200.000	240.000	350.000	240.000	240.000	240.000	240.000	0.0
ET	0.0	982.000	1016.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.534	10.000	982.000	1016.000	40.000	40.000	40.000	0.0	0.0	0.0
GR	100.000	485.000	90.000	595.000	82.000	670.000	82.000	982.000	77.000	992.000
GR	77.000	1008.000	82.000	1016.000	82.000	1140.000	86.000	1170.000	96.000	1190.000
ET	0.0	982.000	1016.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.595	10.000	982.000	1016.000	320.000	320.000	320.000	0.0	0.0	0.0
GR	96.000	710.000	90.000	760.000	82.000	820.000	82.000	982.000	77.200	992.000
GR	77.200	1008.000	82.000	1016.000	82.000	1160.000	86.000	1185.000	96.000	1255.000
QT	8.000	110.000	170.000	200.000	300.000	200.000	200.000	200.000	200.000	0.0
NC	0.0	0.040	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	982.000	1018.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.636	10.000	982.000	1018.000	230.000	230.000	230.000	0.0	0.0	0.0
GR	92.000	585.000	82.000	705.000	82.000	925.000	82.000	982.000	77.300	992.000
GR	77.300	1008.000	82.300	1018.000	86.000	1026.000	86.400	1046.000	96.000	1076.000
ET	0.0	979.000	1018.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0

X1	0.732	11.000	979.000	1018.000	490.000	490.000	490.000	0.0	0.0	0.0
GR	92.000	865.000	90.000	905.000	88.000	910.000	84.000	950.000	84.000	979.000
GR	77.600	992.000	77.600	1008.000	82.600	1018.000	86.000	1026.000	86.400	1046.000
GR	96.000	1076.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	980.000	1018.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.891	12.000	980.000	1018.000	550.000	850.000	840.000	0.0	0.0	0.0
GR	100.000	440.000	90.000	530.000	88.000	630.000	86.000	770.000	86.000	974.000
GR	83.000	980.000	78.000	992.000	78.000	1008.000	83.000	1018.000	86.000	1026.000
GR	86.400	1046.000	96.000	1076.000	0.0	0.0	0.0	0.0	0.0	0.0
QT	8.000	96.000	150.000	180.000	280.000	180.000	180.000	180.000	180.000	0.0
ET	0.0	1986.000	2014.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.901	14.000	1986.000	2014.000	53.000	53.000	53.000	0.0	0.0	0.0
GR	92.000	910.000	90.000	1000.000	86.000	1060.000	86.000	1410.000	86.000	1580.000
GR	86.000	1810.000	86.000	1984.000	83.000	1986.000	78.000	1996.000	78.000	2004.000
GR	83.000	2014.000	86.000	2020.000	86.400	2040.000	96.000	2070.000	0.0	0.0
ET	0.0	986.000	1014.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	0.997	11.000	986.000	1014.000	800.000	260.000	507.000	0.0	0.0	0.0
GR	90.000	400.000	38.000	530.000	86.000	730.000	86.000	980.000	83.200	986.000
GR	78.200	996.000	78.200	1004.000	83.200	1014.000	86.000	1020.000	86.400	1040.000
GR	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	835.900	1004.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.006	17.000	996.000	1004.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.000	86.300	0.0
GR	90.000	340.000	88.000	530.000	86.000	690.000	86.000	980.000	84.000	984.000
GR	83.000	986.000	79.000	994.900	79.000	995.000	78.300	995.900	78.300	996.000
GR	78.300	1004.000	78.300	1004.100	79.000	1005.000	79.000	1005.100	86.000	1020.000
GR	86.400	1040.000	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0
SB	0.0	1.560	2.800	0.0	8.000	0.0	40.000	0.0	78.300	78.300
ET	0.0	855.900	1004.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.018	0.0	0.0	0.0	62.000	62.000	62.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	83.300	86.000	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.000	86.300	0.0
BT	17.000	340.000	90.000	0.0	530.000	88.000	0.0	690.000	86.000	0.0
BT	980.000	86.000	0.0	984.000	86.000	0.0	986.000	86.000	0.0	994.900
BT	86.300	0.0	995.000	87.300	0.0	995.900	87.300	0.0	996.000	87.300
BT	83.300	1004.000	87.300	83.300	1004.100	87.300	0.0	1005.000	87.300	0.0
BT	1005.100	86.300	0.0	1020.000	86.300	0.0	1040.000	86.400	0.0	1070.000
BT	96.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	986.000	1014.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.028	12.000	986.000	1014.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	90.000	290.000	88.000	510.000	86.000	630.000	86.000	970.000	86.000	980.000
GR	83.300	986.000	78.300	996.000	78.300	1004.000	83.300	1014.000	86.000	1020.000
GR	86.400	1040.000	96.000	1070.000	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	986.000	1014.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.062	13.000	986.000	1014.000	180.000	180.000	180.000	0.0	0.0	0.0
GR	90.000	150.000	88.000	370.000	86.000	460.000	86.000	780.000	86.000	978.000
GR	86.000	980.000	83.400	986.000	78.400	996.000	78.400	1004.000	83.400	1014.000
GR	86.000	1020.000	86.400	1040.010	96.000	1070.000	0.0	0.0	0.0	0.0
NC	0.060	0.060	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	2982.400	3013.300	0.0	0.0	0.0	0.0	0.0	2.100	0.0

X1	1.071	17.000	2997.000	3003.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	82.400	82.400	0.0
GR	90.000	1140.000	88.000	1360.000	86.000	1450.000	86.000	1780.000	86.000	2950.000
GR	85.500	2980.000	80.000	2997.000	79.000	2997.100	78.400	3000.000	79.000	3002.900
GR	80.000	3003.000	85.500	3015.000	86.100	3050.000	85.900	3100.000	86.000	3470.000
GR	86.000	3890.000	100.000	3920.000	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	2968.000	3026.700	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	2.800	0.0	0.000	0.0	27.600	0.0	78.300	78.300
X1	1.084	0.0	0.0	0.0	65.000	65.000	65.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	82.400	85.900	0.0	0.0	0.0	0.0	0.0
X3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.000	85.900	0.0
BT	17.000	1140.000	90.000	0.0	1360.000	88.000	0.0	1450.000	86.000	0.0
BT	1780.000	86.000	0.0	2990.000	86.000	0.0	2980.000	86.100	0.0	2997.000
BT	86.100	0.0	2997.100	86.100	82.400	3000.000	86.100	82.400	3002.900	86.100
BT	82.400	3003.000	86.100	0.0	3015.000	86.100	0.0	3050.000	86.100	0.0
BT	3100.000	85.900	0.0	3470.000	86.000	0.0	3890.000	86.000	0.0	3920.000
BT	100.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	993.000	1007.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.094	19.000	993.000	1007.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	96.000	180.000	90.000	200.000	88.000	460.000	86.000	590.000	86.000	860.000
GR	82.000	880.000	82.000	985.000	80.000	990.000	79.500	993.000	78.500	995.000
GR	78.300	1000.000	78.500	1005.000	79.500	1007.000	80.000	1015.000	82.000	1050.000
GR	84.000	1140.000	86.000	1240.000	86.000	1930.000	100.000	1950.000	0.0	0.0
ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.249	17.000	995.000	1005.000	818.000	818.000	818.000	0.0	0.0	0.0
GR	94.000	360.000	88.000	380.000	86.000	530.000	84.000	780.000	84.000	960.000
GR	82.000	985.000	81.000	990.000	80.000	995.000	79.600	998.000	79.500	1000.000
GR	79.600	1004.000	80.000	1005.000	82.000	1011.000	82.000	1160.000	84.000	1180.000
GR	86.000	1240.000	110.000	1290.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	1998.000	2039.300	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.258	19.000	1998.000	2002.000	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.300	83.500	0.0
GR	94.000	730.000	92.000	1140.000	90.000	1650.000	87.900	1900.000	87.700	1950.000
GR	83.000	1980.000	81.100	1998.000	80.000	1998.300	79.400	1999.000	79.100	2000.000
GR	79.400	2001.000	80.000	2001.700	81.100	2002.000	83.000	2016.000	87.000	2050.000
GR	87.300	2100.000	87.000	2360.000	87.000	3280.000	110.000	3330.000	0.0	0.0
ET	0.0	1998.000	2038.500	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	2.800	0.0	4.000	0.0	12.600	0.0	79.700	79.100
X1	1.269	0.0	0.0	0.0	56.000	56.000	56.000	0.0	0.600	0.0
X2	0.0	0.0	1.000	83.100	86.000	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.300	86.000	0.0
BT	19.000	730.000	94.000	0.0	1140.000	92.000	0.0	1650.000	90.000	0.0
BT	1900.000	87.900	0.0	1950.000	87.700	0.0	1980.000	87.500	0.0	1998.000
BT	87.300	81.100	1998.300	87.300	82.200	1999.000	87.300	82.800	2000.000	87.300
BT	83.100	2001.000	87.300	82.800	2001.700	87.300	82.200	2002.000	87.300	81.100
BT	2015.000	87.200	0.0	2050.000	87.000	0.0	2100.000	86.700	0.0	2360.000
BT	86.000	0.0	3280.000	86.700	0.0	3330.000	110.000	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.279	16.000	995.000	1005.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	100.000	150.000	90.000	350.000	86.000	430.000	84.000	950.000	82.200	973.000
GR	82.700	983.000	80.900	994.800	80.000	995.000	79.600	995.100	79.600	1000.000
GR	80.100	1005.000	83.000	1007.000	83.700	1012.000	83.700	1210.000	86.000	1280.000

NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	405.000	2270.700	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.297	18.000	997.500	1002.500	95.000	95.000	95.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.000	85.000	0.0
GR	100.000	70.000	92.000	160.000	90.000	250.000	86.000	420.000	86.000	709.500
GR	100.000	710.000	100.000	949.500	85.900	950.000	83.000	990.000	80.000	997.500
GR	79.700	998.000	79.700	1002.000	80.000	1002.500	85.000	1015.000	85.900	1050.000
GR	86.000	1060.000	86.000	2270.000	106.000	2310.000	0.0	0.0	0.0	0.0
ET	0.0	405.000	2270.700	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	2.300	0.0	7.000	0.0	11.300	0.0	79.100	79.700
X1	1.304	21.000	997.500	1002.500	37.000	37.000	37.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	83.100	85.900	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	85.900	85.900	0.0
BT	21.000	70.000	100.000	0.0	160.000	92.000	0.0	250.000	90.000	0.0
BT	420.000	86.000	0.0	709.500	86.000	0.0	710.000	100.000	0.0	949.500
BT	100.000	0.0	950.000	85.900	0.0	990.000	85.900	0.0	997.500	85.900
BT	80.600	998.000	85.900	82.100	999.000	85.900	82.000	1000.000	85.900	83.100
BT	1001.000	85.900	82.900	1002.000	85.900	82.100	1002.500	85.900	80.600	1015.000
BT	85.900	0.0	1050.000	85.900	0.0	1060.000	86.000	0.0	2270.000	86.000
BT	0.0	2310.000	106.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GR	100.000	70.000	92.000	160.000	90.000	250.000	86.000	420.000	86.000	709.500
GR	100.000	710.000	100.000	949.500	85.900	950.000	83.000	990.000	80.600	997.500
GR	79.100	998.000	79.100	999.000	79.100	1000.000	79.100	1001.000	79.100	1002.000
GR	80.600	1002.500	85.000	1015.000	85.900	1050.000	86.000	1060.000	86.000	2270.000
GR	106.000	2310.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.100	0.300	0.0	0.0	0.0	0.0	0.0
ET	0.0	994.000	1006.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.313	20.000	994.000	1006.000	50.000	50.000	50.000	0.0	0.0	0.0
GR	100.000	130.000	96.000	170.000	94.000	250.000	92.000	255.000	90.000	325.000
GR	86.000	530.000	84.000	930.000	82.500	955.000	82.400	991.000	80.300	994.000
GR	79.400	996.000	79.100	1000.000	79.300	1004.000	80.300	1006.000	83.400	1010.000
GR	85.000	1015.000	85.100	1020.000	86.000	1035.000	86.000	2290.000	106.000	2335.000
ET	0.0	995.000	1005.000	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.487	17.000	995.000	1005.000	918.000	918.000	918.000	0.0	0.0	0.0
GR	100.000	140.000	90.000	375.000	90.000	775.000	88.000	845.000	86.000	975.000
GR	84.000	980.000	82.000	995.000	81.000	996.000	80.700	1000.000	81.000	1004.000
GR	82.000	1003.000	88.000	1020.000	88.000	1140.000	90.000	1180.000	90.000	1320.000
GR	92.000	1320.000	96.000	1410.000	0.0	0.0	0.0	0.0	0.0	0.0
NC	0.0	0.0	0.0	0.300	0.500	0.0	0.0	0.0	0.0	0.0
ET	0.0	994.100	1005.900	0.0	0.0	0.0	0.0	0.0	2.100	0.0
X1	1.496	17.000	994.100	1005.900	50.000	50.000	50.000	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	86.500	86.500	0.0
GR	100.000	280.000	92.000	530.000	90.000	830.000	88.700	900.000	88.100	950.000
GR	84.000	985.000	82.000	994.100	81.200	994.200	81.000	1000.000	81.200	1005.800
GR	82.000	1005.900	84.000	1010.000	87.600	1050.000	88.400	1100.000	90.000	1220.000
GR	92.000	1270.000	94.000	1305.000	0.0	0.0	0.0	0.0	0.0	0.0
ET	0.0	994.100	1005.900	0.0	0.0	0.0	0.0	0.0	2.100	0.0
SB	0.0	1.560	2.600	0.0	11.800	0.0	36.600	0.0	81.000	81.000
X1	1.505	0.0	0.0	0.0	51.000	51.000	51.000	0.0	0.0	0.0
X2	0.0	0.0	1.000	84.000	87.600	0.0	0.0	0.0	0.0	0.0
X3	10.000	0.0	0.0	0.0	0.0	0.0	0.0	87.700	87.600	0.0
BT	17.000	280.000	100.000	0.0	530.000	90.000	0.0	830.000	90.000	0.0
BT	900.000	88.700	0.0	950.000	88.100	0.0	985.000	87.800	0.0	994.100
BT	87.700	0.0	994.200	87.700	84.000	1001.000	87.700	84.000	1005.800	87.700
BT	84.000	1005.900	87.700	0.0	1010.000	87.700	0.0	1050.000	87.600	0.0

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BT      94.000      0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
NC      0.0         0.0         0.0         0.100       0.300       0.0         0.0         0.0         0.0         0.0
ET      0.0         995.000     1005.000    0.0         0.0         0.0         0.0         0.0         2.100       0.0

X1      1.515       17.000      995.000     1005.000    50.000      50.000      50.000      0.0         0.0         0.0
GR      100.000     385.000     92.000      500.000     90.000      865.000     88.000      870.000     86.000      930.000
GR      85.100      982.000     84.400      991.000     81.500      995.000     81.200      997.000     81.300      1000.000
GR      81.000      1003.000    81.300      1005.000    84.000      1009.000    84.200      1019.000    86.000      1055.000
GR      90.000      1170.000    94.000      1270.000    0.0         0.0         0.0         0.0         0.0         0.0
EJ      0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
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THIS RUN EXECUTED 07/12/78 09.32.00

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************

T1      FLOOD INSURANCE STUDY   READING,MASS
T2      WALKERS BROOK
T3      TYPE 1 ENCROACHMENT

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ
        0.        9.        0.        0.  0.0           0.0       0.0       0.    80.340    0.0
J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE
    15.000    0.0       -1.000    0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

THIS RUN EXECUTED 07/12/78 09.32.50

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**********************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

100 YEAR NATURAL

SUMMARY PRINTOUT

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
	0.006	0.0	0.0	0.0	76.00	280.00	79.34	0.0	79.56	72.30	988.00	1012.00	3.83
	0.006	0.0	0.0	0.0	76.00	280.00	80.34	0.0	80.47	102.62	988.00	1012.00	2.91
	0.087	438.00	0.0	0.0	76.60	280.00	80.11	0.0	80.42	58.51	990.00	1010.00	4.46
	0.087	438.00	0.0	0.0	76.60	280.00	80.74	0.0	80.96	76.14	990.00	1010.00	3.71
	0.096	60.00	0.0	0.0	76.60	280.00	80.22	0.0	80.52	69.90	990.70	1009.40	4.39
	0.096	60.00	0.0	0.0	76.60	280.00	80.81	0.0	81.03	74.38	990.70	1009.40	3.74
	0.116	103.00	87.60	83.50	76.60	280.00	80.41	0.0	80.68	76.67	990.70	1009.40	4.15
	0.116	103.00	87.60	83.50	76.60	280.00	80.97	0.0	81.17	78.98	990.70	1009.40	3.59
A	0.125	50.00	0.0	0.0	77.50	280.00	80.50	0.0	80.76	64.34	990.00	1010.00	4.29
	0.125	50.00	0.0	0.0	77.50	280.00	81.00	0.0	81.27	61.64	990.00	1010.00	4.21
B	0.139	74.00	0.0	0.0	76.90	280.00	80.40	0.0	81.51	26.06	995.00	1005.00	8.46
	0.139	74.00	0.0	0.0	76.90	280.00	80.98	0.0	81.79	32.49	995.00	1005.00	7.22
	0.148	50.00	0.0	0.0	76.30	280.00	81.45	0.0	81.99	43.89	995.00	1005.00	5.86
	0.148	50.00	0.0	0.0	76.30	280.00	81.63	0.0	82.13	46.12	995.00	1005.00	5.64
	0.164	82.00	88.90	82.00	76.70	280.00	81.78	0.0	82.33	43.08	995.00	1005.00	5.95
	0.164	82.00	88.50	82.00	76.70	280.00	82.05	0.0	82.55	34.51	995.00	1005.00	5.69
	0.173	50.00	0.0	0.0	76.10	280.00	82.16	0.0	82.50	58.82	995.00	1005.00	4.66
	0.173	50.00	0.0	0.0	76.10	280.00	82.42	0.0	82.73	61.26	995.00	1005.00	4.47
	0.243	370.00	0.0	0.0	76.50	280.00	83.31	0.0	83.96	39.17	995.00	1005.00	6.48
	0.243	370.00	0.0	0.0	76.50	280.00	83.46	0.0	84.07	40.94	995.00	1005.00	6.27
	0.252	50.00	0.0	0.0	76.60	280.00	83.94	0.0	84.18	82.55	995.00	1005.00	3.94
	0.252	50.00	0.0	0.0	76.60	280.00	84.06	0.0	84.29	74.71	995.00	1005.00	3.88
	0.255	14.00	85.10	84.50	76.30	280.00	83.98	0.0	84.20	87.81	995.00	1005.00	3.77
	0.255	14.00	85.10	84.50	76.30	280.00	84.10	0.0	84.32	78.40	995.00	1005.00	3.72
C	0.265	50.00	0.0	0.0	77.10	280.00	84.16	0.0	84.23	219.02	992.00	1008.00	2.21
	0.265	50.00	0.0	0.0	77.10	280.00	84.26	0.0	84.36	133.25	992.00	1008.00	2.56

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
	0.293	148.00	0.0	0.0	76.50	280.00	84.19	0.0	84.25	218.18	992.00	1008.00	2.20
	0.293	148.00	0.0	0.0	76.50	280.00	84.33	0.0	84.42	144.60	992.00	1008.00	2.44
	0.302	50.00	0.0	0.0	75.70	280.00	84.20	0.0	84.26	180.58	1994.80	2005.20	2.34
	0.302	50.00	0.0	0.0	75.70	280.00	84.40	0.0	84.45	170.68	1994.80	2005.20	2.08
	0.305	14.00	84.10	84.80	76.40	280.00	84.14	0.0	84.34	110.39	1994.80	2005.20	3.58
	0.305	14.00	84.10	84.80	76.40	280.00	84.34	0.0	84.53	97.57	1994.80	2005.20	3.49
D	0.315	50.00	0.0	0.0	77.00	280.00	84.29	0.0	84.37	199.00	1993.00	2007.00	2.43
	0.315	50.00	0.0	0.0	77.00	280.00	84.45	0.0	84.57	118.88	1993.00	2007.00	2.80
	0.342	143.00	0.0	0.0	76.70	280.00	84.30	0.0	84.41	164.24	993.00	1007.00	2.83
	0.342	143.00	0.0	0.0	76.70	280.00	84.52	0.0	84.66	108.86	993.00	1007.00	3.00
	0.352	50.00	0.0	0.0	76.30	280.00	84.26	0.0	84.53	77.07	994.80	1005.20	4.10
	0.352	50.00	0.0	0.0	76.30	280.00	84.52	0.0	84.76	75.28	994.80	1005.20	3.95
	0.355	14.00	84.50	84.70	76.50	280.00	84.28	0.0	84.55	73.68	994.80	1005.20	4.23
	0.355	14.00	84.50	84.70	76.50	280.00	84.53	0.0	84.79	72.16	994.80	1005.20	4.08
E	0.365	50.00	0.0	0.0	77.00	280.00	84.52	0.0	84.59	211.04	993.00	1007.00	2.34
	0.365	50.00	0.0	0.0	77.00	280.00	84.73	0.0	84.84	126.18	993.00	1007.00	2.68
F	0.526	850.00	0.0	0.0	77.50	280.00	84.60	0.0	84.60	1762.85	994.00	1006.00	0.29
	0.526	850.00	0.0	0.0	77.50	280.00	85.23	0.0	85.37	104.13	994.00	1006.00	3.04
G	0.534	40.00	0.0	0.0	77.00	240.00	84.60	0.0	84.60	813.51	982.00	1016.00	0.47
	0.534	40.00	0.0	0.0	77.00	240.00	85.37	0.0	85.39	370.41	982.00	1016.00	1.00
	0.595	320.00	0.0	0.0	77.20	240.00	84.60	0.0	84.61	661.87	982.00	1016.00	0.57
	0.595	320.00	0.0	0.0	77.20	240.00	85.38	0.0	85.40	359.69	982.00	1016.00	1.02
H	0.638	230.00	0.0	0.0	77.30	200.00	84.61	0.0	84.61	638.06	982.00	1018.00	0.49
	0.638	230.00	0.0	0.0	77.30	200.00	85.40	0.0	85.41	371.19	982.00	1018.00	0.82
I	0.732	490.00	0.0	0.0	77.60	200.00	84.61	0.0	84.62	302.76	979.00	1018.00	0.95
	0.732	490.00	0.0	0.0	77.60	200.00	85.41	0.0	85.42	353.23	979.00	1018.00	0.84
J	0.891	840.00	0.0	0.0	78.00	200.00	84.65	0.0	84.66	283.97	980.00	1018.00	1.01
	0.891	840.00	0.0	0.0	78.00	200.00	85.44	0.0	85.45	331.34	980.00	1018.00	0.88
K	0.901	53.00	0.0	0.0	78.00	180.00	84.64	0.0	84.67	184.54	1986.00	2014.00	1.31
	0.901	53.00	0.0	0.0	78.00	180.00	85.44	0.0	85.46	213.26	1986.00	2014.00	1.14
L	0.997	507.00	0.0	0.0	78.20	180.00	84.69	0.0	84.72	174.55	986.00	1014.00	1.36
	0.997	507.00	0.0	0.0	78.20	180.00	85.48	0.0	85.50	203.65	986.00	1014.00	1.17
	1.006	50.00	0.0	0.0	78.30	180.00	84.63	0.0	84.82	72.97	996.00	1004.00	3.56
	1.006	50.00	0.0	0.0	78.30	180.00	85.43	0.0	85.59	61.31	996.00	1004.00	3.16
	1.018	62.00	86.00	83.30	78.30	180.00	84.94	0.0	85.12	78.08	996.00	1004.00	3.39
	1.018	62.00	86.00	83.30	78.30	180.00	85.78	0.0	85.92	65.00	996.00	1004.00	3.01
	1.028	50.00	0.0	0.0	78.30	180.00	85.12	0.0	85.14	196.04	986.00	1014.00	1.27
	1.028	50.00	0.0	0.0	78.30	180.00	85.92	0.0	85.94	223.13	986.00	1014.00	1.10

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
M	1.062	180.00	0.0	0.0	78.40	180.00	85.13	0.0	85.16	190.44	986.00	1014.00	1.29
	1.062	180.00	0.0	0.0	78.40	180.00	85.93	0.0	85.95	218.24	986.00	1014.00	1.12
	1.071	50.00	0.0	0.0	78.40	180.00	85.11	0.0	85.21	84.67	2997.00	3003.00	3.01
	1.071	50.00	0.0	0.0	78.40	180.00	85.92	0.0	85.98	112.62	2997.00	3003.00	2.45
	1.084	65.00	85.90	82.40	78.40	180.00	85.95	0.0	86.00	115.30	2997.00	3003.00	2.40
	1.084	65.00	85.90	82.40	78.40	180.00	86.01	0.0	86.06	117.79	2997.00	3003.00	2.36
	1.094	50.00	0.0	0.0	78.30	180.00	86.01	0.0	86.01	837.11	993.00	1007.00	0.40
	1.094	50.00	0.0	0.0	78.30	180.00	86.02	0.0	86.07	125.18	993.00	1007.00	1.73
	1.249	818.00	0.0	0.0	79.50	180.00	86.01	0.0	86.01	829.01	995.00	1005.00	0.37
	1.249	818.00	0.0	0.0	79.50	180.00	86.35	0.0	86.46	67.86	995.00	1005.00	2.69
	1.258	50.00	0.0	0.0	79.10	180.00	86.01	0.0	86.05	66.76	1998.00	2002.00	2.33
	1.258	50.00	0.0	0.0	79.10	180.00	86.48	0.0	86.51	82.65	1998.00	2002.00	1.92
	1.269	56.00	86.00	83.10	79.70	180.00	86.30	0.0	86.36	58.17	1998.00	2002.00	2.64
	1.269	56.00	86.00	83.10	79.70	180.00	86.46	0.0	86.51	62.83	1998.00	2002.00	2.46
N	1.279	50.00	0.0	0.0	79.60	180.00	86.37	0.0	86.37	732.05	995.00	1005.00	0.42
	1.279	50.00	0.0	0.0	79.60	180.00	86.46	0.0	86.57	67.73	995.00	1005.00	2.67
	1.297	95.00	0.0	0.0	79.70	180.00	86.37	0.0	86.38	217.57	997.50	1002.50	1.42
	1.297	95.00	0.0	0.0	79.70	180.00	86.61	0.0	86.61	327.60	997.50	1002.50	0.96
	1.304	37.00	85.90	83.10	79.10	180.00	86.37	0.0	86.38	209.87	997.50	1002.50	1.24
	1.304	37.00	85.90	83.10	79.10	180.00	86.61	0.0	86.61	319.33	997.50	1002.50	0.83
O	1.313	50.00	0.0	0.0	79.10	180.00	86.38	0.0	86.38	523.23	994.00	1006.00	0.59
	1.313	50.00	0.0	0.0	79.10	180.00	86.57	0.0	86.64	96.40	994.00	1006.00	2.10
	1.487	918.00	0.0	0.0	80.70	180.00	86.45	0.0	86.50	121.44	995.00	1005.00	2.16
	1.487	918.00	0.0	0.0	80.70	180.00	87.08	0.0	87.22	61.28	995.00	1005.00	2.95
	1.496	50.00	0.0	0.0	81.00	180.00	86.43	0.0	86.56	72.53	994.10	1005.90	2.87
	1.496	50.00	0.0	0.0	81.00	180.00	87.16	0.0	87.26	73.98	994.10	1005.90	2.52
	1.505	51.00	87.60	84.00	81.00	180.00	86.91	0.0	87.02	82.24	994.10	1005.90	2.63
	1.505	51.00	87.60	84.00	81.00	180.00	87.65	0.0	87.73	82.07	994.10	1005.90	2.33
	1.515	50.00	0.0	0.0	81.00	180.00	87.02	0.0	87.03	190.21	995.00	1005.00	1.51
	1.515	50.00	0.0	0.0	81.00	180.00	87.65	0.0	87.77	63.87	995.00	1005.00	2.80

100 YEAR NATURAL
SUMMARY PRINTOUT

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
0.006	79.34	0.0	0.0	0.0	985.32	0.0	29.76	0.0	1015.08	1.84	276.02	2.15
0.006	80.34	1.00	0.91	0.0	988.00	988.00	24.00	1012.00	1012.00	0.0	280.00	0.0
0.087	80.11	0.0	0.0	0.77	989.59	0.0	20.74	0.0	1010.33	0.00	280.00	0.00
0.087	80.74	0.63	0.54	0.40	990.00	990.00	20.00	1010.00	1010.00	0.0	280.00	0.0
0.096	80.22	0.0	0.0	0.11	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.096	80.81	0.59	0.51	0.07	990.70	990.70	18.70	1009.40	1009.40	0.0	280.00	0.0
0.116	80.41	0.0	0.0	0.19	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.116	80.97	0.56	0.49	0.16	990.70	990.70	18.70	1009.40	1009.40	0.0	280.00	0.0
0.125	80.50	0.0	0.0	0.09	986.17	0.0	31.65	0.0	1017.83	7.46	241.63	30.91
0.125	81.00	0.50	0.52	0.03	990.00	990.00	20.00	1010.00	1010.00	0.0	280.00	0.0
0.139	80.40	0.0	0.0	-0.10	995.02	0.0	9.96	0.0	1004.97	0.0	280.00	0.0
0.139	80.98	0.58	0.27	-0.02	995.00	995.00	9.98	1005.00	1004.98	0.0	280.00	0.0
0.148	81.45	0.0	0.0	1.05	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.148	81.63	0.18	0.14	0.66	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.164	81.78	0.0	0.0	0.33	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.164	82.05	0.26	0.22	0.42	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.173	82.16	0.0	0.0	0.38	994.72	0.0	10.89	0.0	1005.62	0.00	280.00	0.00
0.173	82.42	0.25	0.23	0.37	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.243	83.31	0.0	0.0	1.14	995.17	0.0	9.65	0.0	1004.83	0.0	280.00	0.0
0.243	83.46	0.15	0.11	1.04	995.13	995.00	9.73	1005.00	1004.86	0.0	280.00	0.0
0.252	83.94	0.0	0.0	0.63	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.252	84.06	0.12	0.11	0.60	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.255	83.98	0.0	0.0	0.04	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.255	84.10	0.12	0.12	0.04	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.265	84.16	0.0	0.0	0.19	974.89	0.0	43.42	0.0	1018.32	27.98	238.54	13.48
0.265	84.26	0.09	0.13	0.16	992.00	992.00	16.00	1008.00	1008.00	0.0	280.00	0.0
0.293	84.19	0.0	0.0	0.02	974.71	0.0	41.93	0.0	1016.64	22.40	247.19	10.40
0.293	84.33	0.14	0.17	0.07	992.00	992.00	16.00	1008.00	1008.00	0.0	280.00	0.0
0.302	84.20	0.0	0.0	0.01	1884.01	0.0	121.19	0.0	2005.20	77.37	202.63	0.0
0.302	84.40	0.20	0.19	0.08	1884.00	1884.00	121.20	2005.20	2005.20	95.57	184.43	0.0
0.305	84.14	0.0	0.0	-0.06	1955.04	0.0	50.16	0.0	2005.20	0.0	280.00	0.0
0.305	84.34	0.20	0.19	-0.06	1955.00	1955.00	50.20	2005.20	2005.20	0.0	280.00	0.0
0.315	84.29	0.0	0.0	0.15	1971.08	0.0	47.28	0.0	2018.35	22.87	237.17	19.96
0.315	84.45	0.16	0.20	0.11	1993.00	1993.00	14.00	2007.00	2007.00	0.0	280.00	0.0
0.342	84.30	0.0	0.0	0.01	990.35	0.0	403.07	0.0	1393.42	2.84	255.24	21.91
0.342	84.52	0.22	0.25	0.07	993.00	993.00	14.00	1007.00	1007.00	0.0	280.00	0.0

100 YEAR NATURAL
SUMMARY PRINTOUT

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
0.006	79.34	0.0	0.0	0.0	985.32	0.0	29.76	0.0	1015.08	1.84	276.02	2.15
0.006	80.34	1.00	0.91	0.0	988.00	988.00	24.00	1012.00	1012.00	0.0	280.00	0.0
0.087	80.11	0.0	0.0	0.77	989.59	0.0	20.74	0.0	1010.33	0.00	280.00	0.00
0.087	80.74	0.63	0.54	0.40	990.00	990.00	20.00	1010.00	1010.00	0.0	280.00	0.0
0.096	80.22	0.0	0.0	0.11	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.096	80.81	0.59	0.51	0.07	990.70	990.70	18.70	1009.40	1009.40	0.0	280.00	0.0
0.116	80.41	0.0	0.0	0.19	990.70	0.0	18.70	0.0	1009.40	0.0	280.00	0.0
0.116	80.97	0.56	0.49	0.16	990.70	990.70	18.70	1009.40	1009.40	0.0	280.00	0.0
0.125	80.50	0.0	0.0	0.09	986.17	0.0	31.65	0.0	1017.83	7.46	241.63	30.91
0.125	81.00	0.50	0.52	0.03	990.00	990.00	20.00	1010.00	1010.00	0.0	280.00	0.0
0.139	80.40	0.0	0.0	-0.10	995.02	0.0	9.96	0.0	1004.97	0.0	280.00	0.0
0.139	80.98	0.58	0.27	-0.02	995.00	995.00	9.98	1005.00	1004.98	0.0	280.00	0.0
0.148	81.45	0.0	0.0	1.05	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.148	81.63	0.18	0.14	0.66	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.164	81.78	0.0	0.0	0.33	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.164	82.05	0.26	0.22	0.42	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.173	82.16	0.0	0.0	0.38	994.72	0.0	10.89	0.0	1005.62	0.00	280.00	0.00
0.173	82.42	0.25	0.23	0.37	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.243	83.31	0.0	0.0	1.14	995.17	0.0	9.65	0.0	1004.83	0.0	280.00	0.0
0.243	83.46	0.15	0.11	1.04	995.13	995.00	9.73	1005.00	1004.86	0.0	280.00	0.0
0.252	83.94	0.0	0.0	0.63	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.252	84.06	0.12	0.11	0.60	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.255	83.98	0.0	0.0	0.04	995.00	0.0	10.00	0.0	1005.00	0.0	280.00	0.0
0.255	84.10	0.12	0.12	0.04	995.00	995.00	10.00	1005.00	1005.00	0.0	280.00	0.0
0.265	84.16	0.0	0.0	0.19	974.89	0.0	43.42	0.0	1018.32	27.98	238.54	13.48
0.265	84.26	0.09	0.13	0.16	992.00	992.00	16.00	1008.00	1008.00	0.0	280.00	0.0
0.293	84.19	0.0	0.0	0.02	974.71	0.0	41.93	0.0	1016.64	22.40	247.19	10.40
0.293	84.33	0.14	0.17	0.07	992.00	992.00	16.00	1008.00	1008.00	0.0	280.00	0.0
0.302	84.20	0.0	0.0	0.01	1884.01	0.0	121.19	0.0	2005.20	77.37	202.63	0.0
0.302	84.40	0.20	0.19	0.08	1884.00	1884.00	121.20	2005.20	2005.20	95.57	184.43	0.0
0.305	84.14	0.0	0.0	-0.06	1955.04	0.0	50.16	0.0	2005.20	0.0	280.00	0.0
0.305	84.34	0.20	0.19	-0.06	1955.00	1955.00	50.20	2005.20	2005.20	0.0	280.00	0.0
0.315	84.29	0.0	0.0	0.15	1971.08	0.0	47.28	0.0	2018.35	22.87	237.17	19.96
0.315	84.45	0.16	0.20	0.11	1993.00	1993.00	14.00	2007.00	2007.00	0.0	280.00	0.0
0.342	84.30	0.0	0.0	0.01	990.35	0.0	403.07	0.0	1393.42	2.84	255.24	21.91
0.342	84.52	0.22	0.25	0.07	993.00	993.00	14.00	1007.00	1007.00	0.0	280.00	0.0

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	GLOB	QCH	QRCB
0.352	84.26	0.0	0.0	-0.03	994.80	0.0	10.40	0.0	1005.20	0.0	280.00	0.0
0.352	84.52	0.26	0.24	-0.00	994.80	994.80	10.40	1005.20	1005.20	0.0	280.00	0.0
0.355	84.28	0.0	0.0	0.01	994.80	0.0	10.40	0.0	1005.20	0.0	280.00	0.0
0.355	84.53	0.26	0.24	0.01	994.80	994.80	10.40	1005.20	1005.20	0.0	280.00	0.0
0.365	84.52	0.0	0.0	0.24	575.98	0.0	485.79	0.0	1461.77	3.41	237.80	38.79
0.365	84.73	0.22	0.25	0.20	993.00	993.00	14.00	1007.00	1007.00	0.0	280.00	0.0
0.526	84.60	0.0	0.0	0.08	618.75	0.0	561.93	0.0	1180.67	160.91	24.21	89.88
0.526	85.23	0.63	0.07	0.49	994.00	994.00	12.00	1006.00	1006.00	0.0	280.00	0.0
0.534	84.60	0.0	0.0	-0.00	645.58	0.0	513.95	0.0	1159.53	98.70	101.12	40.18
0.534	85.37	0.77	0.78	0.14	982.00	982.00	34.00	1016.00	1016.00	0.0	240.00	0.0
0.595	84.60	0.0	0.0	0.00	800.49	0.0	375.78	0.0	1176.26	63.70	119.81	56.49
0.595	85.38	0.78	0.79	0.01	982.00	982.00	34.00	1016.00	1016.00	0.0	240.00	0.0
0.638	84.61	0.0	0.0	0.00	673.74	0.0	349.25	0.0	1022.98	94.15	105.16	0.69
0.638	85.40	0.79	0.80	0.01	982.00	982.00	36.00	1018.00	1018.00	0.0	200.00	0.0
0.732	84.61	0.0	0.0	0.00	943.88	0.0	78.85	0.0	1022.73	1.91	196.98	1.11
0.732	85.41	0.80	0.80	0.01	979.00	979.00	39.00	1018.00	1018.00	0.0	200.00	0.0
0.891	84.65	0.0	0.0	0.04	97..72	0.0	45.65	0.0	1022.37	0.33	198.89	0.79
0.891	85.44	0.79	0.79	0.03	980.00	980.00	38.00	1018.00	1018.00	0.0	200.00	0.0
0.901	84.64	0.0	0.0	-0.00	1984.90	0.0	32.40	0.0	2017.30	0.11	179.08	0.81
0.901	85.44	0.79	0.79	-0.00	1986.00	1986.00	28.00	2014.00	2014.00	0.0	180.00	0.0
0.997	84.69	0.0	0.0	0.05	982.81	0.0	34.38	0.0	1017.19	0.40	178.90	0.70
0.997	85.48	0.78	0.77	0.04	986.00	986.00	28.00	1014.00	1014.00	0.0	180.00	0.0
1.006	84.63	0.0	0.0	-0.07	996.00	0.0	8.00	0.0	1004.00	0.0	180.00	0.0
1.006	85.43	0.80	0.76	-0.04	996.00	855.90	8.00	1004.00	1004.00	0.0	180.00	0.0
1.018	84.94	0.0	0.0	0.31	996.00	0.0	8.00	0.0	1004.00	0.0	180.00	0.0
1.018	85.78	0.84	0.80	0.35	996.00	855.90	8.00	1004.00	1004.00	0.0	180.00	0.0
1.028	85.12	0.0	0.0	0.18	981.96	0.0	36.08	0.0	1018.04	0.63	178.26	1.10
1.028	85.92	0.80	0.80	0.14	986.00	986.00	28.00	1014.00	1014.00	0.0	180.00	0.0
1.062	85.13	0.0	0.0	0.01	982.00	0.0	35.99	0.0	1018.00	0.60	178.36	1.04
1.062	85.93	0.80	0.80	0.01	986.00	986.00	28.00	1014.00	1014.00	0.0	180.00	0.0
1.071	85.11	0.0	0.0	-0.02	2981.20	0.0	32.95	0.0	3014.15	38.44	115.25	26.32
1.071	85.92	0.81	0.77	-0.01	2982.40	2982.40	30.90	3013.30	3013.30	44.27	105.93	29.80
1.084	85.55	0.0	0.0	0.84	2953.21	0.0	271.67	0.0	3272.15	44.96	103.88	31.16
1.084	86.61	0.06	0.06	0.08	2968.00	2968.00	58.70	3026.70	3026.70	45.49	103.07	31.44
1.094	86.01	0.0	0.0	0.06	589.56	0.0	1340.45	0.0	1930.01	66.96	41.30	71.74
1.094	86.02	0.02	0.06	0.02	993.00	993.00	14.00	1007.00	1007.00	0.0	180.00	0.0
1.249	86.01	0.0	0.0	0.00	529.18	0.0	710.85	0.0	1240.02	60.96	23.32	95.72
1.249	86.35	0.34	0.45	0.33	995.00	995.00	10.00	1005.00	1005.00	0.0	180.00	0.0

SECNO	CWSEL	DIFWSP	DIFEG	DIFWSX	SSTA	STENCL	TOPWID	STENCR	ENDST	QLOB	QCH	QROB
1.258	86.01	0.0	0.0	-0.00	1998.00	0.0	43.35	0.0	2041.35	0.0	59.85	126.14
1.258	86.48	0.48	0.46	0.13	1998.00	1998.00	41.30	2039.30	2039.30	0.0	52.83	127.17
1.269	86.30	0.0	0.0	0.30	1998.00	0.0	40.65	0.0	2038.65	0.0	64.47	115.53
1.269	86.46	0.16	0.15	-0.02	1998.00	1998.00	40.50	2038.50	2038.50	0.0	61.59	118.41
1.279	86.37	0.0	0.0	0.07	422.62	0.0	858.30	0.0	1280.92	78.51	27.96	73.53
1.279	86.46	0.09	0.20	-0.00	995.00	995.00	10.00	1005.00	1005.00	0.0	180.00	0.0
1.297	86.37	0.0	0.0	-0.00	404.34	0.0	1625.92	0.0	2270.74	56.11	47.01	76.88
1.297	86.61	0.24	0.23	0.15	405.00	405.00	1625.25	2270.70	2270.70	51.80	33.10	95.10
1.304	86.37	0.0	0.0	0.00	404.00	0.0	1626.28	0.0	2270.75	57.03	44.12	78.85
1.304	86.61	0.24	0.23	0.00	405.00	405.00	1625.25	2270.70	2270.70	52.37	30.61	97.03
1.313	86.38	0.0	0.0	0.01	510.82	0.0	1780.02	0.0	2290.84	103.46	49.56	26.98
1.313	86.57	0.20	0.26	-0.04	994.00	994.00	12.00	1006.00	1006.00	0.0	180.00	0.0
1.487	86.45	0.0	0.0	0.07	945.82	0.0	70.30	0.0	1016.12	47.23	118.04	14.73
1.487	87.08	0.63	0.72	0.51	995.00	995.00	10.00	1005.00	1005.00	0.0	180.00	0.0
1.496	86.43	0.0	0.0	-0.02	994.10	0.0	11.80	0.0	1005.90	0.0	180.00	0.0
1.496	87.16	0.73	0.72	0.08	994.10	994.10	11.80	1005.90	1005.90	0.0	180.00	0.0
1.505	86.51	0.0	0.0	0.48	994.10	0.0	11.80	0.0	1005.90	0.0	180.00	0.0
1.505	87.65	0.74	0.71	0.48	994.10	994.10	11.80	1005.90	1005.90	0.0	180.00	0.0
1.515	87.02	0.0	0.0	0.11	899.54	0.0	184.65	0.0	1084.19	42.00	87.30	50.70
1.515	87.65	0.64	0.74	0.01	995.00	995.00	10.00	1005.00	1005.00	0.0	180.00	0.0

SUMMARY OF ERRORS

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -  01,02
  MODIFICATION -  50,51,52,53
**************************************************
```

THIS RUN EXECUTED 07/12/78 09.33.07

HEC-RAS Model Report

HEC-RAS HEC-RAS 6.5 February 2024
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X      X   X     X  X    X
X     X  X        X           X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X           X  X     X    X        X
X     X  X        X    X      X   X    X    X        X
X     X  XXXXXX    XXXX       X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: WalkersBrook
Project File : WalkersBrook.prj
Run Date and Time: 3/13/2025 8:59:27 PM

Project in English units

PLAN DATA

Plan Title: EX
Plan File : C:\Users\FlahertyD\AECOM\Reading - Walkers brook - CAD_GIS\HEC-RAS\Walkers Brook V2\WalkersBrook.p18

Geometry Title: EX
Geometry File : C:\Users\FlahertyD\AECOM\Reading - Walkers brook - CAD_GIS\HEC-RAS\Walkers Brook V2\WalkersBrook.g17

Flow Title : EX_PR
Flow File : C:\Users\FlahertyD\AECOM\Reading - Walkers brook - CAD_GIS\HEC-RAS\Walkers Brook V2\WalkersBrook.f07

Plan Summary Information:

Number of:	Cross Sections	= 24	Multiple Openings	=	0
	Culverts	= 0	Inline Structures	=	0
	Bridges	= 5	Lateral Structures	=	0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01

```
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow




FLOW DATA

Flow Title: EX_PR
Flow File : C:\Users\FlahertyD\AECOM\Reading - Walkers brook -
CAD_GIS\HEC-RAS\Walkers Brook V2\WalkersBrook.f07

Flow Data (cfs)


  River           Reach           RS                      10              50
   100             500
  River 1         Reach 1         1947                   140             230
   280             420



Boundary Conditions


  River           Reach           Profile                       Upstream
    Downstream


  River 1         Reach 1         10
 Known WS = 77.54
  River 1         Reach 1         50
 Known WS = 78.22
  River 1         Reach 1         100
 Known WS = 78.54
  River 1         Reach 1         500
 Known WS = 79.33




SUMMARY OF MANNING'S N VALUES
```

River:River 1

Reach	River Sta.	n1	n2	n3
Reach 1	1947	.16	.05	.16
Reach 1	1907	.1	.02	.1
Reach 1	1904.36	Bridge		
Reach 1	1876	.16	.05	.16
Reach 1	1862	.16	.05	.16
Reach 1	1833	.16	.05	.16
Reach 1	1680	.16	.05	.16
Reach 1	1646	.1	.02	.1
Reach 1	1631.63	Bridge		
Reach 1	1600	.16	.05	.16
Reach 1	1587	.16	.05	.16
Reach 1	1399	.16	.05	.16
Reach 1	1379	.16	.03	.16
Reach 1	1367.717	.1	.02	.1
Reach 1	1361	Bridge		
Reach 1	1359	.1	.02	.1
Reach 1	1342.288	.16	.03	.16
Reach 1	1313	.16	.05	.16
Reach 1	919	.16	.05	.16
Reach 1	885	.1	.02	.1
Reach 1	873.47	Bridge		
Reach 1	780	.1	.02	.1
Reach 1	725	.16	.05	.16
Reach 1	659	.16	.05	.16
Reach 1	618	.1	.02	.1
Reach 1	600	Bridge		
Reach 1	480	.16	.05	.16
Reach 1	448	.16	.05	.16
Reach 1	4	.16	.05	.16

SUMMARY OF REACH LENGTHS

River: River 1

Reach	River Sta.	Left	Channel	Right
Reach 1	1947	67.7	40.6	59.4
Reach 1	1907	31	30.5	34.3
Reach 1	1904.36	Bridge		
Reach 1	1876	15.7	14.5	13.8
Reach 1	1862	27.2	28.4	30.9
Reach 1	1833	152.5	153.3	157.6

Reach 1	1680		34.6	33.8	31
Reach 1	1646		56.7	46	45.6
Reach 1	1631.63	Bridge			
Reach 1	1600		14.6	13.3	16.3
Reach 1	1587		197.3	188.4	187
Reach 1	1399		21.6	20.2	20.5
Reach 1	1379		11.2	10.6	10.6
Reach 1	1367.717		15.8	15.8	15.9
Reach 1	1361	Bridge			
Reach 1	1359		9.6	9.6	9.6
Reach 1	1342.288		47.6	46.7	47.2
Reach 1	1313		376.8	376.4	376.3
Reach 1	919		33.9	33.8	33.9
Reach 1	885		106	105.1	103.4
Reach 1	873.47	Bridge			
Reach 1	780		59.1	55.6	47.6
Reach 1	725		65.6	66.1	62.9
Reach 1	659		40.4	40.4	40.4
Reach 1	618		136.1	138.2	139.5
Reach 1	600	Bridge			
Reach 1	480		27.1	31.8	33
Reach 1	448		440.2	444.3	446.1
Reach 1	4				

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: River 1

Reach	River Sta.		Contr.	Expan.
Reach 1	1947		.1	.3
Reach 1	1907		.3	.5
Reach 1	1904.36	Bridge		
Reach 1	1876		.3	.5
Reach 1	1862		.1	.3
Reach 1	1833		.1	.3
Reach 1	1680		.1	.3
Reach 1	1646		.3	.5
Reach 1	1631.63	Bridge		
Reach 1	1600		.3	.5
Reach 1	1587		.1	.3
Reach 1	1399		.1	.3
Reach 1	1379		.1	.3
Reach 1	1367.717		.3	.5
Reach 1	1361	Bridge		
Reach 1	1359		.3	.5
Reach 1	1342.288		.1	.3

Reach 1	1313		.1	.3
Reach 1	919		.1	.3
Reach 1	885		.3	.5
Reach 1	873.47	Bridge		
Reach 1	780		.3	.5
Reach 1	725		.1	.3
Reach 1	659		.1	.3
Reach 1	618		.3	.5
Reach 1	600	Bridge		
Reach 1	480		.3	.5
Reach 1	448		.1	.3
Reach 1	4		.1	.3

Profile Output Table - Standard Table 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.
E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	
			(cfs)	(ft)	(ft)	(ft)
(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		
Reach 1	1947	10	140.00	76.00	81.251	77.79
81.30	0.000661	1.82	81.23	483.98	0.15	
Reach 1	1947	50	230.00	76.00	82.491	78.42
82.57	0.000751	2.29	112.20	607.56	0.17	
Reach 1	1947	100	280.00	76.00	83.136	78.72
83.23	0.000761	2.48	130.21	750.73	0.18	
Reach 1	1907	10	140.00	75.35	81.196	77.48
81.28	0.000212	2.38	59.93	235.80	0.19	
Reach 1	1907	50	230.00	75.35	82.393	78.22
82.55	0.000280	3.15	80.65	371.15	0.22	
Reach 1	1907	100	280.00	75.35	83.018	78.57
83.20	0.000299	3.46	94.42	413.17	0.23	
Reach 1	1904.36		Bridge			
Reach 1	1876	10	140.00	76.00	81.157	77.88
81.26	0.001598	2.56	55.30	12.71	0.21	
Reach 1	1876	50	230.00	76.00	82.338	78.59
82.51	0.002052	3.36	73.38	17.44	0.24	
Reach 1	1876	100	280.00	76.00	82.958	78.94
83.17	0.002160	3.68	84.65	48.71	0.25	

Reach 1	1862	10	140.00	76.00	81.177	
81.22	0.000461	1.57	90.68	21.93	0.13	
Reach 1	1862	50	230.00	76.00	82.379	
82.44	0.000564	2.03	118.11	24.12	0.15	
Reach 1	1862	100	280.00	76.00	83.009	
83.08	0.000586	2.21	137.68	50.35	0.15	
Reach 1	1833	10	140.00	76.00	81.153	
81.20	0.000600	1.72	83.56	24.24	0.15	
Reach 1	1833	50	230.00	76.00	82.351	
82.42	0.000691	2.18	114.46	27.39	0.17	
Reach 1	1833	100	280.00	76.00	82.980	
83.07	0.000702	2.37	132.31	31.10	0.17	
Reach 1	1680	10	140.00	77.04	81.003	
81.07	0.001215	2.08	68.45	24.87	0.21	
Reach 1	1680	50	230.00	77.04	82.200	
82.29	0.001069	2.44	100.27	28.31	0.21	
Reach 1	1680	100	280.00	77.04	82.836	
82.94	0.000986	2.57	118.96	31.13	0.21	
Reach 1	1646	10	140.00	77.15	80.969	78.98
81.05	0.000251	2.33	61.74	23.94	0.24	
Reach 1	1646	50	230.00	77.15	82.164	79.54
82.28	0.000215	2.70	93.01	28.40	0.23	
Reach 1	1646	100	280.00	77.15	82.799	79.80
82.92	0.000196	2.84	111.81	30.78	0.23	
Reach 1	1631.63		Bridge			
Reach 1	1600	10	140.00	77.04	80.932	78.97
81.02	0.001566	2.33	61.35	23.07	0.24	
Reach 1	1600	50	230.00	77.04	82.132	79.50
82.24	0.001339	2.70	91.59	27.38	0.23	
Reach 1	1600	100	280.00	77.04	82.771	79.75
82.89	0.001218	2.83	109.82	29.71	0.23	
Reach 1	1587	10	140.00	76.83	80.932	
80.99	0.000882	1.86	76.21	25.45	0.18	
Reach 1	1587	50	230.00	76.83	82.136	
82.21	0.000830	2.23	108.83	28.72	0.19	
Reach 1	1587	100	280.00	76.83	82.776	

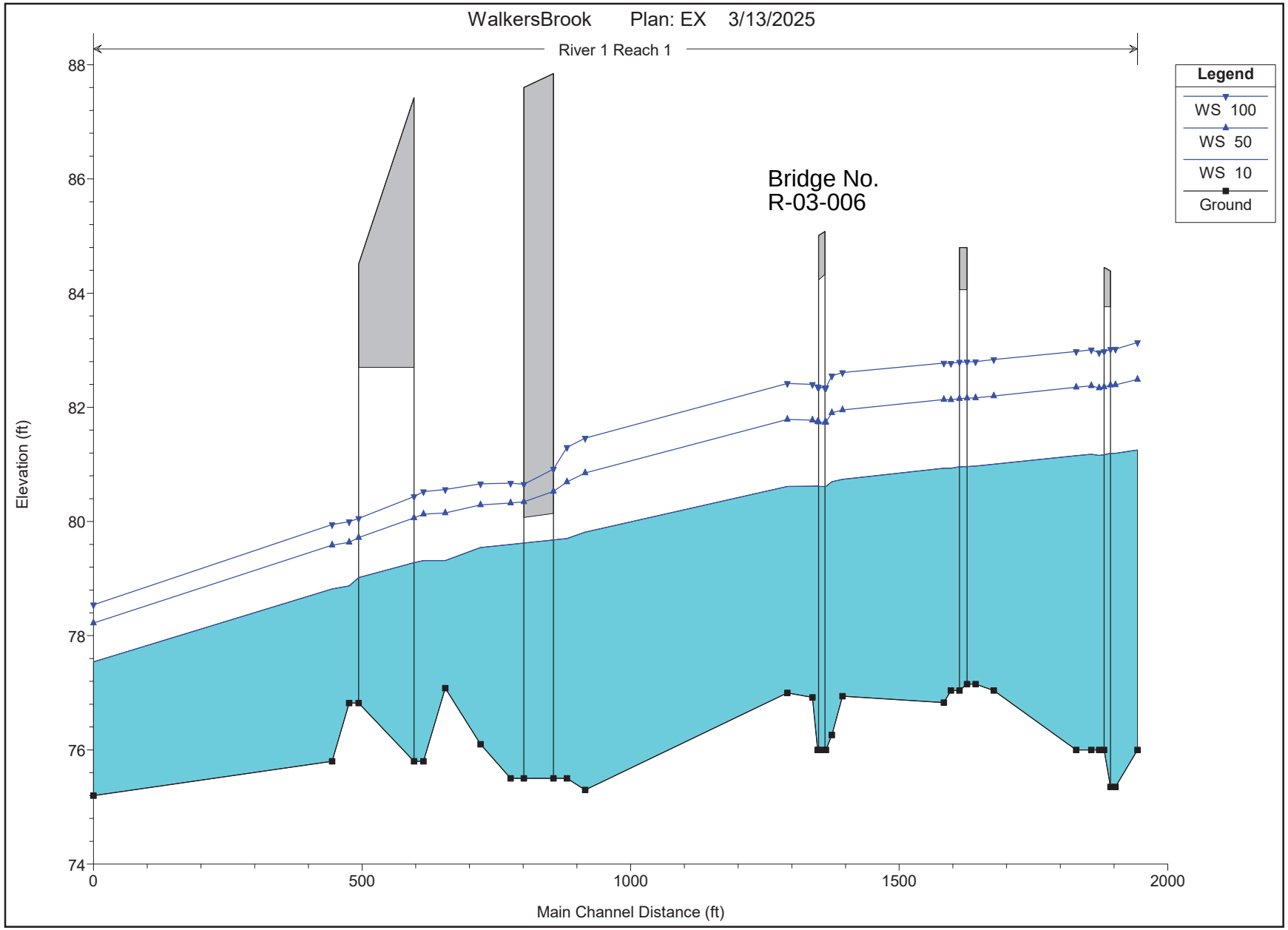
82.86	0.000782	2.36	127.78	30.46	0.18	
Reach 1	1399	10	140.00	76.94	80.738	
80.80	0.001100	2.00	70.75	24.44	0.20	
Reach 1	1399	50	230.00	76.94	81.956	
82.04	0.000988	2.36	102.69	27.97	0.20	
Reach 1	1399	100	280.00	76.94	82.607	
82.70	0.000913	2.49	121.54	29.86	0.20	
Reach 1	1379	10	140.00	76.26	80.699	
80.78	0.000521	2.32	61.20	20.89	0.23	
Reach 1	1379	50	230.00	76.26	81.905	
82.02	0.000492	2.78	89.15	25.67	0.23	
Reach 1	1379	100	280.00	76.26	82.552	
82.69	0.000462	2.95	106.67	28.51	0.23	
Reach 1	1367.717	10	140.00	76.00	80.614	78.01
80.77	0.000479	3.17	44.24	10.47	0.27	
Reach 1	1367.717	50	230.00	76.00	81.740	78.76
82.00	0.000595	4.13	56.20	10.78	0.31	
Reach 1	1367.717	100	280.00	76.00	82.345	79.13
82.66	0.000620	4.52	62.77	10.94	0.32	
Reach 1	1361		Bridge			
Reach 1	1359	10	140.00	76.00	80.621	77.85
80.75	0.000382	2.87	48.90	11.38	0.24	
Reach 1	1359	50	230.00	76.00	81.753	78.56
81.97	0.000479	3.74	62.13	12.00	0.28	
Reach 1	1359	100	280.00	76.00	82.361	78.91
82.62	0.000500	4.10	69.52	12.32	0.29	
Reach 1	1342.288	10	140.00	76.92	80.620	
80.74	0.000909	2.75	51.17	19.53	0.29	
Reach 1	1342.288	50	230.00	76.92	81.777	
81.93	0.000760	3.18	75.31	22.58	0.28	
Reach 1	1342.288	100	280.00	76.92	82.400	
82.57	0.000685	3.33	90.07	24.81	0.28	
Reach 1	1313	10	140.00	77.00	80.613	
80.67	0.001141	1.98	71.00	24.55	0.20	
Reach 1	1313	50	230.00	77.00	81.787	

```
   81.87     0.001024       2.34      101.28       27.16           0.20
Reach 1       1313          100        280.00       77.00      82.417
   82.51     0.000947       2.47      118.89       28.72           0.20


Reach 1       919           10         140.00       75.30      79.812
   79.97     0.003542       3.14       44.56        9.95           0.26
Reach 1       919           50         230.00       75.30      80.851
   81.12     0.004908       4.19       54.92        9.99           0.31
Reach 1       919           100        280.00       75.30      81.461
   81.79     0.005124       4.59       61.44       12.80           0.33


Reach 1       885           10         140.00       75.50      79.702       77.67
   79.91     0.000821       3.66       38.28        9.96           0.33
Reach 1       885           50         230.00       75.50      80.694       78.40
   81.05     0.001058       4.77       48.38       10.95           0.38
Reach 1       885           100        280.00       75.50      81.299       78.76
   81.71     0.001056       5.16       55.40       12.37           0.39


Reach 1       873.47                   Bridge



Reach 1       780           10         140.00       75.50      79.599       77.67
   79.82     0.000861       3.76       37.26        9.96           0.34
Reach 1       780           50         230.00       75.50      80.324       78.40
   80.74     0.001289       5.17       44.49       10.10           0.43
Reach 1       780           100        280.00       75.50      80.672       78.76
   81.20     0.001487       5.84       48.28       11.74           0.47


Reach 1       725           10         140.00       76.10      79.545
   79.70     0.003556       3.32       58.71       28.62           0.33
Reach 1       725           50         230.00       76.10      80.290
   80.53     0.004349       4.24       81.23       31.73           0.38
Reach 1       725           100        280.00       76.10      80.659
   80.94     0.004597       4.63       93.22       33.11           0.40


Reach 1       659           10         140.00       77.08      79.315
   79.42     0.004601       2.57       54.41       36.36           0.37
Reach 1       659           50         230.00       77.08      80.151
   80.26     0.002854       2.69       86.15       39.50           0.31
Reach 1       659           100        280.00       77.08      80.559
   80.68     0.002445       2.78      102.56       40.97           0.30


Reach 1       618           10         140.00       75.80      79.316       77.20
```

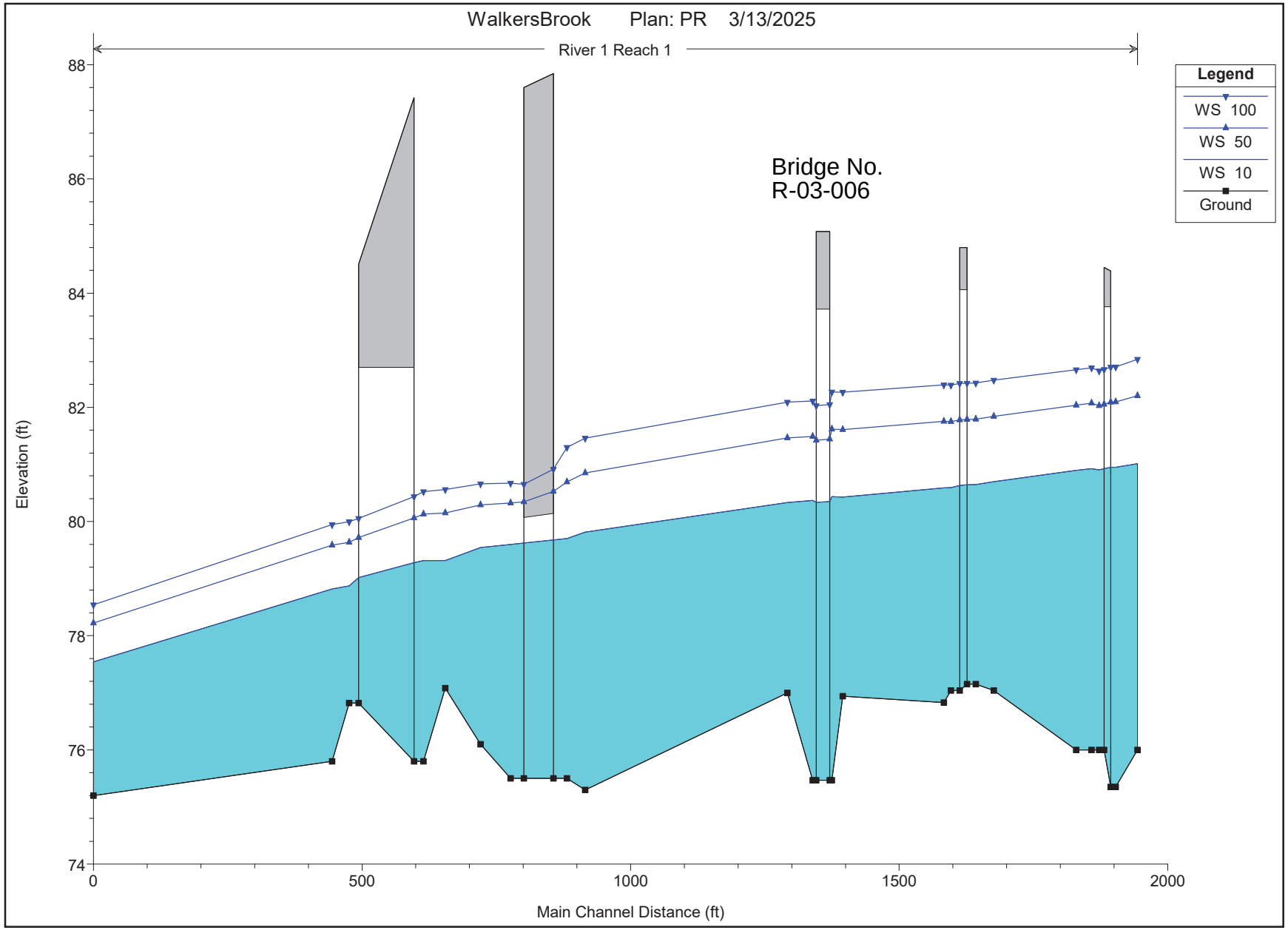
```
   79.38     0.000233       2.05       68.23       33.90           0.21
Reach 1       618            50         230.00       75.80      80.130       77.66
   80.24     0.000273       2.62       88.42       39.32           0.24
Reach 1       618            100        280.00       75.80      80.524       77.89
   80.65     0.000288       2.88       98.69       42.03           0.25

Reach 1       600                       Bridge

Reach 1       480            10         140.00       76.82      78.872       78.27
   79.09     0.009154       3.71       38.59       32.07           0.53
Reach 1       480            50         230.00       76.82      79.636       78.73
   79.88     0.006124       3.97       65.26       36.97           0.46
Reach 1       480            100        280.00       76.82      79.996       78.95
   80.25     0.005457       4.14       78.98       39.08           0.45

Reach 1       448            10         140.00       75.80      78.819
   78.90     0.001970       2.38       68.32       36.72           0.26
Reach 1       448            50         230.00       75.80      79.585
   79.71     0.002139       2.95       98.01       40.48           0.28
Reach 1       448            100        280.00       75.80      79.946
   80.10     0.002207       3.21      112.86       41.71           0.29

Reach 1       4              10         140.00       75.20      77.540       76.52
   77.67     0.004120       2.90       48.66       26.49           0.36
Reach 1       4              50         230.00       75.20      78.220       76.94
   78.41     0.004160       3.55       67.94       30.49           0.38
Reach 1       4              100        280.00       75.20      78.540       77.14
   78.77     0.004205       3.84       77.97       32.19           0.39
```

HEC-RAS Profiles

Existing Conditions Model

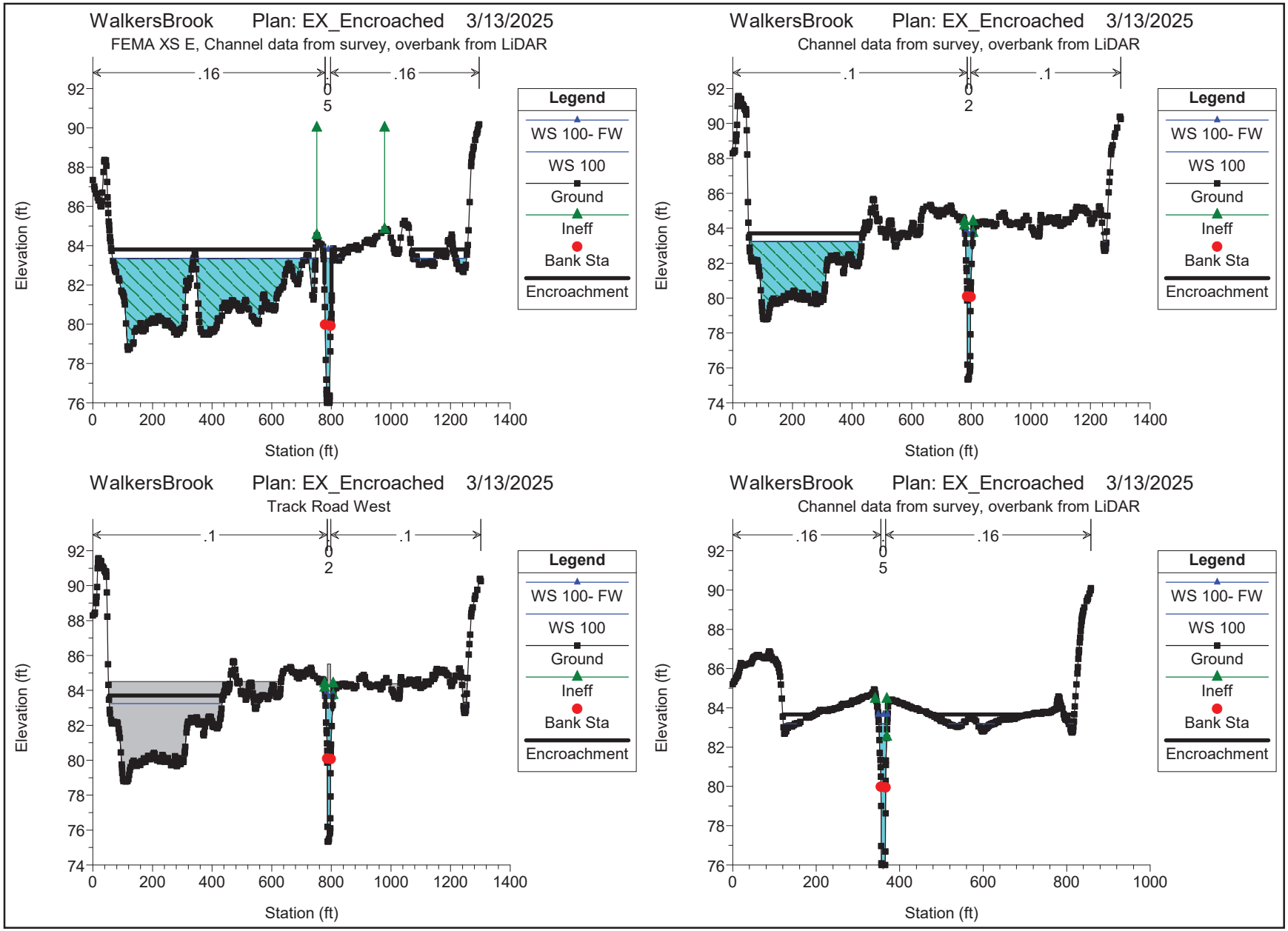

WalkersBrook Plan: EX 3/13/2025
River 1 Reach 1
Bridge No.
R-03-006
Legend
WS 100
WS 50
WS 10
Ground
Elevation (ft)
88
86
84
82
80
78
76
74
0
500
1000
1500
2000
Main Channel Distance (ft)

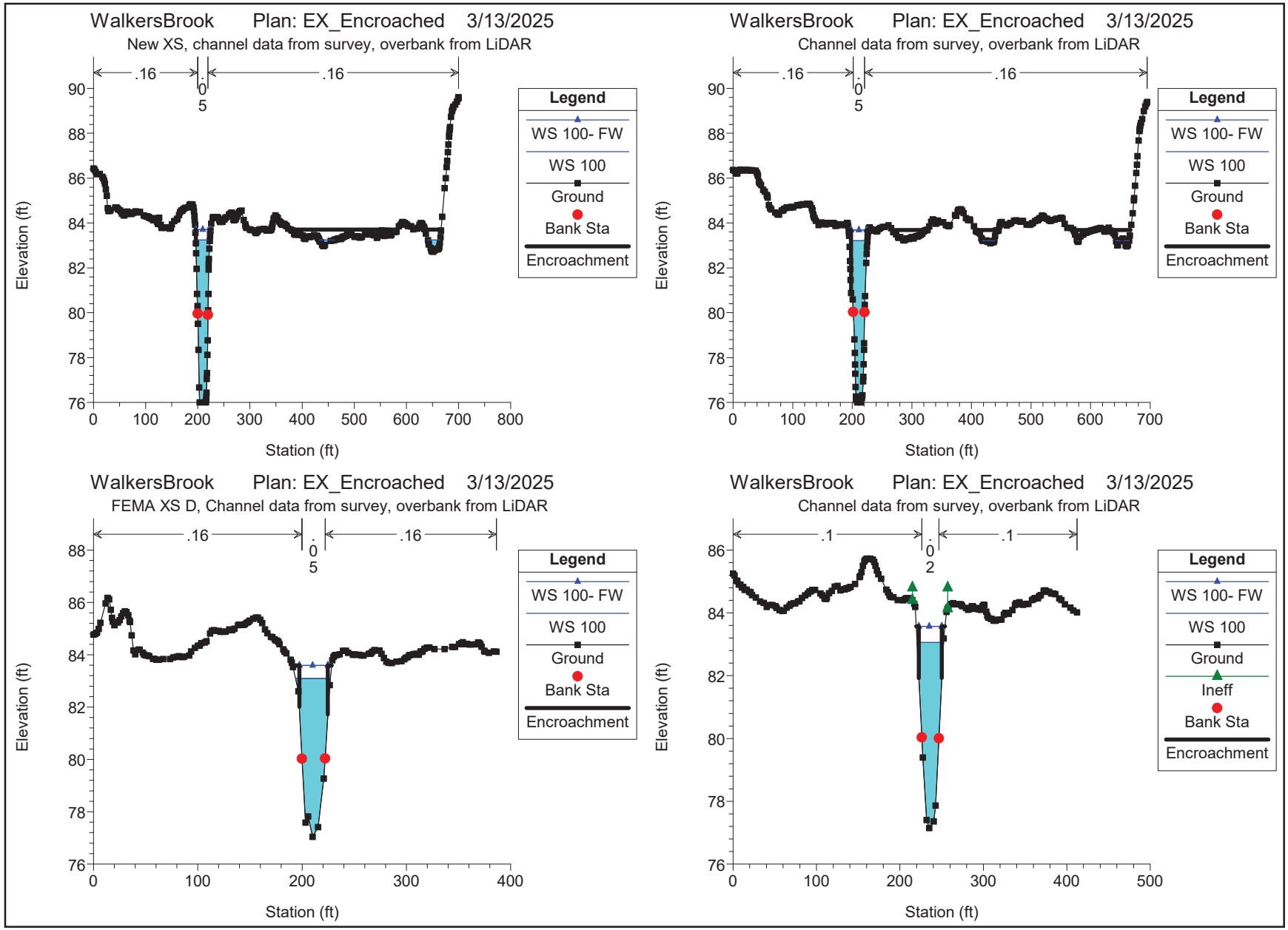
Proposed Conditions Model

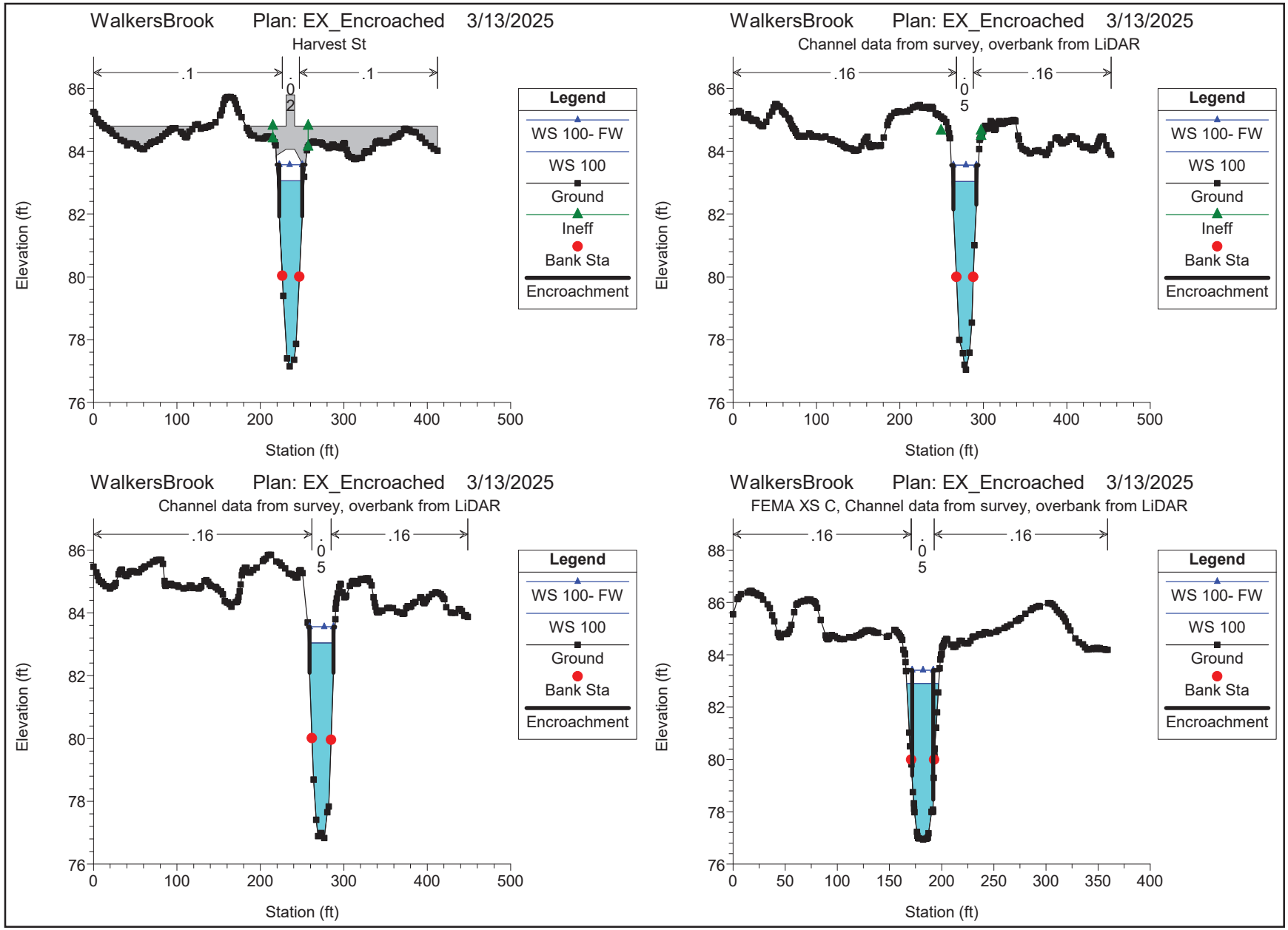

WalkersBrook Plan: PR 3/13/2025
River 1 Reach 1
Bridge No.
R-03-006
Legend
WS 100
WS 50
WS 10
Ground
Elevation (ft)
88
86
84
82
80
78
76
74
0
500
1000
1500
2000
Main Channel Distance (ft)

HEC-RAS Cross Sections

Existing Conditions Model


WalkersBrook Plan: EX_Encroached 3/13/2025
FEMA XS E, Channel data from survey, overbank from LiDAR
.16
0
5
.16
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.1
0
2
.1
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Track Road West
.1
0
2
.1
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
0
5
.16
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)


WalkersBrook Plan: EX_Encroached 3/13/2025
New XS, channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
FEMA XS D, Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment


WalkersBrook Plan: EX_Encroached 3/13/2025
Harvest St
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
FEMA XS C, Channel data from survey, overbank from LiDAR
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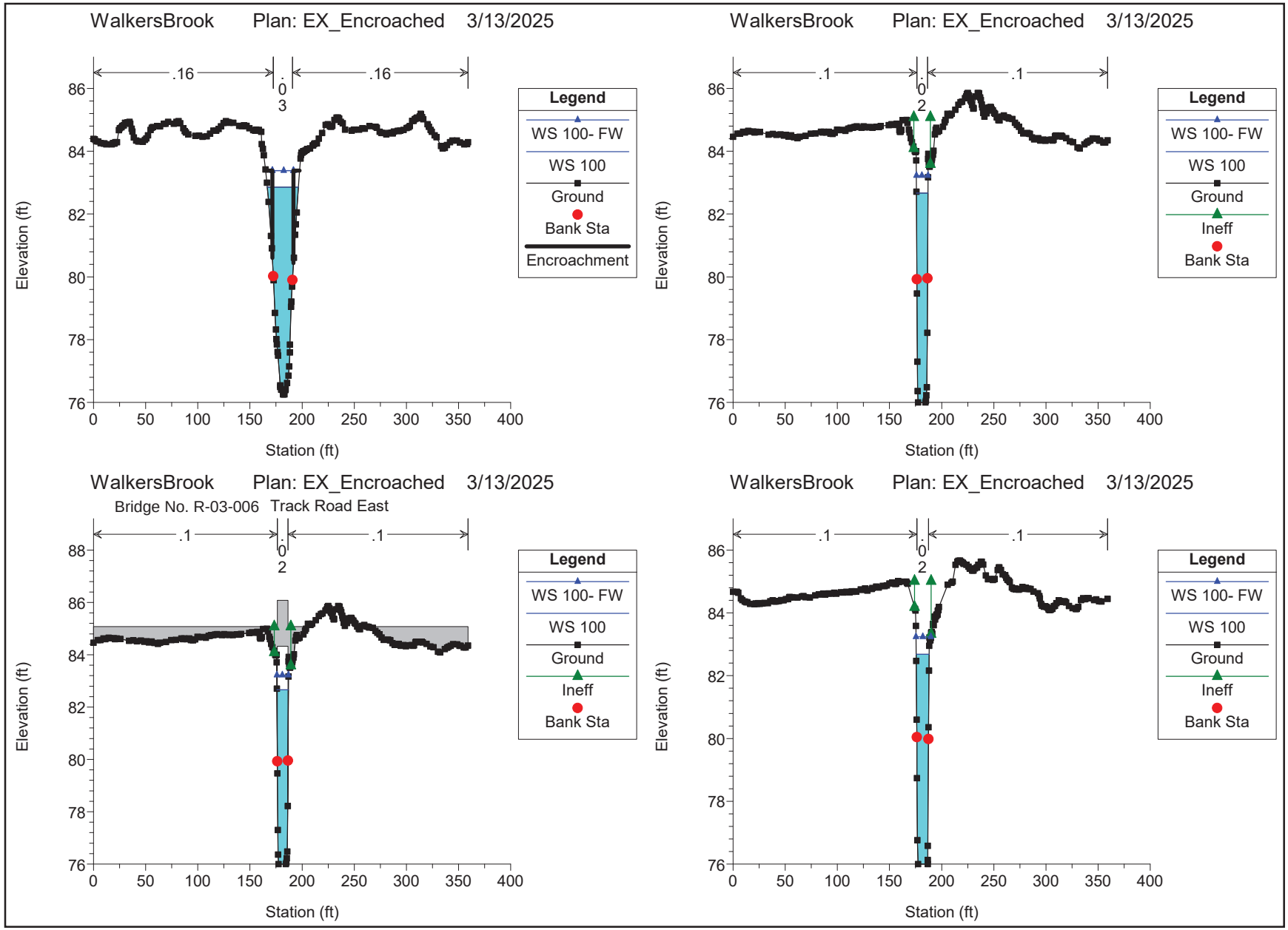
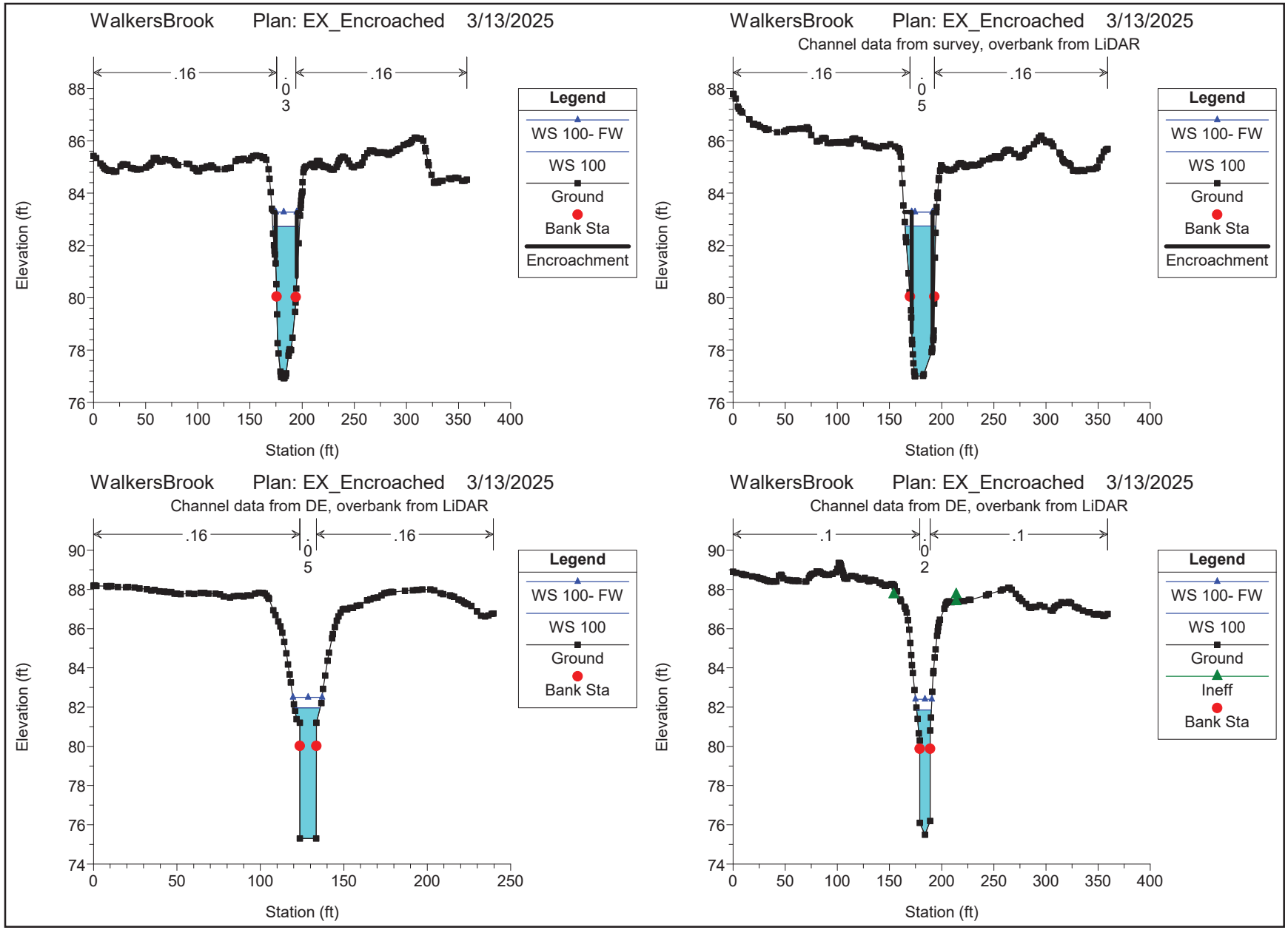
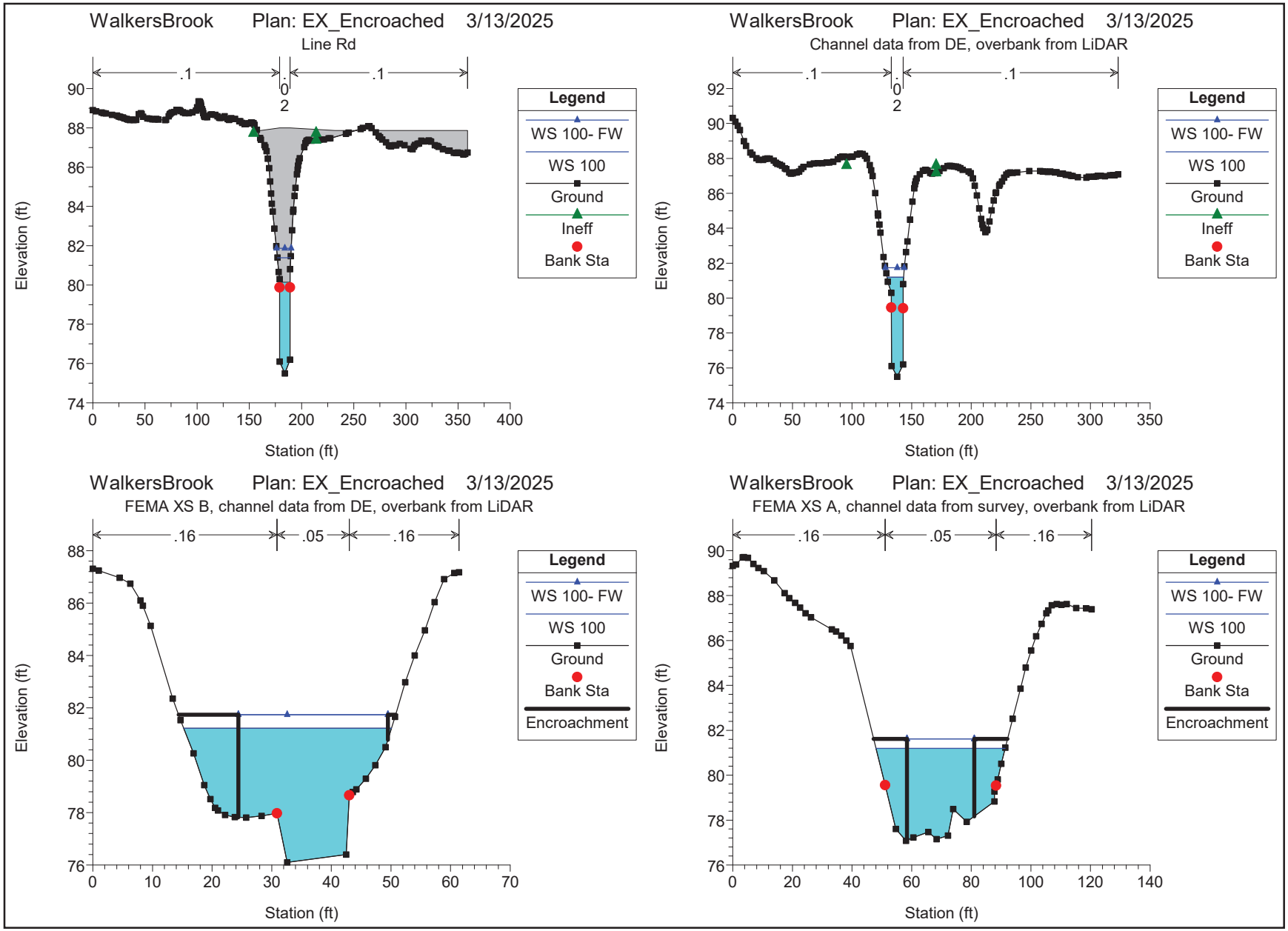
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment


WalkersBrook Plan: EX_Encroached 3/13/2025
.16
.03
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: EX_Encroached 3/13/2025
Bridge No. R-03-006 Track Road East
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: EX_Encroached 3/13/2025
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta


WalkersBrook Plan: EX_Encroached 3/13/2025
.16
.03
.16
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.16
.05
.16
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Elevation (ft)
Station (ft)
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.1
.02
.1
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


WalkersBrook Plan: EX_Encroached 3/13/2025
Line Rd
.1
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.1
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: EX_Encroached 3/13/2025
FEMA XS B, channel data from DE, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
FEMA XS A, channel data from survey, overbank from LiDAR
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.05
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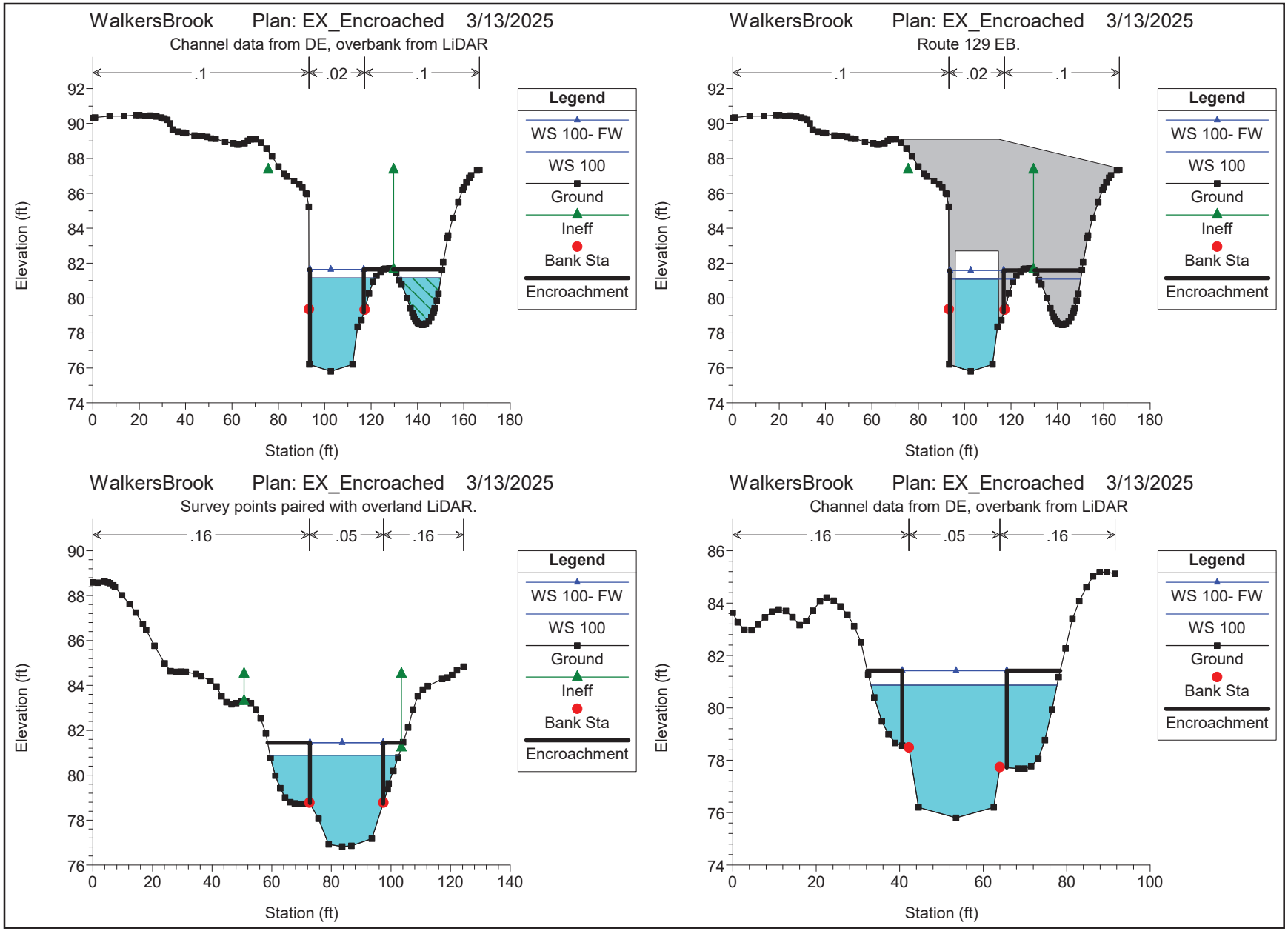
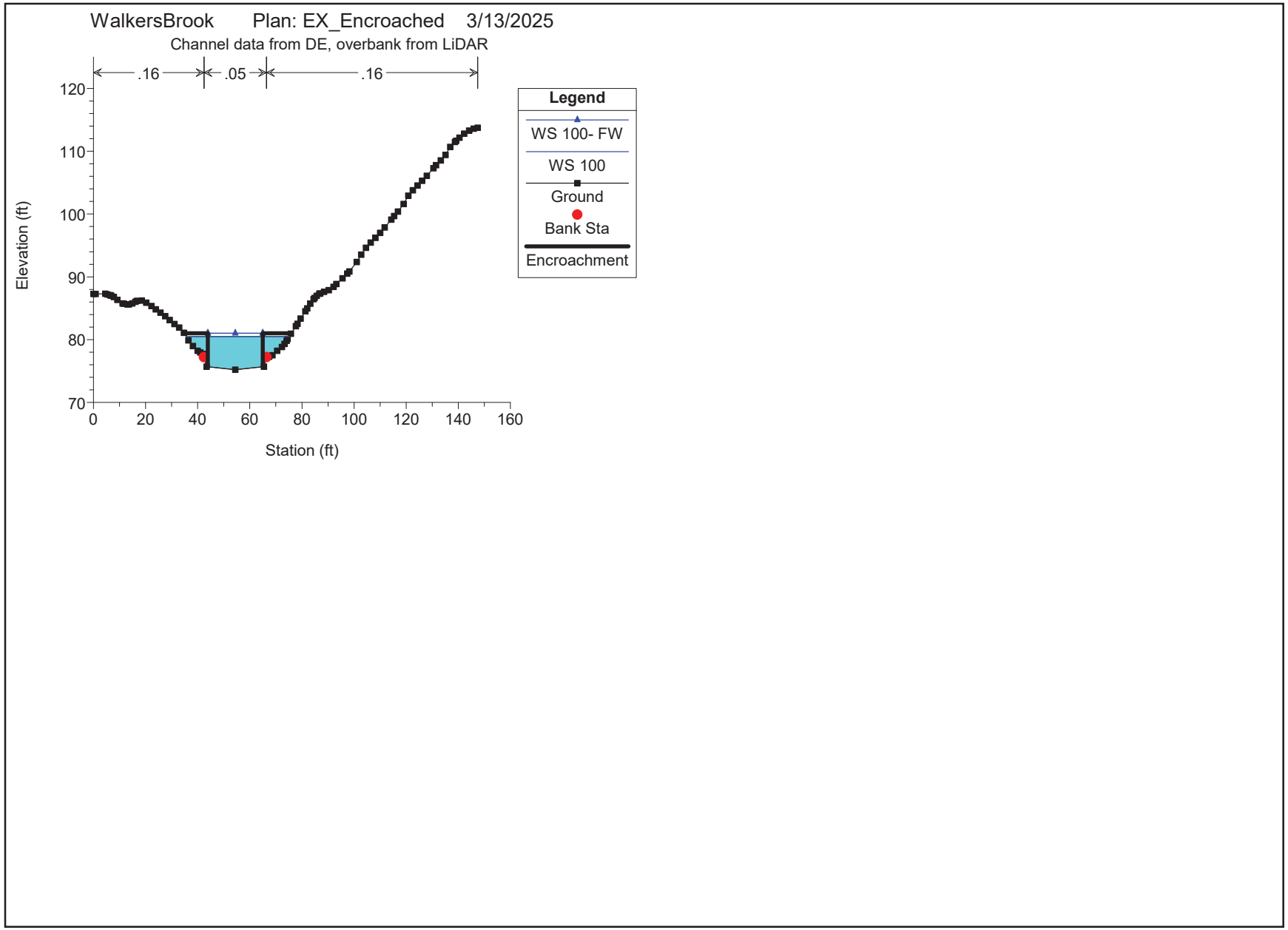
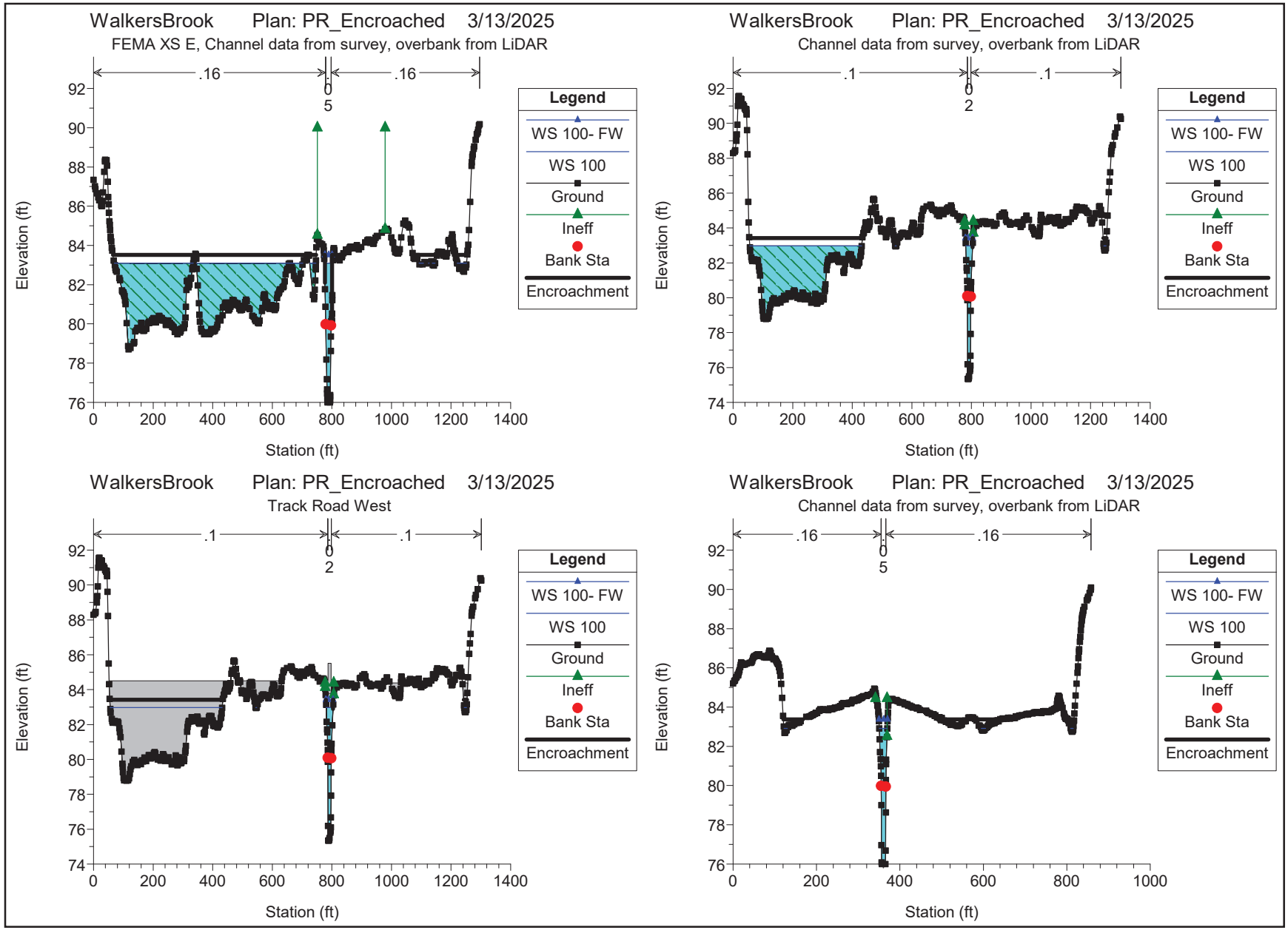
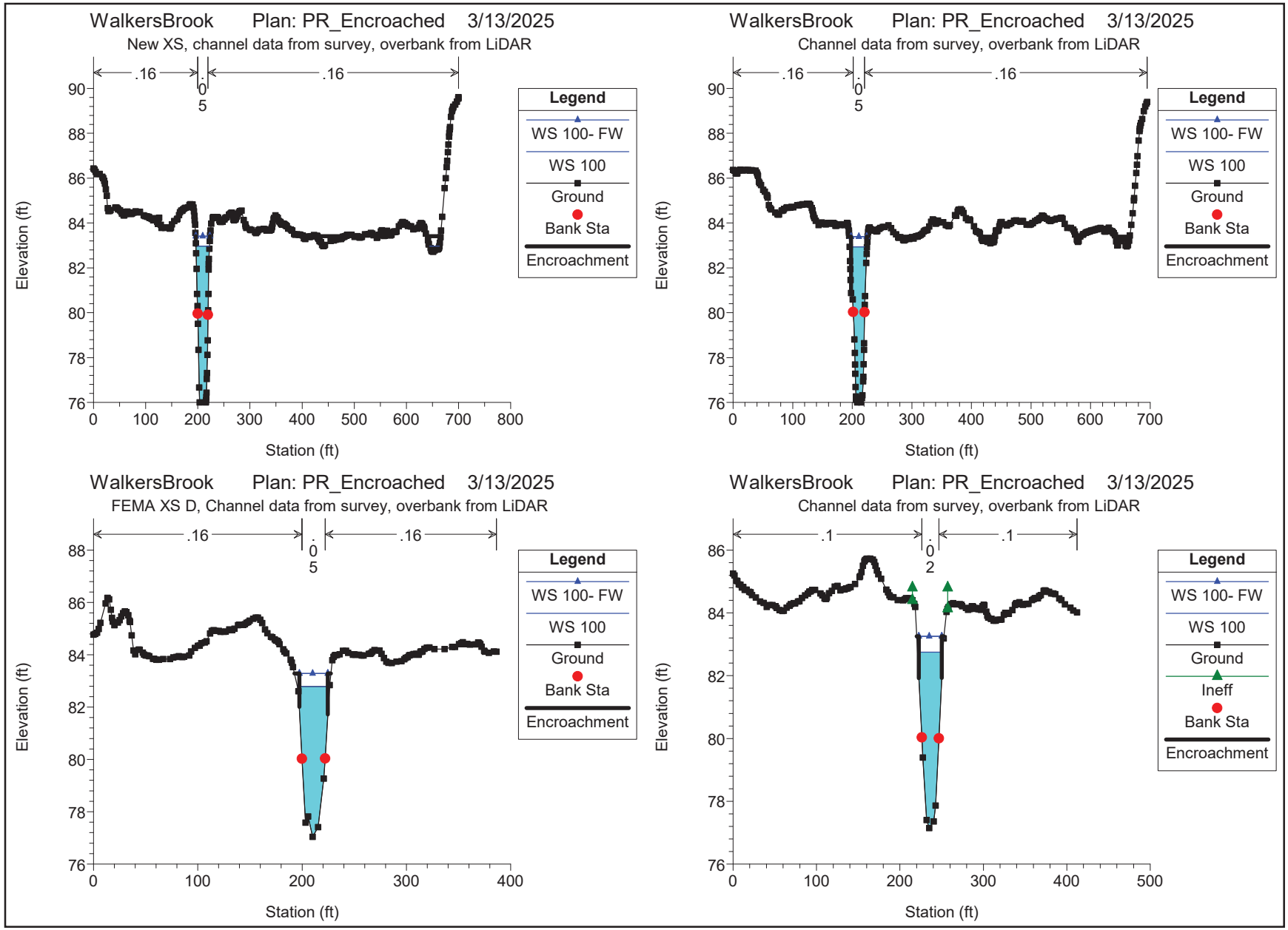
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment

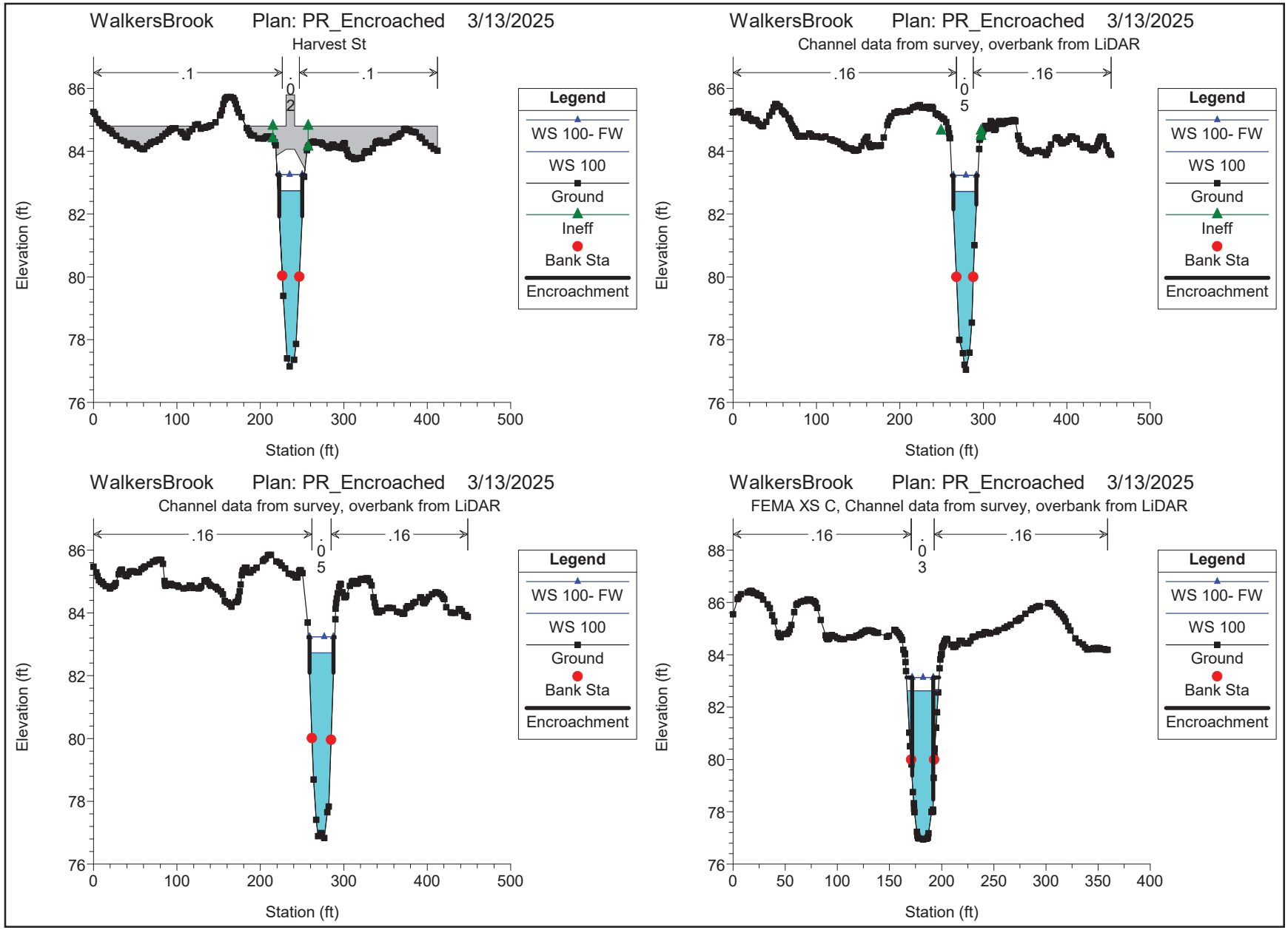

WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Route 129 EB.
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Survey points paired with overland LiDAR.
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment

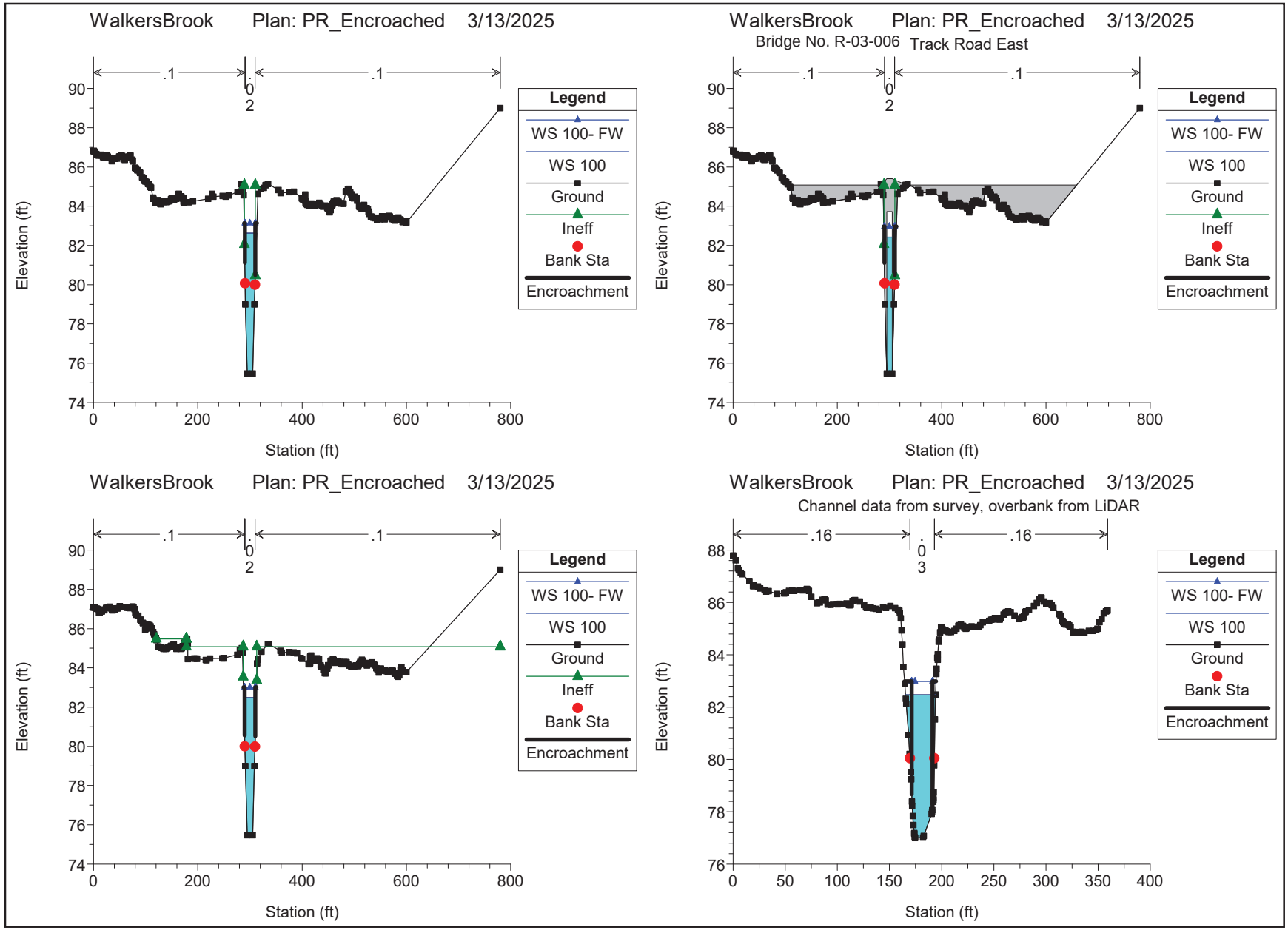

WalkersBrook Plan: EX_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.16
.05
.16
Elevation (ft)
120
110
100
90
80
70
0
20
40
60
80
100
120
140
160
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment

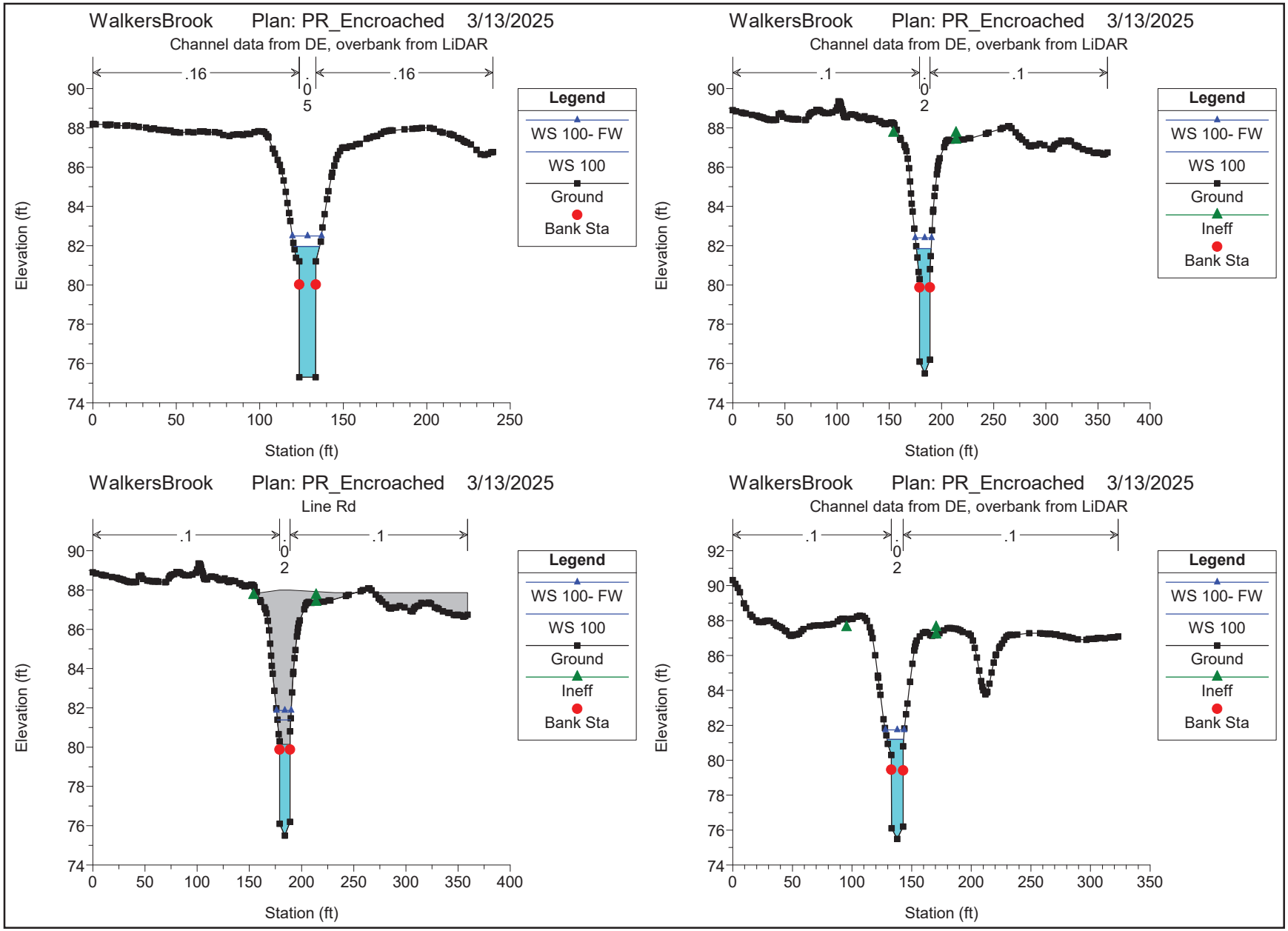
Proposed Conditions Model

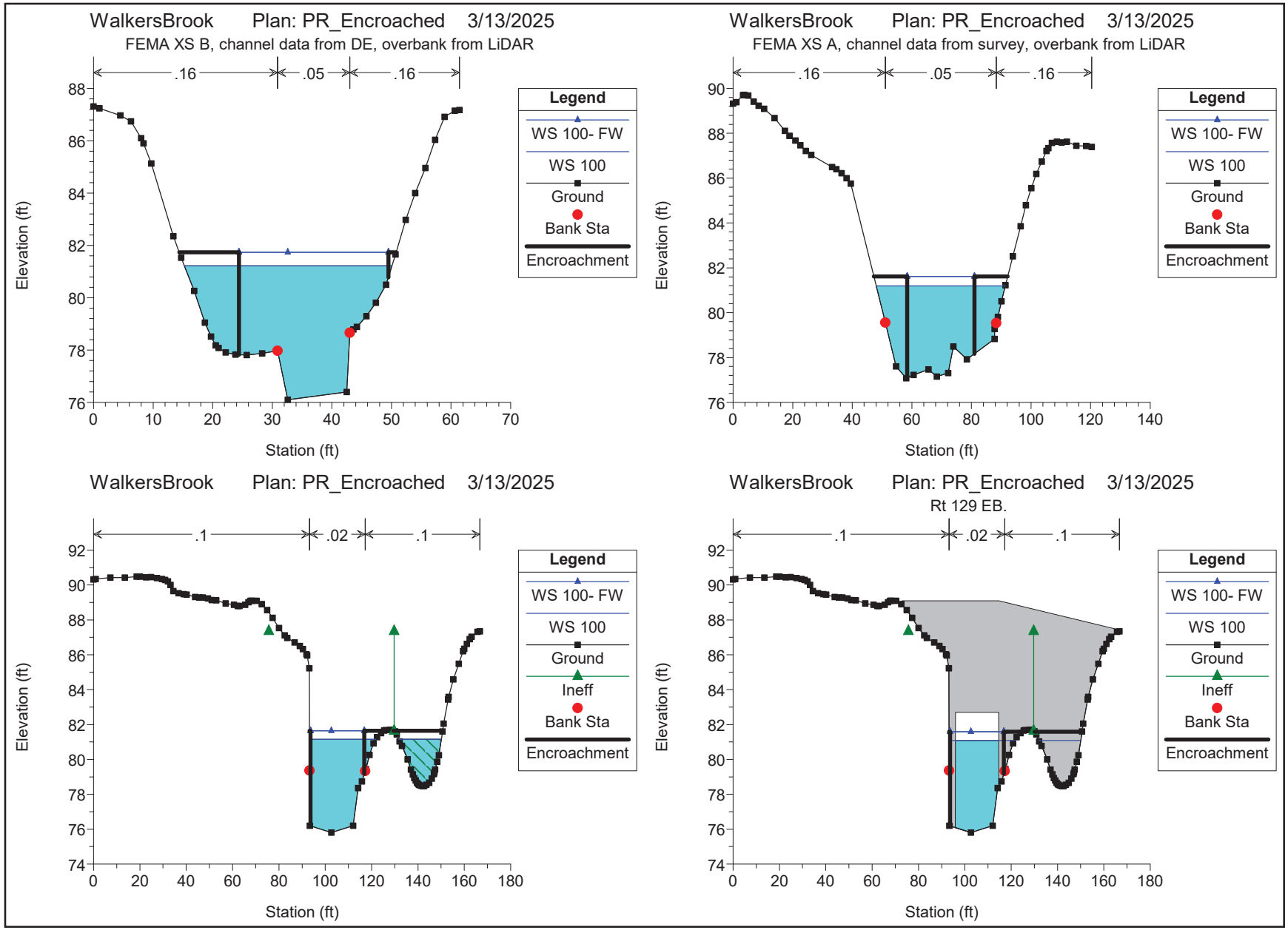

WalkersBrook Plan: PR_Encroached 3/13/2025
FEMA XS E, Channel data from survey, overbank from LiDAR
.16
0
5
.16
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.1
0
2
.1
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: PR_Encroached 3/13/2025
Track Road West
.1
0
2
.1
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
0
5
.16
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
Elevation (ft)
Station (ft)

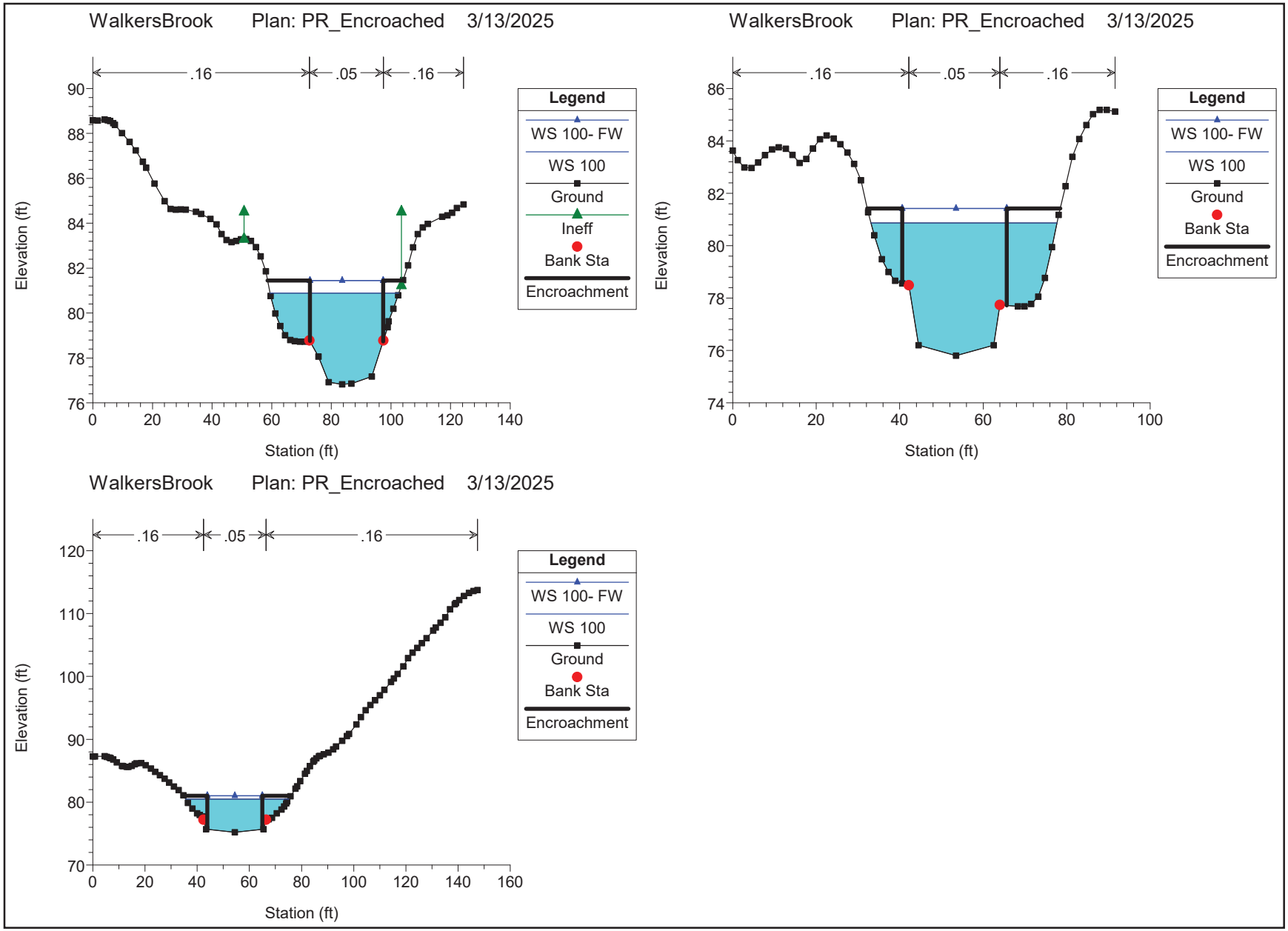

WalkersBrook Plan: PR_Encroached 3/13/2025
New XS, channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
FEMA XS D, Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment


WalkersBrook Plan: PR_Encroached 3/13/2025
Harvest St
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
FEMA XS C, Channel data from survey, overbank from LiDAR
.16
.03
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment


WalkersBrook Plan: PR_Encroached 3/13/2025
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Bridge No. R-03-006 Track Road East
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from survey, overbank from LiDAR
.16
.03
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment


WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: PR_Encroached 3/13/2025
Line Rd
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
WalkersBrook Plan: PR_Encroached 3/13/2025
Channel data from DE, overbank from LiDAR
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta


WalkersBrook Plan: PR_Encroached 3/13/2025
FEMA XS B, channel data from DE, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
FEMA XS A, channel data from survey, overbank from LiDAR
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
Rt 129 EB.
.1
.02
.1
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment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.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Ineff
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment
WalkersBrook Plan: PR_Encroached 3/13/2025
.16
.05
.16
Elevation (ft)
Station (ft)
Legend
WS 100- FW
WS 100
Ground
Bank Sta
Encroachment

HEC-RAS Simulation Output for No-Rise Analysis

100-Year Duplicate Effective No-Rise Model Results

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Channel (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
1	1900	100	280	76.2	83.6		83.69	0.00021	2.56	261.38	483.27	0.17
1	1851	100	280	75.5	83.38	79.69	83.65	0.00117	4.16	67.35	36.07	0.29
1	1850	Track Road West Bridge										
1	1836	100	280	75.5	83.35		83.62	0.00119	4.18	67	33.11	0.29
1	1786	100	280	75.9	83.39		83.52	0.00034	3	174.04	398.07	0.21
1	1643	100	280	76.2	83.38		83.47	0.00022	2.53	168.15	46.4	0.17
1	1594	100	280	74.9	83.28	77.89	83.45	0.00038	3.28	85.4	115.09	0.2
1	1593	Harvest Road Bridge										
1	1579	100	280	74.9	83.26		83.43	0.00038	3.29	85.19	104.73	0.2
1	1529	100	280	75.7	83.3		83.37	0.00017	2.23	175.95	41.49	0.15
1	1381	100	280	76.3	83.27		83.34	0.00018	2.29	176.64	42.61	0.16
1	1332	100	280	75.8	83.06	78.92	83.31	0.00089	3.99	70.26	33.16	0.27
1	1331	Track Road East Bridge (R-03-006)										
1	1317	100	280	75.8	83.03		83.28	0.0009	4	69.93	32.96	0.27
1	1267	100	280	75.7	82.35		83.05	0.00563	6.72	41.66	9.57	0.57
1	897	100	280	75.3	81.33		81.67	0.00231	4.69	59.76	10.71	0.34
1	848	100	280	75.5	81.08	78.75	81.53	0.00301	5.38	52.08	11.46	0.42
1	847	Line Road Bridge										
1	765	100	280	75.5	80.69		81.21	0.00389	5.82	48.1	10.39	0.47
1	715	100	280	76.1	79.26	79.16	80.62	0.01542	9.36	29.91	9.97	0.95
1	641	100	280	76.7	79.63		79.95	0.00232	4.69	72.1	31.47	0.5
1	592	100	280	75.8	79.58	77.9	79.85	0.0013	4.18	66.99	26.91	0.39
1	591	State Route 129 EB										
1	488	100	280	75.8	79.39		79.7	0.00156	4.41	63.47	26.28	0.42
1	438	100	280	75.8	79.29		79.6	0.00234	4.49	62.4	20.6	0.45
1	0	100	280	75.2	78.54	77.14	78.76	0.0015	3.83	76.02	29.76	0.39

100-Year Existing Condition No-Rise Model Results (Unencroached)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Channel (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
Reach 1	1947	100	280	76	83.14	78.72	83.23	0.00076	2.48	130.21	750.73	0.18
Reach 1	1907	100	280	75.35	83.02	78.57	83.2	0.0003	3.46	94.42	413.17	0.23
Reach 1	1904.36	Track Road West Bridge										
Reach 1	1876	100	280	76	82.96	78.94	83.17	0.00216	3.68	84.65	48.71	0.25
Reach 1	1862	100	280	76	83.01		83.08	0.00059	2.21	137.68	50.35	0.15
Reach 1	1833	100	280	76	82.98		83.07	0.0007	2.37	132.31	31.1	0.17
Reach 1	1680	100	280	77.04	82.84		82.94	0.00099	2.57	118.96	31.13	0.21
Reach 1	1646	100	280	77.15	82.8	79.8	82.92	0.0002	2.84	111.81	30.78	0.23
Reach 1	1631.63	Harvest Road Bridge										
Reach 1	1600	100	280	77.04	82.77	79.75	82.89	0.00122	2.83	109.82	29.71	0.23
Reach 1	1587	100	280	76.83	82.78		82.86	0.00078	2.36	127.78	30.46	0.18
Reach 1	1399	100	280	76.94	82.61		82.7	0.00091	2.49	121.54	29.86	0.2
Reach 1	1379	100	280	76.26	82.55		82.69	0.00046	2.95	106.67	28.51	0.23
Reach 1	1367.717	100	280	76	82.34	79.13	82.66	0.00062	4.52	62.77	10.94	0.32
Reach 1	1361	Track Road East Bridge (R-03-006)										
Reach 1	1359	100	280	76	82.36	78.91	82.62	0.0005	4.1	69.52	12.32	0.29
Reach 1	1342.288	100	280	76.92	82.4		82.57	0.00069	3.33	90.07	24.81	0.28
Reach 1	1313	100	280	77	82.42		82.51	0.00095	2.47	118.89	28.72	0.2
Reach 1	919	100	280	75.3	81.46		81.79	0.00512	4.59	61.44	12.8	0.33
Reach 1	885	100	280	75.5	81.3	78.76	81.71	0.00106	5.16	55.4	12.37	0.39
Reach 1	873.47	Line Road Bridge										
Reach 1	780	100	280	75.5	80.67	78.76	81.2	0.00149	5.84	48.28	11.74	0.47
Reach 1	725	100	280	76.1	80.66		80.94	0.0046	4.63	93.22	33.11	0.4
Reach 1	659	100	280	77.08	80.56		80.68	0.00245	2.78	102.56	40.97	0.3
Reach 1	618	100	280	75.8	80.52	77.89	80.65	0.00029	2.88	98.69	42.03	0.25
Reach 1	600	State Route 129 EB										
Reach 1	480	100	280	76.82	80	78.95	80.25	0.00546	4.14	78.98	39.08	0.45
Reach 1	448	100	280	75.8	79.95		80.1	0.00221	3.21	112.86	41.71	0.29
Reach 1	4	100	280	75.2	78.54	77.14	78.77	0.00421	3.84	77.97	32.19	0.39

100-Year Proposed Condition No-Rise Model Results (Unencroached)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Channel (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
Reach 1	1947	100	280	76	82.84	78.72	82.94	0.0009	2.62	121.78	658.14	0.19
Reach 1	1907	100	280	75.35	82.71	78.57	82.91	0.00035	3.64	87.34	395.35	0.25
Reach 1	1904.36	Track Road West Bridge										
Reach 1	1876	100	280	76	82.64	78.94	82.87	0.00257	3.88	78.72	18.33	0.27
Reach 1	1862	100	280	76	82.69		82.78	0.0007	2.34	125.84	25.08	0.17
Reach 1	1833	100	280	76	82.66		82.75	0.00085	2.51	123.02	28.31	0.18
Reach 1	1680	100	280	77.04	82.47		82.59	0.00128	2.78	108.16	29.1	0.23
Reach 1	1646	100	280	77.15	82.43	79.8	82.57	0.00026	3.09	100.64	29.39	0.26
Reach 1	1631.63	Harvest Road Bridge										
Reach 1	1600	100	280	77.04	82.39	79.75	82.54	0.00162	3.09	98.76	28.32	0.26
Reach 1	1587	100	280	76.83	82.4		82.5	0.00102	2.56	116.37	29.43	0.21
Reach 1	1399	100	280	76.94	82.27		82.38	0.00042	2.68	111.54	28.87	0.22
Reach 1	1379	100	280	75.47	82.27	78.07	82.37	0.00014	2.54	112.71	23.06	0.19
Reach 1	1364	Track Road East Bridge (R-03-006)										
Reach 1	1342.29	100	280	75.47	82.11	78.08	82.21	0.00016	2.6	111.97	23.42	0.19
Reach 1	1313	100	280	77	82.09		82.2	0.00043	2.65	109.7	27.95	0.22
Reach 1	919	100	280	75.3	81.46		81.79	0.00512	4.59	61.44	12.8	0.33
Reach 1	885	100	280	75.5	81.3	78.76	81.71	0.00106	5.16	55.4	12.37	0.39
Reach 1	873.47	Line Road Bridge										
Reach 1	780	100	280	75.5	80.67	78.76	81.2	0.00149	5.84	48.28	11.74	0.47
Reach 1	725	100	280	76.1	80.66		80.94	0.0046	4.63	93.22	33.11	0.4
Reach 1	659	100	280	77.08	80.56		80.68	0.00245	2.78	102.56	40.97	0.3
Reach 1	618	100	280	75.8	80.52	77.89	80.65	0.00029	2.88	98.69	42.03	0.25
Reach 1	600	State Route 129 EB										
Reach 1	480	100	280	76.82	80	78.95	80.25	0.00546	4.14	78.98	39.08	0.45
Reach 1	448	100	280	75.8	79.95		80.1	0.00221	3.21	112.86	41.71	0.29
Reach 1	4	100	280	75.2	78.54	77.14	78.77	0.00421	3.84	77.97	32.19	0.39

100-Year Proposed Condition No-Rise Model Results (Encroached)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Channel (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
Reach 1	1947	100	280	76	83.09	78.72	83.19	0.00078	2.5	129	729.4	0.18
Reach 1	1907	100	280	75.35	82.97	78.57	83.16	0.00031	3.49	93.39	410.84	0.23
Reach 1	1904.36	Track Road West Bridge										
Reach 1	1876	100	280	76	82.91	78.94	83.12	0.00221	3.7	83.81	43.57	0.25
Reach 1	1862	100	280	76	82.96		83.04	0.0006	2.23	135.57	44.62	0.16
Reach 1	1833	100	280	76	82.93		83.02	0.00072	2.39	130.98	29.12	0.17
Reach 1	1680	100	280	77.04	82.79		82.89	0.00102	2.6	117.42	30.77	0.21
Reach 1	1646	100	280	77.15	82.75	79.8	82.87	0.0002	2.87	110.23	30.58	0.23
Reach 1	1631.63	Harvest Road Bridge										
Reach 1	1600	100	280	77.04	82.72	79.75	82.84	0.00127	2.87	108.26	29.51	0.23
Reach 1	1587	100	280	76.83	82.72		82.81	0.00081	2.39	126.18	30.32	0.19
Reach 1	1399	100	280	76.94	82.62		82.72	0.00033	2.49	122	29.9	0.2
Reach 1	1379	100	280	75.47	82.62	78.07	82.71	0.00012	2.39	120.07	23.68	0.17
Reach 1	1364	Track Road East Bridge (R-03-006)										
Reach 1	1342.288	100	280	75.47	82.48	78.08	82.57	0.00013	2.43	120.81	24.15	0.18
Reach 1	1313	100	280	77	82.47		82.56	0.00033	2.44	120.46	28.85	0.2
Reach 1	919	100	280	75.3	81.97		82.25	0.00391	4.23	68.59	15.34	0.29
Reach 1	885	100	280	75.5	81.85	78.76	82.19	0.00076	4.67	62.7	14.03	0.34
Reach 1	873.47	Line Road Bridge										
Reach 1	780	100	280	75.5	81.2	78.76	81.63	0.00105	5.25	55.14	13.95	0.4
Reach 1	725	100	280	76.1	81.22		81.43	0.0029	3.99	112.29	34.86	0.32
Reach 1	659	100	280	77.08	81.19		81.27	0.0012	2.24	129.29	43.29	0.22
Reach 1	618	100	280	75.8	81.16	77.89	81.25	0.00018	2.48	116.15	47.08	0.2
Reach 1	600	State Route 129 EB										
Reach 1	480	100	280	76.82	80.89	78.95	81.03	0.00197	3.02	115.94	43.25	0.28
Reach 1	448	100	280	75.8	80.87		80.96	0.001	2.5	152.85	44.6	0.2
Reach 1	4	100	280	75.2	80.5	77.14	80.58	0.00074	2.26	149.15	39.61	0.18

100-Year Existing Condition No-Rise Model Results (Encroached)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Channel (fps)	Flow Area (sq. ft.)	Top Width (ft)	Froude # Channel
Reach 1	1947	100	280	76	83.36	78.72	83.44	0.00067	2.39	137.19	809.71	0.17
Reach 1	1907	100	280	75.35	83.25	78.57	83.42	0.00027	3.34	99.98	424.23	0.22
Reach 1	1904.36	Track Road West Bridge										
Reach 1	1876	100	280	76	83.19	78.94	83.39	0.00191	3.54	89.12	135.63	0.24
Reach 1	1862	100	280	76	83.24		83.31	0.00052	2.13	152.44	79.44	0.15
Reach 1	1833	100	280	76	83.22		83.29	0.00061	2.27	142.78	68.44	0.16
Reach 1	1680	100	280	77.04	83.09		83.19	0.00083	2.44	127.28	33.31	0.19
Reach 1	1646	100	280	77.15	83.06	79.8	83.17	0.00016	2.69	120.04	31.76	0.21
Reach 1	1631.63	Harvest Road Bridge										
Reach 1	1600	100	280	77.04	83.04	79.75	83.15	0.00101	2.68	117.92	30.68	0.21
Reach 1	1587	100	280	76.83	83.04		83.12	0.00066	2.24	136.03	31.19	0.17
Reach 1	1399	100	280	76.94	82.9		82.99	0.00075	2.34	130.53	30.7	0.18
Reach 1	1379	100	280	76.26	82.86		82.97	0.00038	2.78	115.56	29.96	0.21
Reach 1	1367.717	100	280	76	82.67	79.13	82.95	0.00052	4.29	66.32	11.03	0.3
Reach 1	1361	Track Road East Bridge (R-03-006)										
Reach 1	1359	100	280	76	82.68	78.91	82.92	0.00042	3.89	73.51	12.49	0.27
Reach 1	1342.288	100	280	76.92	82.72		82.87	0.00054	3.1	98.18	25.66	0.25
Reach 1	1313	100	280	77	82.74		82.82	0.00076	2.31	128.24	29.52	0.18
Reach 1	919	100	280	75.3	81.97		82.25	0.00391	4.23	68.59	15.34	0.29
Reach 1	885	100	280	75.5	81.85	78.76	82.19	0.00076	4.67	62.7	14.03	0.34
Reach 1	873.47	Line Road Bridge										
Reach 1	780	100	280	75.5	81.2	78.76	81.63	0.00105	5.25	55.14	13.95	0.4
Reach 1	725	100	280	76.1	81.22		81.43	0.0029	3.99	112.29	34.86	0.32
Reach 1	659	100	280	77.08	81.19		81.27	0.0012	2.24	129.29	43.29	0.22
Reach 1	618	100	280	75.8	81.16	77.89	81.25	0.00018	2.48	116.15	47.08	0.2
Reach 1	600	State Route 129 EB										
Reach 1	480	100	280	76.82	80.89	78.95	81.03	0.00197	3.02	115.94	43.25	0.28
Reach 1	448	100	280	75.8	80.87		80.96	0.001	2.5	152.85	44.6	0.2
Reach 1	4	100	280	75.2	80.5	77.14	80.58	0.00074	2.26	149.15	39.61	0.18

APPENDIX 7.5

HYDROLOGIC ANALYSES

FINAL

Aberjona River and Saugus River Drainage Study
Summary Report
for
Town of Reading, Massachusetts

View of Walker's Brook by Track Road Neighborhood

October 2013

Prepared by

AECOM

2.0 HYDROLOGIC AND HYDRAULIC METHODOLOGY AND MODEL DEVELOPMENT

This section identifies the available hydrologic and hydraulic models for the study areas and provides a summary of the data collected and reviewed for the current study. This section also presents the model development methodology for each study area.

2.1 Hydrologic and Hydraulic Models for the Study Areas

Hydrologic and hydraulic modeling was previously conducted for portions of the project area as part of Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS), as described below.

In Area 1, a hydraulic computer simulation model developed by the U.S. Army Corps of Engineers called HEC-2 was used to model a portion of Walkers Brook. The model was created in the 1970s and extends from the Town Line upstream to Ash Street, and was used for the recent Middlesex County FEMA FIS (FEMA, 2010). The peak flows used in this model were based on regression equations and did not include the extensive development that has occurred in the watershed since the model was developed. In addition, the model is no longer available in electronic format.

Existing hydraulic models are not available for Areas 2 and 3. In general, the hydraulic issues in Areas 2 and 3 are related primarily to the pipe drainage system, which is best modeled using the USEPA Storm Water Management Model (SWMM). The SWMM software is designed for piped drainage systems, but can also be used for open channel flow in wetlands and river systems. Areas 2 and 3 are tributary to Area 1. Therefore, changes in Areas 2 and 3 can affect Area 1. Based on these considerations, it was decided to combine Areas 1, 2, and 3 into a single SWMM model. The SWMM model incorporates information from the previous FEMA FIS model where appropriate. This SWMM model is hereafter referred to as the Saugus River Model.

In 2007, AECOM performed a FIS of the Mystic River drainage basin for FEMA. The FIS included an unsteady flow hydraulic analysis for the entire Mystic River watershed but modeled the Aberjona River headwater along with most of Area 4 as one subbasin. Details about local road crossing structures within Area 4 were not studied hydraulically in the FIS. Since many of the hydraulic issues in Area 4 are related primarily to river hydraulics, it was decided to extend the existing HEC-RAS model of the Aberjona River upstream to include the entire Area 4 project area. An exception to this general approach for Area 4 is in the Bond Street area. The flooding issues in the Bond Street area are primarily related to the piped drainage system as opposed to open channels found elsewhere along the Aberjona River. As noted above, the USEPA SWMM model is designed for piped drainage systems. Therefore, a detailed model of the Bond Street drainage system was created using the USEPA SWMM software.

Per the scope of work for the current study, the models developed are based on historic precipitation data and do not take into consideration potential future climate changes.

2.2 Record Information, Supplemental Survey, and Field Investigations

The Town of Reading provided AECOM with an archive of electronic files, including construction plans, as-built plans, assessors maps, and GIS mapping and elevation data. From these files, AECOM was able to obtain invert elevations, culvert dimensions, and other critical measurements pertaining to the various roadway crossings within the project area.

The record information was supplemented with survey data obtained by Hancock Associates under subcontract to AECOM in January 2012 (identified hereinafter as the 2012 survey). Survey data were obtained for 12 culvert crossings underneath roads or railroads, including invert elevation of pipe/culvert, depth of sediment above invert, depth of water, pipe/culvert dimensions, and elevation of top of road over culvert. Survey data was also obtained for 22 stream locations including elevation of bottom of stream, depth of water above bottom of stream, location and elevation of top of bank on each side of stream, and width between banks. An AECOM employee accompanied the survey crew to aid in identifying survey points and obtaining depth of sediment at key locations. The 2012 survey results are provided in Appendix B.

Subsequent to the 2012 survey, the Town of Reading provided AECOM with an additional set of electronic files, including data from a field inspection of high water marks observed as the result of a storm event that occurred between March 13 and March 15, 2010. AECOM used these high water marks to help verify results from the hydrologic and hydraulic models. AECOM also obtained a draft copy of the Town of Reading's stormwater infrastructure GIS database from the Town's stormwater consultant. This database was dated March 29, 2013. AECOM was able to use this database to perform more accurate drainage basin delineations for the Aberjona River study area.

Supplemental field survey was performed in Area 4 at the culvert beneath Birch Meadow Drive. The survey included the culvert, the roadway in the immediate vicinity of the culvert, and stream cross-sections upstream and downstream of the culvert.

For the Bond Street vicinity (in area 4), supplemental field survey was conducted to locate the outfall in the wetland and determine the amount of sediment in the stream channel immediately downstream from the outfall. Survey was also conducted in the vicinity of the overtopping manhole to confirm key elevations. The survey at the outfall shows sediment in the immediate area of the outfall has been removed, resulting in a defined channel about 6-feet across and about 2-feet deep. On the day of the survey, the water surface was 85.94 feet NAVD, roughly 2-feet above the invert of the 30-inch outfall (83.89 feet NAVD). Since sediment has only been removed from a limited area, the bottom of the channel rises 1.3 feet within a distance of about 5 feet to an elevation of 85.25 feet.

The survey at the overflowing manhole shows the rim elevation is 89.32 feet NAVD, roughly 2-feet above the ground surface at the base of the manhole. The water surface at this location is about 85.9 feet. Thus, the ground surface is about 1.4 feet above the water surface. The ground surface slopes to the wetland and reaches the water surface in about 20 feet.

The supplemental survey for Area 4 was also performed by Hancock Associates under subcontract to AECOM in April 2013 (identified hereinafter as the 2013 survey), and the complete results are provided in Appendix C.

For Area 4, AECOM engineers conducted additional field investigations along the Aberjona River to gather information. This information included the dimensions of the channel, the condition of the channel and overbank areas, and relative measurements of crossing structures and adjacent flood plain areas. AECOM engineers also inspected the crossing structures within the area to verify critical dimensions and assumptions used in hydraulic modeling.

In addition to the supplemental survey discussed above, field inspections were performed in the Bond Street vicinity of Area 4 to estimate the capacity of the catch basins on Lowell Street and confirm the

general configuration of the Lowell Street drainage system (see Figure 2-1). The Lowell Street drainage is generally configured as mapped by the Town's draft stormwater infrastructure GIS database with the following exceptions:

- **High Street.** Two catch basins were observed on High Street that were not shown in the GIS database. With the Town's assistance, the catch basins and associated manholes were inspected which indicated the catch basins connect directly to the Lowell Street drainage system and are not connected to the Bond Street drainage system. No evidence of blockages were observed in the field; however, the field inspections were not able to confirm the condition of the pipes.

- **Puritan Road.** Two catch basins are located near the intersection of Puritan Road and Lowell Street. The locations of the catch basins were confirmed in the field; however, the available mapping does not indicate how these catch basins are connected to the drainage system. Flow in Lowell Street which is not able to enter the Lowell Street drainage system would flow north on Puritan Road and be intercepted by these catch basins. It was assumed that these catch basins connect to the Lowell Street drainage system.

- **Grand Street.** The available GIS mapping shows four catch basins at the intersection of Grand Street and Lowell Street. The field inspection confirmed there are four catch basins, but the orientation is slightly different with two catch basins configured as double catch basins. Although the configuration of the catch basins is different than mapped, the hydraulic performance should be similar.

- **Hartshorn Street.** A catch basin was observed at the end of Hartshorn Street, but is not shown in the GIS mapping. It was assumed the catch basin connects to the Lowell Street Drainage System.

- **Bond Street.** Flow in the upper portion of Bond Street is conveyed via 18- and 21-inch pipes to about midway on Bond Street, at which point the pipe turns 90 degrees and heads toward the wetland below Bond Street. At the location where the pipe turns west, the mapping shows two catch basins; however, only one catch basin was observed at this location in the field. A catch basin near the intersection of Bond Street and Vine Street was observed to be partially blocked, and another catch basin on Vine Street near the intersection with Bond Street was observed to be completely blocked. The catch basin capacity on Bond Street is important because flow that cannot get into the drain system will flow north down Bond Street toward 46 Bond Street, which is the location of a residence with historic reports of an overtopping manhole in the backyard. Erosion in the Bond Street gutter was observed, suggesting excessive gutter flow may be occurring. It is noted that the Town's older drainage maps show the pipe along Bond Street at 18-inches, while the new draft stormwater GIS mapping shows the pipe at 21-inches. The model was updated to use the 21-inch size.

- **Lowell Street.** Several catch basins are not clearly mapped or differ from the available GIS mapping, and these are described below. It is also noted that the GIS mapping shows the Lowell Street drain below the connection with the 18-inch drain between Harvard Street and Harthshorn Street as a 12-inch pipe, while the older Master drainage drawings show this pipe as an 18-inch. It was assumed that the correct pipe size is 18-inches.

G:\Projects\MUNI\60236393REA\Maps\Figure 2-1 Confirmation Lowell Street.mxd

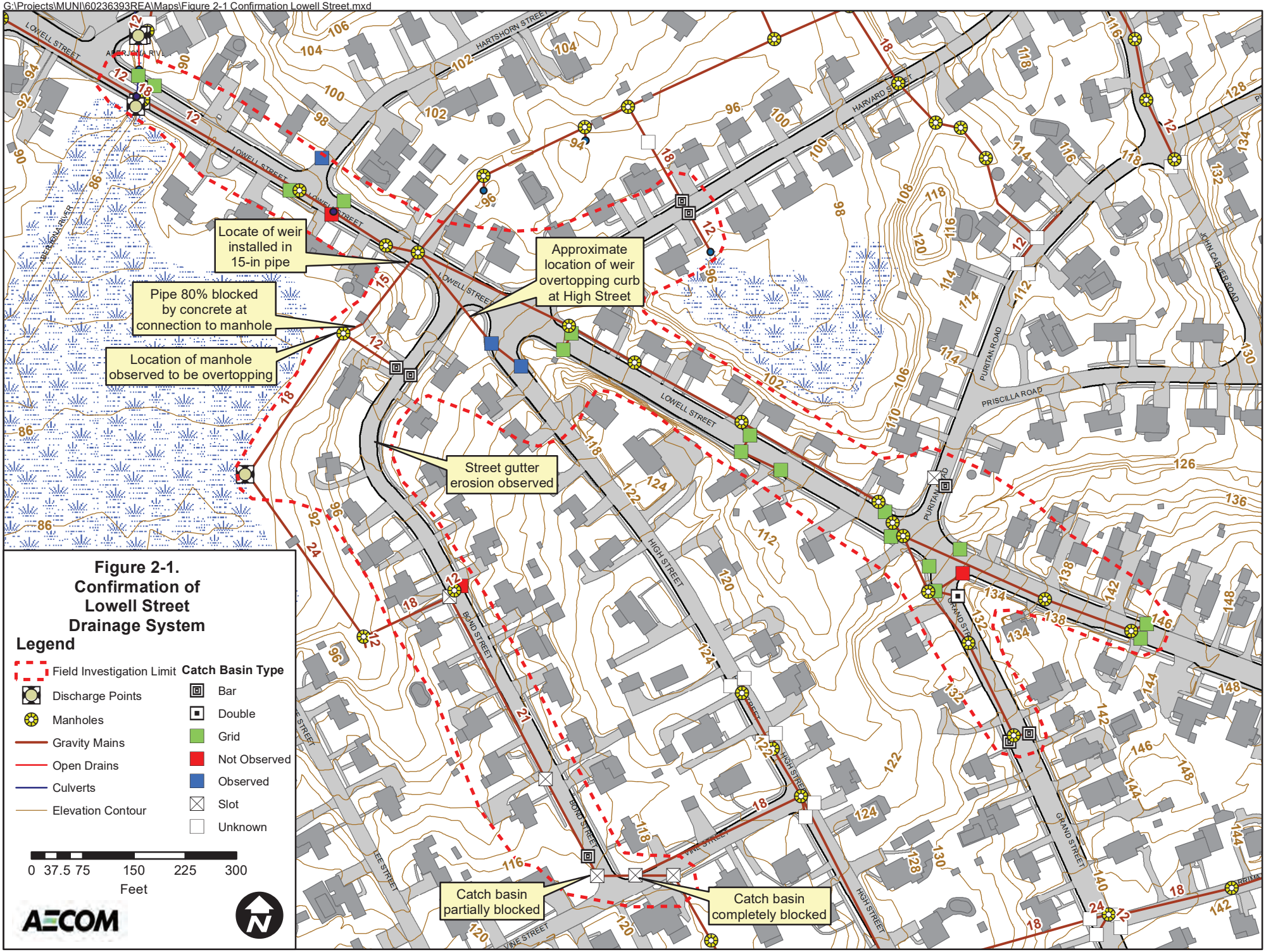


Figure 2-1. Confirmation of Lowell Street Drainage System

Legend

- Field Investigation Limit
- Discharge Points
- Manholes
- Gravity Mains
- Open Drains
- Culverts
- Elevation Contour

Catch Basin Type

- Bar
- Double
- Grid
- Not Observed
- Observed
- Slot
- Unknown

0 37.5 75 150 225 300
Feet

AECOM

- **Opposite Grand Street:** A catch basin opposite from Grand Street is shown in the GIS mapping and observed in the field. However, the catch basin is not connected in the GIS. It is assumed that the catch basin connects to the Lowell Street drainage system.

- **Opposite Hartshorn Street:** Two catch basins are shown in the GIS mapping opposite Hartshorn Street; however, only one was observed in the field.

- **Connection with Aberjona River:** Four catch basins are shown in the GIS mapping at the connection of the Lowell Street drain with the Aberjona River. The field observations indicated two single catch basins are on the north side of Lowell Street and two sets of double catch basins were observed on the south side, for a total of six catch basins at this location.

During the site walk, a brief discussion was held with the resident at 20 Bond Street. Figure 2-2 is a photograph of the overtopping manhole taken by the resident. Figure 2-3 is another photograph taken by the resident showing water flowing from Bond Street down the resident's driveway. The date of the photographs was not known by the resident; however, the electronic date stamp on the photographs was August 2, 2011. The resident also noted they had lived at this location for 38 years, and the first instance of flooding was approximately 8 years ago. After the first incidence of flooding, the manhole was replaced. Since then, flooding has occurred several times. The exact date of when the first episode of flooding is not precisely known. However, the observation that flooding did not occur for around 30 years suggests conditions may have changed recently in the drainage system or that more recent events (e.g. May 2007, April 2007, March 2010) have been more severe.

Another important observation that was made during the site walk is that yard erosion occurs above the 15-inch pipe from Lowell Street to the overflowing manhole. The Town installed a weir covering about 80 to 90 % of the pipe at the upstream manhole; however, this did not solve either the overflowing manhole or the yard erosion problem.

2.3 Saugus River Model (Areas 1, 2, and 3)

A hydrologic / hydraulic model of the key storms drains and streams in Areas 1, 2, 3 was created using the USEPA SWMM5 model. The PCSWMM graphical user interface was used to facilitate model development and analysis. Figure 2-2 illustrates the model extent. The model development includes specification of the hydrologic and hydraulic parameters and comparison of the simulated flows and water levels with available data and with observations.

2.3.1 Hydrology

The hydrologic component of the model is the portion used for flow generation and considers the following information: evaporation, rainfall, climate data, depression storage, soil infiltration, percentage of impervious area, and hydrologic runoff routing. The watershed for Areas 1, 2, and 3 was divided into 34 sub-basins for the hydrologic model, and these sub-basins are illustrated in Figure 2-4.

Evaporation

The evaporation rate is the amount of water that evaporates per day. Monthly averages for evaporation were input into the model. These values were estimated using *USGS Hydrologic Investigations Atlas HA-589*, *1980* for the coastal drainage basins of northeastern Massachusetts from Castle Rock River, Ipswich to Mystic River. Table 2-1 provides the monthly averages for evaporation used in the model. The

Figure 2-2. Photograph of Overtopping Manhole at 20 Bond Street

Figure 2-3. Photograph of Water Flowing Down Driveway at 20 Bond Street

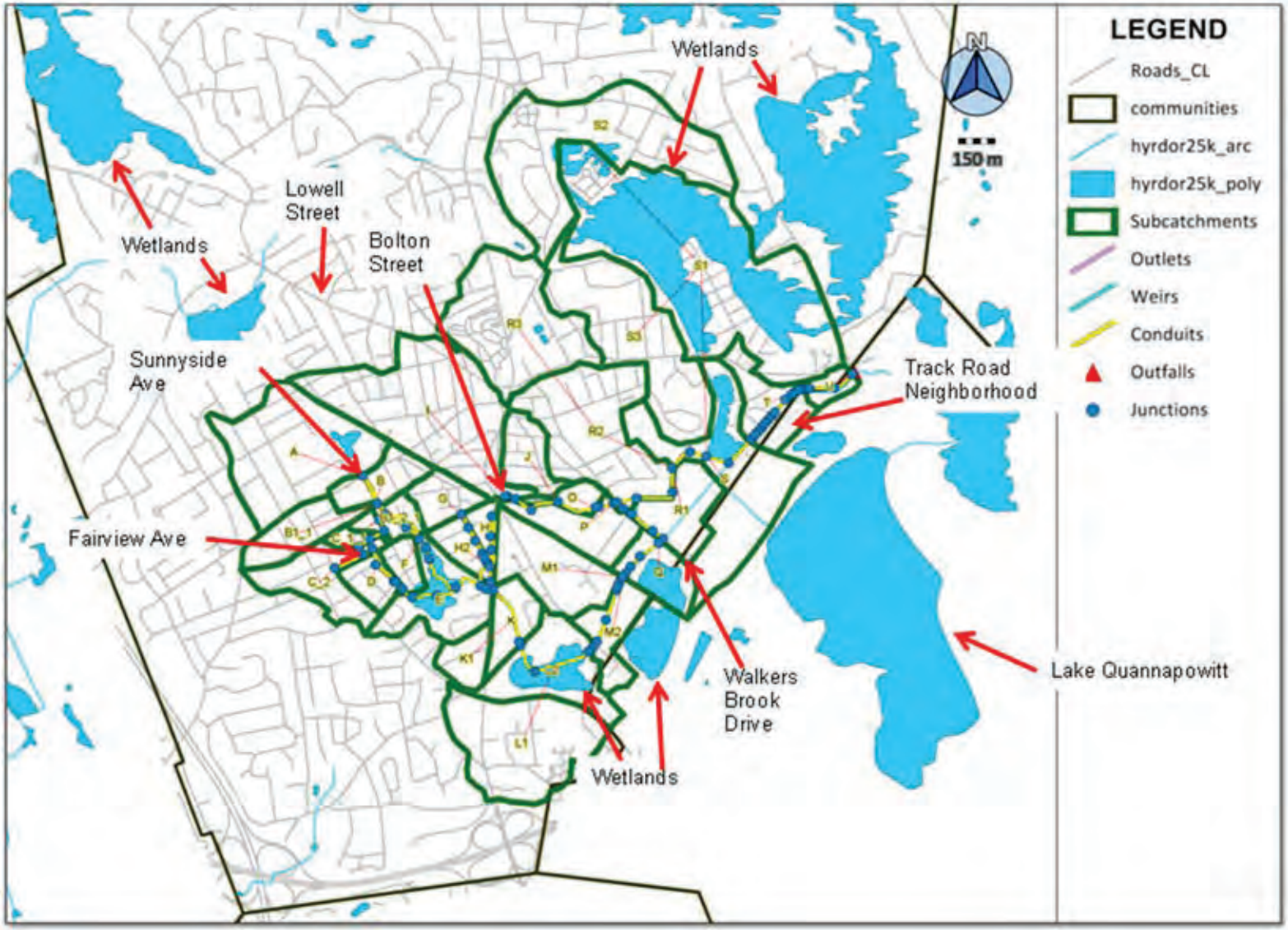


Figure 2-4. Areal Extent of Model and Sub-basin Delineation for Study Areas 1, 2, and 3

Table 2-1. Monthly Evaporation and Rainfall Summary

	Evaporation	Average Rainfall
Month	Inches/Day	(inches)
Jan	0.00	3.62
Feb	0.00	3.39
Mar	0.013	4.15
Apr	0.05	3.66
May	0.11	3.43
Jun	0.15	3.24
Jul	0.19	2.96
Aug	0.16	3.46
Sep	0.11	3.42
Oct	0.07	3.57
Nov	0.03	4.12
Dec	0.00	3.97
Average	.074 (Daily)	42.85 (Annual)

evaporation ranges from zero in the winter to 0.19 inches per day in July, with an overall annual average of 0.074 inches per day.

Rainfall

Boston Logan Airport data were obtained from NOAA for 1949 to 2010. The hourly data for March 2010 were adjusted based on rainfall data obtained from MWRA at gages closer to Reading. Additional data for the May 2006 flood were obtained from Beverly Airport. Table 2-1 summarizes the monthly average rainfall used for the analysis. The average rainfall ranges from 2.96 in July to 4.15 inches in March, with an overall annual average of 42.85 inches.

Climate Data

Climate data are needed for snowfall simulation. The climate data consisting of daily maximum and minimum air temperature for Boston were purchased from NOAA and these data were directly input into the computer model used for the hydraulic analyses.

Depression Storage

The depression storage is the amount of storage in the watershed that must fill up during a storm event before runoff occurs. Typical values of 0.05 inches and 0.2 inches were used for pervious and impervious areas, respectfully.

Soil Infiltration

The soil infiltration is the amount of water that infiltrates into the soil during a storm. The Horton infiltration model was used which requires specification of maximum and minimum infiltration rates. These values were determined based on soil data and are summarized in Table 2-2.

Percentage of Impervious Area

The percentage of impervious area is the fraction of impervious area that is directly connected to the watershed and it is a critical parameter that must be specified in the model. The impervious area was estimated based on land use. The impervious area percentages are summarized in Table 2-2. It is noted that open water and saturated wetlands behave hydraulically as impervious areas since 100 percent of

Table 2-2. Summary of Sub-Basin Characteristics for Study Areas 1, 2, and 3

Sub-Basin Name	Area (acres)	Impervious Area (%)	Maximum Infiltration Rate (in/hr)	Minimum Infiltration Rate (in/hr)	Width (feet)	Average Slope (%)	Estimated Time of Concentration (minutes)
L1	90.3	40	4	0.16	2315	14.4	14
K1	16.8	40	4	0.26	814	13.2	10
K	23.5	27	4	0.12	1100	1.0	22
Q	27.8	9	2.7	0.1	950	1.0	26
M2	28.1	15	4	0.12	1300	1.0	22
D	15.1	40	4	0.25	881	5.0	12
P	33.7	70	4	0.1	736	1.0	34
R2	97.7	40	4	0.27	2128	9.8	17
T	35.3	40	4	0.37	1400	1.0	24
G	19.7	54	4	0.38	414	5.9	20
S3	105.8	40	4	0.33	2880	8.5	16
R3	98.5	40	4	0.2	838	11.8	29
U	9.9	40	4	0.23	900	11.5	7
L2	56.1	14	2.7	0.11	1800	1.0	27
S2	138.5	21	4	0.22	3016	9.8	17
S1	241.7	10	2.7	0.17	1197	1.0	83
R1	35.7	79	4	0.17	1415	12.0	11
S	103.0	40	2.7	0.17	1495	1.0	44
O	10.2	15	4	0.37	444	8.1	12
J	24.6	48	4	0.34	669	6.9	17
M1	53.7	57	4	0.1	487	1.0	58
F	11.9	40	4	0.4	519	6.6	13
B	24.0	44	4	0.33	847	8.8	13
A	101.6	30	4	0.21	1200	2.0	40
H2	15.1	40	4	0.44	1097	4.8	10
H	9.7	62	4	0.26	849	6.4	9
E	47.9	17	2.7	0.26	2000	1.0	23
I	129.5	51	4	0.17	352	9.1	61
C_2	37.6	40	4	0.15	2045	5.0	12
C_1_1	5.3	40	4	0.23	700	3.0	8
C_1_2	2.4	40	4	0.23	200	1.0	15
B1_1	29.8	33	4	0.21	700	3.0	23
B1_2_1	11.1	40	4	0.21	478	8.2	12
B1_2_2	4.1	40	4	0.21	400	8.2	7
Total	1,695.5						

the precipitation falling on open water contributes to an increase in downstream flow (i.e. there is little or no infiltration).

Hydrologic Runoff Routing Parameters
In SWMM, the hydrologic routing of runoff depends on specification of basin slope and characteristic catchment width. The basin slope was estimated using a digital elevation model (DEM) developed using the Town of Reading's 2-foot contour data. The characteristic catchment width was estimated by dividing the catchment area by the length of the longest flow path for areas in which flows travel primarily through a storm drain system. For areas in which flow enters a stream system via overland flow, the width was taken as 2 times the length of the flow channel. Although the time of concentration is not specified or used in the SWMM hydrology, it is possible to estimate the equivalent time of concentration based on the basin slope and catchment width using the equations outlined in the SWMM documentation. The average slope, basin width, and time of concentration are summarized in Table 2-2.

2.3.2 Hydraulics
The hydraulic portion of the model refers to the components of the river system that route flow through the watershed and consists of the stream channels, culverts, weirs, pipes and downstream boundary conditions.

Stream Channels
AECOM conducted a FEMA record search to obtain available information related to the existing FEMA FIS HEC-2 model. These data contained scanned copies of the field notes / survey, work map, and model input and output files. Where appropriate, AECOM recreated the cross-section data and compared with the Town's 2-foot contour data and survey data. In general, the stream channel was close to survey data and 2-foot contour data. The FEMA FIS HEC-2 survey data was very useful because it contained detailed information on the stream channel geometry at numerous locations. Figure 2-5 is an example for cross-section S-1, which is located downstream of Salem Street.

In cases where the FEMA FIS HEC-2 survey data were not available or were found to have changed since 1978, such as in the vicinity of Walkers Book Drive, the stream channels were based on field survey and the Town's 2-foot contour data.

Culverts
The culvert dimensions and inverts were obtained from the site survey, drainage mapping, and the FEMA FIS HEC-2 model.

Weir
The only structure that behaves as a weir is the pipe encasement near Sunnyside Avenue (see **Figure 2-6**). This structure was surveyed and incorporated into the model.

Pipes
Portions of the pipe drainage system were added to the model for Areas 2 and 3 based on the Town's drainage mapping.

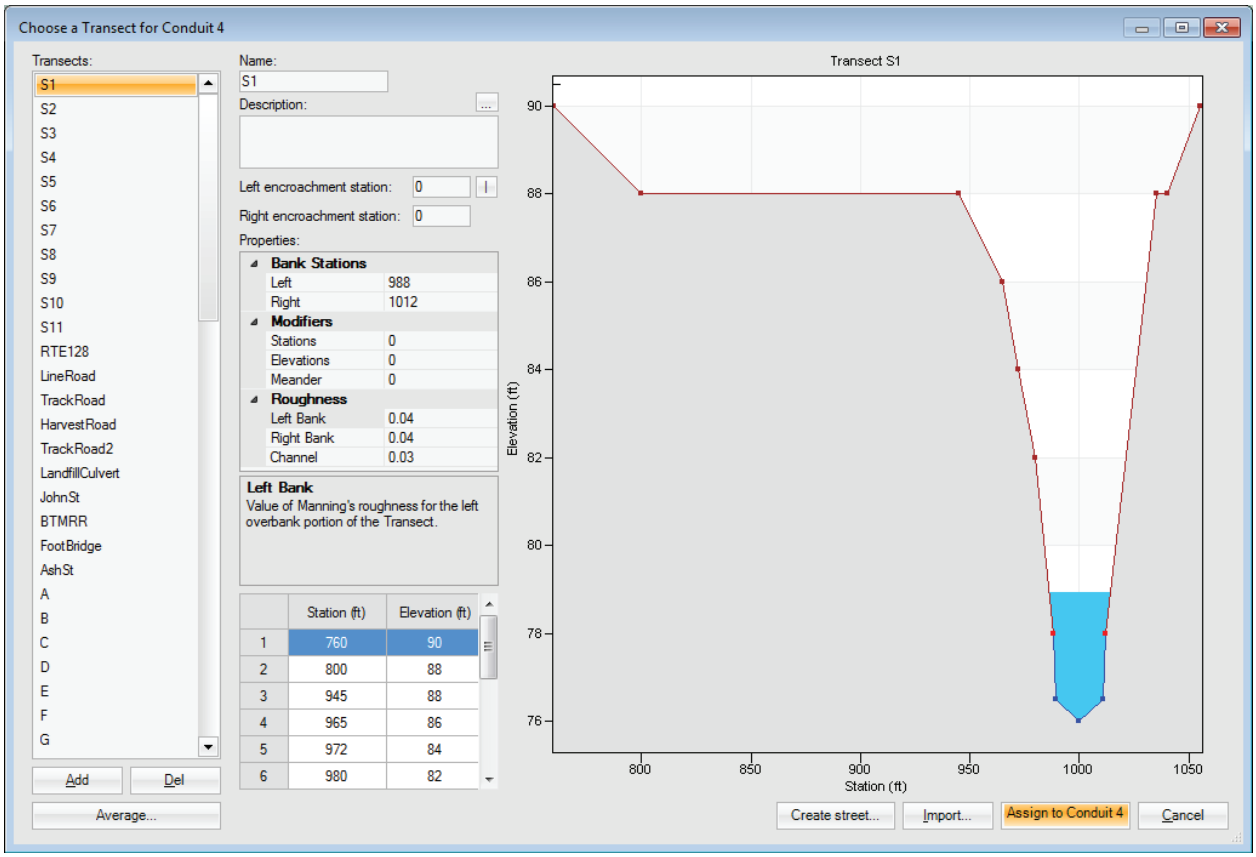


Figure 2-5. Example of Stream Cross-Section S-1 Created from 1978 Walkers Brook FEMA FIS HEC-2 Model

Figure 2-6. Pipe Encasement near Sunnyside Avenue

Downstream Boundary Condition

The downstream boundary of the hydraulic model is at the Town border with Wakefield. It is necessary to specify a boundary condition in the model since the water levels in Reading are influenced by downstream conditions in Wakefield. Figure 2-7 illustrates the water level in Reedy Meadow juxtaposed with the FEMA FIS water levels. There are two key points to note regarding this figure:

1. The water level downstream of Reading at the downstream side of the railroad right-of-way (ROW) in Reedy Meadow during a dry period in March 2012 is roughly equal to the 500-year flood elevation as shown in the FEMA FIS. The high water level is due to sedimentation / eutrophication in Reedy Meadow and is actually causing water to flow under Route 128 via the railroad ROW into the Mill River watershed in Wakefield. This high water may also be impacting the Town of Reading by causing a backwater effect that result in higher base flow elevations.

2. The water level on the upstream side of the railroad is only predicted to increase based on the FEMA model by about 0.75 feet between the 10-year and 500-year floods. This modest increase in water level is due to the water spreading laterally over a large wetland area. What this means for the Town of Reading is that the restrictions in Reedy Meadow may be causing an increase in water level near the border with the Town of Wakefield during a dry weather period, but it is less likely that the restrictions are causing an issue during flood conditions due to the lateral spreading of the water in Reedy Meadow.

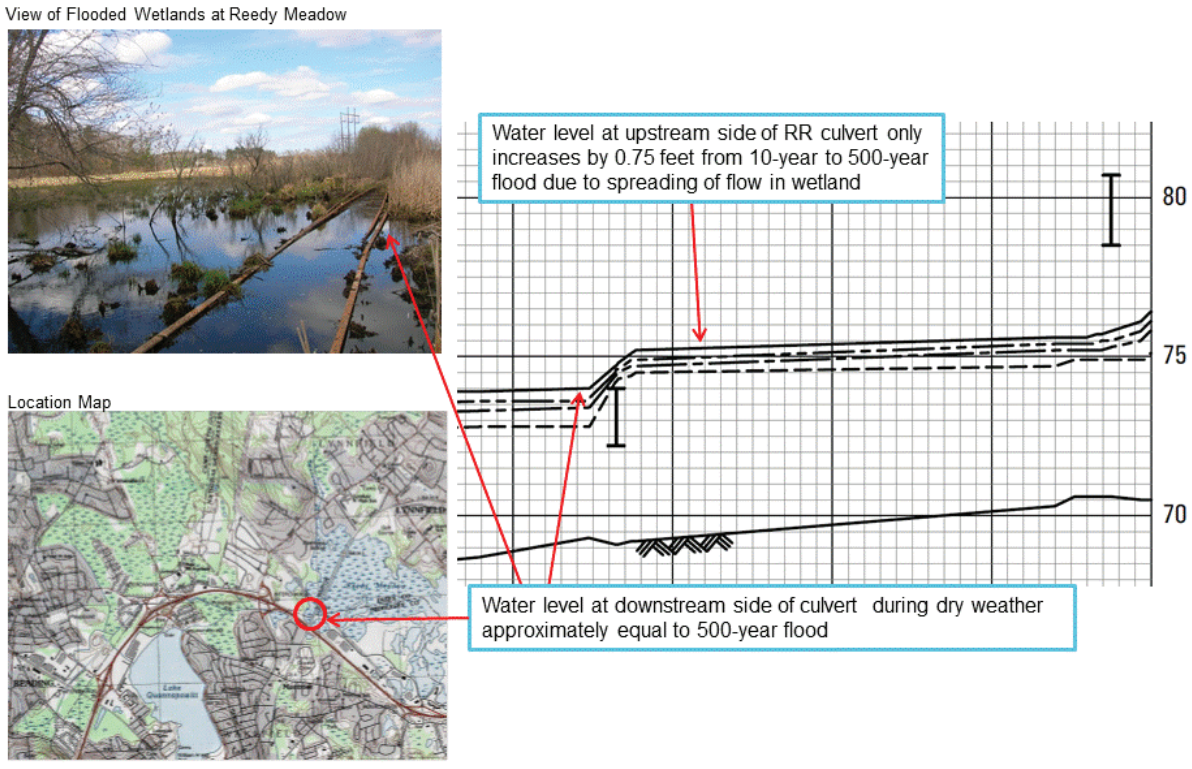


Figure 2-7. Downstream Restriction in Reedy Meadow

The Reedy Meadow restriction issue was studied in 1992 by Camp, Dresser, and McKee (CDM). In their report, flow and water levels at the downstream end of Walkers Brook were tabulated. These water levels take into account the restrictions in Reedy Meadow. The water level during dry weather was also measured during the 2012 survey. The flow rate during the 2012 survey was estimated based on the Saugus River USGS gage by ratio of the tributary area, and these data are plotted together with the FEMA FIS data in Figure 2-8. The figure shows that water levels during dry weather are higher than the water levels predicted by the FIS model for the 2-year storm, but then appear to follow a more predictable pattern for larger flows. The higher values in the curve were used to create a depth-discharge relationship for the downstream boundary condition as shown in Figure 2-9. The depth-discharge relationship was used to represent the downstream boundary condition for existing conditions.

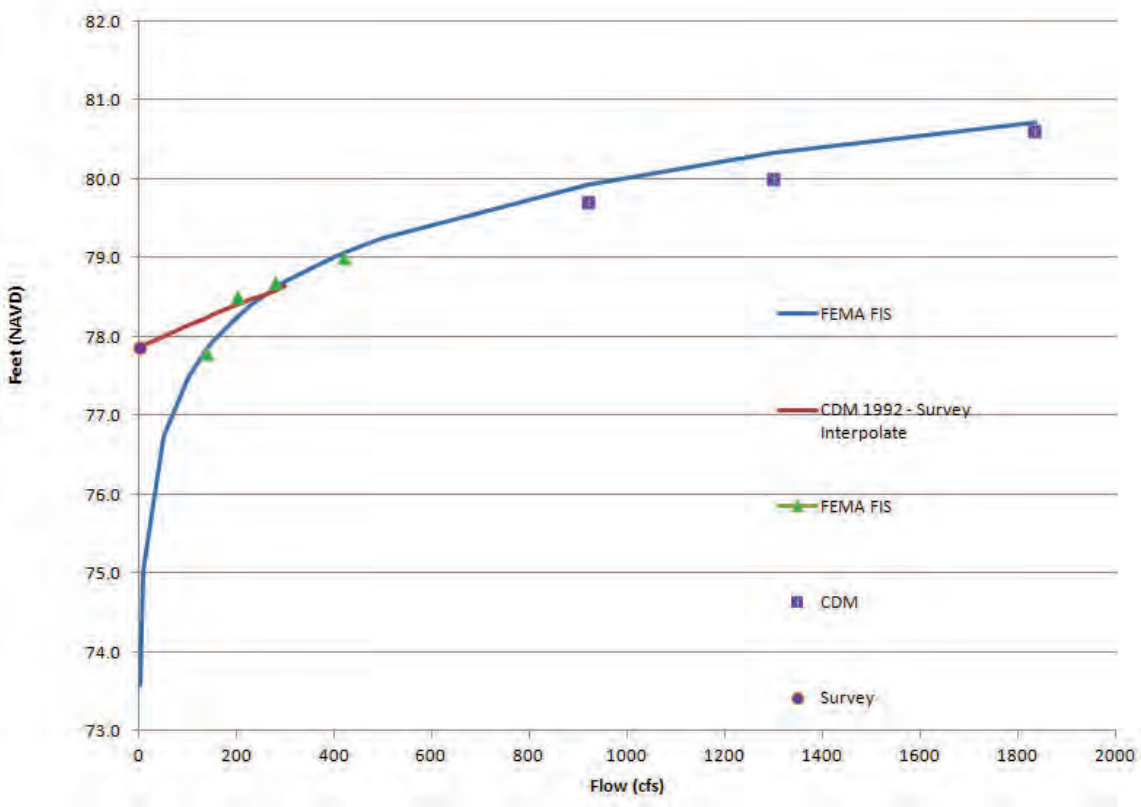


Figure 2-8. Water Levels versus Flow at Downstream End of Walkers Brook

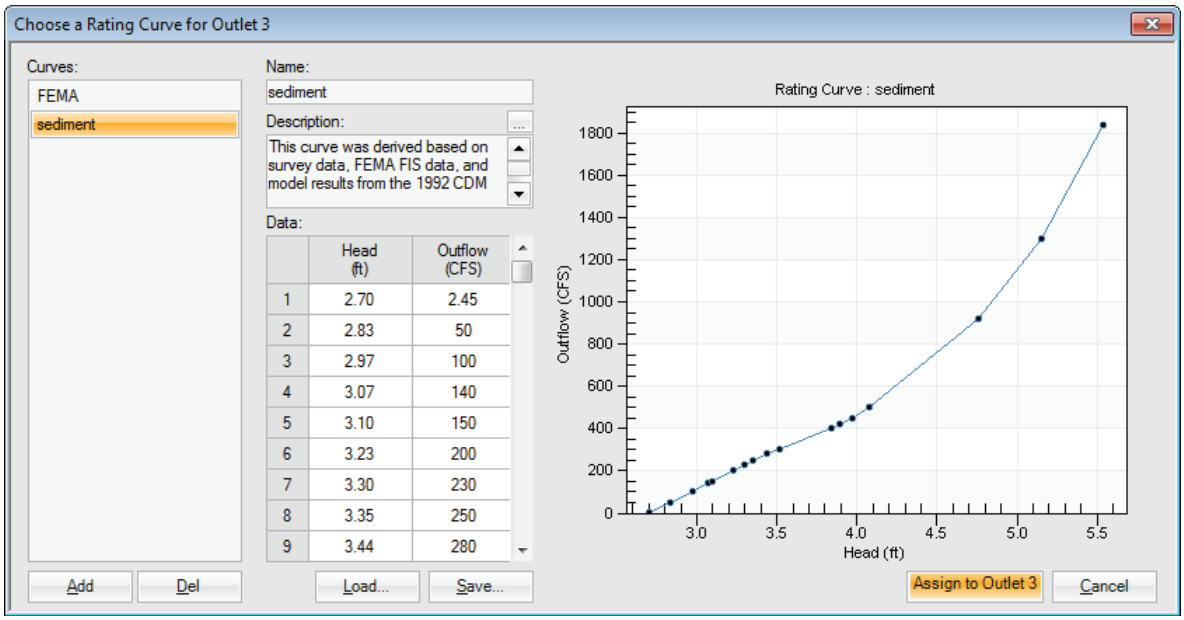


Figure 2-9. Estimated Depth – Discharge Relationship Representing Downstream Restrictions in Reedy Meadow to be Used as Downstream Boundary Condition for Existing Conditions in Walkers Brook

2.3.3 Comparison of Model to Observations and FEMA FIS

Comparison to Observations

The hydraulic model was run for the May 2006 flood using the Beverly Airport rainfall depths and then compared with available observations. The model successfully simulated the observed impacts for this flood event, as represented in Figure 2-10. In general, the model correctly simulates observed conditions.

Comparison to FEMA FIS Flows

The model was also compared to FEMA FIS flows. The FEMA FIS flows are based on the Wandle regression equation, which was derived from regional USGS stream gauging data. The stream gauge data is typically analyzed using Bulletin 17B procedures, which essentially involves fitting annual peak flows to a log-Pearson Type III probability distribution. Once the log-Pearson Type III parameters have been determined they can be used to calculate the flood frequency return periods. A USGS gage is not available on Walkers Brook; however, the model can be configured to simulate a long-term time series which can then be analyzed using the same procedures outlined in Bulletin 17B to determine the flood frequencies.

The hydrologic – hydraulic model was configured to simulate a 62-year period from 1949 through 2010 using hourly data from Logan airport. Logan Airport was selected as the rain gauge location because it is located relatively close to Reading and has the longest period of record for any gauge in the area. It was also necessary to configure the model to simulate snowfall. This was done by adding 62 years of daily maximum – minimum temperature data from Logan Airport and specifying representative snow fall parameters. It is noted that snowfall simulation is very complex and it is not possible to replicate observed conditions exactly. Nevertheless, the selected parameters produce representative results.

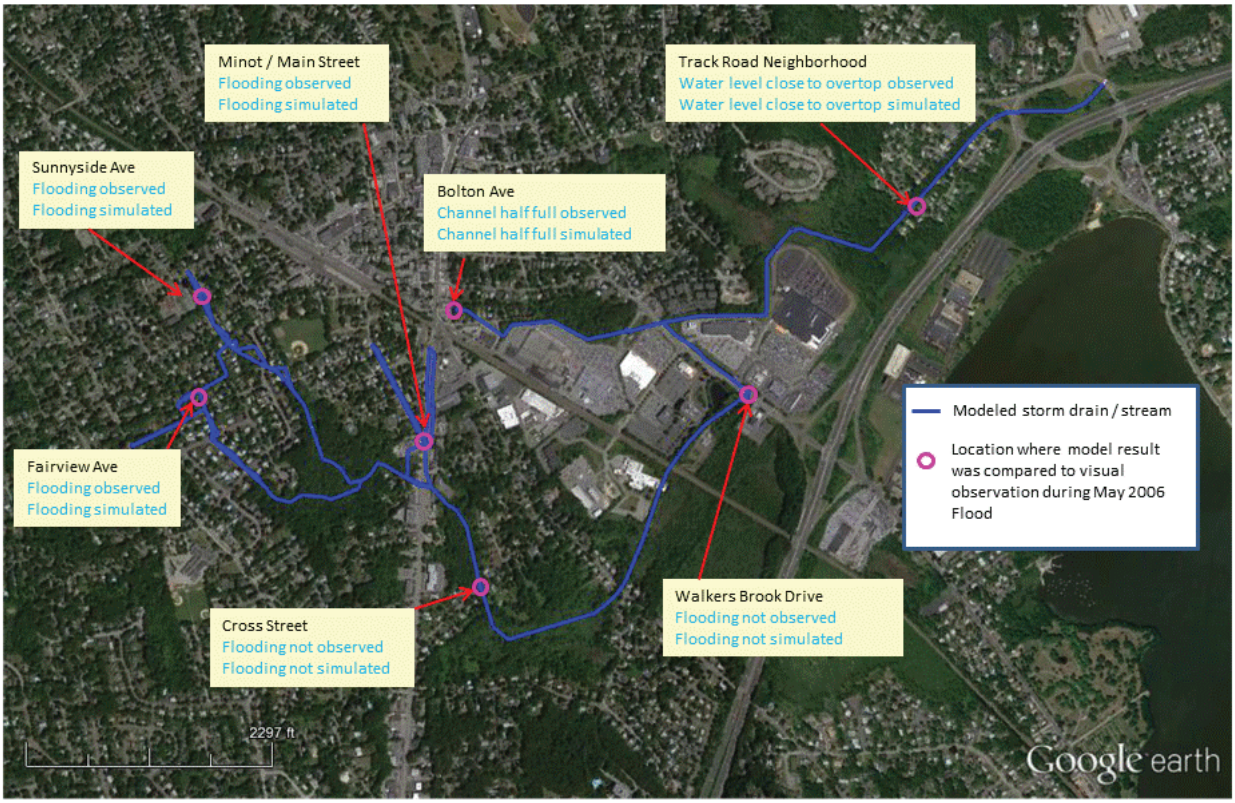


Figure 2-10. Comparison of Observations versus Simulated Results for May 2006 Flood Event

The 62 year simulation period includes thousands of storms. Once the flows for the various flood frequencies have been determined, storms are selected from the period of record that produce flows close to the flood frequency flows.

Figure 2-11 shows rainfall and discharge for the 62-year model run. These results were analyzed to determine discharges for different frequency storm events using Bulletin 17B, as illustrated in Figure 2-12. Table 2-3 is a comparison of the results with the flows from the FEMA FIS study. In general, these results show that the model flows are higher than the FEMA FIS flows for the 10-year and 50-year floods, approximately the same for the 100-year flood, and lower than the 500-year flood. Peak flows from the period of record simulation are within 15% of the calculated flood frequency flows. The actual storms shown in Table 2-3 will be used as design storms. As shown in Table 2-3, these storms produce flows that are close to the flood frequency flows calculated based on the 62-year model simulation using the Bulletin 17B procedures.

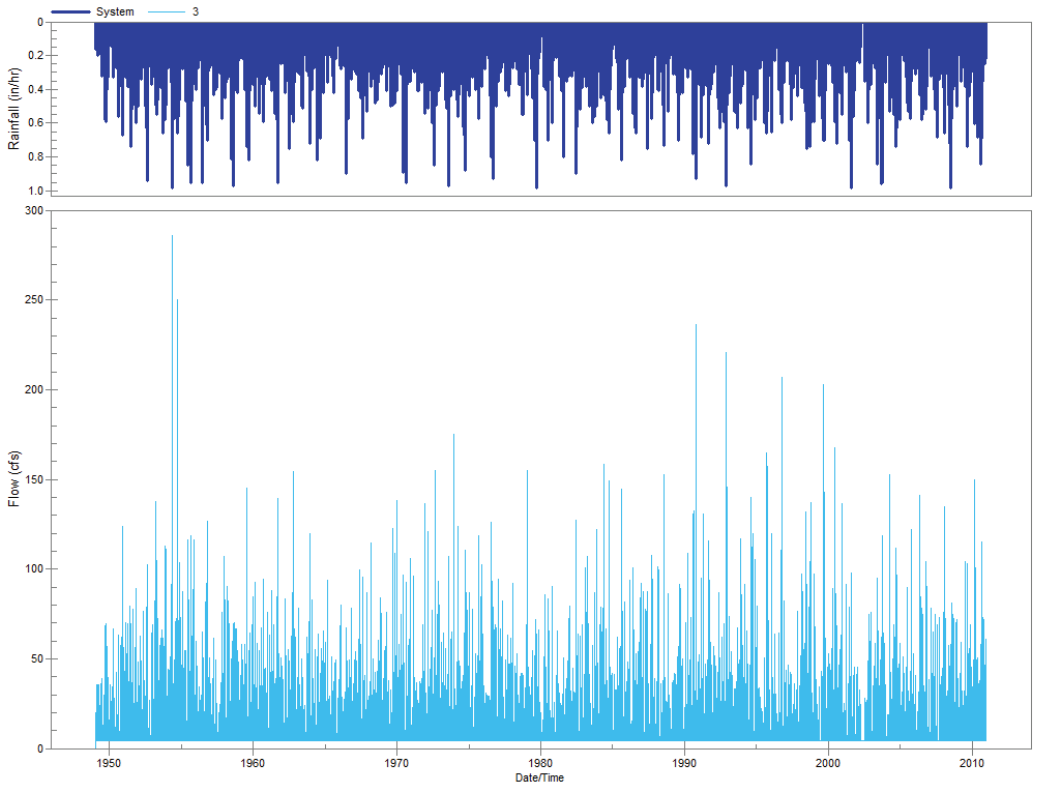


Figure 2-11. 62-year Model Run

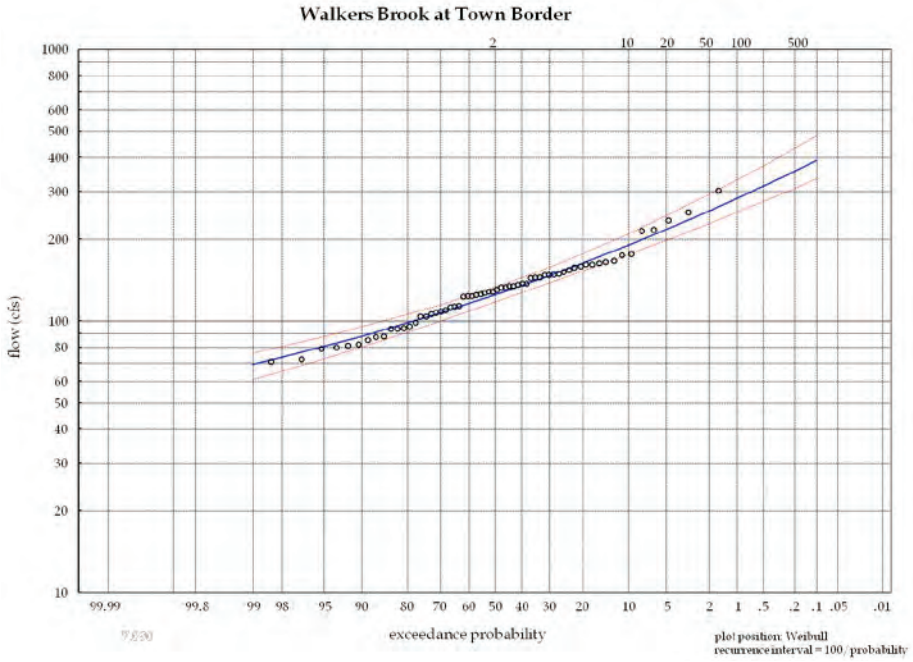


Figure 2-12. Frequency Curve for Bulletin 17B Analysis of 62-year Model Run

Table 2-3. Comparison of 62-Year Peak Discharge Model Results Analyzed Using Bulletin 17B Procedures with FEMA FIS Flows

Return Period	2010 FEMA FIS (cfs)	AECOM Bulletin 17B (cfs)	Actual Storm Date	Simulated Actual Storm Flow (cfs)
2		125	9/23/1994	126
10	140	190	9/10/1999	214
25		226	11/23/1992	233
50	230	254	10/14/1990	251
100	280	283	5/16/1954	301
500	420	356		

2.4 Aberjona River Model (Area 4)

In 2007, AECOM completed a FIS of the Mystic River drainage basin for FEMA, which included a detailed study of a portion of the Aberjona River. In this current study, AECOM extended the detailed study further upstream, and has refined many of the hydrologic and hydraulic parameters used in the 2007 FIS. The sections below describe the data sources and methods used to develop hydrologic and hydraulic models for Area 4.

2.4.1 Hydrologic Model

AECOM developed a hydrologic model for the Aberjona River reach within Area 4 using the United States Army Corps of Engineers' (USACE's) HEC-HMS Version 3.5. The selected runoff calculation within HEC-HMS was based on the procedures outlined in the United States Department of Agricultural (USDA) Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55, 1986) and the Massachusetts Supplement for the TR-55 Hydrology Procedure (Verdi, 1995). Key input parameters to HEC-HMS models include:

- Drainage basin delineations
- Area-weighted runoff curve numbers (CNs)
- Time of concentrations
- Storage coefficients

The following sections describe the data sources and methods used to develop the input parameters for the HEC-HMS hydrologic model.

Basin Delineations

AECOM delineated drainage basins to stream crossings within the study area using ESRI's ArcMap Version 10.0 in conjunction with the following data sources (listed in order of precedence):

1. MassGIS Digital Terrain Model Files (Points and Breaklines)
2. Town of Reading 2-foot Elevation Contours
3. Town of Reading Stormwater Infrastructure GIS Database (draft version provided by the Town's stormwater consultant)
4. USGS Quadrangle Maps (1:25,000 scale series)
5. USGS Color Ortho Imagery (2008/2009)
6. USGS National Hydrography Dataset (NHD)

Refer to Table 2-4 below for tabulated drainage basin areas. See Figure 2-13 for a map showing the drainage basin delineations for the study area. The total drainage basin for this portion of the Aberjona River is 0.9 square miles.

Table 2-4. Hydrologic Input Parameters for the HEC-HMS Model

Drainage Basin	Area (square miles)	CN	TC (hours)	Storage Coefficient (hours)
ABEX1	0.082	74	0.37	0.1000
ABEX2	0.064	73	0.66	0.1000
ABEX3	0.220	72	1.23	7.2406
ABEX4	0.173	75	0.65	5.0700
ABEX5	0.105	66	0.89	0.5038
ABEX6	0.189	70	0.96	5.8510
ABEX7	0.070	76	0.57	0.1000

In the 2007 FIS of the Mystic River basin, AECOM developed a flow accumulation grid using the National Elevation Dataset (2003) and the National Hydrography Dataset (2003). AECOM then used the flow accumulation grid to automatically delineate the drainage basins to select points within the study area. The drainage basin delineation for the headwater of the Aberjona River (Basin NOABER070) was 539.8 acres, approximately 7% smaller than in the current study. The delineation from the current study was based on datasets with finer resolution and incorporated factors that altered natural drainage patterns due to manmade features such as road crossings and drainage pipes.

Runoff Curve Numbers

AECOM calculated runoff curve numbers (CNs) in accordance with the SCS Runoff Curve Number Method described in TR-55 (USDA NRCS, 1986). AECOM used GIS to intersect drainage basin delineations with soil and land use datasets. CNs were then calculated for each drainage basin based on the resulting data. AECOM used the following sources for the soil and land use datasets:

1. MassGIS NRCS SSURGO-Certified Soils Datalayer
2. MassGIS Land Use Datalayer (2005)

Refer to Table 2-4 for the CNs calculated for each drainage basin within the study area. The composite CN was 72 for the total drainage basin area. During model validation, the curve numbers were reduced by approximately 20% to match the 2007 FIS flow hydrograph downstream of the MBTA railroad crossing.

In the 2007 FIS of the Mystic River basin, CNs were calculated using soil data digitized from paper maps and land use data developed by processing IKONOS satellite imagery from 2001 and 2002. The upper Aberjona River drainage area was represented by a single drainage basin (ID NOABER070) with a composite CN number of 58.

Time of Concentration Calculations

Time of concentration is defined as the time for runoff to travel from the hydraulically most distant point of a drainage basin to the outlet of the basin. It is composed of travel time via sheet flow, shallow concentrated flow, and channel flow. AECOM used methodologies outlined in TR-55 to calculate travel time for sheet flow and shallow concentrated flow. For channel flow, AECOM used the methodology

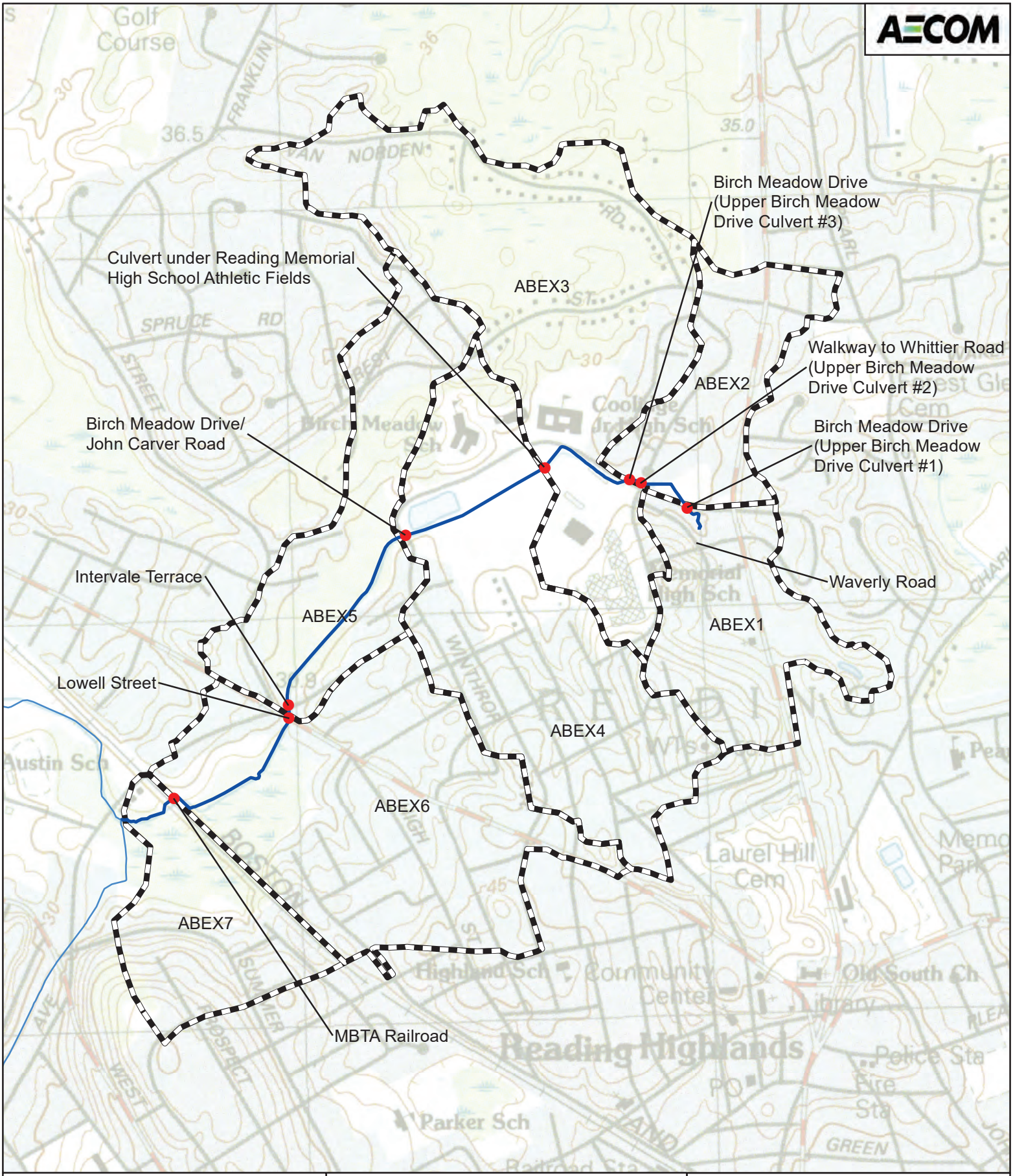


Figure 2-13
Drainage Basin Delineations

Town of Reading
Area 4 - Aberjona River

September 2013

outlined in the Massachusetts Supplement for the TR-55 Hydrology Procedure (Verdi, 1995), which provides average velocities for a variety of channel types found across the state.

For each drainage basin, time of concentration flow paths were drawn in GIS using a combination of the sources previously identified in the basin delineations section. AECOM then calculated the total travel time using the methodologies listed above. Refer to Table 2-4 for the time of concentration (TC) calculated for each drainage basin within the study area.

Storage Coefficient Calculations

In the 2007 FIS of the Mystic River basin, AECOM used the Clark Unit Hydrograph method as the transform method in HEC-HMS. This method was chosen for the FIS as an efficient way to account for short-term storage of stormwater within each watershed. This storage could be in the soil, in streets due to undersized stormwater conveyance systems, and in the smaller tributaries with undersized culverts and/or bridges that were not included in the detailed study. In order to remain consistent with the FIS, AECOM chose to use the Clark Unit Hydrograph method for the current study as well.

The storage coefficient can be calculated for a given hydrograph by the dividing the volume under the hydrograph after the point of inflection on the receding limb by the value of flow at that point of inflection (HEC TD-15, April 1982). The FIS used the following relationship to relate basin area to storage coefficient for each of the drainage basin delineations, with a minimum R of 0.1:

$$R = 20.84 * (\text{Log}(\text{Area}) + 1) + 0.1$$

For more information about the storage coefficient calculations, refer to AECOM's report titled *Mystic River Basin FIS Hydrologic and Hydraulic Modeling Report* (AECOM, 2007). The above relationship was verified against the Winchester USGS gage for calibration during the FIS study. For the current Aberjona River study, AECOM used the same method described above.

Rainfall Statistics

AECOM evaluated flood conditions within the study area for the 5-, 10-, 25-, 50-, 100-, and 500-year return period, 24-hour design storms. As the basis for the design storms, AECOM used rainfall depths and dimensionless rainfall distribution curves from the Northeast Regional Climate Center's (NRCC) Extreme Precipitation in New York & New England Interactive Web Tool, obtained May 9, 2012 (NRCC, 2011). These statistics are based upon recent data and represent the rainfall patterns well for the study area. For the 2007 FIS study, the combination of NRCC rainfall depths and the Soil Conservation Service (SCS) Type III distribution was used.

Table 2-5 summarizes rainfall depths for the NRCC design storms. Figure 2-14 shows the NRCC distribution curves for the selected design storms.

Table 2-5. Design Storm Rainfall Totals (NRCC, 2011)

Return Period	Storm Duration (hours)	Total Rainfall Depth (inches)
1-year	24	2.66
2-year	24	3.20
5-Year	24	4.07
10-Year	24	4.88
25-Year	24	6.20
50-Year	24	7.44
100-Year	24	8.93
500-Year	24	13.66

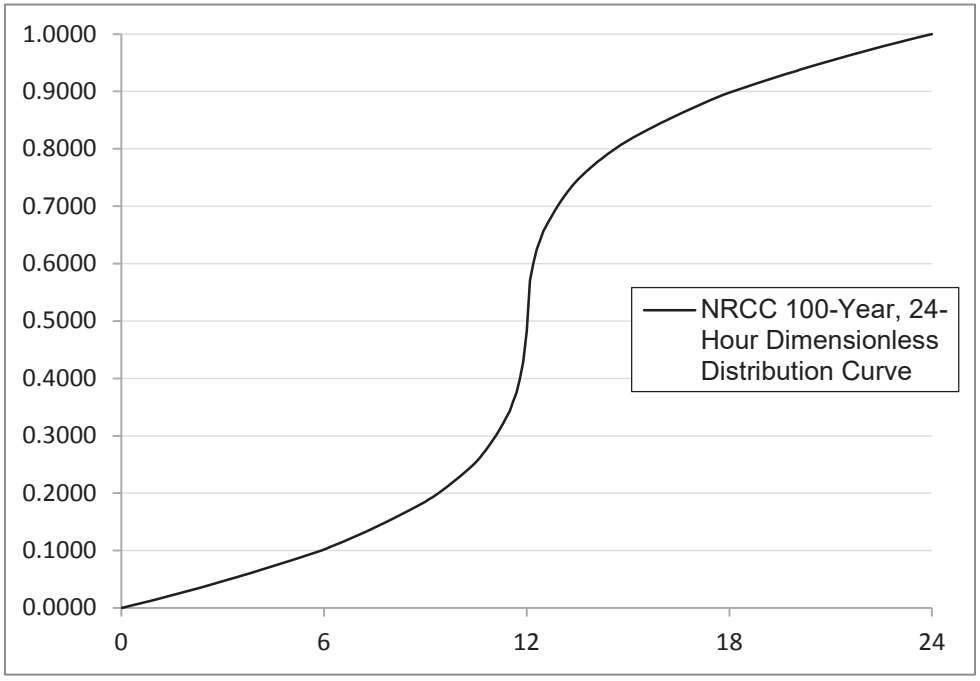


Figure 2-14. Design Storm Rainfall Totals (NRCC, 2011)

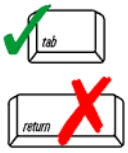
Appendix F – Stormwater Report and Checklist

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

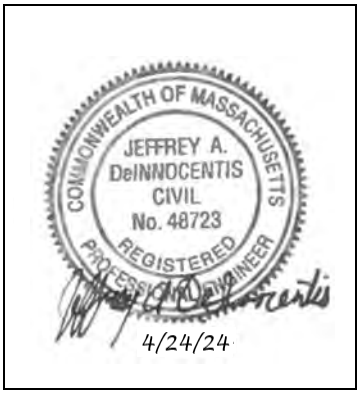
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



Jeffrey A DeInnocentis 4/24/24

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☑ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☑ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☐ Other (describe): _____

Standard 1: No New Untreated Discharges Fully Met

- ☑ No new untreated discharges
- ☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

Met to max. extent practicable (Limited/Redevelopment Project)

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☐ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

Met to max. extent practicable (Limited/Redevelopment Project)

☑ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality Met to max. extent practicable (Limited/Redevelopment Project)

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☐ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☐ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs) Not Applicable

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas Not Applicable

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable Fully Met

☑ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☑ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☑ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☑ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control Fully Met

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☑ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☐ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan Fully Met (Temporary Construction)

☑ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☐ Name of the stormwater management system owners;
- ☑ Party responsible for operation and maintenance;
- ☑ Schedule for implementation of routine and non-routine maintenance tasks;
- ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☐ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges Fully Met

☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☑ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Stormwater Report

Walkers Brook Bridge Replacement Project
Track Road East, Reading Massachusetts

Town of Reading Engineering Department

AECOM Project Number: 60700750

March 2026

Prepared for:

Town of Reading
Engineering Department
16 Lowell Street
Reading, MA 01867

Prepared by:

AECOM
250 Apollo Drive
Chelmsford, MA 01824
aecom.com

Table of Contents

1. Project Description

The purpose of this project is to replace and widen a bridge on Track Road (East) in Reading, Massachusetts. The bridge is an existing culvert that crosses Walkers Brook, a perennial tributary to the Saugus River. The existing bridge crossing is currently a single narrow lane and has been determined to be structurally deficient and has been closed and out of service for several years. The existing structure will be replaced with a new precast concrete four-sided box culvert to improve the functionality and safety of the bridge structure (the Project).

The proposed project qualifies as a "Limited Project" under the WPA regulations 310 CMR 10.53(3)(f) *Maintenance and improvement of existing public roadways, but limited to widening less than a single lane, adding shoulders, correcting substandard intersections, and improving inadequate drainage systems.* The proposed Project also qualifies as a "Redevelopment Project" under Volume 1, Chapter 1 of the Massachusetts Stormwater Handbook. *Maintenance and improvements of existing roadways, including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage systems, and repaving.* As such, Standards 2, 3, 4, 5, and 6 must only be met to the maximum extent practicable.

2. Existing Conditions

The Walkers Brook Track Road (East) Bridge is located in a residential neighborhood at the easternmost crossing of Track Road and Walkers Brook, west of Exit 40 off Interstate 95 and south of Salem Street/Route 129 in Reading, Massachusetts. The approximate location of the Project is shown in **Attachment A**.

The Track Road (East) Bridge is currently a single narrow lane with a span length of approximately 10 feet across Walkers Brook. Vertical abutment faces beneath the bridge confine flow from Walkers Brook through the existing structure. At the Project site, Walkers Brook flows in a northerly direction and is approximately two to three feet in depth under normal conditions. Land adjacent to the project site includes narrow vegetated streambanks, residential properties and driveways.

No existing underground utilities have been identified to be present crossing the bridge or within the proposed project work limits. Aerial utilities cross Walkers Brook parallel to the bridge.

One existing eighteen-inch reinforced concrete drain pipe discharges to the river from the slope at the northeast side of the existing bridge. This drain pipe serves a drainage system of catch basins and manhole collecting stormwater from Line Road. Stormwater runoff from the bridge currently drains to the vegetated streambanks along Walkers Brook.

A wetland resource area delineation was performed by AECOM on May 23, 2023 to delineate the mean annual high water / Bank of Walkers Brook. Results of this wetland delineation are shown in **Attachment B**. **Attachment B** also shows the FEMA base flood elevation at the site, which is 83.4 feet NAVD88. Based on data referenced from the USDA Web Soil Survey (WSS), all soil at the site is NRCS Soil Type A. **Attachment C** provides the WSS Report.

The approximate work areas and limits of construction are shown in **Attachment B**.

3. Proposed Project

The existing bridge structure will be demolished. Waste material generated by demolition will be disposed of at an off-site landfill facility. Existing wingwalls associated with the bridge structure will be demolished. No impacts are proposed outside the right-of-way (ROW).

A precast concrete four-sided box culvert structure will be installed to replace the existing bridge structure. The proposed bridge and adjacent approaches will be widened by approximately 12 feet to a maximum of 24 feet to allow two way traffic. Concrete parapets and guardrail transitions along the side of the bridge will provide protection for vehicular traffic. There will be no provisions for future sidewalk installation and the roadway width will transition to meet the existing roadway approaches.

In the expansion of the bridge width to allow for two-way traffic, approximately 403 square feet of new impervious surface will be added. Due to site spacing constraints, no treatment has been designed to treat runoff from this additional area. Drainage from the proposed bridge will match that of the existing bridge, running overland to the vegetated streambanks along Walkers Brook.

Due to the expansion of the bridge structure, there will be approximately 52 square feet of permanent impacts to Land Under Water, 52 square feet of permanent impacts to Bordering Land Subject to Flooding, 18 linear feet of permanent impacts to Bank, 4,282 square feet of permanent impacts to the Riverfront Area, and 94 cubic feet of new fill within the 100-year floodplain. By elevation, there is a net gain of 8 cubic feet (CF) of flood storage between elevations 80 and 81, and a net loss of 102 CF of flood storage between elevations 81 and 83.4. The project is presumed to have no significant adverse impacts to Walkers Brook and proposes to restore portions of the disturbed Riverfront Area upon completion of construction activities. **Attachment B** displays areas intended for riverfront restoration.

4. MassDEP Stormwater Policy Standards Compliance

The following section describes how the proposed stormwater management design addresses each of the applicable MassDEP Stormwater Management Standards as described in Volume 1 of the *Massachusetts Stormwater Handbook.*

As stated in **Section 1** of this report, this project qualifies as a “Limited Project” under the WPA regulations 310 CMR 10.53(3)(f) and as a “Redevelopment Project” under Volume 1, Chapter 1 of the Massachusetts Stormwater Handbook. As stated in Standard 7 of the MassDEP *Checklist for Stormwater Report,* Limited/Redevelopment Projects such as this are only required to meet Stormwater Management Standards 2, 3, 4, 5, and 6 to the maximum extent practicable.

Standard 1: No New Untreated Discharges – Fully Met

The proposed bridge replacement does not include any new untreated discharges. All runoff from the proposed bridge structure will follow the existing overland flow paths towards Walkers Brook.

Standard 2: Peak Rate Attenuation – Met to Maximum Extent Practicable

Due to site constraints, no stormwater management structures have been designed to manage peak flow attenuation.

Standard 3: Recharge – Met to Maximum Extent Practicable

Due to site constraints, no stormwater management structures have been designed to provide recharge.

Standard 4: Water Quality – Met to Maximum Extent Practicable

Due to site constraints, no stormwater management structures have been designed to treat water quality.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs) – Not Applicable

No LUHPPL exist in the project area.

Section 6: Critical Areas – Not Applicable

The project does not propose any discharges to critical areas.

Section 7: Redevelopments and other projects Subject to the Standards only to the maximum extent practicable – Fully met

This project qualifies as a Limited Project under the WPA regulations 310 CMR 10.53(3)(f) and as a Redevelopment Project under Volume 1, Chapter 1 of the Massachusetts Stormwater Handbook. Certain standards are not fully met, and an explanation of why these standards are not met is contained in this report.

Section 8: Construction Period Pollution prevention and Erosion and Sedimentation Control – Fully Met

The erosion and sedimentation measures to be implemented during the construction phase of this project are displayed in **Attachment B** of this report. Compost filter socks (CFS) and/or temporary silt fences will be installed along the disturbed bank areas and along the limits of work / staging areas on Track Road.

Additional good housekeeping measures have been included in the project plan, including:

- Installation of a temporary turbidity curtain spanning Walkers Brook downstream of the project site.
- During the construction phase, the work zone will be isolated from the Brook using sheet piles and dewatered. A bypass pipe will be installed to direct flow around the work zone. A stream flow energy dissipation plate will be provided at the bypass discharge to reduce the discharge velocity and mitigate potential erosive conditions created by the bypass discharge.
- Dewatering of the excavation zone during construction will be provided by pumping. Discharge from this dewatering will be treated using a strawbale corral or sediment filter bag before discharging to Walkers Brook.
- Temporary stabilization, pavement sweeping, and dust control will be provided as necessary.

After construction is complete, all disturbed areas will be stabilized, and exposed soil will be restored as shown in **Attachment B.**

Standard 9: Operation and Maintenance Plan – Fully Met

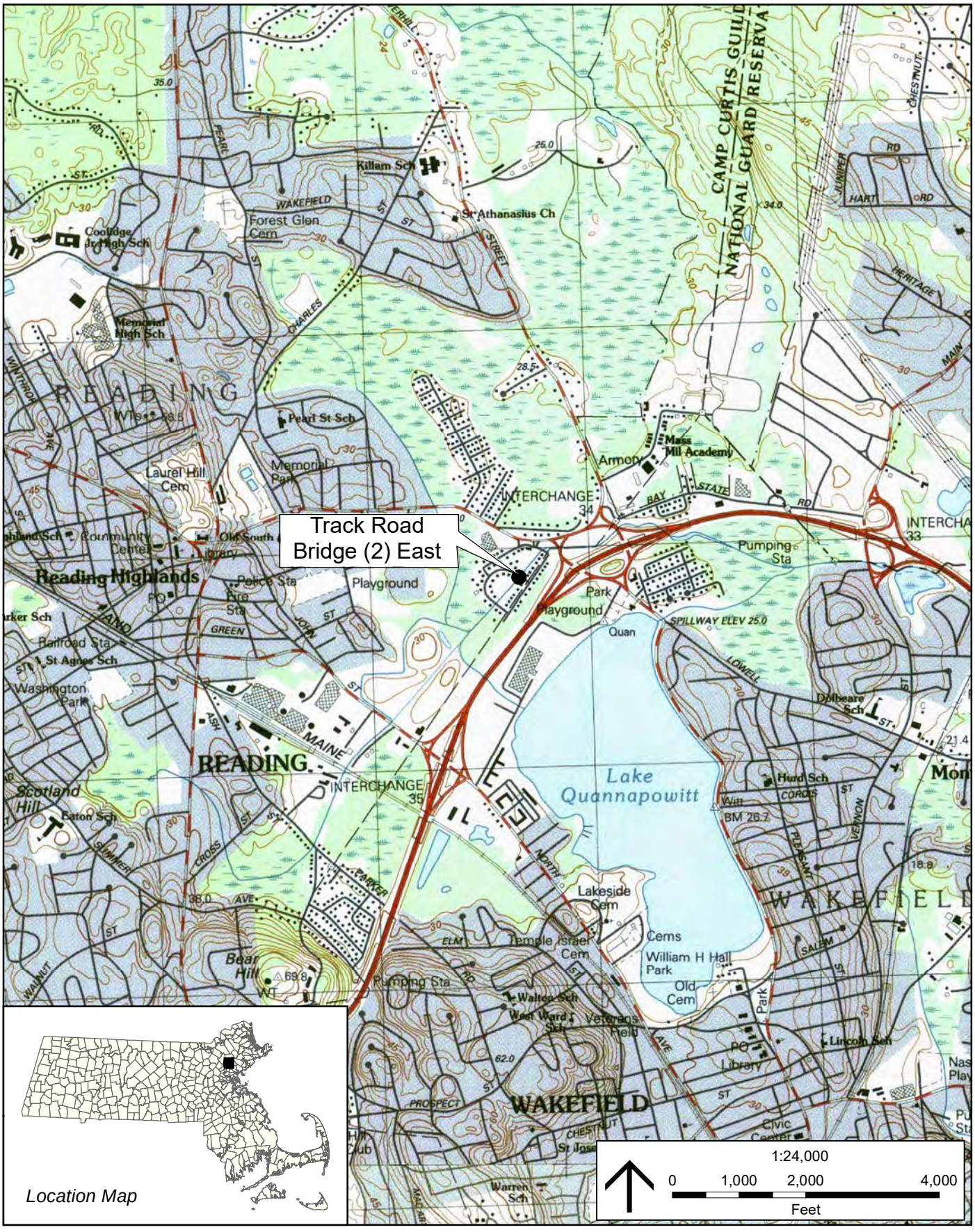
The project does not include the addition or alteration of any permanent stormwater management systems pertaining to the standards that would require an operation and maintenance plan.

The construction phase of this Project is temporary and will require an operation and maintenance plan for the erosion and sedimentation measures to be implemented. The O&M Plan is displayed in **Attachment D** of this report.

Standard 10: Prohibition of Illicit Discharges – Fully met

The applicant is not aware of any illicit discharges and will identify any suspect connections observed during construction. No proposed work or subsequent maintenance will include illicit connections to the existing stormwater system.

Attachment A – Locus Map



M:\work\Site_Maps\TrackRdBridge.mxd 2/26/2020 10:03:39 AM

Portion of Reading and Boston North
7.5' USGS quadrangles.
Scanned quadrangles supplied by MassGIS.

Site Locus
Track Road/Walker's Brook
Bridge Replacement Project
READING, MASSACHUSETTS

Attachment B – Site Plans

See Appendix B of the NOI.

Attachment C – USDA Web Soil Survey Report

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Middlesex County, Massachusetts

Track Road Bridge over Walkers Brook

March 30, 2026

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 25, Sep 5, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
626B	Merrimac-Urban land complex, 0 to 8 percent slopes	1.0	100.0%
Totals for Area of Interest		**1.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Middlesex County, Massachusetts

626B—Merrimac-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2tyr9
Landscape: Valleys, outwash plains
Elevation: 0 to 820 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Merrimac and similar soils: 45 percent
Urban land: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting

Landscape: Valleys, outwash plains
Landform: Moraines, Outwash plains, Outwash terraces, Kames, Eskers
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A
Ecological site: F144AY022MA - Dry Outwash
Hydric soil rating: No

Description of Urban Land

Setting

Landscape: Glaciated uplands
Anthropogenic Feature: Urban land

Typical profile

M - 0 to 10 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Windsor

Percent of map unit: 5 percent
Landscape: Valleys
Landform: Dunes, Outwash plains, Outwash terraces, Deltas
Landform position (three-dimensional): Tread, riser
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landscape: Valleys, lake plains
Landform: Terraces, Outwash plains, Deltas
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Landscape: Valleys, outwash plains
Landform: Outwash plains, Kames, Eskers, Deltas
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Head slope, nose slope, side slope, crest, rise
Down-slope shape: Convex
Across-slope shape: Linear, convex

Hydric soil rating: No

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Attachment D – O&M Plan

Operation and Maintenance Plan (O&M)

This Operation and Maintenance Plan provides for the inspection and maintenance of structural Best Management Practices (BMPs) associated with the erosion and sediment (E&S) control measures at the Walkers Brook Bridge Replacement Project in Reading, MA.

This document has been prepared in accordance with the requirements of the Stormwater Regulations included in the Massachusetts Wetlands Protection Act Regulations (310 CMR 10).

Construction at the Site is temporary and not expected to be in progress for more than 1 month. The O&M measures to be taken reflect this temporary status.

Responsible Party
The Town of Reading owns this site and MassDOT will be responsible for the maintenance of the project site and associated E&S control measures.

Location
The following erosion and sediment BMPs are shown in Attachment B of the Stormwater Report.

Erosion and Sediment Best Management Practices: Operation & Maintenance Measures

Best Management Practice	Mow	Inspect	Clean	Repair	Notes
Compost Filter Socks	NA	Weekly and After Significant Rainfall Events	As Needed Based on Inspection	As Needed Based on Inspection	Sediment removal is required if accumulations meet or exceed 50% capacity
Temporary Silt Fences	NA	Weekly and After Significant Rainfall Events	As Needed Based on Inspection	As Needed Based on Inspection	-
Turbidity Curtain	NA	Daily and After Significant Rainfall Events	As Needed Based on Inspection	As Needed Based on Inspection	-
Stabilization	NA	Weekly and After Significant Rainfall Events	As Needed Based on Inspection	As Needed Based on Inspection	Monitor newly vegetated areas for erosion and bare spots and reseed as necessary
Dewatering	NA	Daily and After Significant Rainfall Events	As Needed Based on Inspection	As Needed Based on Inspection	Replace filter bags when 50-70% full or if discharge flow rate is significantly reduced