DOCUMENT A00861

MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL PROTECTION

ORDER OF CONDITIONS

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TOWN of WILMINGTON
DEPARTMENT OF PLANNING & CONSERVATION
121 GLEN ROAD, WILMINGTON, MA 01887 www.wilmingtonma.gov (978) 658-8238

Wetland Approval Checklist

After you have received your approval, please be sure to complete the following that pertain to your approval

DETERMINATION OF APPLICABILITY (DOA):

- Read the paperwork carefully and note any special conditions that are listed
- 10 business day appeal period (once issued) before building permit can be signed and/or work can begin
- Call for erosion control inspection PRIOR to starting work
- The Determination is good for 3 years from the date of issuance

ORDER OF RESOURCE AREA DELINEATION (ORAD):

- Note which Resource Areas are accurate, modified, and inaccurate as stated in the ORAD
- 10 business day appeal period (once issued) period before Order is valid
- Record this Order at the Middlesex North Registry of Deeds in Lowell, then forward a copy of the recorded document to the Planning and Conservation Department
- The order is good for 3 years from the date of issuance. Extensions can be issued for periods of up to 3 years. Requests for extension must be submitted no later than 30 days prior to expiration, but we recommend they be submitted about 3 months prior to expiration

ORDER OF CONDITIONS (OOC):

- Read the paperwork carefully and note all general and special conditions that are listed
- 10 business day appeal period (once issued) before building permit can be signed and/or work can begin
- Record OOC at the Middlesex North Registry of Deeds in Lowell, then forward a copy of the recorded document to the Planning and Conservation Department
- Pre-construction conditions must be satisfied before ANY work can begin
- Call for a pre-construction meeting and erosion control inspection PRIOR to starting work
- The Order is good for 3 years from the date of issue. Extensions can be issued for periods up to 3 years. Requests for extension should be submitted no later than 30 days prior to expiration, but we recommend they be submitted about 3 months prior to expiration
- Submit a Request for Certificate of Compliance when work is complete and all conditions are met. See Special Conditions for CoC submittal requirements

CERTIFICATE OF COMPLIANCE (COC):

- Record CoC at the Middlesex North Registry of Deeds in Lowell, then forward a copy of the recorded document to the Planning and Conservation Department

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 5 – Order of Conditions

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

Provided by MassDEP:
344-1566
MassDEP File #

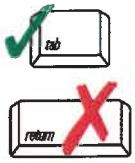
eDEP Transaction #

Wilmington
City/Town

A. General Information

Please note: this form has been modified with added space to accommodate the Registry of Deeds Requirements

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



1. From: Wilmington
Conservation Commission

2. This issuance is for (check one): a. ☒ Order of Conditions b. ☐ Amended Order of Conditions

3. To: Applicant:

Erica	Larner
a. First Name	b. Last Name

Massachusetts Department of Transportation Highway Division
c. Organization

10 Park Plaza, Room 7360
d. Mailing Address

Boston	MA	02116
e. City/Town	f. State	g. Zip Code

4. Property Owner (if different from applicant):

a. First Name	b. Last Name

Massachusetts Department of Transportation – Highway Division
c. Organization

10 Park Plaza
d. Mailing Address

Boston	MA	02116
e. City/Town	f. State	g. Zip Code

5. Project Location:

Route 38 (Main St) from Route 62 (Church St/ Burlington Ave) to Woburn City Line	Wilmington
c. Assessors Map/Plat Number	b. City/Town
N/A	N/A
c. Assessors Map/Plat Number	d. Parcel/Lot Number

Latitude and Longitude, if known: 42°32'47"N- 42°31'16"N (d. Latitude) 71°10'25"W- 71°9'30"W (e. Longitude)

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A. General Information (cont.)

6. Property recorded at the Registry of Deeds for (attach additional information if more than one parcel):

M.N.R.D
a. County

b. Certificate Number (if registered land)

N/A - roadway
c. Book

N/A - roadway
d. Page

7. Da

March 13, 2025
a. Date Notice of Intent Filed

July 9, 2025
b. Date Public Hearing Closed

July 17, 2025
c. Date of Issuance

8. Final Approved Plans and Other Documents (attach additional plan or document references as needed): **SEE ATTACHED**

a. Plan Title

b. Prepared By

c. Signed and Stamped by

d. Final Revision Date

e. Scale

f. Additional Plan or Document Title

g. Date

B. Findings

1. Findings pursuant to the Massachusetts Wetlands Protection Act:

Following the review of the above-referenced Notice of Intent and based on the information provided in this application and presented at the public hearing, this Commission finds that the areas in which work is proposed is significant to the following interests of the Wetlands Protection Act (the Act). Check all that apply:

a. ☒ Public Water Supply b. ☐ Land Containing Shellfish c. ☒ Prevention of Pollution

d. ☒ Private Water Supply e. ☐ Fisheries f. ☒ Protection of Wildlife Habitat

g. ☒ Groundwater Supply h. ☒ Storm Damage Prevention i. ☒ Flood Control

2. This Commission hereby finds the project, as proposed, is: (check one of the following boxes)

Approved subject to:

a. ☒ the following conditions which are necessary in accordance with the performance standards set forth in the wetlands regulations. This Commission orders that all work shall be performed in accordance with the Notice of Intent referenced above, the following General Conditions, and any other special conditions attached to this Order. To the extent that the following conditions modify or differ from the plans, specifications, or other proposals submitted with the Notice of Intent, these conditions shall control.

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B. Findings (cont.)

Denied because:

b. ☐ the proposed work cannot be conditioned to meet the performance standards set forth in the wetland regulations. Therefore, work on this project may not go forward unless and until a new Notice of Intent is submitted which provides measures which are adequate to protect the interests of the Act, and a final Order of Conditions is issued. **A description of the performance standards which the proposed work cannot meet is attached to this Order.**

c. ☐ the information submitted by the applicant is not sufficient to describe the site, the work, or the effect of the work on the interests identified in the Wetlands Protection Act. Therefore, work on this project may not go forward unless and until a revised Notice of Intent is submitted which provides sufficient information and includes measures which are adequate to protect the Act's interests, and a final Order of Conditions is issued. **A description of the specific information which is lacking and why it is necessary is attached to this Order as per 310 CMR 10.05(6)(c).**

3. ☒ Buffer Zone Impacts: Shortest distance between limit of project disturbance and the wetland resource area specified in 310 CMR 10.02(1)(a) — 0 a. linear feet

Inland Resource Area Impacts: Check all that apply below. (For Approvals Only)

Resource Area	Proposed Alteration	Permitted Alteration	Proposed Replacement	Permitted Replacement
4. ☒ Bank	64 (perm) 15 (temp) a. linear feet	64 (perm) 15 (temp) b. linear feet	79 c. linear feet	79 d. linear feet
5. ☒ Bordering Vegetated Wetland	2,792 (perm) 2,258 (temp) a. square feet	2,792 (perm) 2,258 (temp) b. square feet	3,510 c. square feet	3,510 d. square feet
6. ☒ Land Under Waterbodies and Waterways	428 (perm) 60 (temp) a. square feet	428 (perm) 60 (temp) b. square feet	488 c. square feet	488 d. square feet
	e. c/y dredged	f. c/y dredged		
7. ☒ Bordering Land Subject to Flooding	6,815 a. square feet	6,815 b. square feet	4,261 c. square feet	4,261 d. square feet
Cubic Feet Flood Storage	2,155 e. cubic feet	2,155 f. cubic feet	4,161 g. cubic feet	4,161 h. cubic feet
8. ☐ Isolated Land Subject to Flooding	a. square feet	b. square feet		
Cubic Feet Flood Storage	c. cubic feet	d. cubic feet	e. cubic feet	f. cubic feet
9. ☒ Riverfront Area	71,960 a. total sq. feet	71,960 b. total sq. feet		
Sq ft within 100 ft	50,357 c. square feet	50,357 d. square feet	0 e. square feet	0 f. square feet
Sq ft between 100-200 ft	21,603 g. square feet	21,603 h. square feet	0 i. square feet	0 j. square feet

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B. Findings (cont.)

Coastal Resource Area Impacts: Check all that apply below. (For Approvals Only)

	Proposed Alteration	Permitted Alteration	Proposed Replacement	Permitted Replacement
10. ☐ Designated Port Areas	Indicate size under Land Under the Ocean, below			
11. ☐ Land Under the Ocean	a. square feet	b. square feet		
	c. c/y dredged	d. c/y dredged		
12. ☐ Barrier Beaches	Indicate size under Coastal Beaches and/or Coastal Dunes below			
13. ☐ Coastal Beaches	a. square feet	b. square feet	c. nourishment cu yd	d. nourishment cu yd
14. ☐ Coastal Dunes	a. square feet	b. square feet	c. nourishment cu yd	d. nourishment cu yd
15. ☐ Coastal Banks	a. linear feet	b. linear feet		
16. ☐ Rocky Intertidal Shores	a. square feet	b. square feet		
17. ☐ Salt Marshes	a. square feet	b. square feet	c. square feet	d. square feet
18. ☐ Land Under Salt Ponds	a. square feet	b. square feet		
	c. c/y dredged	d. c/y dredged		
19. ☐ Land Containing Shellfish	a. square feet	b. square feet	c. square feet	d. square feet
20. ☐ Fish Runs	Indicate size under Coastal Banks, Inland Bank, Land Under the Ocean, and/or inland Land Under Waterbodies and Waterways, above			
	a. c/y dredged	b. c/y dredged		
21. ☐ Land Subject to Coastal Storm Flowage	a. square feet	b. square feet		
22. ☐ Riverfront Area	a. total sq. feet	b. total sq. feet		
Sq ft within 100 ft	c. square feet	d. square feet	e. square feet	f. square feet
Sq ft between 100-200 ft	g. square feet	h. square feet	i. square feet	j. square feet

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B. Findings (cont.)

*** #23.** 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.5.c (BVW) or B.17.c (Salt Marsh) above, please enter the additional amount here.

23. ☐ Restoration/Enhancement *:

a. square feet of BVW | b. square feet of salt marsh

24. ☐ Stream Crossing(s):

a. number of new stream crossings | b. number of replacement stream crossings

C. General Conditions Under Massachusetts Wetlands Protection Act

The following conditions are only applicable to Approved projects.

1. Failure to comply with all conditions stated herein, and with all related statutes and other regulatory measures, shall be deemed cause to revoke or modify this Order.
2. The Order does not grant any property rights or any exclusive privileges; it does not authorize any injury to private property or invasion of private rights.
3. This Order does not relieve the permittee or any other person of the necessity of complying with all other applicable federal, state, or local statutes, ordinances, bylaws, or regulations.
4. The work authorized hereunder shall be completed within three years from the date of this Order unless either of the following apply:
   a. The work is a maintenance dredging project as provided for in the Act; or
   b. The time for completion has been extended to a specified date more than three years, but less than five years, from the date of issuance. If this Order is intended to be valid for more than three years, the extension date and the special circumstances warranting the extended time period are set forth as a special condition in this Order.
   c. If the work is for a Test Project, this Order of Conditions shall be valid for no more than one year.
5. This Order may be extended by the issuing authority for one or more periods of up to three years each upon application to the issuing authority at least 30 days prior to the expiration date of the Order. An Order of Conditions for a Test Project may be extended for one additional year only upon written application by the applicant, subject to the provisions of 310 CMR 10.05(11)(f).
6. If this Order constitutes an Amended Order of Conditions, this Amended Order of Conditions does not extend the issuance date of the original Final Order of Conditions and the Order will expire on _____ unless extended in writing by the Department.
7. Any fill used in connection with this project shall be clean fill. Any fill shall contain no trash, refuse, rubbish, or debris, including but not limited to lumber, bricks, plaster, wire, lath, paper, cardboard, pipe, tires, ashes, refrigerators, motor vehicles, or parts of any of the foregoing.

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C. General Conditions Under Massachusetts Wetlands Protection Act

8. This Order is not final until all administrative appeal periods from this Order have elapsed, or if such an appeal has been taken, until all proceedings before the Department have been completed.

9. No work shall be undertaken until the Order has become final and then has been recorded in the Registry of Deeds or the Land Court for the district in which the land is located, within the chain of title of the affected property. In the case of recorded land, the Final Order shall also be noted in the Registry's Grantor Index under the name of the owner of the land upon which the proposed work is to be done. In the case of the registered land, the Final Order shall also be noted on the Land Court Certificate of Title of the owner of the land upon which the proposed work is done. The recording information shall be submitted to the Conservation Commission on the form at the end of this Order, which form must be stamped by the Registry of Deeds, prior to the commencement of work.

10. A sign shall be displayed at the site not less then two square feet or more than three square feet in size bearing the words,

"Massachusetts Department of Environmental Protection" [or, "MassDEP"]

"File Number 344-1566 "

11. Where the Department of Environmental Protection is requested to issue a Superseding Order, the Conservation Commission shall be a party to all agency proceedings and hearings before MassDEP.

12. Upon completion of the work described herein, the applicant shall submit a Request for Certificate of Compliance (WPA Form 8A) to the Conservation Commission.

13. The work shall conform to the plans and special conditions referenced in this order.

14. Any change to the plans identified in Condition #13 above shall require the applicant to inquire of the Conservation Commission in writing whether the change is significant enough to require the filing of a new Notice of Intent.

15. The Agent or members of the Conservation Commission and the Department of Environmental Protection shall have the right to enter and inspect the area subject to this Order at reasonable hours to evaluate compliance with the conditions stated in this Order, and may require the submittal of any data deemed necessary by the Conservation Commission or Department for that evaluation.

16. This Order of Conditions shall apply to any successor in interest or successor in control of the property subject to this Order and to any contractor or other person performing work conditioned by this Order.

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C. General Conditions Under Massachusetts Wetlands Protection Act (cont.)

17. Prior to the start of work, and if the project involves work adjacent to a Bordering Vegetated Wetland, the boundary of the wetland in the vicinity of the proposed work area shall be marked by wooden stakes or flagging. Once in place, the wetland boundary markers shall be maintained until a Certificate of Compliance has been issued by the Conservation Commission.

18. All sedimentation barriers shall be maintained in good repair until all disturbed areas have been fully stabilized with vegetation or other means. At no time shall sediments be deposited in a wetland or water body. During construction, the applicant or his/her designee shall inspect the erosion controls on a daily basis and shall remove accumulated sediments as needed. The applicant shall immediately control any erosion problems that occur at the site and shall also immediately notify the Conservation Commission, which reserves the right to require additional erosion and/or damage prevention controls it may deem necessary. Sedimentation barriers shall serve as the limit of work unless another limit of work line has been approved by this Order.

19. The work associated with this Order (the "Project")
    (1) ☒ is subject to the Massachusetts Stormwater Standards
    (2) ☐ is NOT subject to the Massachusetts Stormwater Standards

    If the work is subject to the Stormwater Standards, then the project is subject to the following conditions:

    a) All work, including site preparation, land disturbance, construction and redevelopment, shall be implemented in accordance with the construction period pollution prevention and erosion and sedimentation control plan and, if applicable, the Stormwater Pollution Prevention Plan required by the National Pollution Discharge Elimination System Construction General Permit as required by Stormwater Condition 8. Construction period erosion, sedimentation and pollution control measures and best management practices (BMPs) shall remain in place until the site is fully stabilized.

    b) No stormwater runoff may be discharged to the post-construction stormwater BMPs unless and until a Registered Professional Engineer provides a Certification that:
    i. all construction period BMPs have been removed or will be removed by a date certain specified in the Certification. For any construction period BMPs intended to be converted to post construction operation for stormwater attenuation, recharge, and/or treatment, the conversion is allowed by the MassDEP Stormwater Handbook BMP specifications and that the BMP has been properly cleaned or prepared for post construction operation, including removal of all construction period sediment trapped in inlet and outlet control structures;
    ii. as-built final construction BMP plans are included, signed and stamped by a Registered Professional Engineer, certifying the site is fully stabilized;
    iii. any illicit discharges to the stormwater management system have been removed, as per the requirements of Stormwater Standard 10;

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C. General Conditions Under Massachusetts Wetlands Protection Act (cont.)

iv. all post-construction stormwater BMPs are installed in accordance with the plans (including all planting plans) approved by the issuing authority, and have been inspected to ensure that they are not damaged and that they are in proper working condition;

v. any vegetation associated with post-construction BMPs is suitably established to withstand erosion.

c) The landowner is responsible for BMP maintenance until the issuing authority is notified that another party has legally assumed responsibility for BMP maintenance. Prior to requesting a Certificate of Compliance, or Partial Certificate of Compliance, the responsible party (defined in General Condition 18(e)) shall execute and submit to the issuing authority an Operation and Maintenance Compliance Statement ("O&M Statement) for the Stormwater BMPs identifying the party responsible for implementing the stormwater BMP Operation and Maintenance Plan ("O&M Plan") and certifying the following:

i.) the O&M Plan is complete and will be implemented upon receipt of the Certificate of Compliance, and

ii.) the future responsible parties shall be notified in writing of their ongoing legal responsibility to operate and maintain the stormwater management BMPs and implement the Stormwater Pollution Prevention Plan.

d) Post-construction pollution prevention and source control shall be implemented in accordance with the long-term pollution prevention plan section of the approved Stormwater Report and, if applicable, the Stormwater Pollution Prevention Plan required by the National Pollution Discharge Elimination System Multi-Sector General Permit.

e) Unless and until another party accepts responsibility, the landowner, or owner of any drainage easement, assumes responsibility for maintaining each BMP. To overcome this presumption, the landowner of the property must submit to the issuing authority a legally binding agreement of record, acceptable to the issuing authority, evidencing that another entity has accepted responsibility for maintaining the BMP, and that the proposed responsible party shall be treated as a permittee for purposes of implementing the requirements of Conditions 18(f) through 18(k) with respect to that BMP. Any failure of the proposed responsible party to implement the requirements of Conditions 18(f) through 18(k) with respect to that BMP shall be a violation of the Order of Conditions or Certificate of Compliance. In the case of stormwater BMPs that are serving more than one lot, the legally binding agreement shall also identify the lots that will be serviced by the stormwater BMPs. A plan and easement deed that grants the responsible party access to perform the required operation and maintenance must be submitted along with the legally binding agreement.

f) The responsible party shall operate and maintain all stormwater BMPs in accordance with the design plans, the O&M Plan, and the requirements of the Massachusetts Stormwater Handbook.

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C. General Conditions Under Massachusetts Wetlands Protection Act (cont.)

g) The responsible party shall:
1. Maintain an operation and maintenance log for the last three (3) consecutive calendar years of inspections, repairs, maintenance and/or replacement of the stormwater management system or any part thereof, and disposal (for disposal the log shall indicate the type of material and the disposal location);
2. Make the maintenance log available to MassDEP and the Conservation Commission ("Commission") upon request; and
3. Allow members and agents of the MassDEP and the Commission to enter and inspect the site to evaluate and ensure that the responsible party is in compliance with the requirements for each BMP established in the O&M Plan approved by the issuing authority.

h) All sediment or other contaminants removed from stormwater BMPs shall be disposed of in accordance with all applicable federal, state, and local laws and regulations.

i) Illicit discharges to the stormwater management system as defined in 310 CMR 10.04 are prohibited.

j) The stormwater management system approved in the Order of Conditions shall not be changed without the prior written approval of the issuing authority.

k) Areas designated as qualifying pervious areas for the purpose of the Low Impact Site Design Credit (as defined in the MassDEP Stormwater Handbook, Volume 3, Chapter 1, Low Impact Development Site Design Credits) shall not be altered without the prior written approval of the issuing authority.

l) Access for maintenance, repair, and/or replacement of BMPs shall not be withheld. Any fencing constructed around stormwater BMPs shall include access gates and shall be at least six inches above grade to allow for wildlife passage.

Special Conditions (if you need more space for additional conditions, please attach a text document):

See Attached Conditions

20. For Test Projects subject to 310 CMR 10.05(11), the applicant shall also implement the monitoring plan and the restoration plan submitted with the Notice of Intent. If the conservation commission or Department determines that the Test Project threatens the public health, safety or the environment, the applicant shall implement the removal plan submitted with the Notice of Intent or modify the project as directed by the conservation commission or the Department.

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D. Findings Under Municipal Wetlands Bylaw or Ordinance

1. Is a municipal wetlands bylaw or ordinance applicable? ☐ Yes ☒ No

2. The _____ hereby finds (check one that applies):
   Conservation Commission

   a. ☐ that the proposed work cannot be conditioned to meet the standards set forth in a municipal ordinance or bylaw, specifically:

   1. Municipal Ordinance or Bylaw _____ 2. Citation _____

   Therefore, work on this project may not go forward unless and until a revised Notice of Intent is submitted which provides measures which are adequate to meet these standards, and a final Order of Conditions is issued.

   b. ☐ that the following additional conditions are necessary to comply with a municipal ordinance or bylaw:

   1. Municipal Ordinance or Bylaw _____ 2. Citation _____

3. The Commission orders that all work shall be performed in accordance with the following conditions and with the Notice of Intent referenced above. To the extent that the following conditions modify or differ from the plans, specifications, or other proposals submitted with the Notice of Intent, the conditions shall control.
   The special conditions relating to municipal ordinance or bylaw are as follows (if you need more space for additional conditions, attach a text document):

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E. Signatures

This Order is valid for three years, unless otherwise specified as a special condition pursuant to General Conditions #4, from the date of issuance.

July 17, 2025
1. Date of Issuance

Please indicate the number of members who will sign this form.
This Order must be signed by a majority of the Conservation Commission.

6
2. Number of Signers

The Order must be mailed by certified mail (return receipt requested) or hand delivered to the applicant. A copy also must be mailed or hand delivered at the same time to the appropriate Department of Environmental Protection Regional Office, if not filing electronically, and the property owner, if different from applicant.

Signature	Printed Name
	FRANK SILVOSA
	KELLY ASHTON
	Jean Marie Cole
	Laurie Fine
	Thom Bradley
Donald Pearson	Donald Pearson

☐ by hand delivery on

Date

☒ by certified mail, return receipt requested, on July 17, 2025

Date

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F. Appeals

The applicant, the owner, any person aggrieved by this Order, any owner of land abutting the land subject to this Order, or any ten residents of the city or town in which such land is located, are hereby notified of their right to request the appropriate MassDEP Regional Office to issue a Superseding Order of Conditions. The request must be made by certified mail or hand delivery to the Department, with the appropriate filing fee and a completed Request for Departmental Action Fee Transmittal Form, as provided in 310 CMR 10.03(7) within ten business days from the date of issuance of this Order. A copy of the request shall at the same time be sent by certified mail or hand delivery to the Conservation Commission and to the applicant, if he/she is not the appellant.

Any appellants seeking to appeal the Department's Superseding Order associated with this appeal will be required to demonstrate prior participation in the review of this project. Previous participation in the permit proceeding means the submission of written information to the Conservation Commission prior to the close of the public hearing, requesting a Superseding Order, or providing written information to the Department prior to issuance of a Superseding Order.

The request shall state clearly and concisely the objections to the Order which is being appealed and how the Order does not contribute to the protection of the interests identified in the Massachusetts Wetlands Protection Act (M.G.L. c. 131, § 40), and is inconsistent with the wetlands regulations (310 CMR 10.00). To the extent that the Order is based on a municipal ordinance or bylaw, and not on the Massachusetts Wetlands Protection Act or regulations, the Department has no appellate jurisdiction.

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G. Recording Information

Prior to commencement of work, this Order of Conditions must be recorded in the Registry of Deeds or the Land Court for the district in which the land is located, within the chain of title of the affected property. In the case of recorded land, the Final Order shall also be noted in the Registry's Grantor Index under the name of the owner of the land subject to the Order. In the case of registered land, this Order shall also be noted on the Land Court Certificate of Title of the owner of the land subject to the Order of Conditions. The recording information on this page shall be submitted to the Conservation Commission listed below.

Conservation Commission

Detach on dotted line, have stamped by the Registry of Deeds and submit to the Conservation Commission.

To:

Conservation Commission

Please be advised that the Order of Conditions for the Project at:

Project Location | MassDEP File Number

Has been recorded at the Registry of Deeds of:

County | Book | Page

for: Property Owner

and has been noted in the chain of title of the affected property in:

Book | Page

In accordance with the Order of Conditions issued on:

Date

If recorded land, the instrument number identifying this transaction is:

Instrument Number

If registered land, the document number identifying this transaction is:

Document Number

Signature of Applicant

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

Request for Departmental Action Fee Transmittal Form

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

DEP File Number:

Provided by DEP

A. Request Information

1. Location of Project

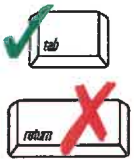
a. Street Address

b. City/Town, Zip

c. Check number

d. Fee amount

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



2. Person or party making request (if appropriate, name the citizen group's representative):

Name

Mailing Address

City/Town

State

Zip Code

Phone Number

Fax Number (if applicable)

3. Applicant (as shown on Determination of Applicability (Form 2), Order of Resource Area Delineation (Form 4B), Order of Conditions (Form 5), Restoration Order of Conditions (Form 5A), or Notice of Non-Significance (Form 6)):

Name

Mailing Address

City/Town

State

Zip Code

Phone Number

Fax Number (if applicable)

4. DEP File Number:

B. Instructions

1. When the Departmental action request is for (check one):

☐ Superseding Order of Conditions – Fee: $120.00 (single family house projects) or $245 (all other projects)

☐ Superseding Determination of Applicability – Fee: $120

☐ Superseding Order of Resource Area Delineation – Fee: $120

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

Request for Departmental Action Fee Transmittal Form

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

DEP File Number:

Provided by DEP

B. Instructions (cont.)

Send this form and check or money order, payable to the *Commonwealth of Massachusetts,* to:

Department of Environmental Protection
Box 4062
Boston, MA 02211

2. On a separate sheet attached to this form, state clearly and concisely the objections to the Determination or Order which is being appealed. To the extent that the Determination or Order is based on a municipal bylaw, and not on the Massachusetts Wetlands Protection Act or regulations, the Department has no appellate jurisdiction.

3. Send a **copy** of this form and a **copy** of the check or money order with the Request for a Superseding Determination or Order by certified mail or hand delivery to the appropriate DEP Regional Office (see https://www.mass.gov/service-details/massdep-regional-offices-by-community).

4. A copy of the request shall at the same time be sent by certified mail or hand delivery to the Conservation Commission and to the applicant, if he/she is not the appellant.

ORDER OF CONDITIONS
#344-1566
Route 38 (Main Street) from Route 62 to Woburn City Line
Erica Larner, Applicant, Massachusetts Department of Transportation Highway Division, Owner

Project: Maintenance and improvement of the existing roadway which includes lane widening, bike lanes, improvement to existing drainage structures, and repaving. This project also includes the replacement of a culvert at Dublin Avenue. The work is within Bordering Land Subject to Flooding (BLSF), 100' Buffer Zone of and within Bordering Vegetated Wetlands (BVWs), Riverfront Area, Land Under Waterbodies and Waterways (LUW), and Bank. Work within resource area includes some temporary and permanent impacts, with replacement and restoration of some of these impacts, as described on page 3 of the WPA Form 5 – Order of Conditions. Erosion controls are proposed and shall act as the limit of work for the project.

SPECIAL CONDITIONS:

General:

(Please review the General Conditions on previous pages)

21. The work shall conform to the following plans and documents, unless otherwise specified in this Order of Conditions (Order):
    a) Notice of Intent (NOI) filed by Erica Larner, Massachusetts Department of Transportation Highway Division, dated March 13, 2025, received by the Commission on March 13, 2025.
    b) Plan set entitled "Massachusetts Department of Transportation Highway Division. Plan and Profile of Route 38 (Main Street)" dated May 2025, prepared by Green International Affiliates, Inc, signed and stamped by Dennis A. Vertiyev (PE)
    c) Revised plan sheets entitled "Resource Area Impacts Plans" sheets 1-6, revised April 23, 2025.
    d) Stormwater Report dated March 2025, last revised April 10, 2025.
    e) Watershed Plans entitled "Existing Watershed Plan" & "Proposed Watershed Plan", prepared by Green International Affiliates, Inc, dated January 5, 2024.
    f) Summary of Minor Revisions Report dated April 28, 2025.
22. The proposed work is in 100' buffer zone of and within Bordering Vegetated Wetlands, Riverfront Area, Bordering Land Subject to Flooding, Land Under Waterbodies and Waterways, and Bank. No other wetland resource areas are proposed to be, or permitted to be, altered under this Order.
23. The Commission reserves the right to impose additional conditions on this project to mitigate any actual or potential impacts resulting from the work herein permitted.
24. With respect to all conditions, the Commission designates the Conservation Agent as its administrative agent with full powers to act on its behalf in administering and enforcing this Order.
25. The Plans of Record for this Order do not constitute specific acceptance of the boundaries of resource areas for any work not described in the corresponding NOI, as amended prior to approval. For any such work not described as per the provisions above, the Commission

may require new plans and/or delineation of wetland resource areas, as it deems appropriate.

26. This document and the approved plans shall be included in all construction contracts and subcontracts for the proposed work and shall supersede any conflicting contract requirements. It shall also be kept on file at the job site at all times during construction. Any contractors or subcontractors may be held jointly liable for any violation of this Order.
27. The owners of the project and any successor in control or in interest of the property, in the event they proceed to alter areas subject to the Commission's jurisdiction under the Order, agree that the Town of Wilmington shall not be liable for any damage. By acceptance of this Order, the owners indemnify and hold harmless the Town of Wilmington and its residents for any damages attributable to alterations undertaken on this property pursuant to this Order. Issuance of this Order does not in any way imply or certify that the site or downstream areas will not be subject to flooding, storm damage or any other form of water damage.

Pre-Construction:

28. Prior to the commencement of any work on site, the Applicant shall submit to the Commission for approval the anticipated sequence of construction and timetable. The Applicant shall include the name(s), address(es), e-mail address(es), and telephone number(s) of the person(s) responsible on site for compliance with this Order.
29. Prior to the start of any work, and in compliance with Condition 10, a sign shall be displayed showing the DEP File Number. This sign shall not be posted on a live tree. It shall be maintained until a Certificate of Compliance (Certificate) is issued.
30. Prior to any activity on the site, a compost-filled sock, straw wattle, siltation fence, or other erosion controls approved by the Commission shall be placed as depicted on the approved plan. The erosion controls shall act as the limit of work. The erosion control barrier shall be placed and properly installed per manufacturer's specifications, maintained according to the approved plan, and shall be inspected and approved by the Conservation Agent prior to the start of construction. This barrier shall remain intact and immediately repaired as necessary until all disturbed areas have been permanently stabilized to prevent erosion.
31. Prior to any work, the Applicant and/or their agents shall meet with the Conservation Agent on the site to review the proposed work, erosion controls, and measures designed to mitigate any impact to wetland resource areas, and to ensure that all of the conditions of this Order are understood.

Construction:

32. Storm drains shall have siltation control bags placed under the grate, which shall be cleaned after each storm event until construction is complete.
33. Monthly NPDES reports and anticipated project schedules shall be provided to the Department of Planning & Conservation.
34. No proposed earthen embankment in wetland resource areas shall have a slope steeper than 2:1 (horizontal: vertical) without prior written approval of the Commission.
35. There shall be no stockpiling of any soil or other materials within 25 feet of Bank or BVWs without prior written approval of the Conservation Commission.
36. Any dewatering activities on the project shall make use of a settling pond or similar device to remove sediment before water is released. This system must be approved by the Conservation Agent prior to implementation. There shall be no direct discharge of water to

BVWs, the perennial river, or catch basins.

37. Whenever practicable, equipment refueling operations shall be situated in an upland area at a horizontal distance greater than 100 feet from BVWs and Bank. No fuel shall be stored within 100 feet of BVWs and Bank.

38. All stumps, brush, waste and debris shall be removed from the construction site, including existing debris. Construction refuse and debris shall be disposed of promptly and properly and the construction site shall be maintained in a clean condition. Records as to the destination of all materials to be removed from the site including stumps, brush, waste, debris, excess fill, loam and peat shall be kept and supplied to the Commission if requested.

39. All disturbed areas shall be permanently restored by vegetation or as otherwise shown on the above-referenced plans, within 30 days of final grading for this project. If permanent vegetative stabilization is not possible due to snow or frozen conditions outside of the growing season, temporary stabilization shall be provided, and permanent stabilization shall be achieved as soon as possible. Once the ground is permanently stabilized, all erosion controls shall be removed prior to issuance of a Certificate.

40. If any unforeseen problem occurs during construction, which affects any of the eight statutory interests of the Wetlands Protection Act (WPA), upon discovery, the Applicant shall notify the Conservation Agent immediately and a meeting shall be held with the Applicant and any other concerned parties to determine the corrective measures to be employed. The Applicant shall then correct the problem(s) using the agreed upon corrective measures or any other measures as determined by the Commission.

Post Construction:

41. Upon completion of this project, but no more than 30 days after expiration of the Order, the Applicant or their representative is responsible for submitting the Request for a Certificate of Compliance. Completion means all construction and site work is finished per this Order, and permanent stabilization is achieved. The following is to be submitted to the Commission to receive a Certificate:

    a) A Request for a Certificate of Compliance (DEP WPA form 8A).

    b) An as-built plan, at the same scale as the approved plan, signed and stamped by a PE or Land Surveyor (PLS) of the Commonwealth. The as-built shall show and label all construction, wetland resource area locations, and the 100' buffer zone.

    c) A written statement from a PE or PLS of the Commonwealth certifying that the work has been completed in compliance with this Order and the approved plans referenced herein (or approved revisions). Any discrepancies shall be noted. As-built compensatory flood storage volumes shall be included with this statement.

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DOCUMENT A00870

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

CONCURRENCE VERIFICATION LETTER

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Ecological Services Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5094
Phone: (603) 223-2541 Fax: (603) 223-0104

In Reply Refer To: 10/10/2024 13:38:13 UTC
Project code: 2024-0120128
Project Name: 608051 - WILMINGTON- RECONSTRUCTION ON ROUTE 38

Subject: Concurrence verification letter for the '608051 - WILMINGTON- RECONSTRUCTION ON ROUTE 38' project under the amended February 5, 2018, FHWA, FRA, FTA Programmatic Biological Opinion (dated March 23, 2023) for Transportation Projects within the Range of the Indiana Bat and Northern Long-eared Bat (NLEB).

To whom it may concern:

The U.S. Fish and Wildlife Service (Service) has received your request dated October 10, 2024 to verify that the **608051 - WILMINGTON- RECONSTRUCTION ON ROUTE 38** (Proposed Action) may rely on the concurrence provided in the amended February 5, 2018, FHWA, FRA, FTA Programmatic Biological Opinion (dated March 23, 2023) for Transportation Projects within the Range of the Indiana Bat and Northern Long-eared Bat (PBO) to satisfy requirements under Section 7(a)(2) of the Endangered Species Act of 1973 (ESA) (87 Stat.884, as amended; 16 U.S.C. 1531 *et seq.*).

Based on the information you provided (Project Description shown below), you have determined that the Proposed Action is within the scope and adheres to the criteria of the PBO, including the adoption of applicable avoidance and minimization measures. **At least one of the qualification interview questions indicated an activity or portion of your project is consistent with a not likely to adversely affect determination therefore, the overall determination for your project is, may affect, and is not likely to adversely affect (NLAA) the endangered Indiana bat (*Myotis sodalis*) and/or the endangered northern long-eared bat (*Myotis septentrionalis*)**. Consultation with the Service pursuant to section 7(a)(2) of ESA (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) is required.

The Service has 14 calendar days to notify the lead Federal action agency or designated non-federal representative if we determine that the Proposed Action does not meet the criteria for a NLAA determination under the PBO. If we do not notify the lead Federal action agency or designated non-federal representative within that timeframe, you may proceed with the Proposed Action under the terms of the NLAA concurrence provided in the PBO. This verification period

allows Service Field Offices to apply local knowledge to implementation of the PBO, as we may identify a small subset of actions having impacts that were unanticipated. In such instances, Service Field Offices may request additional information that is necessary to verify inclusion of the proposed action under the PBO.

For Proposed Actions that include bridge/culvert or structure removal, replacement, and/or maintenance activities: If your initial bridge/culvert or structure assessment documented signs of bat use or occupancy, or an assessment failed to detect Indiana bats and/or NLEBs, yet are later detected prior to, or during construction, please submit the Post Assessment Discovery of Bats at Bridge/Culvert or Structure Form (User Guide Appendix E) to this Service Office within 2 working days of any potential take. In these instances, potential incidental take of Indiana bats and/or NLEBs is covered under the Incidental Take Statement in the 2018 FHWA, FRA, FTA PBO (provided that the take is reported to the Service).

If the Proposed Action is modified, or new information reveals that it may affect the Indiana bat and/or northern long-eared bat in a manner or to an extent not considered in the PBO, further review to conclude the requirements of ESA Section 7(a)(2) may be required.

For Proposed Actions that include bridge/culvert or structure removal, replacement, and/or maintenance activities:
If your initial bridge/culvert or structure assessments failed to detect Indiana bats and/or NLEB use or occupancy, yet bats are later detected prior to, or during construction, please submit the Post Assessment Discovery of Bats at Bridge/Culvert or Structure Form (User Guide Appendix E) to this Service Office within 2 working days of the incident. In these instances, potential incidental take of Indiana bats and/or NLEBs may be exempted provided that the take is reported to the Service.

If the Proposed Action may affect any other federally-listed or proposed species, and/or any designated critical habitat, additional consultation between the lead Federal action agency and this Service Office is required. If the proposed action has the potential to take bald or golden eagles, additional coordination with the Service under the Bald and Golden Eagle Protection Act may also be required. In either of these circumstances, please contact this Service Office.

The following species may occur in your project area and **are not** covered by this determination:

- Monarch Butterfly *Danaus plexippus* Candidate
- Tricolored Bat *Perimyotis subflavus* Proposed Endangered

PROJECT DESCRIPTION

The following project name and description was collected in IPaC as part of the endangered species review process.

NAME

608051 - WILMINGTON- RECONSTRUCTION ON ROUTE 38

DESCRIPTION

608051 - WILMINGTON- RECONSTRUCTION ON ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L.

project will reconstruct Route 38 from Route 62 to the Woburn City line. The roadway will consist of two 11 foot lanes, two 5 foot bike lanes and a 6 foot sidewalk. Turn lanes and upgraded traffic signals will be installed at Route 62.

Project limits DOES NOT include work on bridge W-38-002

Tricolored Bat: Proposed Endangered Species only. The project action will not jeopardize the continued existence of a proposed species.

Monarch Butterfly: Candidate Species only, no conservation measures at this time.

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@42.533519,-71.15924573280542,14z



DETERMINATION KEY RESULT

Based on your answers provided, this project(s) may affect, but is not likely to adversely affect the endangered Indiana bat and/or the endangered northern long-eared bat, therefore, consultation with the U.S. Fish and Wildlife Service pursuant to Section 7(a)(2) of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended 16 U.S.C. 1531 *et seq.*) is required. However, also based on your answers provided, this project may rely on the concurrence provided in the amended February 5, 2018, FHWA, FRA, FTA Programmatic Biological Opinion (dated March 23, 2023) for Transportation Projects within the Range of the Indiana Bat and Northern Long-eared Bat.

QUALIFICATION INTERVIEW

1. Is the project within the range of the Indiana bat[1]?

   [1] See Indiana bat species profile

   Automatically answered
   No

2. Is the project within the range of the northern long-eared bat[1]?

   [1] See northern long-eared bat species profile

   Automatically answered
   Yes

3. Which Federal Agency is the lead for the action?

   A) Federal Highway Administration (FHWA)

4. Are *all* project activities limited to non-construction[1] activities only? (examples of non-construction activities include: bridge/abandoned structure assessments, surveys, planning and technical studies, property inspections, and property sales)

   [1] Construction refers to activities involving ground disturbance, percussive noise, and/or lighting.

   No

5. Does the project include *any* activities that are **greater than** 300 feet from existing road/rail surfaces[1]?

   [1] Road surface is defined as the actively used [e.g. motorized vehicles] driving surface and shoulders [may be pavement, gravel, etc.] and rail surface is defined as the edge of the actively used rail ballast.

   No

6. Does the project include *any* activities **within** 0.5 miles of a known Indiana bat and/or NLEB hibernaculum[1]?

   [1] For the purpose of this consultation, a hibernaculum is a site, most often a cave or mine, where bats hibernate during the winter (see suitable habitat), but could also include bridges and structures if bats are found to be hibernating there during the winter.

   No

7. Is the project located **within** a karst area?

   No

8. Is there *any* suitable[1] summer habitat for Indiana Bat or NLEB **within** the project action area[2]? (includes any trees suitable for maternity, roosting, foraging, or travelling habitat)

   [1] See the Service's summer survey guidance for our current definitions of suitable habitat.

   [2] The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR Section 402.02). Further clarification is provided by the User's Guide for the Range-wide Programmatic Consultation for Indiana Bat and Northern Long-eared Bat.

   Yes

9. Will the project remove *any* suitable summer habitat[1] and/or remove/trim any existing trees **within** suitable summer habitat?

   [1] See the Service's summer survey guidance for our current definitions of suitable habitat.

   Yes

10. Will the project clear more than 20 acres of suitable habitat per 5-mile section of road/rail?

    No

11. Have presence/probable absence (P/A) summer surveys[1][2] been conducted[3][4] **within** the suitable habitat located within your project action area?

    [1] See the Service's summer survey guidance for our current definitions of suitable habitat.

    [2] Presence/probable absence summer surveys conducted within the fall swarming/spring emergence home range of a documented Indiana bat hibernaculum (contact local Service Field Office for appropriate distance from hibernacula) that result in a negative finding requires additional consultation with the local Service Field Office to determine if clearing of forested habitat is appropriate and/or if seasonal clearing restrictions are needed to avoid and minimize potential adverse effects on fall swarming and spring emerging Indiana bats.

    [3] For projects within the range of either the Indiana bat or NLEB in which suitable habitat is present, and no bat surveys have been conducted, the transportation agency will assume presence of the appropriate species. This assumption of presence should be based upon the presence of suitable habitat and the capability of bats to occupy it because of their mobility.

    [4] Negative presence/probable absence survey results obtained using the summer survey guidance are valid for a minimum of two years from the completion of the survey unless new information (e.g., other nearby surveys) suggest otherwise.

    Yes

SUBMITTED DOCUMENTS

- *608051_Wilmington-bat_acoustic_report_2023.pdf https://ipac.ecosphere.fws.gov/project/RZEIN5M225HN5DTRAKLKCYNUKE/projectDocuments/146781987*

12. Did the presence/probable absence (P/A) summer surveys detect Indiana bats and/or NLEB[1]?

    [1] P/A summer surveys conducted within the fall swarming/spring emergence home range of a documented Indiana bat hibernaculum (contact local Service Field Office for appropriate home range) that result in a negative finding requires additional consultation with the local Service Field Office to determine if clearing of forested habitat is appropriate and/or if seasonal clearing restrictions are needed to avoid and minimize potential adverse effects on fall swarming and spring emerging Indiana bats.

    No

13. Were the P/A summer surveys conducted **within** the fall swarming/spring emergence range of a documented Indiana bat hibernaculum[1]?

    [1] Contact the local Service Field Office for appropriate distance from hibernacula.

    No

14. Does the project include activities **within documented NLEB habitat**[1][2]?

    [1] Documented roosting or foraging habitat – for the purposes of this consultation, we are considering documented habitat as that where Indiana bats and/or NLEB have actually been captured and tracked using (1) radio telemetry to roosts; (2) radio telemetry biangulation/triangulation to estimate foraging areas; or (3) foraging areas with repeated use documented using acoustics. Documented roosting habitat is also considered as suitable summer habitat within 0.25 miles of documented roosts.)

    [2] For the purposes of this key, we are considering documented corridors as that where Indiana bats and/or NLEB have actually been captured and tracked to using (1) radio telemetry; or (2) treed corridors located directly between documented roosting and foraging habitat.

    No

15. Will the removal or trimming of habitat or trees occur **within** suitable but **undocumented NLEB** roosting/foraging habitat or travel corridors?

    Yes

16. What time of year will the removal or trimming of habitat or trees **within** suitable but **undocumented NLEB** roosting/foraging habitat or travel corridors occur?

    C) During both the active and inactive seasons

17. Will *any* tree trimming or removal occur **within** 100 feet of existing road/rail surfaces?

    Yes

18. Will *any* tree trimming or removal occur **between** 100-300 feet of existing road/rail surfaces?

    No

19. Are *all* trees that are being removed clearly demarcated?

    Yes

20. Will the removal of habitat or the removal/trimming of trees involve the use of **temporary** lighting?

    Yes

21. Will the removal of habitat or the removal/trimming of trees include installing new or replacing existing **permanent** lighting?

    No

22. Does the project include wetland or stream protection activities associated with compensatory wetland mitigation?

    Yes

23. Does the project include slash pile burning?

    No

24. Does the project include *any* bridge removal, replacement, and/or maintenance activities (e.g., any bridge repair, retrofit, maintenance, and/or rehabilitation work)?

    Yes

25. Is there *any* suitable habitat[1] for Indiana bat or NLEB **within** 1,000 feet of the bridge? (includes any trees suitable for maternity, roosting, foraging, or travelling habitat)

    [1] See the Service's current summer survey guidance for our current definitions of suitable habitat.

    Yes

26. Has a bridge assessment[1] been conducted **within** the last 24 months[2] to determine if the bridge is being used by bats?

    [1] See User Guide Appendix D for bridge/structure assessment guidance

    [2] Assessments must be completed no more than 2 years prior to conducting any work below the deck surface on all bridges that meet the physical characteristics described in the Programmatic Consultation, regardless of whether assessments have been conducted in the past. Due to the transitory nature of bat use, a negative result in one year does not guarantee that bats will not use that bridge/structure in subsequent years.

    Yes

    SUBMITTED DOCUMENTS

    - *608051_WILMINGTON_Bridge_Assessment.pdf https://ipac.ecosphere.fws.gov/project/RZEIN5M225HN5DTRAKLKCYNUKE/projectDocuments/150795136*

27. Did the bridge assessment detect *any* signs of Indiana bats and/or NLEBs roosting in/under the bridge (bats, guano, etc.)[1]?

    [1] If bridge assessment detects signs of *any* species of bats, coordination with the local FWS office is needed to identify potential threatened or endangered bat species. Additional studies may be undertaken to try to identify which bat species may be utilizing the bridge prior to allowing *any* work to proceed.

    Note: There is a small chance bridge assessments for bat occupancy do not detect bats. Should a small number of bats be observed roosting on a bridge just prior to or during construction, such that take is likely to occur or does occur in the form of harassment, injury or death, the PBO requires the action agency to report the take. Report all unanticipated take within 2 working days of the incident to the USFWS. Construction activities may continue without delay provided the take is reported to the USFWS and is limited to 5 bats per project.

    No

28. Will the bridge removal, replacement, and/or maintenance activities include installing new or replacing existing **permanent** lighting?

    No

29. Does the project include the removal, replacement, and/or maintenance of *any* structure other than a bridge? (e.g., rest areas, offices, sheds, outbuildings, barns, parking garages, etc.)

    No

30. Will the project involve the use of *any* **temporary** lighting in addition to the lighting already indicated for habitat removal (including the removal or trimming of trees), or bridge/structure removal, replacement or maintenance activities?

    Yes

31. Is there *any* suitable habitat **within** 1,000 feet of the location(s) where **temporary** lighting (other than the lighting already indicated for habitat removal (including the removal or trimming of trees) or bridge/structure removal, replacement or maintenance activities) will be used?

    Yes

32. Will the project install new or replace existing **permanent** lighting?

    No

33. Does the project include percussives or other activities (**not including tree removal/ trimming or bridge/structure work**) that will increase noise levels above existing traffic/ background levels?

    Yes

34. Will the activities that use percussives (**not including tree removal/trimming or bridge/ structure work**) and/or increase noise levels above existing traffic/background levels be conducted *during* the active season[1]?

    [1] Coordinate with the local Service Field Office for appropriate dates.

    Yes

35. Will *any* activities that use percussives (**not including tree removal/trimming or bridge/ structure work**) and/or increase noise levels above existing traffic/background levels be conducted *during* the inactive season[1]?

    [1] Coordinate with the local Service Field Office for appropriate dates.

    Yes

36. Are *all* project activities that are **not associated with** habitat removal, tree removal/ trimming, bridge and/or structure activities, temporary or permanent lighting, or use of percussives, limited to actions that DO NOT cause any additional stressors to the bat species?

    Examples: lining roadways, unlighted signage , rail road crossing signals, signal lighting, and minor road repair such as asphalt fill of potholes, etc.

    Yes

37. Will the project raise the road profile **above the tree canopy**?

    No

38. Are the wetland or stream protection activities associated with compensatory wetland/ stream mitigation portion of this project consistent with a Not Likely to Adversely Affect determination in this key?

    Automatically answered
    Yes, because your activities associated with compensatory wetland/stream mitigation activities do not clear suitable summer habitat and are not within 0.5 miles of Indiana bat or NLEB hibernaculum.

39. Are the project activities that use percussives (not including tree removal/trimming or bridge/structure work) consistent with a Not Likely to Adversely Affect determination in this key?

    Automatically answered
    Yes, because the activities are within 300 feet of the existing road/rail surface, greater than 0.5 miles from a hibernacula, and conducted during the active season within undocumented habitat.

40. Are the project activities that use percussives (not including tree removal/trimming or bridge/structure work) and/or increase noise levels above existing traffic/background levels consistent with a No Effect determination in this key?

    Automatically answered
    Yes, because the activities are within 300 feet of the existing road/rail surface, greater than 0.5 miles from a hibernacula, and conducted during the inactive season

41. Is the location of this project consistent with a Not Likely to Adversely Affect determination in this key?

    Automatically answered
    Yes, because no bats were detected during presence/probable absence surveys conducted during the summer survey season and outside of the fall swarming/spring emergence periods. Additionally, all activities were at least 0.5 miles from any hibernaculum.

42. Is the bridge removal, replacement, or maintenance activities portion of this project consistent with a No Effect determination in this key?

    Automatically answered
    Yes, because the bridge has been assessed using the criteria documented in the BA and no signs of bats were detected

43. **General AMM 1**
    Will the project ensure *all* operators, employees, and contractors working in areas of known or presumed bat habitat are aware of *all* FHWA/FRA/FTA (Transportation Agencies) environmental commitments, including all applicable Avoidance and Minimization Measures?

    Yes

PROJECT QUESTIONNAIRE

1. Please describe the proposed bridge work:

Bridge W-38-011 is an existing culvert over Maple Meadow Brook in Wilmington. It consists of an open bottom with masonry walls on either side with a concrete slab roof, soil between this slab and the roadway surface. The original design was to add a structural slab over the entire culvert, keeping it in place, with new precast headwalls on each end. The current proposal although not designed yet will be a 3 sided precast concrete culvert on new footings, most likely a concrete cap on top of piles (type to be determined). It is expected that the hydraulic opening will remain the same to prevent down stream flooding.

2. Please state the timing of all proposed bridge work:

   Spring 2026 - Spring 2031

3. Please enter the date of the bridge assessment:

   8/19/2024

4. Have you made a No Effect determination for *all* other species indicated on the FWS IPaC generated species list?

   N/A

5. Have you made a May Affect determination for *any* other species on the FWS IPaC generated species list?

   N/A

6. How many acres[1] of trees are proposed for removal between 0-100 feet of the existing road/rail surface?

   [1] If described as number of trees, multiply by 0.09 to convert to acreage and enter that number.

   3.7

AVOIDANCE AND MINIMIZATION MEASURES (AMMS)

This determination key result includes the committment to implement the following Avoidance and Minimization Measures (AMMs):

GENERAL AMM 1

Ensure all operators, employees, and contractors working in areas of known or presumed bat habitat are aware of all FHWA/FRA/FTA (Transportation Agencies) environmental commitments, including all applicable AMMs.

DETERMINATION KEY DESCRIPTION: FHWA, FRA, FTA PROGRAMMATIC CONSULTATION FOR TRANSPORTATION PROJECTS AFFECTING NLEB OR INDIANA BAT

This key was last updated in IPaC on October 30, 2023. Keys are subject to periodic revision.

This decision key is intended for projects/activities funded or authorized by the Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), and/or Federal Transit Administration (FTA), which may require consultation with the U.S. Fish and Wildlife Service (Service) under Section 7 of the Endangered Species Act (ESA) for the endangered **Indiana bat** (*Myotis sodalis*) and the endangered **northern long-eared bat** (NLEB) (*Myotis septentrionalis*).

This decision key should only be used to verify project applicability with the Service's amended February 5, 2018, FHWA, FRA, FTA Programmatic Biological Opinion (dated March 23, 2023) for Transportation Projects. The programmatic biological opinion covers limited transportation activities that may affect either bat species, and addresses situations that are both likely and not likely to adversely affect either bat species. This decision key will assist in identifying the effect of a specific project/activity and applicability of the programmatic consultation. The programmatic biological opinion is not intended to cover all types of transportation actions. Activities outside the scope of the programmatic biological opinion, or that may affect ESA-listed species other than the Indiana bat or NLEB, or any designated critical habitat, may require additional ESA Section 7 consultation.

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DOCUMENT A00871

NORTHERN LONG-EARED BAT (NLEB) PRESENCE/ABSENCE ACOUSTIC SURVEY

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NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

November 1, 2023

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Project	Northern Long-eared Bat (NLEB) Presence/Absence Acoustic Survey
MassDOT Project #	608051
MassDOT Project Title	RECONSTRUCTION ON ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L.
Town	Wilmington, Massachusetts
Surveyor Name/Firm	*Jamie O'Brien / Normandeau Associates, Inc.*
Detector Operation Dates	May 30–June 6, 2023
Acoustic Survey Results	**NLEB NOT DETECTED**
Acoustic Survey Results	**MYLE NOT DETECTED**
Acoustic Survey Results	**MYLU DETECTED**
Acoustic Survey Results	**PESU DETECTED**

Dear Mr. Paulson,

This report contains the results of the Massachusetts Department of Transportation (MassDOT) northern long-eared bat (*Myotis septentrionalis*, hereafter NLEB) summer presence/absence survey performed for the MassDOT Project #608051, *RECONSTRUCTION ON ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L.*, in Wilmington, Massachusetts. Acoustic detectors deployed by *NORMANDEAU ASSOCIATES, INC. did not* detect the presence of NLEB. Seven (7) bat passes were initially classified as the federally endangered NLEB by analysis software but zero were identified with high certainty of probable presence by analysis software (p-value <0.05) so manual review was not performed for NLEB. Sixty-nine (69) bat passes were initially classified as the state endangered little brown bat (*Myotis lucifugus*) and 12 were identified with high certainty of probable presence by analysis software. One (1) bat pass was initially classified as the state endangered eastern small-footed bat (*Myotis leibeii*) and zero (0) were identified with high certainty of probable presence by analysis software. Twenty (20) bat passes were initially classified as the state endangered tri-colored bat (*Perimyotis subflavus*) and one (1) was confirmed as such during our qualitative assessment.

Sincerely,

Jamie O'Brien, AWB®
Project Manager

Attachments: NLEB Survey Report for Wilmington 608051

Northern Long-eared Bat Acoustic Survey MassDOT Project District 4

#608051, Reconstruction on Route 38 (Main Street)

Wilmington, MA

Prepared For

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November 1, 2023

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Summary

An ultrasonic acoustic survey was conducted to inventory the federally and state endangered northern long-eared bat (NLEB; *Myotis septentrionalis,* or MYSE), tricolored bat (TCB; *Perimyotis subflavus,* or PESU); proposed for federal listing), and other state-listed bat species within the proposed limits of work for a Massachusetts Department of Transportation (MassDOT) maintenance project, located in the Town of Wilmington, MA (MassDOT Project #608051). The survey was designed specifically to sample for NLEB, and detectors were placed in five locations along the Project corridor from May 30 through June 6, 2023. **Zero bat calls were identified by the Kaleidoscope Pro software package with high certainty of probable presence for the NLEB or TCB during its auto-identification. However, one (1) bat call was identified as belonging to TCB during our qualitative assessment.** Bat species potentially or likely present, based on Kaleidoscope Pro results that met the maximum likelihood estimator (MLE) threshold (prior to review by an analyst), consisted of big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), Silver-haired bat (*Lasionycteris noctivagans*), and little brown bat (*Myotis lucifugus*). Manual review of NLEB calls by an acoustic analyst was not performed due to the absence of calls meeting the MLE threshold. Qualitative assessment was completed for all TCB calls, regardless of MLE/P-value, per U.S. Fish and Wildlife Service (USFWS) request.

1 Project Overview

Project #608051, Reconstruction on Route 38 (Main Street) from Route 62 to the Woburn city limit, located in the Town of Wilmington, MA, involves work activities that include pavement milling and resurfacing, full depth reconstruction, variable travel lane and shoulder widths, five- to six- foot sidewalks, granite curbing, and guardrails. Approximately two acres will be cleared/grubbed, nine trees will be removed, and there will be about 3,100 feet of trimming/limbing. The total length of the Project is approximately 4.6 kilometers (km; 2.86 miles; Project).

The Project is within the range of the federally endangered NLEB, which encompasses all of Massachusetts. The Project is also within the anticipated range of the TCB, which has been proposed for listing under the federal Endangered Species Act (ESA). These tree-roosting bat species use forested habitats during their active season, from April 15 through October 31. The Project has the potential to affect these species through tree clearing and limbing.

Normandeau Associates, Inc. (Normandeau) identified the portion(s) of the Project area that required a presence/absence survey based on presence of suitable habitat and then conducted acoustic surveys in these locations as described below. All habitat assessments and presence/absence surveys conducted were consistent with the USFWS' 2023 Range-wide Indiana Bat & Northern Long-eared Bat Survey Guidelines[1] (Guidelines). The protocols for NLEB summer surveys are described in the Guidelines, which explicitly include the NLEB and provide NLEB-specific guidance. The Guidelines indicate that the same NLEB guidance can be used for TCB. Results of the surveys are summarized below, and these results include all elements requested in Appendix C of the Guidelines. The Project does not occur within the known summer range of the Indiana bat (*Myotis sodalis*), the only other federally listed (endangered) species in the northeast region.

2 Methods

The survey was conducted in conformance with the methods and approach outlined in the Guidelines. The field survey and the data analysis were conducted by personnel trained and qualified to conduct their respective tasks. Staff resumes are included in Appendix G.

Habitat Assessment

The general habitat suitability on this site was assessed by examining recent aerial photography (Google Earth™) prior to deploying the detectors. In the field, habitat characteristics were examined to confirm suitability in all locations where acoustic detectors were placed. The desktop assessment and on-site observations of the vegetation within the Project area were conducted by Jamie O'Brien, Associate Wildlife Biologist® (AWB®). Characteristics of the overall habitat within the Project area are presented in Section 3.1.

[1] https://www.fws.gov/sites/default/files/documents/USFWS_Range-wide_IBat_%26_NLEB_Survey_Guidelines_2023.05.10.pdf

Detector Deployment

Normandeau conducted surveys using equipment from Wildlife Acoustics, Inc. This included 1) Song Meter SM4BAT Recorders, full-spectrum ultrasonic acoustic detectors; and 2) SMM-U2 Ultrasonic receivers, omnidirectional microphones designed specifically for ultrasonic monitoring and analysis. The microphones were attached to the inside of a PVC elbow to protect them from precipitation and damage during transport.

As defined by the Guidelines, the Project was categorized as a linear project, and required four detector nights (e.g., one detector deployed for four nights) of survey effort per kilometer (0.62 miles) of Project length. The approximately 4.6 km (2.86 miles) Project was surveyed using five total detectors that were placed in suitable roosting habitat within the proposed limits of work. All acoustic detectors were left in place to collect data on at least four nights with suitable weather conditions as described in the Guidelines. This provided the minimum of twenty total successful detector nights needed for the Project.

The sampling locations were selected based on a combination of factors including access, proximity/opportunity for minimal human disturbance, an open cone of detection for the microphones to sample, and apparent bat habitat quality (e.g., mature trees, snags, hollows and crevices, and wetland habitat). The detector set-up adhered to specifications detailed in the 2023 Guidelines, which include deployment of microphones: a) at least 10 feet (3 meters) in any direction from vegetation or other obstructions; b) in areas without, or with minimal, vegetation within 100 feet (30 meters) of highly directional microphones or 33 feet (10 meters) from other microphones; c) parallel to woodland edges; and d) at least 49 feet (15 meters) from known or suitable roosts (e.g., trees/snags, buildings, bridges, bat houses, cave or mine portal entrances). Photos of these locations are provided in Appendix C and field data sheets are presented in Appendix D.

To ensure that the detectors were functioning correctly during every survey period, settings were checked upon retrieval of the detector in a similar fashion as to when they are deployed: 1) the microphones were checked for proper recording of sounds and archiving of data onto the internal drive/SDXC (SD cards); and 2) the program settings including recording times and acoustic range were verified.

Call Analysis

Each full spectrum acoustic file was processed as required by the 2023 Guidelines using Kaleidoscope Pro version 5.4.7 (KPro) and the Bats of North America 5.4.0 classifier with -1 More Sensitive (Liberal) setting, which is one of the USFWS-approved automated bat call classification software packages[2]. The software analyzes bat calls and uses a multinomial likelihood-ratio test known as maximum likelihood estimator (MLE) to determine the probability of presence ("P-value") of a certain bat species. Any MLE $p<0.05$ is considered a statistically significant value and is interpreted to mean that a species was detected for that site

[2] https://www.fws.gov/media/automated-acoustic-bat-id-software-programs

night, with a likelihood greater than 95%. Any site night that meets the MLE standard for NLEB presence is required to be manually reviewed by an acoustic analyst. The analyst can use a combination of programs to assess the call and call characteristics to make their determination of species. Analook W Version 4.5z by Titley Scientific can be used to identify NLEB presence based on minimum slope parameters of zero cross calls, when call quality allows. None of the site nights met the MLE for probable presence of NLEB so manual review was not completed for NLEB.

Manual review of all recorded TCB (PESU) calls, regardless of MLE, was conducted per USFWS request. USFWS has received multiple reports that KPro is underrepresenting TCB during its autoclassification, so they have requested anyone with capacity to manually vet TCB calls to do so, especially if the p-values are low but not quite 0.05. Acoustic analyst Dr. Eran Amichai conducted the manual review. Results of the manual review are in Appendix E and representative calls for state and/or federal species (if identified) are provided in Appendix F. Dr. Amichai's resume is provided in Appendix G.

Particular call characteristics are used to make a determination regarding species identification. Specifically, the myotid call characteristics are as follows:

a) MYLU calls are identified by the following characteristics: a characteristic frequency (Fc) of 38-41 kilohertz (kHz), minimum frequency (Fmin) 27-43, longer duration and a curved look (average characteristic slope [Sc] 60-110), a maximum frequency (Fmax) usually below 80 kHz and the presence of a Myotis tail;

b) MYLE calls are identified by the following characteristics: an Fc of 40-45 kHz, Fmin 31-44, shorter duration and near vertical in slope, a maximum frequency of 95 kHz and a slightly different look near Fc than other Myotis species and the presence of a Myotis tail;

c) MYSE calls are identified by the following characteristics: an Fc of 38-47 kHz, Fmin 25-50, shortest duration (<5 ms) with the most vertical pulse (>75 kHz), slight or no slope to pulse (Sc 210+), a maximum frequency above 105 kHz, the presence of a Myotis tail and usually quieter than other Myotis. A call with minimum slope of >200 octaves per second (OPS) in Analook W was also considered diagnostic.

Call characteristics specific to tricolored bats include:

a) PESU calls are identified by the following characteristics: an Fc of 40-43, Fmin 34-46, and a steady Fmin across the call sequence. The narrowband (flat) calls have a higher frequency (40) than other species calls that have a taller call at the same frequency.

3 Results

3.1 Overall Habitat Assessment

An overview of the Project area is depicted in Figure A-1, Appendix A, which contains highly developed areas following Route 38. These vary from commercial to residential, and are

abutted by wooded areas, including Central Park Conservation Area. The on-site trees consisted primarily of red maple (*Acer rubrum*), white pine (*Pinus strobus*), black cherry (*Prunus serotina*), eastern red cedar (*Juniperus virginiana*), and red oak (*Quercus rubra*) with several other species in less abundance such as American elm (*Ulmus americana*), white ash (*Fraxinus americana*), white cedar (*Thuja occidentalis*), glossy buckthorn (*Rhamnus frangula*), and white oak (*Quercus alba*). A small number of snags were identified along the Project corridor. Details of the habitat at the detector locations are described in Section 3.2.

3.2 Deployment Details

The survey was conducted between May 30 and June 6, 2023 by Jamie O'Brien, AWB®, and the detectors were programed to run from 19:32 EDT until 6:01 EDT the following morning. This recording range was selected as it encompasses sunset and sunrise times across New England for the duration of the acoustic survey season (May 15 through August 15). The detectors were placed in five different locations along the Project corridor (Figure A-1, Appendix A). The detectors were placed at least 200 meters apart, as per USFWS guidelines. Details of the survey for each of the recording nights are summarized in Table 1 and specifications of the detectors and microphones used are summarized in Table 2. Kaleidoscope Pro Software Settings are presented in Table 3.

The hourly weather conditions from Laurence G Hanscom Field Airport (KBED), the NOAA weather reporting station nearest to the Town of Wilmington, MA, are presented in Appendix B for each of the survey nights.

Table 1. Deployment Details, Project #608051, Reconstruction on Route 38 (Wilmington)

Location	Deployment Date	Latitude[1]	Longitude[1]	Begin	End	Sunset	Hi Temp (°F)[2]	Low Temp (°F)[2]	Max wind (mph)[3]	Weather[2]
Segment 1	05/30/2023	42.54403	-71.17098	19:32	6:01	20:13	60	50	7	Fair
	05/31/2023	42.54403	-71.17098	19:32	6:01	20:14	74	59	9	Fair
	06/01/2023	42.54403	-71.17098	19:32	6:01	20:15	82	67	9	Fair
	06/02/2023	42.54403	-71.17098	19:32	6:01	20:16	68	57	15	Rain/Fog/Mist
	06/03/2023	42.54403	-71.17098	19:32	6:01	20:16	49	47	14	Overcast
	06/04/2023	42.54403	-71.17098	19:32	6:01	20:17	51	50	10	Overcast
	06/05/2023	42.54403	-71.17098	19:32	6:01	20:18	60	53	5	Mostly Cloudy
Segment 2	05/30/2023	42.54025	-71.16487	19:32	6:01	20:13	60	50	7	Fair
	05/31/2023	42.54025	-71.16487	19:32	6:01	20:14	74	59	9	Fair
	06/01/2023	42.54025	-71.16487	19:32	6:01	20:15	82	67	9	Fair
	06/02/2023	42.54025	-71.16487	19:32	6:01	20:16	68	57	15	Rain/Fog/Mist
	06/03/2023	42.54025	-71.16487	19:32	6:01	20:16	49	47	14	Overcast
	06/04/2023	42.54025	-71.16487	19:32	6:01	20:17	51	50	10	Overcast
	06/05/2023	42.54025	-71.16487	19:32	6:01	20:18	60	53	5	Mostly Cloudy
Segment 3	05/30/2023	42.53290	-71.15925	19:32	6:01	20:13	60	50	7	Fair
	05/31/2023	42.53290	-71.15925	19:32	6:01	20:14	74	59	9	Fair

Location	Deployment Date	Latitude[1]	Longitude[1]	Begin	End	Sunset	Hi Temp (°F)[2]	Low Temp (°F)[2]	Max wind (mph)[3]	Weather[2]
	06/01/2023	42.53290	-71.15925	19:32	6:01	20:15	82	67	9	Fair
	06/02/2023	42.53290	-71.15925	19:32	6:01	20:16	68	57	15	Rain/Fog/Mist
	06/03/2023	42.53290	-71.15925	19:32	6:01	20:16	49	47	14	Overcast
	06/04/2023	42.53290	-71.15925	19:32	6:01	20:17	51	50	10	Overcast
	06/05/2023	42.53290	-71.15925	19:32	6:01	20:18	60	53	5	Mostly Cloudy
Segment 4	05/30/2023	42.52813	-71.15935	19:32	6:01	20:13	60	50	7	Fair
	05/31/2023	42.52813	-71.15935	19:32	6:01	20:14	74	59	9	Fair
	06/01/2023	42.52813	-71.15935	19:32	6:01	20:15	82	67	9	Fair
	06/02/2023	42.52813	-71.15935	19:32	6:01	20:16	68	57	15	Rain/Fog/Mist
	06/03/2023	42.52813	-71.15935	19:32	6:01	20:16	49	47	14	Overcast
	06/04/2023	42.52813	-71.15935	19:32	6:01	20:17	51	50	10	Overcast
	06/05/2023	42.52813	-71.15935	19:32	6:01	20:18	60	53	5	Mostly Cloudy
Segment 5	05/30/2023	42.52271	-71.15972	19:32	6:01	20:13	60	50	7	Fair
	05/31/2023	42.52271	-71.15972	19:32	6:01	20:14	74	59	9	Fair
	06/01/2023	42.52271	-71.15972	19:32	6:01	20:15	82	67	9	Fair
	06/02/2023	42.52271	-71.15972	19:32	6:01	20:16	68	57	15	Rain/Fog/Mist
	06/03/2023	42.52271	-71.15972	19:32	6:01	20:16	49	47	14	Overcast
	06/04/2023	42.52271	-71.15972	19:32	6:01	20:17	51	50	10	Overcast
	06/05/2023	42.52271	-71.15972	19:32	6:01	20:18	60	53	5	Mostly Cloudy

Cells highlighted in gray did not meet weather requirements listed in the Guidelines.

[1]GPS coordinates use standard positioning service with <15m accuracy. These are verified with cellular device units, which have positional accuracy of approximately 3 feet to 20 feet.

[2]High temp, low temp, max wind speed, and weather within the first five hours of survey. NOAA records values hourly, and this table summarizes conditions across those five values. Hourly observations reported as 'Light Rain' with no measurable precipitation amount were assumed to be less than 30 minutes in duration.

[3]NOAA reports wind speeds hourly; "Max Wind" is the highest speed reported over the first 5 hours of the survey period. The Guidelines specify no wind speeds of >9mph for ≥30 minutes during this period. If a maximum wind speed >9 mph was reported during the first or last hour of the survey, survey start time (i.e. sunset time) was used to determine if the wind speed lasted 30 minutes or more if possible, otherwise it was assumed the duration of that wind speed was <30 minutes.

Table 2. Acoustic Monitoring Equipment Settings

Detector Setting	Specification	Microphone Setting	Specification
Amplifier Gain	12 dB	Recording format	Single-channel 16-bit PCM, Differential
16k High Filter	off		
Sample Rate	256 kHZ	Sample rates	Full spectrum (256kHz)
Min Duration	1.5 ms	Directional pattern	Cardioid
Max Duration	none		
Min Trig Freq	16 kHz		

Detector Setting	Specification	Microphone Setting	Specification
Trigger Level	12 dB		
Trigger Window	3 seconds		
Max Length	00m:15s		
Compression	None		

Table 3. Kaleidoscope Pro Software Settings

System and Batch Settings		Signal Parameters	
Version	5.4.7	Minimum and maximum frequency range (kHz)	8-120
Classifier	NA 5.4.0 (Deselected Indiana Bat per current range map[3] and USFWS communication)	Minimum and maximum length of detected pulses (ms)	2-500
Settings	"-1" sensitivity	Maximum inter-syllable gap (ms)	500
Call Type	Full spectrum	Minimum number of pulses	2

Habitat from each individual detector location follows below, and photos of the detector set-ups and surrounding area are presented in Appendix C.

- **Segment 1** – The detector was deployed along Route 38 (Main Street), facing west (275°) toward railroad tracks bordered by trees. The microphone height was approximately 3.66 meters and vertical orientation of the microphone was roughly 0 degrees (parallel with the ground). Within the immediate detector area, commercial development is high. Light residential development was present in the north, with further moderate commercial development running east to west. To the northeast and south, wooded areas were present. Red oak, red maple, white pine, white cedar, and white ash were observed near the detector with an average DBH of 3-6 inches across all species. Red maple and red oak had individual trees with a DBH of 24 and 30 inches, respectively.

- **Segment 2** – The detector was deployed along Route 38 (Main Street), facing south (165°) along the forested road edge. The microphone height was approximately 3.66 meters and vertical orientation of the microphone was roughly 0 degrees (parallel with the ground). A brick building was present within 50 feet of the detector (Figure C-9). A marsh was present near the detector, southwest from the detector across Route 38. There was moderate commercial development to the east and west, with woods/wetlands to the north and south. Past the wetlands, there is light to moderate

[3] https://www.fws.gov/species/indiana-bat-myotis-sodalis/map

residential development to both the north and south. Further past the residential areas are woodlands. Glossy buckthorn, Eastern juniper, white pine, red oak, and red maple were observed near the detector with an average DBH of 4-6 inches across all species. Red maple was the dominant species.

- **Segment 3** – The detector was deployed along Route 38 (Main Street) facing south (160°), near a dog park and commercial development. The microphone height was approximately 3.66 meters and vertical orientation of the microphone was roughly 0 degrees (parallel with the ground). There were trees overhanging on the roadside, with ornamental trees across Route 38. A wooded area was present to the south abutting the dog park. More moderate commercial development was present in the east, with more forested land to the west including Maple Meadow Brook. Beyond the wooded area to the south is light residential development. White pine, red oak, and black cherry were observed near the detector with an average DBH of 12 and 18 inches across all species. White pine was the dominant tree species. One large snag was observed near the detector.

- **Segment 4** – The detector was deployed along Route 38 (Main Street) facing south (220°) at the forested roadway border near a school/residential area. The microphone height was approximately 3.66 meters and vertical orientation of the microphone was roughly 0 degrees (parallel with the ground). Residential homes are present west from the detector. Past the homes is a large forested system surrounding Maple Meadow Brook. To the east, a small, wooded area is adjacent to the roadside. Further in the west is an industrial area. To the north and south, moderate commercial development is present. White pine, black cherry, red oak, and eastern red cedar were observed near the detector with an average DBH of 8 and 18 inches across all species.

- **Segment 5** – The detector was deployed along Route 38 (Main St), at the edge of the road facing south (180°) toward the tree line and overhanging trees. The microphone height was approximately 3.66 meters and vertical orientation of the microphone was roughly 0 degrees (parallel with the ground). There were rocky outcrops present alongside the road ahead of the detector. The site is within a powerline corridor, amongst a moderately developed area, interspersed with forested plots. The area is primarily industrial/commercial with nearby residential homes in Woburn. Further south is highly developed, particularly past the Woburn town line. White oak, red maple, white pine, American elm, and red oak were observed near the detector with an average DBH of approximately 12 inches across all species. Red maple was the dominant species.

3.3 Survey Results

Upon retrieval from the field, all Secure Digital (SD) cards were backed up to an external drive for long term storage. A copy of these files was saved to a separate external drive for processing through KPro, and the SD cards were erased for use on future projects. Prior to KPro processing, files were manually grouped into survey night folders and a separate folder was

used for calls recorded during microphone testing at deployment and retrieval. Additionally, the log files were examined to ensure the detector was functioning properly for the duration of the survey. All files were run through KPro with the Bats of North America classifier and -1 sensitivity setting. Indiana bat was deselected, resulting in bat calls being assigned to one of eight remaining Massachusetts bat species. Noise files were deleted and WAV files were output to a new directory using a Time Expansion Factor of 1. All output files from KPro processing were saved to the Normandeau network drive for backup. KPro processing was completed by Jamie O'Brien, AWB®.

The number of calls recorded by species and location is presented in Table 4. Blue cells are those with likelihood of presence values p<0.05 and correspond to species considered by KPro to be present. Calls from five species, consisting of big brown bat, eastern red bat, hoary bat, silver-haired bat, and little brown bat, were recorded with MLE (p-values) of less than 0.05. **Zero site nights meeting MLE standards for probable presence of NLEB or TCB were auto-identified by Kaleidoscope Pro software, however one TCB call was identified during review.**

Table 4. Acoustic Survey Results by Date, Site, and Species for Project #608051, Reconstruction on Route 38 (Wilmington)

Location	Detector Night	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	PESU
Number of calls recorded									
Segment 1	20230530	58	6	16	12		1	1	1
	20230531	67	4	73	48		1	1	2
	20230601	108	9	207	34		2	1	1
	20230602	62	1	10	7				1
	20230603	1	2	3	2		2		
	20230604			2					
	20230605	100	3	8	11		1	1	1
Segment 2	20230530	30	4	39	25		4		2
	20230531	86	6	82	72		4		1
	20230601	85	4	104	80		1	1	1
	20230602	151	1	25	28		2		
	20230603	2	3		1		1		2
	20230604	8	1	2	1				
	20230605	16	2	35	40				
Segment 3	20230530	11	10	61	82		6	1	1
	20230531	20	11	58	86	1	2		1
	20230601	39	10	99	232		3		
	20230602	2	1	8	16				1
	20230603	1	1	5	1		3		
	20230604			2					
	20230605	7	4	28	46		4	1	
	20230530	1	5	3	1		3		

Location	Detector Night	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	PESU
Segment 4	20230531	10	8	22	21		4		1
	20230601	12	5	15	21				
	20230602	2	1	3	2				
	20230603	6		1	1		5		
	20230604								1
	20230605	5	1	8	5		2		1
Segment 5	20230530	6	5	13	6		1		
	20230531	25	15	41	69		7		
	20230601	67	12	41	107		4		1
	20230602	18	2	6	11				
	20230603			1	2		4		1
	20230604				3				
	20230605	4	6	15	6		2		
Presence P-Value									
Segment 1	20230530	0	3E-07	0.00076	1	1	1	0.241562	1
	20230531	0	9.96E-05	0	0.017035	1	0.996303	0.255064	0.855546
	20230601	0	0	0	1	1	0.984242	0.41992	1
	20230602	0	0.087906	0.184224	1	1	1	1	0.66326
	20230603	0.802516	0.042344	0.007328	0.616794	1	0.268132	1	1
	20230604	1	1	0.006322	1	1	1	1	1
	20230605	0	0.001194	1	1	1	0.938246	0.268688	0.996958
Segment 2	20230530	0	0.001015	0	0.074963	1	0.143382	1	0.867797
	20230531	0	6.2E-06	0	9.9E-06	1	0.227845	1	1
	20230601	0	6.68E-05	0	2.4E-06	1	0.988132	0.257905	1
	20230602	0	0.328348	0.011791	1	1	0.133527	1	1
	20230603	0.110115	0.001292	1	0.839377	1	0.972294	1	0.712373
	20230604	4.6E-06	0.064213	0.453454	1	1	1	1	1
	20230605	0.054515	0.004124	0	0	1	1	1	1
Segment 3	20230530	1	0	0	0	1	0.092779	0.822329	1
	20230531	0.630352	0	0	0	0.071342	1	1	1
	20230601	1	0	0	0	1	0.762312	1	1
	20230602	1	0.087925	6.12E-05	2.3E-06	1	1	1	0.663175
	20230603	0.751865	0.436131	3.76E-05	1	1	0.02866	1	1
	20230604	1	1	0.006322	1	1	1	1	1
	20230605	1	0.00249	0	0	1	0.057644	0.689023	1
Segment 4	20230530	0.642065	8.01E-05	0.004615	0.982694	1	0.309613	1	1
	20230531	0.088228	0	0	0.000485	1	0.370726	1	1
	20230601	0.011235	1.1E-06	1E-07	0.000107	1	1	1	1
	20230602	0.30433	0.064216	0.016044	0.755177	1	1	1	1

Location	Detector Night	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	PESU
	20230603	0.000117	1	0.834068	1	1	0.00011	1	1
	20230604	1	1	1	1	1	1	1	0.214468
	20230605	0.053971	0.294036	1.17E-05	0.530104	1	0.206275	1	0.728357
Segment 5	20230530	0.043059	6.7E-06	0	0.669114	1	0.99566	1	1
	20230531	0.014846	0	0	0	1	0.153082	1	1
	20230601	0	0	0	0	1	0.670556	1	1
	20230602	0	0.004124	0.060578	0.150462	1	1	1	1
	20230603	1	1	0.281874	0.196229	1	0.001625	1	0.31547
	20230604	1	1	1	0.009423	1	1	1	1
	20230605	0.339186	2.1E-06	0	0.65082	1	0.776105	1	1

EPFU= Eptesicus fuscus, LABO= Lasiurus borealis, LACI= Lasiurus cinereus, LANO= Lasionycteris noctivagans, MYLE= Myotis leibii, MYLU= Myotis lucifugus, MYSE= Myotis septentrionalis, PESU= Perimyotis subflavus

Cells highlighted in gray indicate detector nights that did not meet suitable weather conditions as described in the Guidelines. Cells highlighted in blue are species calls/MLE considered by KPro to be present.

4 Appendices

Appendix A. Figures.

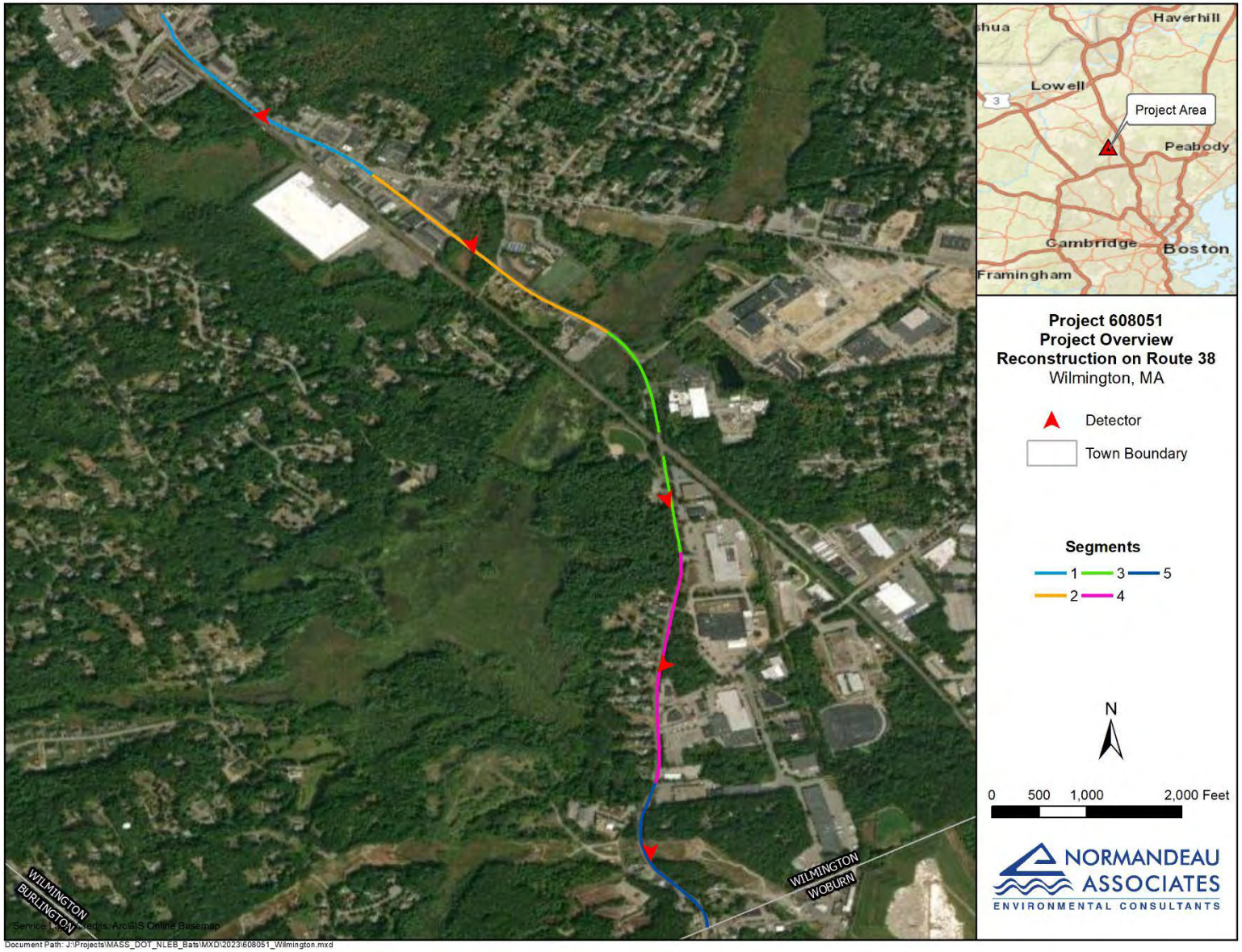


Figure A- 1 Overview of Project area showing 1-km survey segments for Project #608051, Reconstruction on Route 38 (Wilmington)

Table A- 1. Geographical coordinates of bat detector survey locations

Site	Coordinates	
	Latitude	*Longitude*
Segment 1	42.54403	-71.17098
Segment 2	42.54025	-71.16487
Segment 3	42.53290	-71.15925
Segment 4	42.52813	-71.15935
Segment 5	42.52271	-71.15972

Appendix B. Weather Data.

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.[1]	Temperature (ºF)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour					Altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
								Max.	Min								
5/30/2023																	
30	18:51	E 9	10	Fair	CLR	64	49			58%	NA	NA	30.18	1023.1			
30	19:51	E 6	10	Fair	CLR	60	49	71	60	67%	NA	NA	30.18	1023.2			
30	20:51	E 6	10	Fair	CLR	58	50			75%	NA	NA	30.18	1023.4			
30	21:51	S 7	10	Fair	CLR	57	45			64%	NA	NA	30.19	1023.7			
30	22:51	S 7	10	Fair	CLR	54	48			80%	NA	NA	30.2	1023.9			
30	23:51	S 5	10	Fair	CLR	53	48			83%	NA	NA	30.2	1024			
31	0:51	SW 5	10	Fair	CLR	51	48			89%	NA	NA	30.2	1024			
31	1:51	S 3	10	Fair	CLR	50	48	61	49	93%	NA	NA	30.19	1023.7			
31	2:51	S 3	10	Fair	CLR	49	47			93%	NA	NA	30.19	1023.7			
31	3:51	Calm	10	Fair	CLR	48	45			89%	NA	NA	30.19	1023.6			
31	4:51	Calm	10	Fair	CLR	45	43			93%	NA	NA	30.19	1023.5			
31	5:51	Calm	10	Fair	CLR	44	43			96%	NA	NA	30.2	1024			
31	6:51	Calm	10	Fair	CLR	50	48			93%	NA	NA	30.21	1024.2			
5/31/2023																	
31	18:51	S 7	10	Fair	CLR	79	46			31%	NA	79	30.09	1020			
31	19:51	S 9	10	Fair	CLR	74	53	82	74	48%	NA	NA	30.09	1020.2			
31	20:51	S 5	10	Fair	CLR	68	52			57%	NA	NA	30.1	1020.5			
31	21:51	S 6	10	Fair	CLR	66	54			65%	NA	NA	30.12	1021.1			
31	22:51	S 5	10	Fair	CLR	62	54			75%	NA	NA	30.12	1021.1			
31	23:51	SW 6	10	Fair	CLR	61	54			78%	NA	NA	30.11	1020.9			
1	0:51	SW 6	10	Fair	CLR	60	53			78%	NA	NA	30.1	1020.6			
1	1:51	SW 3	10	Fair	CLR	59	52	73	58	78%	NA	NA	30.1	1020.4			
1	2:51	SW 5	10	Fair	CLR	58	52			81%	NA	NA	30.09	1020.1			
1	3:51	Calm	10	Fair	CLR	56	52			87%	NA	NA	30.08	1019.8			
1	4:51	W 3	9	Fair	CLR	55	52			90%	NA	NA	30.08	1019.8			
1	5:51	Calm	8	Fair	CLR	55	52			90%	NA	NA	30.08	1019.8			

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.[1]	Temperature (ºF)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour					Altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
								Max.	Min								
1	6:51	SW 5	10	Fair	CLR	60	55			84%	NA	NA	30.08	1019.9			
6/01/2023																	
1	18:51	W 3	10	Fair with Haze	CLR	87	60			40%	NA	87	29.95	1015.1			
1	19:51	S 9	10	Fair with Haze	CLR	82	60	91	81	47%	NA	82	29.95	1015.3			
1	20:51	Calm	10	Fair with Haze	CLR	77	59			54%	NA	79	29.96	1015.7			
1	21:51	S 3	10	Fair with Haze	CLR	73	59			62%	NA	NA	29.97	1016			
1	22:51	Vrbl 5	10	Fair with Haze	CLR	71	57			61%	NA	NA	29.97	1015.9			
1	23:51	S 3	10	Fair	CLR	68	58			70%	NA	NA	29.96	1015.7			
2	0:51	SW 5	10	Fair	CLR	67	59			76%	NA	NA	29.95	1015.3			
2	1:51	SW 6	10	Mostly Cloudy	BKN110	67	59	81	66	76%	NA	NA	29.94	1014.8			
2	2:51	Calm	10	Fair	CLR	65	58			78%	NA	NA	29.93	1014.4			
2	3:51	Calm	10	Fair	CLR	62	58			86%	NA	NA	29.91	1013.9			
2	4:51	Calm	10	Fair	CLR	62	59			90%	NA	NA	29.9	1013.6			
2	5:51	Calm	10	Fair	CLR	61	58			90%	NA	NA	29.91	1013.9			
2	6:51	Calm	10	Fair	CLR	65	60			84%	NA	NA	29.91	1013.8			
6/02/2023																	
2	18:51	NE 6	10	Thunderstorm	BKN075	74	64			71%	NA	NA	29.86	1012.4			
2	19:51	N 9	6	Thunderstorm in Vicinity Light Rain Fog/Mist	BKN046 OVC090	68	66	93	67	93%	NA	NA	29.91	1014	0.82		0.82
2	20:51	E 8	5	Rain Fog/Mist	FEW070 BKN090 OVC110	66	65			96%	NA	NA	29.91	1014	0.14		
2	21:51	NE 15	6	Rain Fog/Mist	SCT006 BKN090 OVC110	63	61			93%	NA	NA	29.94	1014.8	0.13		

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.[1]	Temperature (ºF)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour Max.	6 hour Min				Altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
2	22:51	NE 10	10	Light Rain	SCT008 SCT095 OVC110	60	58			93%		NA	NA	29.97	1015.8	0.02	0.29
2	23:51	NE 9	8	Overcast	OVC008	59	57			93%		NA	NA	29.97	1015.8		
3	0:51	N 10	9	Overcast	OVC011	58	56			93%		NA	NA	29.98	1016.3		
3	1:51	NE 9	10	Overcast	OVC013	57	54	68	57	90%		NA	NA	29.98	1016.2		0.29
3	2:51	NE 9	9	Overcast	OVC010	56	53			90%		NA	NA	29.98	1016.3		
3	3:51	NE 9	7	Overcast	OVC011	56	53			90%		NA	NA	29.98	1016.3		
3	4:51	NE 14	5	Fog/Mist	OVC008	54	52			93%		NA	NA	30	1016.9		
3	5:51	NE 10	8	Overcast	OVC009	53	51			93%		NA	NA	30.02	1017.7		
3	6:51	NE 13	10	Overcast	OVC009	53	51			93%		NA	NA	30.03	1018		
6/03/2023																	
3	18:51	NE 14	10	Overcast	BKN014 OVC021	49	45			86%		44	NA	30.14	1022.1		
3	19:51	NE 8	10	Overcast	BKN018 OVC046	49	44	51	48	83%		46	NA	30.15	1022.2		
3	20:51	N 7	10	Overcast	BKN018 OVC046	48	44			86%		45	NA	30.15	1022.2		
3	21:51	N 14	10	Overcast	FEW021 FEW026 OVC060	49	43			80%		44	NA	30.14	1022.1		
3	22:51	N 8	10	Overcast	FEW020 OVC060	48	42			80%		44	NA	30.12	1021.4		
3	23:51	N 6	10	Overcast	FEW019 BKN034 OVC060	48	43			83%		45	NA	30.11	1021		
4	0:51	NW 5	10	Overcast	FEW021 SCT027 OVC060	47	44			90%		45	NA	30.08	1020.1		
4	1:51	NW 7	10	Overcast	BKN028 OVC033	48	44	49	47	86%		45	NA	30.06	1019.2		
4	2:51	N 7	10	Overcast	OVC024	49	44			83%		46	NA	30.04	1018.6		

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.[1]	Temperature (ºF)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour Max.	6 hour Min				Altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
4	3:51	N 5	10	Overcast	FEW017 BKN029 OVC034	49	44			83%		47	NA	30.03	1018.1		
4	4:51	N 7	10	Overcast	FEW016 OVC043	48	44			86%		45	NA	30.02	1017.7		
4	5:51	N 7	10	Overcast	BKN017 OVC023	48	44			86%		45	NA	30.01	1017.7		
4	6:51	NE 9	9	Overcast	OVC014	47	44			90%		43	NA	30.02	1017.7		
6/04/2023																	
4	18:51	N 9	10	Overcast	BKN018 BKN027 OVC039	51	48			89%		NA	NA	29.99	1016.8	0.01	
4	19:51	N 8	4	Rain Fog/Mist	BKN009 BKN034 OVC046	50	48	53	50	93%		47	NA	29.99	1017	0.06	0.07
4	20:51	N 10	7	Overcast	BKN009 BKN034 OVC046	50	48			93%		46	NA	29.99	1016.8	0.03	
4	21:51	N 8	10	Overcast	BKN015 OVC032	50	48			93%		47	NA	29.99	1016.8		
4	22:51	N 9	10	Overcast	OVC013	50	48			93%		46	NA	29.97	1016.4		0.03
4	23:51	N 6	10	Overcast	OVC013	50	48			93%		48	NA	29.95	1015.6		
5	0:51	N 6	10	Overcast	OVC011	51	48			89%		NA	NA	29.93	1014.7		
5	1:51	NW 6	8	Overcast	BKN011 OVC016	50	49	51	50	96%		48	NA	29.91	1014.2		0.03
5	2:51	N 8	10	Overcast	FEW008 OVC013	51	49			92%		NA	NA	29.89	1013.5		
5	3:51	NW 8	10	Overcast	OVC013	51	49			92%		NA	NA	29.87	1013		
5	4:51	N 6	7	Overcast	OVC012	51	49			92%		NA	NA	29.87	1012.7		
5	5:51	N 6	6	Fog/Mist	OVC009	51	50			96%		NA	NA	29.86	1012.4	0.01	
5	6:51	NE 6	1.5	Light Rain Fog/Mist	BKN007 BKN012 OVC018	51	49			92%		NA	NA	29.86	1012.5	0.03	
6/05/2023																	

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.[1]	Temperature (ºF)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour					Altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
								Max.	Min								
5	18:51	Calm	10	Overcast	BKN065 OVC080	61	54			78%		NA	NA	29.76	1008.9		
5	19:51	Calm	10	Light Rain	BKN046 OVC060	60	55	63	58	84%		NA	NA	29.76	1008.9		
5	20:51	Calm	10	Mostly Cloudy	BKN080 BKN095	55	54			96%		NA	NA	29.76	1008.9		
5	21:51	Calm	10	Mostly Cloudy	BKN090	56	54			93%		NA	NA	29.76	1008.9		
5	22:51	Calm	10	Mostly Cloudy	BKN075	53	52			96%		NA	NA	29.74	1008.4		
5	23:51	Calm	10	Overcast	OVC075	55	53			93%		NA	NA	29.72	1007.8		
6	0:51	SW 3	10	Overcast	FEW060 BKN075 OVC095	55	52			90%		NA	NA	29.71	1007.1		
6	1:51	W 5	10	Overcast	OVC060	55	52	60	53	90%		NA	NA	29.68	1006.4		
6	2:51	W 5	10	A Few Clouds	FEW070	52	50			93%		NA	NA	29.67	1006		
6	3:51	Calm	10	Fair	CLR	52	50			93%		NA	NA	29.66	1005.6		
6	4:51	Calm	10	Partly Cloudy	SCT120	50	48			93%		NA	NA	29.65	1005.1		
6	5:51	W 5	10	Fair	CLR	51	48			89%		NA	NA	29.64	1004.8		
6	6:51	W 3	10	Fair	CLR	54	50			87%		NA	NA	29.63	1004.4		

[1]*CLR: Sky clear; FEW: Few, 1/8-2/8 of sky covered; SCT: Scattered, 3/8-4/8 of sky covered BKN: Broken, 5/8-7/8 of sky covered; OVC: Sky completely covered; Three digits represent the height of the cloud layer in hundreds of feet*

NA is a National Weather Service designation and is believed to refer to values that are negligible and/or below the detection limit for the given parameter

Appendix C. Photos of Detector Set-up & Habitat.



Figure C-1. Project 608051; Segment 1 – overview of set-up.



Figure C-2. Project 608051; Segment 1 – cone of detection.



Figure C-3. Project 608051; Segment 1 – facing north.



Figure C-4. Project 608051; Segment 1 – facing east.



Figure C-5. Project 608051; Segment 1 – facing south.



Figure C-6. Project 608051; Segment 1 – facing west.



Figure C-7. Project 608051; Segment 2 – overview of set-up.



Figure C-8. Project 608051; Segment 2 – cone of detection.



Figure C-9. Project 608051; Segment 2 – facing north.



Figure C-10. Project 608051; Segment 2 – facing east.



Figure C-11. Project 608051; Segment 2 – facing south.



Figure C-12. Project 608051; Segment 2 – facing west.



Figure C-13. Project 608051; Segment 2 – facing marsh sw from detector.



Figure C-14. Project 608051; Segment 2 – brick building within 50 ft.



Figure C-15. Project 608051; Segment 3 – overview of set-up.



Figure C-16. Project 608051; Segment 3 – cone of detection.



Figure C-17. Project 608051; Segment 3 – facing north.



Figure C-18. Project 608051; Segment 3 – facing east.



Figure C-19. Project 608051; Segment 3 – facing south.



Figure C-20. Project 608051; Segment 3 – facing west.



Figure C-21. Project 608051; Segment 3 – snag near detector.



Figure C-22. Project 608051; Segment 4 – overview of set-up.



Figure C-23. Project 608051; Segment 4 – cone of detection.



Figure C-24. Project 608051; Segment 4 – facing north.



Figure C-25. Project 608051; Segment 4 – facing east.



Figure C-26. Project 608051; Segment 4 – facing south.



Figure C-27. Project 608051; Segment 4 – facing west.



Figure C-28. Project 608051; Segment 5 – overview of set-up.



Figure C-29. Project 608051; Segment 5 – cone of detection.



Figure C-30. Project 608051; Segment 5 – facing north.



Figure C-31. Project 608051; Segment 5 – facing east.

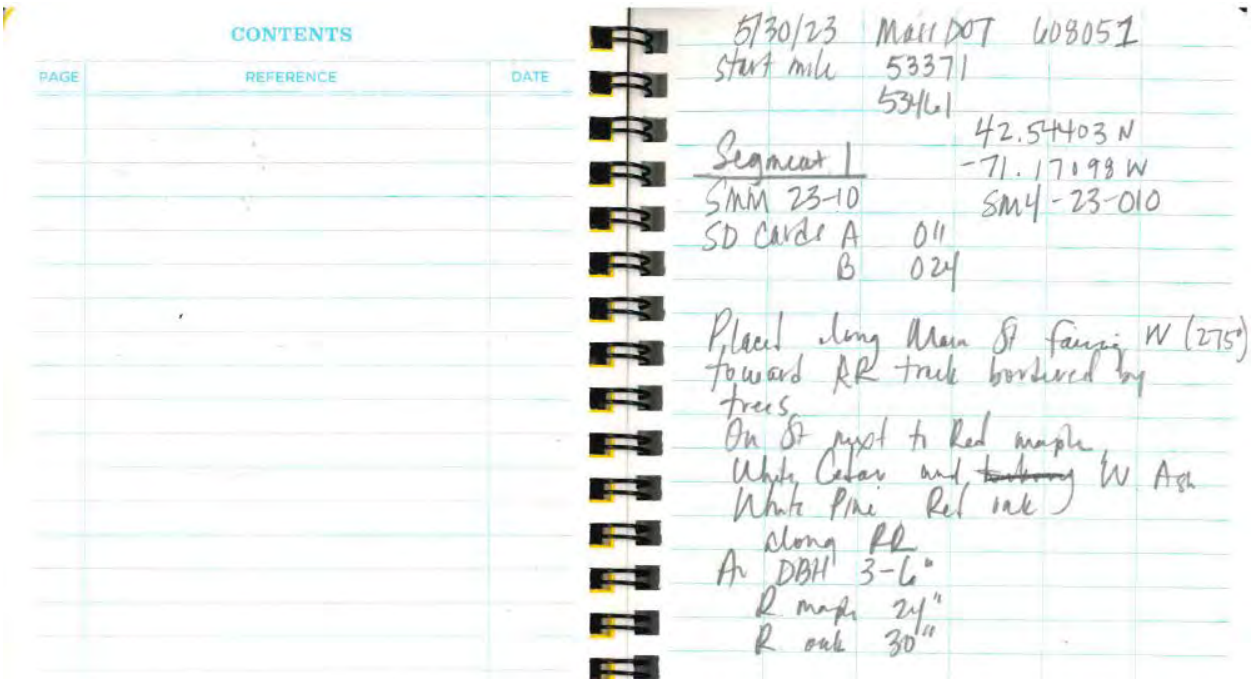


Figure C-32. Project 608051; Segment 5 – facing south.



Figure C-33. Project 608051; Segment 5 – facing west.

Appendix D. Field Data Sheets.



CONTENTS

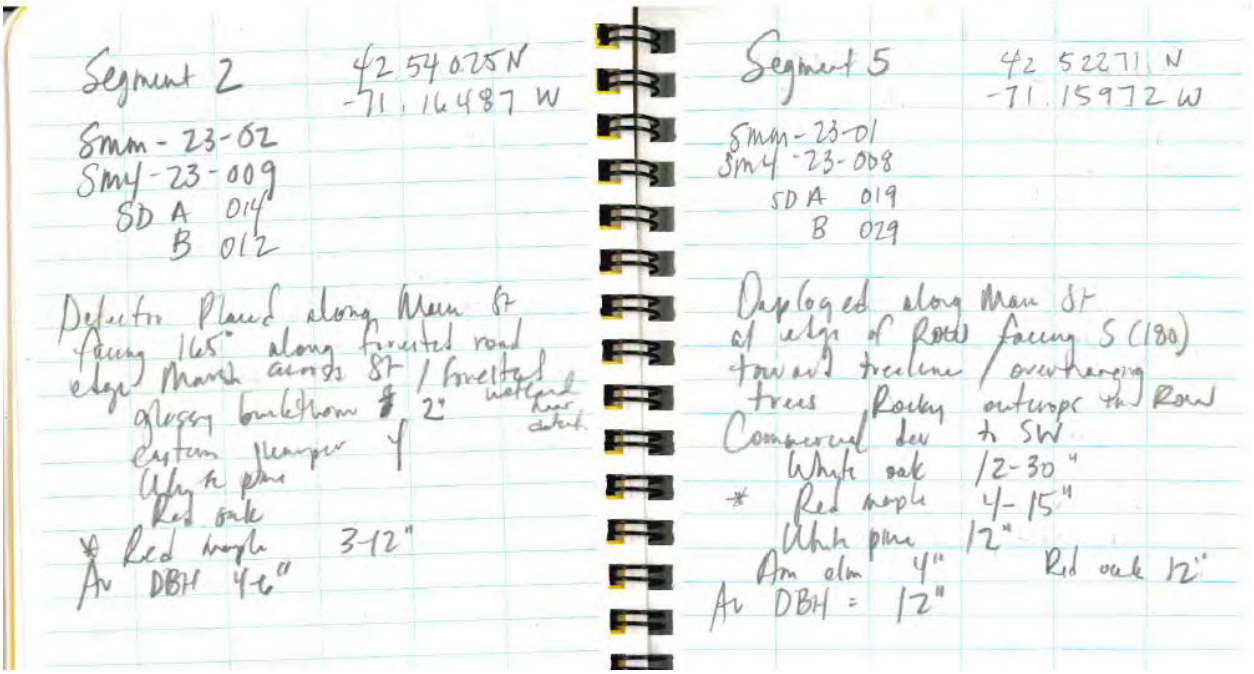
PAGE	REFERENCE	DATE

5/30/23 MassDOT 608051
Start mile 53371
53461

42.54403 N
-71.17098 W

Segment 1
SMM 23-10
SD Cards A 011
B 024
SM4-23-010

Placed along Main St facing W (275°) toward RR track bordered by trees
On St pipe to Red maple
White Cedar and ~~[illegible]~~ W Ash
White Pine Red oak
along RR
At DBH 3-6"
R maple 24"
R oak 30"



Segment 2 42.54025 N
-71.16487 W

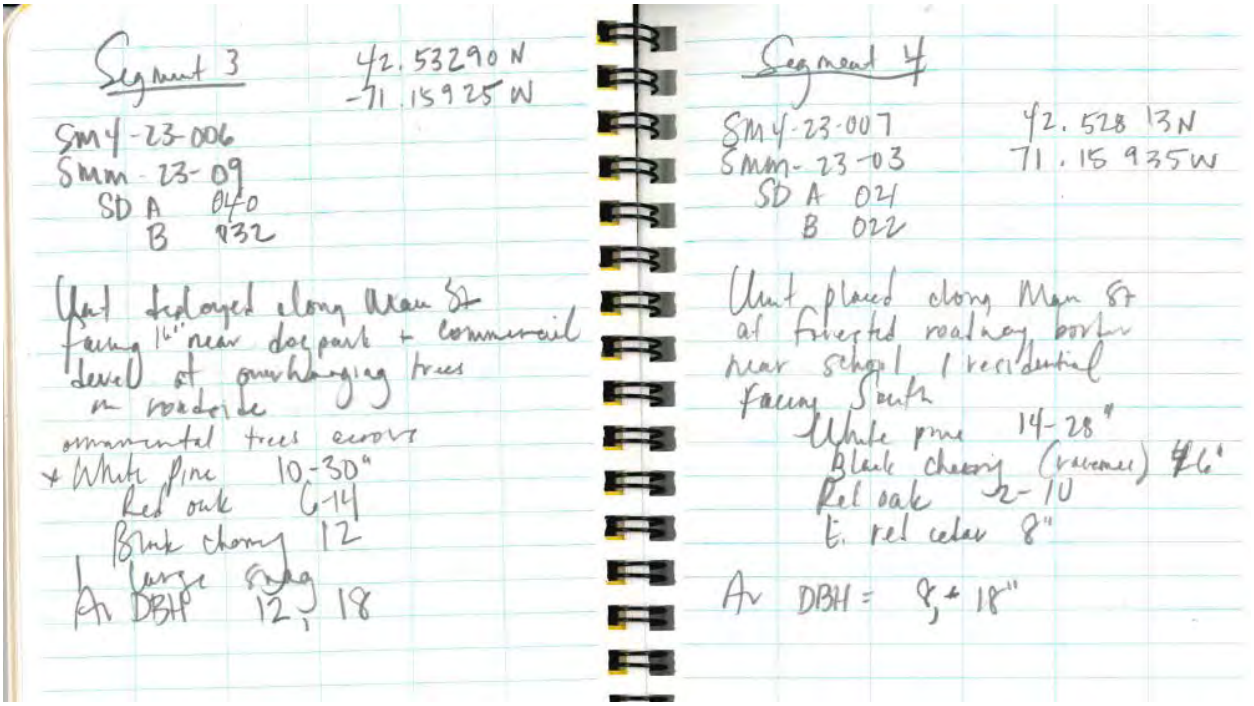
SMM-23-02
SM4-23-009
SD A 014
B 012

Detector Placed along Main St facing 165° along forested road edge Marsh across St / forested wetland
glossy buckthorn @ 2"
eastern hemlock 4
Ash to pine
Red oak
* Red maple 3-12"
At DBH 46"

Segment 5 42 52271 N
-71.15972 W

SMM-23-01
SM4-23-008
SD A 019
B 029

Deployed along Main St at edge of Road facing S (180) toward treeline / overhanging trees Rocky outcrops to Road
Compacted dev to SW
White oak 12-30"
* Red maple 4-15"
White pine 12"
Am elm 4" Red oak 12"
At DBH = 12"



Segment 3

42.53290 N
-71.15925 W

SM4-23-006
SMM-23-09
SD A 040
B 032

Unit deployed along Main St facing 14° near dog park + commercial level of overhanging trees in roadside ornamental trees across
+ White Pine 10-30"
Red oak 6-14
Black cherry 12
large Ash
Av DBH 12, 18

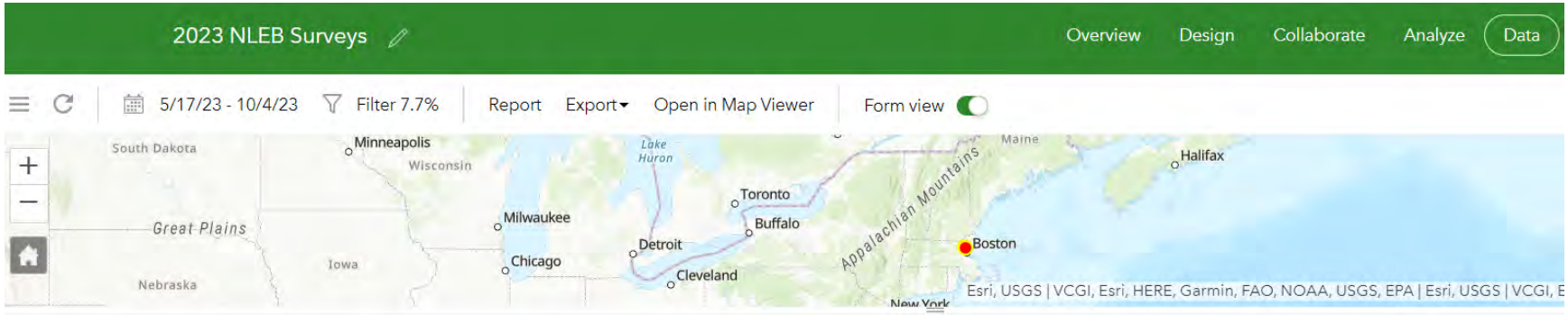
Segment 4

SM4-23-007
SMM-23-03
SD A 024
B 022

42.528 13N
71.15 935W

Unit placed along Main St at forested roadway portion near school / residential facing South
White pine 14-28"
Black cherry (racemes) 16"
Red oak 2-10
E. red cedar 8"

Av DBH = 8, 18"



2023 NLEB Surveys | Habitat Photos:

Observer	Project Name/Number	Segment/Location	Deployment Date	Deployment Time	IFR number	mic number	Detector orientation	Battery Cha Date #1
JO	608051	1	May 30, 2023	09:50	Sm4-23-010	Smm-23-10	275	
JO	608051	2	May 30, 2023	10:16	Sm4-23-009	Smm-23-02	165	
JO	608051	3	May 30, 2023	11:20	Sm4-23-006	Smm-23-09	160	
JO	608051	4	May 30, 2023	11:44	Sm4-23-007	Smm-23-03	220	
JO	608051	5	May 30, 2023	10:51	Sm4-23-008	Smm-23-01	180	

Appendix E. Summary of Call Analyst's Findings.

This appendix summarizes the findings of the manual call analysis, by location. As required by the USFWS Guidelines, if KPro indicates probable presence of NLEB with high levels of certainty (MLE/p-value(s) <0.05) for any site night, all high frequency (>35 kHz) calls recorded for that site night at that location are required to be examined by a qualified call analyst. Manual review confirms or refutes species identified by KPro when the call quality allows for such determinations. Some calls, however, are determined by the analyst as 'Unkn HiFreq' or 'Multi_Unkn'. These calls are generally of poor call quality and/or contain characteristics for multiple species of interest. Because of this ambiguity, these calls cannot be ruled out as belonging to state and/or federal listed species. In the following table, the calls confirmed through manual review as state listed species calls (MYLE, MYLU, and PESU), or those that could not be ruled out as such, are highlighted in green. No site nights met probable presence (MLE/p-value <0.05) for NLEB or PESU calls to trigger review by an analyst. However, all calls flagged as PESU were reviewed regardless of MLE/P-value as requested by USFWS.

Table E-1. Summary of the call analyst's findings at Segment 1 for Project #608051, Reconstruction on Route 38 (Wilmington)

Date, Time	Kpro ID	Analyst ID	Analyst Notes, Conclusions
05/30/2023, 23:09:02	PESU	Noise	
05/31/2023, 23:20:03	PESU	PESU	Stable terminal frequency
05/31/2023, 22:15:27	PESU	Noise	
06/01/2023, 22:18:13	PESU	Noise	
06/03/2023, 01:45:55	PESU	LABO	Random shifts in terminal frequency
06/05/2023, 23:30:29	PESU	Noise	

Table E-2. Summary of the call analyst's findings at Segment 2 for Project #608051, Reconstruction on Route 38 (Wilmington)

Date, Time	Kpro ID	Analyst ID	Analyst Notes, Conclusions
05/30/2023, 23:15:14	PESU	LABO	Random shifts in terminal frequency
05/31/2023, 05:11:48	PESU	Noise	
06/01/2023, 01:57:30	PESU	LABO	Random shifts in terminal frequency
06/02/2023, 02:02:57	PESU	LABO	Random shifts in terminal frequency
06/03/2023, 20:23:41	PESU	Noise	
06/03/2023, 19:55:56	PESU	Noise	

Table E-3. Summary of the call analyst's findings at Segment 3 for Project #608051, Reconstruction on Route 38 (Wilmington)

Date, Time	Kpro ID	Analyst ID	Analyst Notes, Conclusions
05/31/2023, 05:45:42	PESU	Noise	
05/31/2023, 19:54:05	PESU	Noise	
06/03/2023, 05:43:59	PESU	Noise	

Table E-4. Summary of the call analyst's findings at Segment 4 for Project #608051, Reconstruction on Route 38 (Wilmington)

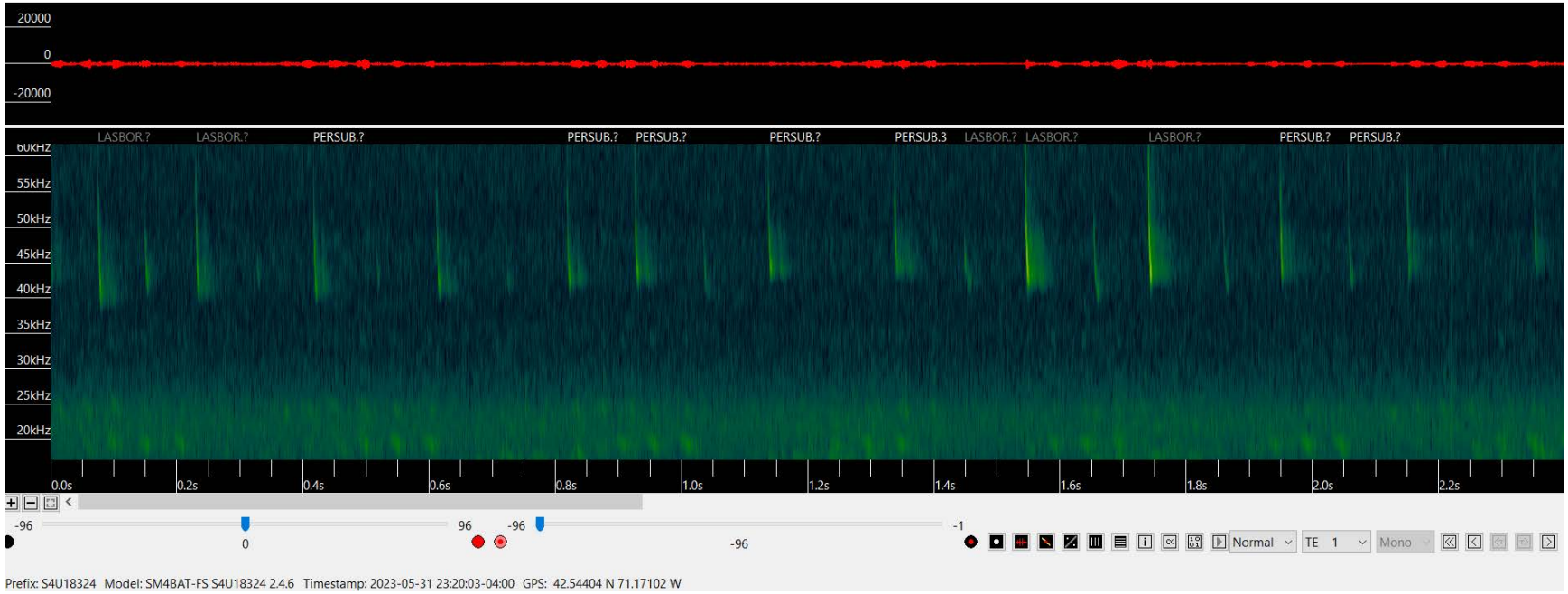
Date, Time	Kpro ID	Analyst ID	Analyst Notes, Conclusions
05/31/2023, 22:01:02	PESU	Noise	
06/04/2023, 21:59:40	PESU	Noise	
06/05/2023, 21:07:00	PESU	Noise	

Table E-5. Summary of the call analyst's findings at Segment 5 for Project #608051, Reconstruction on Route 38 (Wilmington)

Date, Time	Kpro ID	Analyst ID	Analyst Notes, Conclusions
06/01/2023, 19:52:16	PESU	Noise	
06/04/2023, 01:34:17	PESU	Noise	

Appendix F. Screen Capture(s) of Representative Calls from Qualitative Analysis.

F-1. PESU, Segment 1 for Project #608051, Reconstruction on Route 38 (Wilmington)



Appendix G. Resumes.

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

JAMIE L. O'BRIEN, AWB®

Biologist/Data Analyst

Ms. O'Brien is a biologist with over ten years of professional experience in wildlife research, conservation, and natural resource management and permitting throughout New England. Her projects have emphasized protecting and managing threatened and endangered species, assessing environmental impacts, regulating and managing natural resources and wildlife, and ensuring Federal Endangered Species Act compliance. Her diverse wildlife background includes experience with forest, wetlands, and marsh birds, shorebirds, waterfowl, songbirds, raptors, amphibians, freshwater mussels, and small mammals. Ms. O'Brien is adept at using visual and auditory clues to identify species. Furthermore, she has performed numerous vegetation surveys as part of visual assessments, plot based surveys, and wetland delineations. In addition to her field skills, Ms. O'Brien possesses a strong foundation in project planning and implementation, project management and organization, and data analysis and quality control. Furthermore, she is a GIS Analyst and SAS Programmer, competent in working with and running analysis on large datasets. She is skilled at quality control procedures that involve the integrity and quality of data and generation of final data deliverables. Ms. O'Brien routinely conducts desktop assessments for habitat and wildlife and performs analysis and interpretation on aerial signatures.

EDUCATION

M.S.E.S., Applied Ecology, Indiana University, Bloomington

M.P.A., Environmental Policy and Natural Resource Management, Indiana University, Bloomington

B.A., (cum laude) Biology, Saint Anselm College

PROFESSIONAL EXPERIENCE

2013-Present	Normandeau Associates
2011-2013	U.S. Fish & Wildlife Service, Umbagog National Wildlife Refuge
2012	Ducks Unlimited, Inc. U.S. Great Lakes Region
2009-2011	Office of Sustainability, Indiana University, Bloomington
Summer 2008	Office of Sustainability, Dickinson College

PROFESSIONAL AFFILIATIONS

- New Hampshire Audubon
- New Hampshire Association of Natural Resource Scientists
- The Wildlife Society
- Maine DIFW Credentialed Vernal Pool Observer

REPRESENTATIVE PROJECT EXPERIENCE

NHDOT Bridge Preservation of Manchester and Hooksett Bridges. HNTB Corporation. Manchester, NH (2019-present). This Project includes preliminary design, public involvement process, final design, and associated environmental and cultural services for the bridge preservation of five bridges in Manchester and Hooksett, NH. Environmental efforts are needed to prepare and complete all appropriate environmental documentation including cultural resource investigations and permitting, to satisfy NEPA and state requirements. Ms. O'Brien is performing wetland delineations, GIS mapping, bridge surveys for roosting bats, and CE documentation for both the northbound and southbound portions of this project. Biologist/GIS Analyst.

Biodiversity Assessments. Veolia Energy North America Holdings, Inc., North America (2016-present). Normandeau is designing biodiversity assessments for numerous Veolia operating sites throughout the United States. Ms. O'Brien is conducting desktop analysis, writing and copy editing report sections, generating GIS figures, and recommending opportunities for increasing biodiversity. Additionally, she coordinates field assessments and logistics. Project Manager.

MassDOT Statewide Northern Long-eared Bat Surveys, Parsons Brinkerhoff, MA (2016-present). In support of over 50 MassDOT projects, Normandeau conducted acoustic surveys in 2016, 2017, 2018, 2019, and 2020 for the state and federally listed northern long-eared bat. Ms. O'Brien is assisting with Northern long-eared bat surveys, which involve deployment and retrieval of acoustic detectors, weather recording, habitat characterization, and reporting. She is also coordinating field efforts and project logistics as well as report writing and deliverables. Project Manager.

Errol Hydroelectric Dam Relicensing, Gomez and Sullivan Engineers, NH and ME (2018-2022). Normandeau is providing natural resource support for a hydroelectric relicensing project at the Errol Dam in Errol, NH. Ms. O'Brien is preparing cost proposals, study plans, reports, and figures, and writing sections and completing analysis for the Botanical Resource Assessment, Leonard Marsh and Harper's Meadow vegetation study, and Bat Acoustic study. She completed cover type mapping based on aerial imagery for the study area, focusing on emergent and submerged aquatic vegetation cover types and conducted some of the field analysis for the Leonard Marsh and Harper's Meadow vegetation study. Assistant Project Manager.

Green and Co. Wildlife Impact Assessment, Portsmouth, NH (2020). Normandeau was hired to review natural resource impacts associated with a building development planned in Portsmouth NH. Ms. O'Brien conducted the natural resource field assessment. Biologist.

Blacks Nook In-lake Restoration Project, City of Cambridge Water Department, Cambridge, MA (2020). Once a cove connected to Fresh Pond, Black's Nook is now a separate, shallow two acre pond with a heavily forested wetland border. Over the years, work has been done to minimize inflow of golf-course runoff and improve ecosystem functionality in the directly surrounding watershed. Normandeau was contracted to execute an existing conditions assessment, and develop and execute an in-lake restoration plan that slows cultural eutrophication, keeps Black's Nook an open water body, and ultimately supports downgrading its Category 5 status as an impaired waterbody on the State's 303(d) list. Ms. O'Brien conducted acoustic surveys for bats and a nesting bird survey. Biologist.

I-93 Exit 4A FEIS, CDL Consulting Engineers, Londonderry/Derry, NH (2016-2020). Normandeau is preparing a Final Environmental Impact Statement for a proposed new exit between Exits 4 and 5 on I-93 in southern NH. Ms. O'Brien conducted the northern long-eared bat surveys, which involved deployment and retrieval of acoustic detectors and habitat analysis of detector sites. Additionally, Ms. O'Brien assisted with wetland and vernal pool impact assessments and review, field delineation of proposed stormwater areas, and wetland permitting associated with the DEIS. Biologist.

Seacoast Reliability Project – F107 Line. Eversource Energy, Seacoast Region, NH (2014-2020). Normandeau is providing permitting assistance and construction oversight monitoring to the Public Service of New Hampshire for a proposed 115 kW, 13-mile transmission project that is sited along an existing right-of-way and includes a one-mile submarine crossing of Little Bay. Ms. O'Brien performed mitigation calculations for wetland impacts and wrote the SAS code for error checking raw data and for processing data into final deliverables for report analysis and production. Additionally, she conducted Northern long-eared bat surveys along the project corridor, performed post-construction vegetation assessments, and was responsible for post-processing data collected from water quality monitoring. Biologist/Data Analyst.

Acoustic Bat Surveys, Lamprey River Advisory Committee, Lamprey River Watershed, NH (2018). Normandeau conducted Northern long-eared bat surveys throughout the Lamprey River Watershed. Ms. O'Brien conducted the surveys, which involved coordination with property owners and advisory committee members, deployment and retrieval of acoustic detectors, habitat analysis of detector sites, and reporting. Biologist.

Critical Issues Analysis for Confidential Downeast Maine Wind Project (2018). Normandeau identified key issues and potential fatal flaws associated with a wind development project in downeast Maine. Ms. O'Brien performed the desktop site assessment, where she reviewed available data and contributed to report discussion regarding likelihood for unusual or particularly sensitive natural resources to occur on the project site. Biologist.

NHDOT Route 16 Bridge over Ellis River, Greenman-Pedersen, Inc., Jackson, NH (2018). The NH Department of Transportation proposes to rehabilitate the historic stone-faced bridge that carries NH Route 16 over the Ellis River in Jackson, New Hampshire. The historic structure, built in 1938, accommodates one lane of traffic in each

direction and currently has narrow sidewalks that parallel each lane. In support of this project, Ms. O'Brien conducted a bridge assessment for roosting bats. Biologist.

Northern Pass HVDC New Hampshire Transmission Line Expansion Project, Northern Pass, LLC, Multiple Locations, NH (2014-2018). Northeast Utilities is proposing the Northern Pass Transmission Line, a 180-mile HVDC and AC Transmission project to bring hydropower from Quebec into New Hampshire and the New England region. Ms. O'Brien performed wetland mitigation research, prepared NHDES Shorelands, Wetlands, and Alteration of Terrain Permits, provided GPS support for delineated wetland boundaries, and participated in natural resource surveys including rare plants, vernal pools, and bats. Additionally, Ms. O'Brien oversaw geotechnical borings at the Deerfield Substation and installation of a work pad in Pittsfield to ensure compliance of wetland regulations and rare, threatened, and endangered species avoidance, particularly snakes and turtles. Biologist.

Balsams Ski Resort Expansion, Dixville LLC, Dixville, NH (2015-2017). Normandeau was retained to undertake natural resources surveys and provide permitting support for the revival and expansion of the Balsams Grand Resort and Wilderness Ski Area. Ms. O'Brien played a large role in the 2015 Northern long-eared bat surveys, where, in addition to deployment and retrieval of detectors, she coordinated site access and field crew schedules, and was responsible for data reporting and habitat assessments. Biologist.

Blackstone River Northern Long-eared Bat Surveys, New England Hydropower Company, LLC, Lincoln/Cumberland, RI (2016). Normandeau conducted Northern long-eared bat surveys for proposed bridge repairs and upgrades along the Blackstone River. Ms. O'Brien conducted the surveys, which involved deployment and retrieval of acoustic detectors, habitat analysis of detector sites, and reporting. Biologist.

Confidential Project, PA, NY, MA, CT, NH (2014-2016). This natural gas pipeline project runs from the Marcellus Shale fields across Pennsylvania, New York, Massachusetts and New Hampshire. Ms. O'Brien was involved with various aspects of this project, including wetlands and mitigation in a fatal flaw analysis, map revisions in ArcGIS, wetland compensatory mitigation research and ARM fund numbers. Ms. O'Brien also provided GPS support for delineated wetland boundaries, and participating in natural resource surveys including vernal pools and rare species surveys for turtles, snakes, Northern Harriers, and bat hibernacula. Biologist.

Pike Industries Northern Long-eared Bat Surveys, Hooksett, New Hampshire (2015). Normandeau was hired to perform Northern long-eared bat surveys for a proposed quarry expansion. Ms. O'Brien conducted the surveys, which involved deployment and retrieval of acoustic detectors, habitat analysis of detector sites, and reporting. Biologist.

Bat Monitoring, U.S. Fish & Wildlife Service, Umbagog National Wildlife Refuge, NH/ME (2011- 2013). Ms. O'Brien evaluated resident bat populations adjacent to Lake Umbagog. Monitoring activities included conducting maternity roost emergence surveys and acoustic driving transect surveys. Coordinating volunteer efforts, completing required documentation following each survey, maintaining and preserving accurate records, and updating database records was also practiced. Biological Technician.

REPRESENTATIVE PRESENTATIONS

Current Distribution of Bats in New Hampshire. S. Barnum, J. O'Brien, J. Collins. Joint Bat Working Group Meeting (Roanoke, VA) and Northeast Fish and Wildlife Conference (Burlington, VT). 2018.

SPECIAL TRAINING

Normandeau's in-house 40 hour acoustic bat survey training

Vesper Bat Detection Service's Echolocation 101 & Best Practices Course

Vesper Bat Detection Service's Acoustic ID of Eastern Species Course

NORMANDEAU ASSOCIATES
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ERAN AMICHAI, PhD
Principal Scientist

Dr. Amichai's research focuses on bioacoustics and other sensory biology tools to understand animal behavior and movement ecology. In addition to research Dr. Amichai has more than 10 years' experience in bat conservation on a national scale in Israel, including monitoring and policy advising and planning for conservation and wind energy mitigation policies.

EDUCATION

Ph.D., Zoology, Tel Aviv University, Tel Aviv, Israel

M.Sc., Ecology & Environmental Quality, Tel Aviv University, Tel Aviv, Israel

B.Sc., Biology, Tel Aviv University, Tel Aviv, Israel

PROFESSIONAL EXPERIENCE

2022-Present	Normandeau Associates
2019-Present	Dartmouth College
2009-2019	Tel Aviv University, Israel
2009-2019	The Society for the Protection of Nature in Israel

PROFESSIONAL AFFILIATIONS

- North American Society of Bat Research
- The Wildlife Society
- Ecological Society of America
- Animal Behavior Society
- New York Academy of Sciences
- International Society of Neuroethology
- Zoological Society of Israel

REPRESENTATIVE PROJECT EXPERIENCE

New Hampshire Department of Energy: Deployment of Offshore Wind in the Gulf of Maine – New Hampshire Impact Assessment (2022-present). Bats section: risk assessment and current state of knowledge with regard to bats and offshore wind energy in New England

NYSERDA Metocean Buoys. Offshore buoy and boat-based bat acoustic recordings in the Hudson Bay Area – familiarity with data, application of data for dissemination of knowledge

Dominion Energy ATOM Project. Offshore wind turbine acoustic recordings and thermal imagery of bats offshore the Virginia coastline – image identification, familiarity with data, application of data for dissemination of knowledge

Israel's Long Term National Bat Monitoring and Conservation Program (2013-2018). Planning and project management, acoustic analyst, and data scientist

Anthropogenic Effects in the Dead Sea Region: Bats as Bioindicators (2015-2017). Project manager**,** acoustic analyst, and data scientist

Various Wind Energy Projects in Israel (2010-2018). Terrestrial wind energy facilities – pre-construction impact assessment surveys (acoustic, physical, & literature) planning, preforming, and reporting.

Israel Taxonomic Initiative: An Attempt to Resolve Bat Taxonomy (2009-2011). Field work manager and data collection

SELECTED PEER-REVIEWED PUBLICATIONS

Amichai, E., Boerma, D. B., Page, R. A., Swartz, S. M. & ter Hofstede, H. (2023). By a whisker: the sensory role of vibrissae in hovering flight in nectarivorous bats. Proceedings of the Royal Society B 290, 20222085, http://doi.org/10.1098/rspb.2022.2085

Amichai, E., & Yovel, Y. (2021). Echolocating bats rely on an innate time reference. Proceedings of the National Academy of Sciences 118 (19), https://doi.org/10.1073/pnas.2024352118

Boonman, A.*, Rieger, I.*, **Amichai, E.*,** Greif, S.*, Eitan, O., Goldshtein, A. & Yovel, Y. (2020). Echolocating bats adjust sensory acquisition based on internal cues. BMC Biology. 18, 166, https://doi.org/10.1186/s12915-020-00904-2 *equal first authorship

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Hoyt, J. R., [et al, including **Amichai, E.**] (2020). Environmental reservoir dynamics predict global infection patterns and population impacts for the fungal disease white-nose syndrome. Proceedings of the National Academy of Sciences 117, 7255-7262, **https://doi.org/10.1073/pnas.1914794117**

Amichai, E., Kronfeld-Schor, N. (2019). Artificial light at night promotes activity throughout the night in nesting common swifts (*Apus apus*). Scientific Reports 9, 11052, **https://doi.org/10.1038/s41598-019-47544-3**

Amichai, E., Blumrosen, G. & Yovel, Y. (2015). Calling louder and longer: how bats use biosonar under severe acoustic interference from other bats. Proceedings of the Royal Society B 282, 1821, **https://doi.org/10.1098/rspb.2015.2064**

Amichai, E., Levin, E., Kronfeld-Schor, N., Roll, U. & Yom-Tov, Y. (2013). Natural history, physiology and energetic strategies of *Asellia tridens* (Chiroptera). Mammalian Biology 78, 94-103, **https://doi.org/10.1016/j.mambio.2012.06.006**

SELECTED TECHNICAL REPORTS

Amichai, E., Taub, M., Talmon, I., & Yedvab, S. **Anthropogenic effects on the Dead Sea region ecology-bats as bioindicators.** Commissioned by the Israel Ministry for Environmental Protection & the Israel Nature and Parks Authority. (2018) ***English abstract*** ***Hebrew full text***

Amichai, E., Yedvab, S., Dolev, A., et al. **National Monitoring Plan for Israel's Bat Species: Insectivorous bat survey in Israel 2014.** Commissioned by the Israel Nature and Parks Authority. (2015) ***Full text with English abstract***

Amichai, E. & Dolev, A. **Insectivorous bat survey in the Judean Hills.** Commissioned by the Israel Nature and Parks Authority (2013)

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Maura Healey, Governor
Kimberley Driscoll, Lieutenant Governor
Monica Tibbits-Nutt, Secretary and CEO
Jonathan L. Gulliver, Highway Administrator

massDOT
Massachusetts Department of Transportation
Highway Division

September 24, 2024

RE:
Wilmington (DOT Project #608051) RECONSTRUCTION ON ROUTE 38 (MAIN STREET)
Bat Habitat Inspection

Desktop review and field surveys revealed that there is suitable habitat for the northern long-eared bat (*Myotis septentrionalis*; NLEB) and/or tricolored bat (*Perimyotis subflavus*; TCB) within 1,000 feet of Bridge W-38-011 (including trees that may be suitable for maternity, roosting, foraging or travelling habitat) associated with MassDOT Project #608051 WILMINGTON- RECONSTRUCTION ON ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L. The project will include the reconstruction of Route 38 from Route 62 to the Woburn City line. The roadway will consist of two 11-foot lanes, two 5-foot bike lanes and a 6-foot sidewalk. Turn lanes and upgraded traffic signals will be installed at Route 62. The project proposes construction work on or over Bridge W-38-011, which may contain federally listed bat species and cause disturbance or take.

A visual bridge inspection following the protocols and methods set forth in the 2024 Range-Wide Indiana bat & Northern Long-eared Bat survey Guidelines was required and conducted by the MassDOT Wildlife and Endangered Species Unit (WESU) on 8/19/2024. Bridge W-38-011, a flat slab structure with concrete decking over Maple Meadow Brook, was assessed from above and adjacent to the abutments at this time (Figure 1). However, the bridge was not assessed from underneath the structure due to high-water levels (Figure 3). During the inspection, WESU biologists used flashlights, binoculars, and a borescope to search gaps, concrete surfaces, and any small cracks/crevices on bridge structures that could potentially hold roosting bats (Figures 3-5). **No bats, guano, or staining were observed during the inspection of Bridge W-38-011. The underside of Bridge W-38-011 was determined to be unsuitable habitat for roosting bats due to minimal cracks/crevices and the lack of space between the water and concrete decking.**

In sum, Bridge W-38-011 was determined unsuitable for roosting bats, and the MassDOT WESU therefore conclude that construction impacts on this structure will have no effect on the federally listed bat species. This letter and the provided photographs serve as evidence of no impact to those bat species. A bridge assessment form is included as Appendix A.

Sincerely,

David Paulson
Wildlife and Endangered Species Unit Supervisor, MassDOT, Environmental Services

Ten Park Plaza, Suite 4160, Boston, MA 02116
Tel: 857-368-4636, TTY: 857-368-0655
mass.gov/massdot



Figure 1. Bridge W-38-011 over Maple Meadow Brook



Figure 2. Atop Bridge W-38-011 over Maple Meadow Brook



Figures 3-4. Concrete surfaces and stone/masonry on Bridge W-38-011 over Maple Meadow Brook



Figure 5. Concrete surfaces on Bridge W-38-011 over Maple Meadow Brook

APPENDIX A Bridge Assessment Form

APPENDIX D: Bridge/Structure Bat Assessment Form

Bridge/Structure Bat Assessment Form Instructions

- This form will be completed to document bat occupancy or bat use of bridges, culverts, and other structures. This form shall be submitted to the appropriate personnel within the DOT and USFWS for recordkeeping (or uploaded into the Information, Planning, and Consultation (IPaC) Determination Key for use of the Programmatic Biological Opinion for Transportation Projects in the Range of the Indiana Bat and Northern Long-Eared Bat) prior to conducting: any activities below the deck surface either from the underside or from above the deck surface that bore down to the underside; any activities that could impact expansion joints; any activities involving deck removal on bridges; or any activities involving structure demolition for bridges, culverts, and/or other structures.
- Assessments must be completed within two (2) years of conducting any work (see the above bullet), regardless of whether assessments have been conducted in the past. Assessments must be completed in appropriate weather conditions, suitable for the assessor to observe common signs of bat use.
- Evidence of bat use may include visual observation (live and/or dead), presence of guano, presence of staining, audible observation, and/or odor observation. Presence of one or more indicators is sufficient evidence that bats may be using the bridge, culvert, and/or other structure.
- If bat use of a bridge, culvert, and/or other structure is noted, additional studies may be undertaken during bat active season to identify the specific bat species utilizing the structure, or protected bat species presence can be assumed, in order to comply with threatened and endangered species regulations. Bat active season dates, typically between April and November, vary regionally and by species, so assessors should consult with their local USFWS Field Office for more specific active season dates.
- For use of the Programmatic Biological Opinion for Transportation Projects in the Range of the Indiana Bat and Northern Long-Eared Bat – If the bridge/structure is 1,000 feet or more from suitable bat habitat[1] (e.g., an urban or agricultural area without suitable foraging habitat or corridors linking the bridge to suitable foraging habitat), check the appropriate box and fill out the table below. **No further assessment is required.**

Date & Time of Assessment	**DOT Project #**	**Route/Facility Carried**	**County**
8/19/2024 10:00am	608051	Route 38 (Main St)	Middlesex County, MA
Federal Structure ID W-38-011	**Structure Coordinates** (latitude and longitude) 42.53758507, -71.16073471	☐ This bridge/structure is 1,000 feet or more from suitable bat habitat[2] Name: Trevor Burns Signature: Trevor Burns	

- Any questions pertaining to assessments or this form should be directed to the local USFWS Field Office.

[1] Refer to the USFWS's summer survey guidance for the definition of suitable habitat (http://www.fws.gov/midwest/endangered/mammals/inba/inbasummersurveyguidance.html).

[2] This condition is only for use of the Programmatic Biological Opinion for Transportation Projects in the Range of the Indiana Bat and Northern Long-Eared Bat

Bridge/Structure Bat Assessment Form

Date & Time of Assessment: 8/19/2024 10:00am	DOT Project Number: 608051	Route/Facility Carried: Route 38 (Main St)	County: Middlesex County, MA
Federal Structure ID: W-38-011	Structure Coordinates (latitude and longitude): 42.53758507, -71.16073471	Structure Height (approximate): 3 feet	Structure Length: 20 feet

Structure Type (check one)

Bridge Construction Style

- (○) Cast-in-place
- (○) Pre-stressed Girder
- (◉) Flat Slab/Box
- (○) Steel I-beam
- (○) Truss (Side View)
- (○) Covered
- (○) Parallel Box Beam
- (○) Other:

Culvert Type

- (○) Box
- (○) Pipe/Round
- (○) Other:

Other Structure

- (○)

Structure Material (check all that apply)

Deck Material	*Beam Material*	*End/Back Wall Material*
[ ] Metal	[X] None	[X] Concrete
[X] Concrete	[ ] Concrete	[ ] Timber
[ ] Timber	[ ] Steel	[X] Stone/Masonry
[ ] Open grid	[ ] Timber	[ ] Other:
[ ] Other:	[ ] Other:	

Creosote Evidence

(○) Yes (◉) No (○) Unknown

Culvert Material

- [ ] Metal
- [ ] Concrete
- [ ] Plastic
- [ ] Stone/Masonry
- [ ] Other:

Notes:

Crossings Traversed (check all that apply)

[ ] Bare ground	[ ] Open vegetation
[ ] Rip-rap	[ ] Closed vegetation
[X] Flowing water	[ ] Railroad
[ ] Standing water	[ ] Road/trail - Type:
[ ] Seasonal water	[ ] Other:

Surrounding Habitat (check all that apply)

[ ] Agricultural	[ ] Grassland
[X] Commercial	[ ] Ranching
[ ] Residential-urban	[X] Riparian/wetland
[ ] Residential-rural	[ ] Mixed use
[ ] Woodland/forested	[ ] Other:

Areas Assessed (check all that apply)

Check all areas that apply. If an area is not present in the structure, check the "not present" box.
Document all bat indicators observed during the assessment. Include the species present, if known, and provide photo documentation as indicated.

Area (check if assessed)	**Assessment Notes**	**Evidence of Bats** (include photos if present)
[X] All crevices and cracks: **Bridges/culverts:** rough surfaces or imperfections in concrete **Other structures:** soffits, rafters, attic areas	[ ] Not present: Assessed from above and sides. Underneath was inaccesible.	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[X] Concrete surfaces (open roosting on concrete)	[ ] Not present: Assessed from above and sides. Underneath was inaccesible.	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] Spaces between concrete end walls and the bridge deck	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] Crack between concrete railings on top of the bridge deck (Gap / Railing)	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] Vertical surfaces on concrete I-beams	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] Spaces between walls, ceiling joists	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] Weep holes, scupper drains, and inlets/pipes	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[X] All guiderails	[ ] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species
[ ] All expansion joints	[X] Not present	[ ] Visual - live # dead # [ ] Guano [ ] Staining [ ] Audible [ ] Odor [ ] Photos [ ] Species

Name: Trevor Burns

Signature: Trevor Burns

DOCUMENT A00875

POLICY DIRECTIVE P-22-001
AND
POLICY DIRECTIVE P-22-002

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massDOT Massachusetts Department of Transportation Highway Division

Number: P-22-001
Date: 9/23/22

POLICY DIRECTIVE

Jonathan Gulliver (signature on original)
HIGHWAY ADMINISTRATOR

Off-Site Stockpiling of Soil from MassDOT Construction Projects

Purpose

The purpose of this Policy Directive is to formally establish a policy and procedures for managing and stockpiling soil generated and transported from MassDOT construction projects. This Policy Directive does not supersede any Federal, State, or Local regulations.

Date of Effect

This Policy Directive is effective immediately for all projects, including active construction projects.

For active construction projects and for other projects advertised prior to October 15, 2022, changes to the contract documents needed to implement the requirements of this Policy Directive will be considered on a case-by-case basis and shall be approved by the District Highway Director, as necessary.

For projects advertised on or after October 15, 2022, MassDOT will include the requirements and implementation procedures of this Policy Directive in the construction contract documents.

Policy Requirements

This policy is intended to prevent the off-site relocation of excavated soil generated from MassDOT projects to areas near residential receptors and to control potential fugitive dusts and/or contaminants. To that end, excavated soil may not be moved from the project site without knowledge of the content of the material. Knowledge may include visual field observations for presence of staining, odor, and/or debris, screening with a photoionization detector (PID), laboratory analysis, and/or site history. Pavement millings and other non-soil materials are not subject to the requirements of this Policy Directive.

Moving soil from a MassDOT project site to a temporary off-site storage location must be approved in writing by the District Highway Director.

The Contractor must select a storage location that is at least 500 feet away from residential receptors, as defined herein to include, but not be limited to, residential dwellings, residentially

zoned property, schools, daycare facilities, playgrounds, parks, recreational areas, hospitals, elderly housing and convalescent facilities.

Temporary off-site storage of excavated soil from a MassDOT project is only permissible at a location approved and permitted by MassDOT. The temporary storage location should be located within the same municipality where the soil was excavated, where possible. Stockpiled soil must be securely covered, and appropriate measures must be taken to minimize fugitive dust and erosion.

Signs indicating the source of the soil, the date the soil was generated, and contact information must be erected and maintained until the stockpiled soils are transported to a disposal facility or reused on the project site.

Implementation Procedures

To ensure that off-site storage of excavated soils is managed properly on MassDOT projects, this policy requires the following:

1. **Off-Site Stockpile Storage Locations**
    a. The Contractor shall provide proposed off-site storage locations to the Engineer for approval at least 30 days prior to transporting soil off site. Off-site storage locations should be in the same municipality as the work site.
    b. The Contractor shall keep excavated soil on site until adequately characterized to the satisfaction of the Engineer.
    c. The Contractor shall provide notification of the approved off-site storage location to the local Board of Health and the Town Manager's/Mayor's Office at least 7-days prior to transporting soil off site.
    d. The Contractor shall provide the Engineer with at least 3-days' notice prior to transporting soil off site.
    e. For off-site storage locations on MassDOT property, the Contractor is required to obtain an Access Permit through the District Permits Office prior to storage of soil or other materials. MassDOT will issue these permits at no cost to the Contractor. Information to be submitted by the Contractor as part of the permit application shall include:
        i. A description of material to be stored off-site, including available analytical data;
        ii. A figure of the location with distances to residences and residential receptors; and
        iii. Anticipated duration of temporary storage.
    f. Stockpile locations should not be within 500 feet of residential receptors (e.g., residential dwellings, residentially zoned property, schools, daycare facilities, playgrounds, parks, recreational areas, hospitals, elderly housing and convalescent facilities).
        i. If the stockpile location must be within 500 feet of residential receptors, then soil must be less than RCS-1 (per 310 CMR 40.1600) and free of potentially hazardous or regulated items.

g. For off-site storage locations on non-MassDOT property, the Contractor must notify the property owner(s) at least 7 days prior to transporting material.
h. Exceptions to these rules will be reviewed by MassDOT and may be approved by the District Highway Director on a case-by-case basis.

2. Off-Site Stockpile Management

a. The Contractor shall keep soil stockpiles on impermeable surfaces (e.g., asphalt or concrete) or on 10-mil polyethylene sheeting.
b. The Contractor shall cover soil stockpiles with 10-mil polyethylene sheeting and surround with a berm made of hay bales, straw wattles, or similar.
    i. Piles that are actively being worked on must be covered and re-secured at the end of the work shift.
c. The Contractor shall label stockpiles with signs, including:
    i. Location of origin (including any Release Tracking Numbers)
    ii. Stockpile ID number (including MassDOT District office-assigned tracking ID, if different)
    iii. Date of initial accumulation
    iv. Applicable telephone numbers for the Contractor and MassDOT.
d. The Contractor shall mitigate fugitive dust at storage locations under the direction of an appropriately trained/certified environmental professional.
e. The Contractor shall remedy noncompliance with this policy within 48 hours.
f. The Contractor shall remedy noncompliance with this policy on the SAME DAY for potentially hazardous material, as determined by the Engineer.
g. The Contractor shall handle excavated soil according to federal, state, and local regulations.
h. The Contractor shall use appropriate shipping documents for all movements of excavated soil on public roadways (e.g., Bill of Lading, Material Shipping Record, Manifest, Asbestos Waste Shipment Record, etc.).

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massDOT Massachusetts Department of Transportation Highway Division

Number: P-22-002
Date: 9/23/22

POLICY DIRECTIVE

Jonathan Gulliver (signature on original)
HIGHWAY ADMINISTRATOR

Use of MassDOT Property for Staging and other Construction-Related Operations

Purpose

This Policy Directive is intended to address the use of MassDOT property by MassDOT Contractors for construction staging and other construction-related operations that are not specifically defined in the construction contract. Such use of MassDOT property will only be allowed if permitted by the District Office in accordance with 700 CMR 13.00, Approval of Access to MassDOT Highways and Other Property. This includes the use of MassDOT property for staging, laydown, and storage of equipment and materials, including soil excavated from a project site.

This Policy Directive requires the Contractor/applicant to obtain a Non-Vehicular Access Permit from MassDOT to use MassDOT property for these purposes.

This Policy Directive is effective immediately and applies to all MassDOT construction projects.

General Permit Considerations and Conditions

In addition to other normal MassDOT Access Permit procedures, MassDOT shall consider the following during the application, review, implementation and monitoring processes of Access Permits required by this Policy Directive:

- Storage and placement of the Contractor's equipment and materials should not be allowed within the clear zone of the roadway.
- Stockpiled soils should not be located within 500 feet of residential receptors, as defined herein to include, but not be limited to, residential dwellings, residentially zoned property, schools, daycare facilities, playgrounds, parks, recreational areas, hospitals, elderly housing and convalescent facilities.
- The Contractor/applicant shall identify the access/egress locations of the proposed storage areas. MassDOT will only approve locations determined to be safe for roadway users, construction workers and the general public.
- The Contractor may be required to submit a Traffic Management Plan and/or Lighting Plan for MassDOT review and approval as part of the permit application, depending on the proposed use of the area.

- The Contractor shall submit the permit application through MassDOT's online State Highway Access Permit System (SHAPS).
- MassDOT will waive the permit application fee for any application received from a MassDOT Contractor for any permit required by this Policy Directive and will waive any subsequent amendment and extension fees that may otherwise be required.
- MassDOT will review the permit application in accordance with applicable standard procedures and will apply standard permit terms and conditions, as necessary.
- The Resident Engineer will verify that the permit is approved before allowing the Contractor to use the affected area for the requested purpose.
- Areas permitted are for use by the approved applicant only and are not to be shared with or used by other vendors. Subcontractors specifically engaged with the applicant working on the specific MassDOT project will be allowed to use the area in accordance with the terms of the permit.
- Permits are issued on an annual basis and will require the Contractor to file for an extension each year to continue use.

Exemptions from Permit Requirements

Equipment and materials being used for active construction operations and located within the work zone of the construction contract are exempt from this permit requirement, provided they do not interfere with the safety or operation of the roadway or the work zone. Examples of these types of exempt uses are:

- Equipment and materials parked or stored within a protected (barriered) work zone.
- Materials placed in the work zone prior to same-day installation or use.
- Soils excavated temporarily and scheduled to be replaced, such as for trenching operations or for installation of drainage structures.

DOCUMENT A00881

HAZARDOUS MATERIALS REVIEW MEMORANDUM

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To: **Eamon Kernan**

From: **James M. Smith, Supervisor, Hazardous Materials Review** JMS

Date: **July 31, 2025**

Subject: **Wilmington – Reconstruction on Route 38 (Main Street), From Route 62 to the Woburn C.L.**
Project #608051

SUMMARY

The referenced project was reviewed to evaluate the potential for oil and hazardous material impacts to the proposed work. Information regarding the proposed work was obtained from the PS&E submission by Green International Affiliates, Incorporated.

The project consists of improvements to Route 38, including full depth pavement reconstruction, widening to improve bike accommodations, a new traffic signal, signal upgrades, resurfacing, new drainage structures and drainage and water pipe, wetlands area replication, and ADA improvements.

Treated Wood

The 100% estimated quantity for Item 184.1 – Disposal of Treated Wood Products included 325 tons of treated wood disposal. That estimate was reduced in the PS&E design to a contingency volume of 5 tons. **Please explain the reduction is waste quantity, also considering Katie McArthur's comment to the 100% design that a timber curb will be removed and discarded in the vicinity of Sta 224+50, which may add to the total treated wood disposal volume.**

Contaminated Groundwater

The comment below regarding groundwater does not appear to have been addressed in the PS&E design submission. It is restated below - **in bold** - to be addressed by the designer prior to hazmat clearing the project:

> **Please add Item 183.1 – Treatment of Contaminated Groundwater and Item 183.2 – Disposal of Granular Activated Carbon to the Special Provisions. The primary concern is the possibility of encountering contaminated groundwater within the boundaries of the Olin Superfund Site. Please investigate the potential for dewatering within that area. If dewatering is unlikely to be necessary, Item 183.1 and Item 183.2 should be included as a precaution with minimal quantities.**
>
> **The treatment of NDMA-contaminated groundwater may be difficult. Treatability studies on NDMA-contaminated groundwater are ongoing, but it would be**

preferable to avoid dewatering within the NDMA plume, which is located between approximately Sta 287+50 and Sta 300+00 of Main Street.

Summary of Potentially Impacting Sites

The Summary of Potentially Impacting Sites attached to the 100% Hazardous Materials review does not appear to have been included in the Special Provisions for the PSE&E submission. **Please include the release site summary attached to this PS&E hazardous materials review memo in the put-in section of the Special Provisions.**

Any special provisions recommended for this project are considered standard and, as such, should not be modified without prior written approval from Environmental Services.

The Hazardous Materials Review Unit will not clear this project for hazardous materials-related concerns until confirmation of satisfactory inclusion of all requested items (i.e., updated submission including revised design documents) has been received.

This memorandum, the potentially impacting sites summary, and related release site documents have been uploaded to ProjectInfo. Should you have any questions regarding the content of this memorandum please contact James Smith at james.m.smith@dot.state.ma.us.

JMS

Attachment A: Project 608051-Summary of potentially impacting release conditions

Project 608051-Summary of potentially impacting release conditions

The following is a summary of the information obtained during the file review for the Olin Chemical Superfund Site and the release sites at 490 Main Street, 603 Main Street, Bet 685-687 Main Street, 586 Main Street, 880 Main Street, 375-432 Main Street, and 520 Main Street.

Olin Chemical Superfund Site

- The section of the project between the Main Street / Butters Row intersection at approximately Sta 241+50 and the end of project at approximately Sta 319+25 passes through Operating Unit 3 (OU-3) of the Olin Chemical Superfund Site.
- The Olin Chemical Corporation, located at 51 Eames Street in Wilmington, made specialty chemicals for the rubber and plastics industry on the site.
- Waste disposal on-site led to the contamination of off-site groundwater with various chemicals, including N-nitrosodimethylamine (NDMA), VOCs, and metals.
- NDMA treatability studies are ongoing.
- The shallow groundwater contamination plume overlaps with the Main Street construction project between approximately Sta 287+50 and approximately Sta 300+00.
- Depth to groundwater near the intersection of Main Street and Eames Street has been measured at approximately 10 feet.
- Groundwater encountered in this area may be contaminated.
- Early coordination with the Environmental Protection Agency (EPA) will be required.

RTN 3-1511, 490 Main St, BP Gasoline Station

- The site is currently occupied by a gasoline station and an automotive repair shop. An appliance repair shop was also previously present on the property.
- MassDEP was first notified of potential contamination in 1987, after underground storage tank (UST) testing found evidence of a faulty supply line and associated petroleum-impacted soils.
- Further environmental investigations identified BTEX and total petroleum hydrocarbons (TPH) in soil, and BTEX, MTBE, and VOCs in groundwater.
- Groundwater is found at depths ranging from approximately 2 to 4 feet below ground (bg).
- There may be a small area of overlap between the release site and the project area on the 496 Main Street property in the vicinity of Sta 214+00.
- Based on the nature of the planned construction in this area, contamination should not be encountered. However, the construction contractor must be especially attentive to potential signs of contamination in the vicinity of Sta 214+00.

RTN 3-3548, 603 Main St, Wilmington Petrol Former Sunoco Sta

- The site is currently occupied by a gasoline station and associated automotive repair shop, as it has been since approximately 1960.

- The site was first reported to MassDEP in 1990, after a release of petroleum at the property.
- After some delay, subsurface investigation found volatile petroleum hydrocarbons (VPH) in groundwater in exceedance of applicable standards, along with elevated but not violating levels of gasoline constituents. The original source of the contamination is believed to be a release from a former underground storage tank (UST) on the property.
- Groundwater was found at depths ranging from seven to nine feet below grade (bg), flowing roughly northeastward, toward the project area.
- One sample location within the project area also showed soil contamination with extractable petroleum hydrocarbons (EPH) in exceedance of applicable standards at a depth of five to 10 feet bg.
- Excavation to a depth of five feet or greater on Kiernan Avenue and between approximately Sta 225+00 and Sta 227+00 of Main Street may encounter contaminated soil and/or groundwater.

RTN 3-3929, Bet 685-687 Main St, Tennessee Gas Fee Property

- The site consists of a fenced, primarily undeveloped lot, which contains a high pressure natural gas pipeline. There is a history of agricultural use and filling of wetland areas.
- The site was first registered with MassDEP after sampling in 1990 prior to pipeline construction found elevated levels of total petroleum hydrocarbons (TPH) in soil. Further site investigations also found arsenic in soil in exceedance of applicable standards at depths ranging from three to seven feet bg.
- Soil was excavated and removed from a TPH hotspot.
- An A-3 RAO with associated Activity and Use Limitation (AUL) was submitted for the site in 1997. The AUL was amended in 2002.
- The AUL covers the entire property. It forbids the removal of the fencing around the property and any construction work that would result in the off-site migration of contamination.
- The property covered by the AUL is located on the south side of Main Street in Wilmington, between approximately Sta 250+75 and Sta 251+75. Work is not currently planned within the boundaries of the AUL. The property should not be entered or impacted without the oversight of a Licensed Site Professional (LSP).

RTN 3-12586, 586 Main St, Intersection of Route 38 & 129

- The site currently contains a gasoline station and associated convenience store, with a plume of contamination extending beyond the boundaries of that property into roadway and adjacent properties. A gasoline station has been present in this location since 1933.
- RTN 3-12586 was assigned to the site in 1995 after petroleum impacts to soil were found during an equipment upgrade.
- Further site investigations found petroleum-impacted soil at depths ranging from four to 12 feet bg and VPH, ethylene dibromide, and MTBE in groundwater.

- Groundwater is found at depths ranging from approximately six to 10 feet bg and flows roughly easterly to northeasterly.
- Response actions have included the excavation and removal of impacted soil and soil vapor extraction (SVE), air sparging (AS), and high vacuum extraction (HVE) to extract VOCs from groundwater. Site remediation is continuing.
- Excavation to a depth of six feet or greater on Lowell Street may encounter contaminated soil and/or groundwater.

RTN 3-20343, 880 Main St, Larry's Gas Inc

- The site is currently occupied by an auto parts store, Main Street, and a small area on the west side of Main Street. From the 1950s until at least 2003 there was a gasoline service station in place of the auto parts store.
- RTN 3-20343 was assigned to the site in 2001 after a gasoline leak to groundwater was identified.
- Groundwater at the site is found at a depth ranging from 11.5 to 15 feet bg.
- Groundwater treatment was completed in 2003 and an A-2 RAO was submitted for the site at that time.
- Based on the depth to groundwater and the low levels of contamination remaining as of 2003, the project is not likely to be impacted by this release site. However, the contractor must be aware that when performing excavation between approximately Sta 290+00 and Sta 292+75 they are working within a known release site and should be especially attentive to any signs of contamination.

RTN 3-21846, 375-432 Main Street

- The site is currently occupied by a parking lot, commuter rail station, and railroad right-of-way. No information regarding historical uses of the site was available, but the railroad has been present since the 1800s.
- RTN 3-21846 was assigned to the site in 2002 after material excavated during the installation of drainage improvements was found to contain TPH and polycyclic aromatic hydrocarbons (PAHs) in excess of applicable reportable concentrations.
- No further remediation beyond the disposal of the excavated material occurred, and post-excavation sampling found TPH and PAHs were still present in soil. An A-2 RAO was submitted for the site in 2002.
- Excavation within the railroad right-of-way between approximately Sta 207+50 and Sta 210+00 of Main Street may encounter soil contamination.

RTN 3-32172, 520 Main Street

- The site is currently occupied by several businesses, including businesses related to auto repair. Specific knowledge of past uses is not available, but there are indications a gasoline station may have been located there at one time.
- RTN 3-32172 was assigned to the site in 2014 after soil and groundwater were found to contain metals and hydrocarbons in excess of applicable reportable concentrations.

- Groundwater at the site is found at depths ranging from six to eight feet bg.
- A Permanent Solution with No Conditions was submitted for the site in 2014.
- Based on the known contaminated locations within the release site, it is not likely to impact the project. However, the contractor must be aware that when performing excavation within the boundaries of the 520 Main Street property, between approximately Sta 219+75 and Sta 221+75 of Main Street, they are working within the boundaries of a known release site and should be especially attentive to any signs of contamination.

RTN 3-37915, 760 Main Street, 760 Main Street

- There is known groundwater contamination associated with a release site identified in 2023. According to currently available information, it is unlikely that the project will be impacted by this release, but site investigation is ongoing. Up-to-date information regarding RTN 3-37915 should be obtained prior to beginning construction in the vicinity of 760 Main Street.

Railroad

A railroad right-of-way will be impacted by the project during construction on the southwest side of Main Street between approximately Sta 208+00 and Sta 218+00. Based upon the historical use of the land as a railroad line, it is expected that residual contamination is present and it is likely that contaminated soils will be encountered in the project area. It is possible that residual levels of polycyclic aromatic hydrocarbons, trace levels of metals, pesticides (such as lead arsenate), and constituents of oil or fuel (petroleum products), coal ash from engines, and creosote from ties could be present in soil. The proposed construction activities will result in handling of and exposure to potentially contaminated soil.

DOCUMENT A00882

HYDRAULIC REPORT

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HYDRAULIC REPORT

Reconstruction on Route 38 (Main Street) Wilmington, Massachusetts

MassDOT Contract No. 608051



Prepared for

Massachusetts Department of Transportation

June 26, 2025

Prepared by

GREEN
A Lochner Company

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1.0 INTRODUCTION

The purpose of this report is to present the results of a Hydraulic and Scour Study performed by Green International Affiliates, Inc., a Lochner Company (Green) for MassDOT for Bridge W38011-802-DOT-BRI, which carries Main Street (Route 38) over Maple Meadow Brook in Wilmington, Massachusetts. This study evaluates the hydraulic performance of the existing bridge and the proposed bridge. This study was conducted in a manner consistent with the American Association of State Highway Officials (AASHTO), Federal Highway Administration (FHWA), and Massachusetts Highway Department of Transportation (MassDOT) guidelines for preparation of hydraulic studies at bridge sites outlined in the MassDOT Bridge Manual *Hundredth Anniversary* Edition. The Scope of Work for this study included a review of available hydrologic and hydraulic data for Maple Meadow Brook from the Town of Wilmington Flood Insurance Study (FIS) dated July 6, 2016; a detailed hydraulic analysis for the bridge; and a scour/stability analysis. Pertinent data and the hydraulic computer modeling output are contained in the attachments of this report.

2.0 PROJECT DESCRIPTION

2.1 Existing Structure

The existing bridge is designated as Bridge No. W38011-802-DOT-BRI within the MassDOT NBIS inventory. It was originally constructed in 1911 and rehabilitated in 2000. MassDOT has recommended the existing structure be replaced due to the structure's age and due to scour making it difficult to locate the bridge abutments. MassDOT has also expressed interest in having the bridge redesigned to meet stream crossing standards, if feasible without causing rise in flood elevation downstream of the bridge.

The existing bridge record plans and Green's inspection report dated April 24, 2023, indicate that the structure consists of a single span reinforced concrete slab with a bituminous wearing surface, supported by stone masonry abutments. Two steel I-beams that previously supported railroad tracks are embedded in the concrete slab. The inspection report has indicated that, based on the NBIS coding data, the bridge has not yet been evaluated for scour potential.

The bridge and abutments are oriented south to north. The northwest embankment has stone riprap slope protection. Part of the embankment, at the ends of the northwest and southeast parapets, has eroded away, and most of the riprap in that area has slid down the embankment and into the water (Figure 1).



Figure 1: Riprap has slid down the northwest embankment

At the southwest embankment, upstream of the bridge, a beaver dam and heavy buildup of sticks and brush were found. Upstream of the bridge, there is moderate debris accumulation and tree branches partly

restricting the channel flow. Downstream of the bridge there are remnants of a stone and concrete structure, which has caused a heavy buildup of debris restricting the channel flow (Figure 2). This structure is submerged, and does not affect flood elevations, for the 10 year or larger flood events.



(Upstream of Route 38 bridge)



(Downstream of Route 38 bridge)

Figure 2: Debris restricts channel flow on both ends of the bridge

The Route 38 (Main Street) bridge has an approximately 43.0’ wide deck, an 11.7’ clear span, and a 12°-5’-12” skew. The clear span was confirmed in the field.

The distance between the stream centerline and the bottom of the superstructure at the upstream opening is approximately 3.4'. The distance between the stream centerline and the bottom of the superstructure at the downstream opening is approximately 3.5'.

Figure 3 shows the dimensions of the existing bridge from the FEMA FIS.

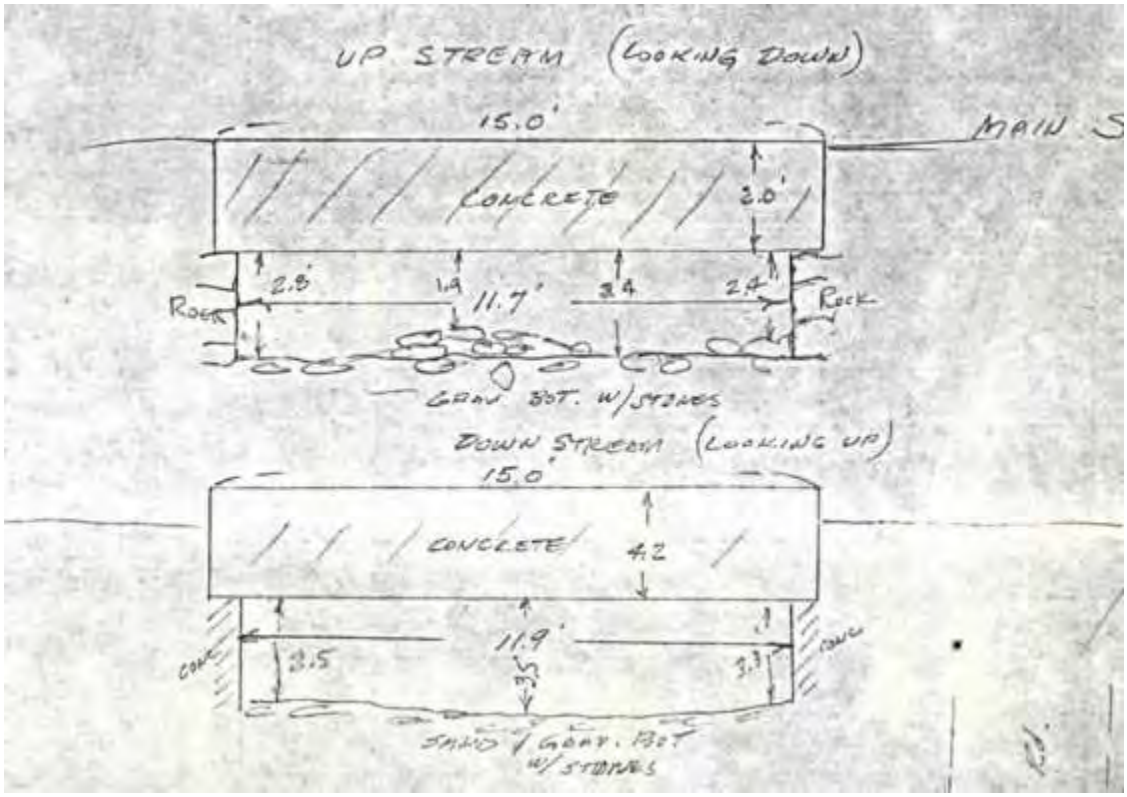


Figure 3: Existing Bridge Dimensions

2.1.1 Crossed Waterway at the Bridge Location

The existing bridge conveys MA Route 38 (Main Street) over Maple Meadow Brook.

Maple Meadow Brook originates from Mill Pond to the southwest in Burlington, MA and flows northeast towards Main Street in Wilmington. The tributary Sawmill Brook, which also originates in Burlington, MA to the southwest, joins with the main stem of Maple Meadow Brook upstream of Route 38. Between the confluence with Sawmill Brook and the Route 38 crossing, the stream crosses under the MBTA Lowell Line railroad track. After crossing Route 38, the stream crosses under MA Route 129 (Lowell Street) and flows north.

The drainage area to the Route 38 bridge crossing over Maple Meadow Brook is approximately 4.1 square miles.

Most of the land cover within the drainage area is forest, low density residential, or non-forested wetland. The approach channel slope is approximately 0.0014 ft/ft. The stream's sinuosity is 1.10 ft/ft, which classifies it as a meandering stream.

2.1.2 Highway Conveyed

Route 38 is functionally classified as an "Urban Principal Arterial" roadway. It is owned and maintained by MassDOT.

The average daily traffic to the roadway is 12,490 vehicles per day. The closest location to the bridge where a traffic count was performed (in October 2016) was 700 feet south of the Route 38 and Cross Street intersection.

2.1.3 Land Use in the Vicinity of the Bridge

The land use in the vicinity of the bridge is typically commercial, residential, and recreational.

2.1.4 Special Site Considerations

NFIP Mapped Area

The subject bridge is located within the National Flood Insurance Program (NFIP) floodway mapped area. NFIP regulations prohibit all project development activities that encroach the river's regulatory floodway delineation unless project proponents demonstrate, through hydrologic and hydraulic analyses, that project implementation will not increase the Base (100-year) Flood Elevation (BFE) profile.

Based on the FEMA Effective Flood Insurance Study (FIS) for the Town of Wilmington, MA, Middlesex County, dated July 6, 2016, the 100-year flood elevation for Maple Meadow Brook is at elevation 81.3 feet NAVD 88 at the upstream face of the structure at Route 38.

The FEMA flood map and FIS output are included as **Appendix A**.

History of Routing Analyses

The flow rates that are included in the effective FIS appear to account for storage upstream of the Main Street bridge, indication that routing analyses (stage vs discharge and stage vs storage computation) were performed. Therefore, making the hydraulic opening larger through the bridge, to meet the Stream Crossing Standards, will impact the peak flow rates downstream of the bridge with a high likelihood to raise the peak water surface elevations on the downstream side and lower peak flow elevations on the upstream side. Making the hydraulic opening larger may result in a requirement for the hydrology and hydraulics of Maple Meadow Brook to be further studied and reviewed by FEMA through the CLOMR process.

Routing Analysis is discussed in Section 5.

2.2 Proposed Action

The proposed substructure is a single span arrangement with cast-in-place footings on drilled micropiles. The newly constructed footings will be offset from the existing abutment footprint to increase the span length to approximately 12.0'.

The proposed superstructure is a single span three-sided frame made of nine (9) three-sided precast concrete frame segments and a 3" bituminous concrete wearing surface.

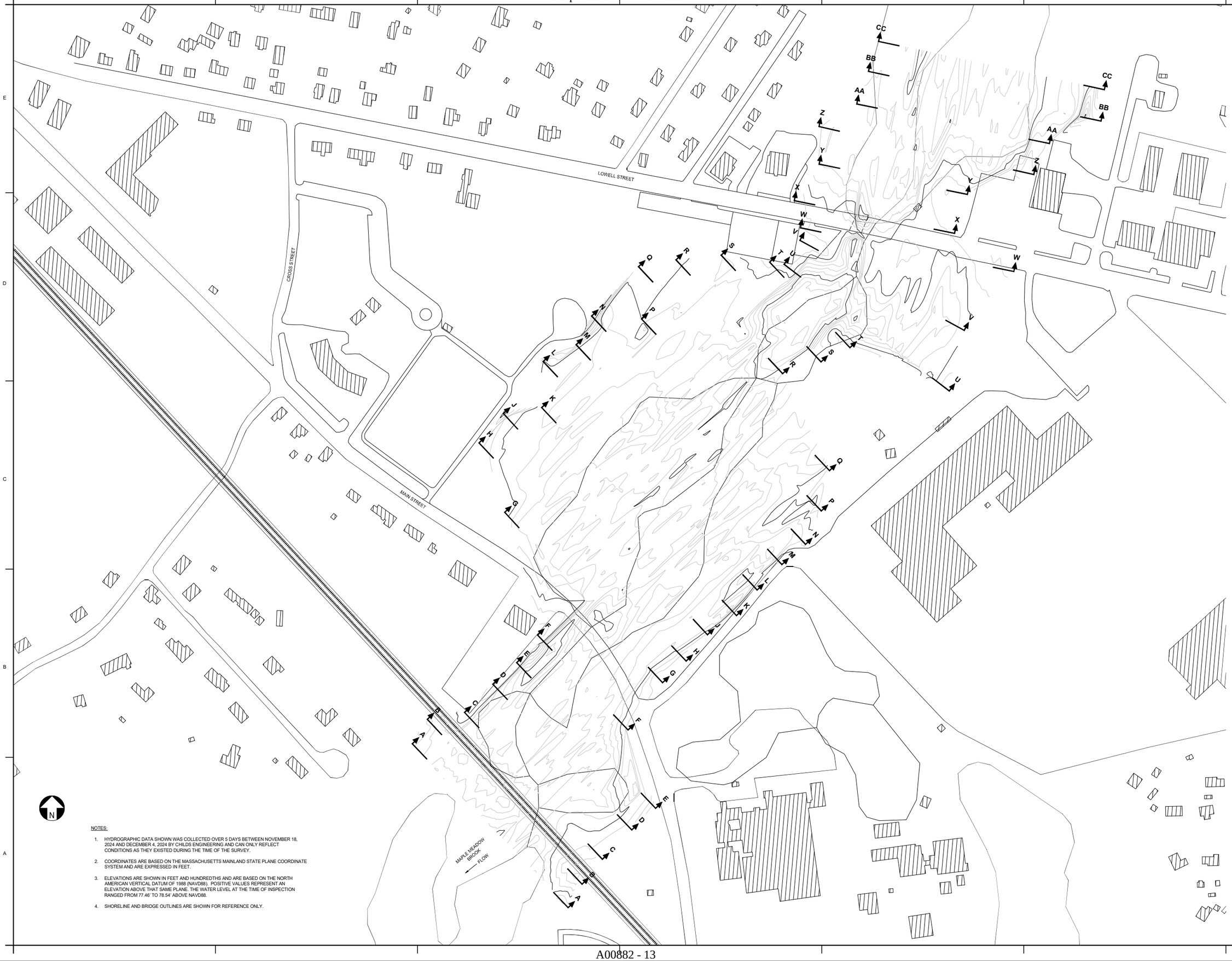
The existing low chord elevation of 78.93' will be maintained under proposed conditions.

3.0 DATA COLLECTION

Data from topographic field surveys performed by Green at Route 38 and Rote 129 was combined with stream bathymetry data performed by Childs Engineering and existing MassGIS LiDAR terrain data to establish cross sections along the stream. The survey limits are shown as Figure 4 on the following page. Green also acquired and reviewed the following information.

Sources

- Federal Emergency Management Agency, Flood Insurance Study, Middlesex County, Massachusetts, July 6, 2016.
- Federal Emergency Management Agency, Original HEC-2 Model for Flood Insurance Study-Town of Wilmington, MA, 1978.
- MassDOT Structures Inspection Field Report, April 2023.
- Sediment Sampling Analytical Report, Alpha Analytical, April 2023.
- Sediment Sampling Laboratory Testing Data Sheets, Thielsch Engineering, February 2025.
- Soils & Foundations Report, Lamson Engineering Corporation, October 2020.
- USGS StreamStats Report, accessed January 23, 2025.



NOTES:

1. HYDROGRAPHIC DATA SHOWN WAS COLLECTED OVER 5 DAYS BETWEEN NOVEMBER 18, 2024 AND DECEMBER 4, 2024 BY CHILDS ENGINEERING AND CAN ONLY REFLECT CONDITIONS AS THEY EXISTED DURING THE TIME OF THE SURVEY.
2. COORDINATES ARE BASED ON THE MASSACHUSETTS MAINLAND STATE PLANE COORDINATE SYSTEM AND ARE EXPRESSED IN FEET.
3. ELEVATIONS ARE SHOWN IN FEET AND HUNDREDTHS AND ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88). POSITIVE VALUES REPRESENT AN ELEVATION ABOVE THAT SAME PLANE. THE WATER LEVEL AT THE TIME OF INSPECTION RANGED FROM 77.46' TO 78.54' ABOVE NAVD88.
4. SHORELINE AND BRIDGE OUTLINES ARE SHOWN FOR REFERENCE ONLY.

CHILDS ENGINEERING
34 WILLIAM WAY, BELLINGHAM, MA 02019 U.S.A.
Phone: (508) 966-4092
E-mail: mm@childseng.com

Mark	Description	Date	Appr

Designed by	Date	Drawing No.	Field Book
MPS	12/20/24	3118-24	1"=100'-0"
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MAPLE MEADOW BROOK SURVEY
GREEN INTERNATIONAL AFFILIATES, INC.
WILMINGTON, MA

CONTOUR PLAN

Sheet reference number: X-01
Sheet 1 of 3

QUINNT K:\3118-24\00 MAPLE MEADOW BROOK SURVEY - GREEN\CADD\CURRENT WORKING DWGS\3118-24 HYDROGRAPHIC SURVEY.DWG Dec 20, 2024 - 1:45pm

4.0 ENGINEERING METHODS

4.1 Peak Discharges

4.1.1 Climate Change Indicator

To determine which level of peak discharge analysis to use, the Climate Change Indicator (CCI) was calculated by applying Hydraulic Engineering Circular (HEC) No. 17 "Highways in the River Environment-Floodplains, Extreme Events, Risk, and Resilience" Equation 7.8 to the precipitation estimates for a 100-year occurrence interval projected to 2070.

$$CCI = \frac{P_{24,100,P} - P_{24,100,O}}{P_{24,100,O,U} - P_{24,100,O}}$$

where,

CCI = Climate change indicator
$P_{24,100,P}$ = The predicted 100-year, 24-hour precipitation
$P_{24,100,O}$ = The observed 100-year, 24-hour precipitation
$P_{24,100,O,U}$ = Upper 90% confidence limit 100-year, 24-hour precipitation for the observed data

Wilmington is located between Cambridge, MA and Lawrence, MA, so the CCI was estimated using precipitations for both locations from the MassDEP NOAA14 PLUS – Summary of Technical Review Memorandum, dated November 15, 2022.

Table 1 – Summary of Climate Change Indicator Estimates

	Predicted 100-year, 24-hour Precipitation	Observed 100-year, 24-hour Precipitation	Observed 100-year, 24-hour Precipitation Upper 90% Confidence Limit	CCI
Cambridge, MA	10 in	8.2 in	11.3 in	0.58
Lawrence, MA	9.5 in	7.8 in	10.8 in	0.57

A CCI of approximately 0.6 indicates that the upper and lower confidence intervals need to be assessed alongside the historical peak flow estimates calculated using the USGS regression equations.

4.1.2 Peak Discharge Estimates

For the No-Rise analysis, peak 10-, 50-, 100-, 200-, and 500-year flood discharges for the Maple Meadow Brook were adopted from the Middlesex County, MA effective FIS.

It should be noted that FEMA performed hydrologic routings using the Muskingum Method to consider the moderating influence of storage in the extensive swamplands along the Maple Meadow Brook. Calculations were made to determine inflow and outflow hydrographs and storage curves. From these working curves,

discharges for the 10-, 50-, 100-, and 500-year flood discharges at the downstream limit of the routed reaches were determined. Refer to the 2016 Middlesex County Effective FIS, Section 3.1 "Hydrologic Analysis" for additional information regarding hydrologic computational procedures.

Because the FIS analysis was completed in August 1978 and because peak flows have risen significantly since the FIS analysis, peak flows for design were the upper 90% confidence interval of flows taken from a report compiled using USGS StreamStats, dated January 23, 2025. The StreamStats report is included as **Appendix B**. The discharges used are highlighted in Table 2.

Table 2 – Summary of Discharges

Description	Drainage Area	Peak Discharge (CFS)					
		10% Annual Chance [10-yr] CFS	4% Annual Chance [25-yr] CFS	2% Annual Chance [50-yr] CFS	1% Annual Chance [100-yr] CFS	0.5% Annual Chance [200-yr] CFS	0.2% Annual Chance [500-yr] CFS
Upstream of Main Street Bridge; 1983 Effective FIS*	4.03 sq. mi.	160	---	260	310	---	460
Upstream of Main Street Bridge; StreamStats	4.03 sq. mi.	223	299	361	427	498	600
Upstream of Main Street Bridge; StreamStats Lower 90% Prediction Interval	4.03 sq. mi.	110	142	166	191	216	248
Upstream of Main Steet Bridge; StreamStats Upper 90% Prediction Interval**	4.03 sq. mi.	453	629	784	956	1150	1450
Upstream of Main Street Bridge; NRCS Method, with Routing***	4.03 sq. mi.	260	320	346	478	723	938

**Flows used for No-Rise analysis*
***Flows used for design*
****See Section 5 for discussion of routing analysis.*

4.2 No-Rise Analysis

Because the existing bridge spans an effective NFIP regulatory floodway delineation, it was necessary to perform a "No-Rise" base flood elevation profile hydraulic analysis, as outlined in the MassDOT Bridge LRFD Manual – Part I, Chapter 2, Subsection 2.6.6, to demonstrate project compliance with applicable NFIP base floodplain development performance standards. The steps taken and the results are described in the following sections.

4.2.1 Duplicate Effective Model

Green obtained a copy of the HEC-2 input files used to create the model used in the August 1978 FIS analysis from FEMA. To compare the FIS analysis to the hydraulic model under existing and proposed conditions, the HEC-2 model was converted to a duplicate effective conditions model in the US Army Corps of Engineers (USACE) Hydraulic Engineering Center's River Analysis System (HEC-RAS). All elevations from the HEC-2 model were converted to the NAVD88 vertical datum.

The boundary condition used for all profiles was the known water surface elevation (feet) taken from the Effective FIS.

Table 3a – Summary of Duplicate Effective Model Results 10-yr

River Station	FIS Cross Section	[1] Published Data (FEET, NAVD88)	[2] Duplicate Effective Model (FEET, NAVD88)	[2] – [1]
147.5	1.407	80.30	80.62	0.32
84.5	1.400	80.20	80.48	0.28
60.8	Bridge			
37.01	1.391	79.50	79.05	-0.45
0	1.389	79.10	79.30	0.20

Table 3b – Summary of Duplicate Effective Model Results 50-yr

River Station	FIS Cross Section	[1] Published Data (FEET, NAVD88)	[2] Duplicate Effective Model (FEET, NAVD88)	[2] – [1]
147.5	1.407	82.77	82.72	-0.05
84.5	1.400	82.77	82.70	-0.07
60.8	Bridge			
37.01	1.391	81.10	80.95	-0.15
0	1.389	81.10	81.00	-0.10

Table 3c – Summary of Duplicate Effective Model Results 100-yr

River Station	FIS Cross Section	[1] Published Data (FEET, NAVD88)	[2] Duplicate Effective Model (FEET, NAVD88)	[2] – [1]
147.5	1.407	82.77	82.85	0.08
84.5	1.400	82.77	82.82	0.05
60.8	Bridge			
37.01	1.391	81.27	81.14	-0.13
0	1.389	81.37	81.20	-0.17

Table 3d – Summary of Duplicate Effective Model Results 500-yr

River Station	FIS Cross Section	[1] Published Data (FEET, NAVD88)	[2] Duplicate Effective Model (FEET, NAVD88)	[2] – [1]
147.5	1.407	83.00	83.10	0.10
84.5	1.400	83.00	83.05	0.05
60.8	Bridge			
37.01	1.391	81.75	81.51	-0.24
0	1.389	81.75	81.60	-0.15

As shown in Tables 3a-3d, the water surface elevations from the HEC-RAS Duplicate Effective Model are within 0.5' of the water surface elevations from the HEC-2 output. The HEC-RAS output from the Duplicate Effective Model is included as **Appendix C**.

4.2.2 Existing Conditions Model

A one-dimensional existing conditions hydraulic model was created in HEC-RAS using information from Green's topographical field survey and Childs Engineering's bathymetry survey. MassGIS LiDAR data was used to supplement the outer boundaries of the cross sections where appropriate. The bridge geometry was modeled based on surveyed conditions. A vertical datum of NAVD88 (English units) was used.

Two additional structures captured within the expanded limits of the bathymetry survey were added to the existing conditions model.

The boundary condition used for all profiles was the same as the Duplicate Effective Model: the known water surface elevation (feet) taken from the Effective FIS. The Manning's coefficients used were 0.03 within the channel and 0.075 (medium to dense brush) on either side of the banks.

4.2.3 Proposed Conditions Model

The bridge geometry in the HEC-RAS model was revised to match the span length under proposed conditions, widening the clear span from 11.7’ to 12’. All other parameters were kept the same between existing and proposed conditions.

The HEC-RAS results from the Existing and Proposed Conditions Models are included as **Appendices D** and **E**.

4.3 Results

4.3.1 No-Rise Analysis

Table 4 –Summary of No-Rise Analysis for FEMA Base Flood (100-yr)

Model Cross Section	FIS Cross Section	Duplicate Effective Model Cross Section	[1] Existing Condition Model (FEET)	[2] Proposed Condition Model (FEET)	[2] – [1] No-Rise Elevation
2765.14	---	---	81.64	81.63	-0.01
2492.94	---	---	81.64	81.63	-0.01
2391.78	---	---	81.64	81.63	-0.01
2284	1.407	147.5	81.64	81.63	-0.01
2194.02	1.400	84.5	81.34	81.33	-0.01
2164.02	Route 38 Bridge; FIS G				
2138.106	1.391	37.01	80.16	80.16	0.00
2137.106	---	---	80.25	80.25	0.00
2112.457	Obstruction				
2103.11	1.389	0	80.24	80.24	0.00
2001.98	---	---	80.24	80.24	0.00
1873.26	---	---	80.24	80.24	0.00
1741.68	---	---	80.24	80.24	0.00
1635.31	---	---	80.24	80.24	0.00
1532.63	---	---	80.24	80.24	0.00
1430.01	---	---	80.24	80.24	0.00
1291.21	---	---	80.23	80.23	0.00
1180.19	---	---	80.23	80.23	0.00
1085.1	---	---	80.23	80.23	0.00
974.91	---	---	80.23	80.23	0.00
880.98	---	---	80.23	80.23	0.00
831.48	---	---	80.23	80.23	0.00
721.16	---	---	80.22	80.22	0.00
679.8376	---	---	80.17	80.17	0.00
639.83	---	---	80.14	80.14	0.00
590.17	Lowell St Bridge; FIS E				
548.93	---	---	79.92	79.92	0.00
469.67	---	---	79.92	79.92	0.00
408.43	---	---	79.92	79.92	0.00
305.54	---	---	79.92	79.92	0.00
204.69	---	---	79.92	79.92	0.00
100.76	---	---	79.92	79.92	0.00
0	---	---	79.92	79.92	0.00

4.3.2 Summary of Hydraulic Performance

Table 5 – Summary of Hydraulic Performance, Compared at Cross Section 2194.02 (Upstream of Bridge)

AEP (%)	Peak Flow (CFS)	Existing		Proposed	
		Water Surface Elevation (ft)	Velocity* (ft/s)	Water Surface Elevation* (ft)	Velocity* (ft/s)
10% (10-yr)	453	82.02	10.37	82.01	10.36
4% (25-yr)	629	82.07	10.20	82.08	10.22
2% (50-yr)	784	81.70	9.84	81.70	9.84
1% (100-yr)	956	83.76	3.42	83.76	3.42
0.5% (200-yr)	1150	83.92	3.69	83.92	3.69
0.2% (500-yr)	1450	84.11	3.84	84.11	3.84

**Velocity is maximum velocity near/under the bridge*

As shown in Table 5, there is negligible change between existing and proposed conditions.

Table 6 –Summary of Hydraulic Performance

Alternative	Description	Hydraulic Design Flood Elevation (Feet-Year)	Freeboard (Feet)	"No-Rise" Required? [Y/N]	"LOMR" Required? [Y/N]
Proposed Alternative	Number of Spans = 1 Deck width out-to-out = 43' Total clear span = 12'-0" Low chord elevation = 78.93'	81.70 (50yr)	0	Y	N

According to the MassDOT Bridge Manual – Volume I, Chapter 2, Subsection 2.6.3, Table 2.6.3.1, for an Urban Principal Arterial roadway, the design flood is the 2% (50-year) flood event. Based on the recommendations from the MassDOT Bridge Manual – Volume I, Chapter 2, Subsection 2.6.4.I, the new structure should be designed to accommodate 2' of freeboard between the design flood and the low chord. If the existing low chord elevation of 78.93' is maintained, the target water surface under the design flood event should be 76.93'. Given roadway profile, the surrounding residential and commercial areas, and the bridge structure type as constraints, the bridge low chord cannot be raised to meet the required 2' of freeboard. A freeboard waiver letter will be required.

5.0 HYDRAULIC AND CONSTRUCTIBILITY ISSUES WITH WIDENING THE HYDRAULIC OPENING

As indicated under section 2.1.4 of this report, FEMA performed routing analysis (stage vs discharge and stage vs storage) computations to account for the storage area along Maple Meadow Brook upstream of Route 38.

The areas upstream and downstream of the bridge are wetlands with wide floodplains. Field observation of bankfull width is not possible in the vicinity of the bridge. Using aerial imagery, the bankfull width is estimated to be approximately 21 ft. Streamstats was used to validate this estimate. Using regression equations, Streamstats calculates the expected bankfull width to be 25 ft. To meet the Stream Crossing Standards for the bridge at Route 38, a 30 ft wide bridge opening is necessary.

Because of the available storage upstream of the bridge, a wider bridge opening will convey more flow downstream and will potentially cause a rise in flood elevations downstream of the bridge.

Hydrology and hydraulic analyses were conducted for the watershed upstream of Route 38. The USACE HEC-HMS and HEC-RAS engineering programs were used in the analysis. The Natural Resources Conservation Services (NRCS) Curve Number (CN) method was selected to estimate peak flow discharges for the different flood events. The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall depths were used in the frequency storm for the 2-, 5-, 10-, 25-, 50-, 100-year flood events. The watershed area, lag time, and average CN were calculated. The average CN was calculated based on land covers and hydrologic soil groups (HSG) obtained from MassGIS. Table 7 lists the watershed characteristics.

Table 7 – Watershed Characteristics upstream of Route 38 bridge

Description	Values
Watershed Area	4.03 sq. miles
Lag Time	112 mins
Average CN	73

An engineering model was developed in HEC-HMS using the parameters listed above. A Stage vs Discharge curve was established by running random flow rates through the HEC-RAS model, under existing conditions (11.7 ft wide bridge opening) and proposed conditions (a 30 ft wide bridge opening to meet the stream crossing standards). The Stage vs Storage curve was developed using MassGIS LiDAR data. The curves were incorporated in the HEC-HMS model. Table 8 summarizes the results.

Table 8 – NRCS Peak Discharges at Route 38 bridge

Description	Peak Discharges (cfs) / [Frequency (years)]					
	2	5	10	25	50	100
Existing Conditions (11.7 ft wide bridge opening)						
Without Routing	512	891	1233	1728	2107	2523
With Routing	**260**	**320**	**346**	**478**	**723**	**938**
30ft wide bridge opening to meet stream crossing standards						
Without Routing	512	891	1233	1728	2107	2523
With Routing	**487**	**739**	**841**	**931**	**975**	**1198**

As listed on Table 7 above, the computed peak discharges are higher than the peak discharges listed on the FEMA effective FIS and the peak discharge estimated by StreamStats. Generally, the NRCS method reveals higher peak flow rates. Also, the higher peak flow rates could be attributed to the higher CN because of the new developments and the higher NOAA Atlas 14 rainfall depths when compared to the rainfall depths listed on the Technical Paper TP 40.

The routed peak discharges for the 100-year flood events were incorporated into HEC-RAS under existing and proposed conditions. The water surface elevations are summarized in Table 9.

Table 9 – Summary of Water Surface Elevations – 100-year flood event

River Station	FIS Cross Section	[1] Existing Condition Model (FEET, NAVD88)	[2] Proposed Condition (30 ft wide) Model (FEET, NAVD88)	[2] – [1]
2284	1.407	83.83	83.99	0.16
2194.02	1.400	83.75	83.90	0.15
2164	Bridge			
2103.11	1.389	81.20	81.54	0.34
2001.98	-	81.20	81.54	0.34

As shown in Table 9, there will be an increase in the base flood elevations if the bridge hydraulic opening is widened to meet the Stream Crossing Standards.

As a result, meeting the Stream Crossing Standards will affect the hydrologic or hydraulic characteristics of the flooding source and thus result in the modification of the existing regulatory floodway, the effective Base Flood Elevations (BFEs), or the Special Flood Hazard Area (SFHA), where a Conditional Letter of Map Revision (CLOMR) process would be required.

Additionally, even if Stream Crossing Standards are to be met, there are structures both upstream and downstream of the Route 38 crossing that constrict the flow. Downstream, there are the remnants of a concrete structure, which has been observed to restrict the flow. Upstream, the MBTA Lowell Line stream crossing has a similar sized opening to the Route 38 crossing (Figure 5).

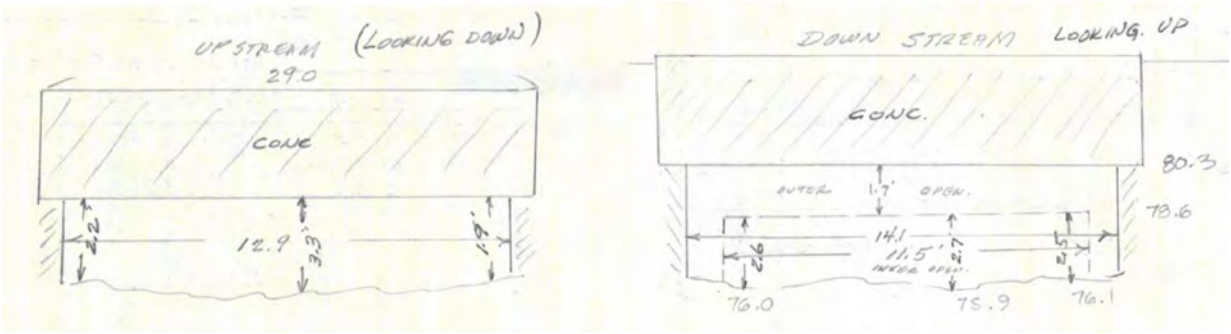


Figure 5: Hydraulic Opening at Upstream Railroad Bridge

The HEC-HMS and HEC-RAS results for the Routing Analysis are included as **Appendix F**.

6.0 SCOUR/STABILITY ANALYSES

6.1 Soil Sampling

Based on the first sediment sample analysis, prepared by Alpha Analytical and dated April 27, 2023 (**Appendix G**), the soils at the crossing were determined to be cohesive, with fines content ranging from 71.3% - 87.5%. Testing for Atterberg limits was not included in the report, so additional testing was necessary to continue with scour analysis.

The second sediment sample analysis, prepared by Thielsch Engineering and dated February 21, 2025 (**Appendix H**), determined the soils to primarily be fibrous peat and fine sands with high organics content. The fines content determined from these samples ranged from 14.6% - 35.2%, indicating the soils were not cohesive. Additionally, the fibrous content of the organic material made it difficult to perform Atterberg tests.

In order to determine whether further testing was necessary, the two sediment sample reports were compared to the bridge boring logs, performed by Lamson Engineering and dated January 2024 (**Appendix I**). The boring logs revealed primarily fine to coarse sand near the abutments.

ASTM D6913 “Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis” states that sieve analysis is not applicable for soils containing fibrous peat or soils containing “extraneous matter, such as organic solvents, oil, asphalt, wood fragments, or similar items,” due to how these materials

can affect the drying, washing, or sieving procedure. The fibrous peat and high organic content could be an explanation for the variation in sediment sample results.

To account for the uncertainty in soil conditions, two scour calculations were completed: one assuming cohesionless conditions, using the Thielsch Engineering results, and one assuming cohesive conditions.

6.2 Scour Equations

HEC-18 "Evaluation Scour at Bridges" was used to estimate scour at the Maple Meadow Brook crossing.

6.2.1 Long Term Aggradation and Degradation

The observed channel bottom elevation based on the bathymetry survey upstream of the bridge was 75.81' (NAVD 88); however, the channel bottom elevation according to the 1978 FIS study was surveyed to be 76.27' (NAVD 88). This suggests that about 0.5' of long term degradation has occurred between the study and now.

6.2.2 Stream Bed Conditions

Green first assessed whether the stream experienced live-bed or clear-water flow conditions by evaluating the median diameter (D_{50}) of the bed material upstream of the bridge.

Cohesionless Soils

For cohesionless soils, this evaluation required calculating the critical velocity using the following equation:

$$V_c = 11.17 y^{\frac{1}{6}} D^{\frac{1}{3}}$$

where,

V_c = Critical velocity above which bed material of size D and smaller will be transported (ft/s)
y = Average depth of flow in the channel upstream of the bridge (ft)
D = Particle size in a mixture of which 50 percent are smaller (ft)

Cohesive Soils

For cohesive soils, the critical velocity is defined by the following equation:

$$V_c = \frac{K_u}{n}\left(\sqrt{\frac{\tau_c}{\rho g}}\right) y_1^{1/6}$$

where,

V_c = Critical velocity for initiation of erosion of the cohesive material (ft/s)
y_1 = Upstream average flow depth (ft)
g = Acceleration due to gravity (32.2 ft/s^2)
n = Manning's roughness coefficient
ρ = Density of water (lb/ft^3)
τ_c = Critical shear stress (lbf/ft^2)
K_u = Unit conversion (1.486 for US customary units)

A recommended design equation for critical shear stress is provided as Figure 63 in Production No. FHWA-HRT-15-033 "Scour in Cohesive Soils" and reproduced below. A conservative design equation was chosen by the study with the goal of reducing the risk of underpredicting erosion.

$$\tau_c = \alpha_d \left(\frac{w}{F}\right)^{-2.0} PI^{1.3} q_u^{0.4}$$

where,

α_d = Unit conversion for design, 0.007 in U.S. customary units
w = Water content, dimensionless ratio
F = Fraction of fines by mass (<75µm), dimensionless ratio
PI = Plasticity index, dimensionless ratio
q_u = Unconfined compressive strength (lbf/ft^2)

However, because of the high organic content in the soils, the sediment sample analyses did not produce a plasticity index. The critical shear stress was instead estimated using Figures 1 and 2 in FHWA-HRT-15-033 (Reproduced below as Figures 6 and 7).

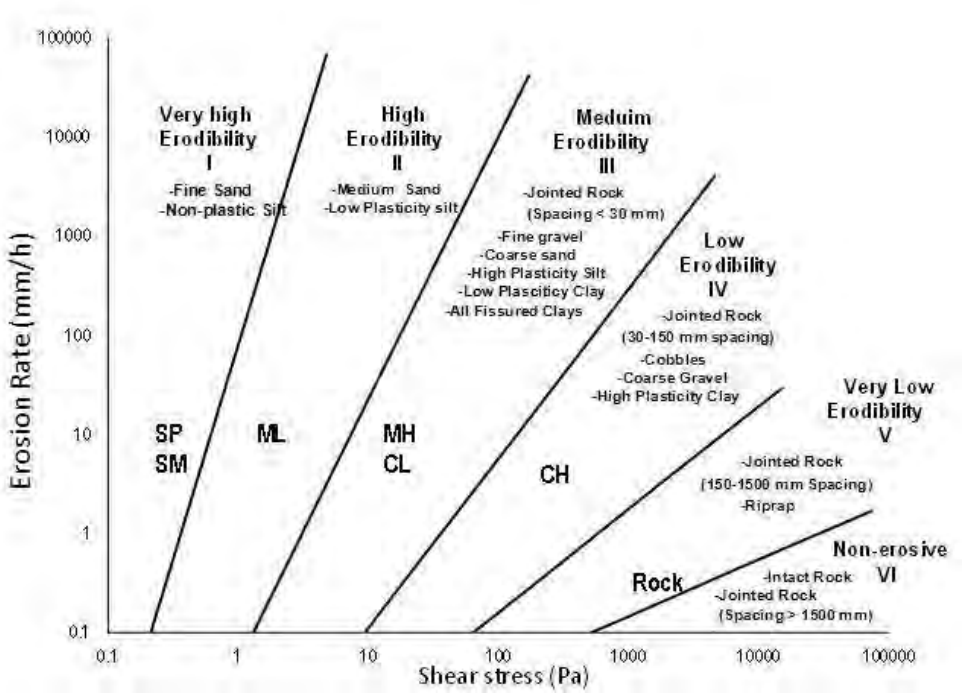


Figure 6: Generalized relationships for erosion in cohesive materials. From FHWA-HRT-15-033.

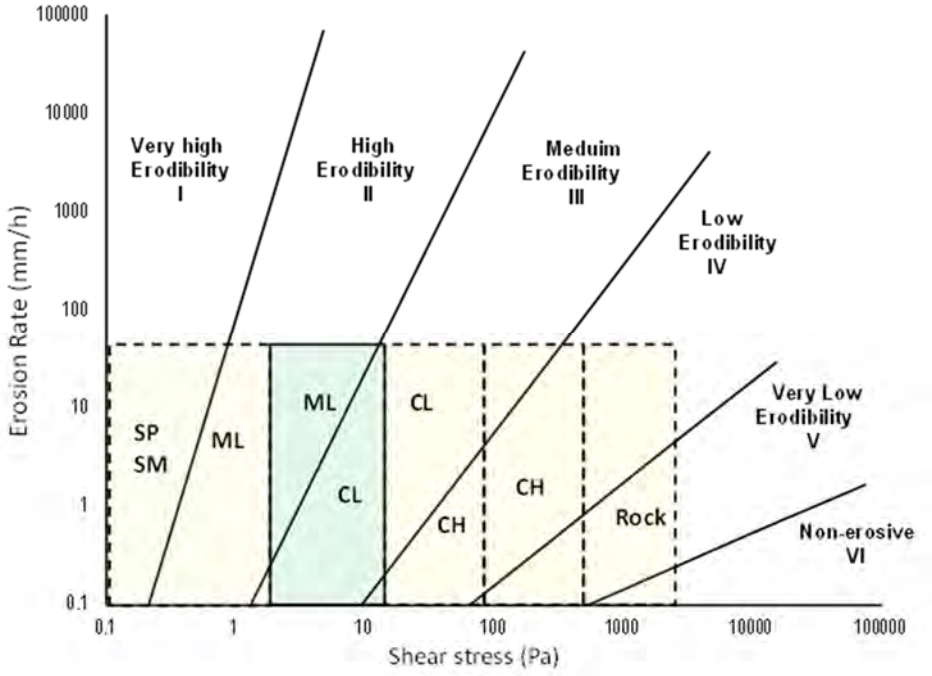


Figure 7: Division of cohesive materials into zones for specific devices. From FHWA-HRT-15-033.

The sediment sample analyses, backed up by the boring logs, defines the soil at the bridge as fine sand, so a critical shear stress range of 0.1-0.5 Pa (0.003-0.01 lbf/ft^2) was assumed.

6.2.3 Contraction Scour

The HEC-RAS analysis indicates that the stream under both the design and check flood events flows under pressure and overtops the roadway. HEC-18 Section 6.10 was used to estimate the pressure flow scour. Pressure flow scour is calculated the same way, regardless of soil characteristics.

HEC-18 Equation 6.14 was used to calculate the pressure flow scour.

$$y_s = y_2 + t - h_b$$

where,

y_s = Average contraction scour depth (ft)
t = Separation zone thickness (ft)
h_b = Vertical size of the bridge opening prior to scour (ft)

Because the critical velocity was determined to be less than the velocity at the approach cross section under both cohesive and cohesionless conditions, a modified HEC-18 Equation 6.2 was used to calculate the average depth in the contracted section y_2.

$$\frac{y_2}{h_{ue}} = \left(\frac{Q_2}{Q_{ue}}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

where,

h_{ue} = Effective upstream channel flow depth for live-bed conditions and bridge overtopping (ft)
y_2 = Average depth in the contracted section (ft)
y_0 = Average depth in the contracted section before scour (ft)
Q_{ue} = Effective channel discharge for live-bed conditions and bridge overtopping flow (ft^3/s)
Q_2 = Flow in the contracted channel (ft^3/s)
W_1 = Bottom width of the upstream main channel (ft)
W_2 = Bottom width of the main channel in contracted section less pier width(s) (ft)
k_1 = Exponent determined below

V*/ω	k_1	Mode of Bed Material Transport
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
> 2.0	0.69	Mostly suspended bed material discharge

ω = Fall velocity of the bed material based on the D_{50}

$$V^* = (g * h_{ue} * S_1)^{\frac{1}{2}}$$

where,

V^* = Shear velocity in the upstream section (ft/s)
S_1 = Slope of energy grade line of main channel (ft/ft)
y_1 = Average depth in the upstream main channel (ft)
g = Acceleration due to gravity (32.2 ft/s^2)

The effective channel discharge Q_{ue} is defined by HEC-18 Equation 6.15.

$$Q_{ue} = Q_1 \left(\frac{h_{ue}}{h_u}\right)^{8/7}$$

where,

Q_1 = Flow in the upstream channel (ft^3/s)
$h_u = y_1$ = Average depth in the upstream main channel (ft)

Under overtopping conditions, the effective upstream channel flow h_{ue} is defined as:

$$h_{ue} = h_b + T$$

where,

T = Deck thickness (ft)

The separation zone thickness *t* was then calculated using HEC-18 Equation 6.16.

$$\frac{t}{h_b} = 0.5\left(\frac{h_b h_t}{h_u^2}\right)^{0.2}\left(1 - \frac{h_w}{h_t}\right)^{-0.1}$$

where,

$h_t = h_u - h_b$ = Distance from the water surface to the lower face of the bridge girders (ft)
$h_w = h_t - T$ = Weir flow height for $h_t > T$ (ft)

6.2.4 Abutment Scour

The scour depths for the abutments were computed using the NCHRP 24-40 Abutment Scour Approach in HEC-18 and computed using the equations shown below:

$$y_{max} = \alpha_A y_c \; or \; \alpha_B y_c$$

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{\frac{6}{7}}$$

$$y_S = y_{max} - y_0$$

where,

y_{max} = Maximum flow depth resulting from abutment scour (ft)
y_c = Flow depth including live-bed or clear-water contraction scour (ft)
α_A = Amplification factor for live-bed conditions
α_B = Amplification factor for clear-water conditions
q_1 = Upstream unit discharge (ft^2/s)
q_2 = Unit discharge in the constricted opening (ft^2/s)
y_s = Abutment scour depth (ft)
y_0 = Flow depth prior to scour (ft)

6.3 Estimated Scour

6.3.1 Calculated Scour

According to the MassDOT Bridge Manual – Volume I, Chapter 2, Subsection 2.6.3, Table 2.6.3.1, the scour design events for an Urban Principal Arterial roadway are the 1% AEP (100-year event) as the scour design event and the 0.5% AEP (200-year event) as the scour check event. However, since the channel overtops the

roadway under both the design and check scour events, the scour caused by the incipient flow was instead used as both the design and check scour.

The incipient flow marks the flood event where overtopping begins and where the maximum amount of scour is expected to occur. It was calculated by running random flows through the HEC-RAS model to identify the flow where overtopping is first expected to occur. The incipient flow at the Route 38 crossing was estimated to be 370 cfs. The HEC-RAS results used to estimate the incipient flow are included as **Appendix J**.

Under pressure, the estimated scour does not vary between cohesive and cohesionless soils.

Tables 10 and 11 show the total estimated scour for the design flood and the check flood under proposed conditions.

Table 10 – Summary of Calculated Bridge Contraction Scour

Alternative	Return Frequency	Peak Flow (cfs)	Upstream Velocity (ft/s)	[1] Long Term Degradation (Feet)	[2] Pressure Scour (Feet)	[1] + [2] Total Channel Scour (Feet)
Proposed Alternative	Incipient Flow	370	4.04	0.5	6.26	6.76

Table 11 – Summary of Calculated Bridge Abutment Scour

Alternative	Return Frequency	Peak Flow (cfs)	Upstream Velocity (ft/s)	[1] Long Term Degradation (Feet)	[2] Worst Local Abutment Scour (Feet)	[1] + [2] Total Abutment Scour (Feet)
Proposed Alternative	Incipient Flow	370	4.04	0.5	8.38	8.88

6.3.2 Field Observations

Field observations of the surveyed contraction scour hole suggest the contraction scour is closer to 2 feet, considerably less than the estimated scour based on HEC-18. Figure 8 shows the observed scour hole.

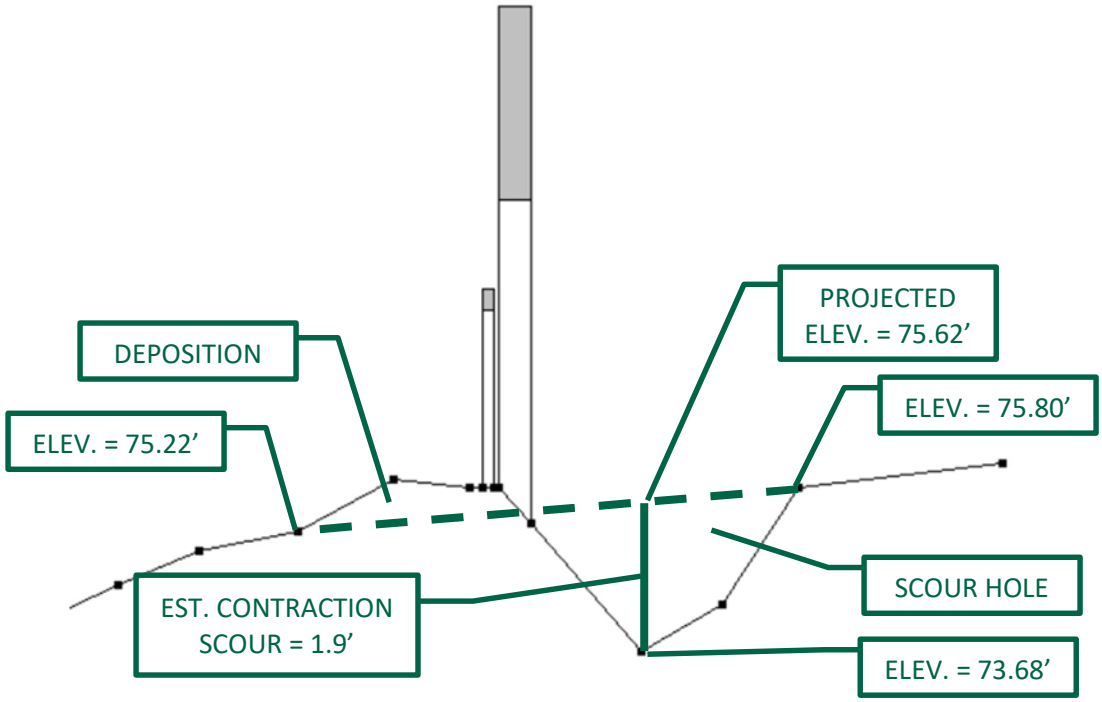


Figure 8: Scour Hole from Field Survey

6.3.3 Scour Re-Evaluation

Since the projected scour differed significantly from the observed scour hole, the footings were designed to handle a scour depth of approximately 4 feet, with the pile cap proposed at elevation 71.00'. Under these conditions, the top of pile cap is proposed to be located more than 3' below the existing thalweg of 74.22', measured from the existing conditions survey. The pile caps will be supported by micropiles that will be drilled into the top of bedrock. The pile caps are 3.5' thick and will be founded on top of 2' thick tremie seals, which will be protected from scour in the channel by cofferdam sheeting that will be cut down below the existing riverbed. Countermeasures will be put in place to reduce the effects of contraction scour.

6.4 Scour Countermeasures

According to the Stream Instability and Bridge Scour Countermeasures Matrix (Table 2.1) in HEC-23 "Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance," a lower foundation is a well-suited application for contraction and abutment scour. The depth of the bridge footings will be the main countermeasure against scour. Additionally, riprap bed armoring can be used as an application for contraction scour. Channel armoring and streambed restoration will also be proposed as a scour countermeasure.

Riprap was sized according to HEC-23 Design Guideline 4 "Riprap Revetment."

To determine the D_{50} of the proposed riprap, first the D_{30} was calculated using HEC-23 Volume 2 Equation 4.1.

$$D_{30} = y(S_f C_S C_V C_T)\left[\frac{V_{des}}{\sqrt{K_1(S_g - 1)gy}}\right]^{2.5}$$

where,

D_{30} = Particle size for which 30% is finer by weight (ft)
y = Local depth of flow (ft)
S_1 = Safety factor
C_s = Stability coefficient
C_V = Velocity distribution coefficient
C_T = Blanket thickness coefficient
V_{des} = Characteristic velocity for design = $V_{avg}(1.74 - 0.52\log(R_c/W)$ for natural channels (ft/s)
V_{avg} = Channel cross-section average velocity (ft/s)
K_1 = Side slope correction factor

$$K_1 = \sqrt{1 - \left(\frac{\sin(\theta - 14°)}{\sin(32°)}\right)^{1.6}}$$

R_c = Centerline radius of curvature of channel bend (ft)
W = Width of water surface at upstream end of channel bend (ft)
S_g = Specific gravity of rock riprap (2.65)
g = Acceleration due to gravity (32.2 ft/s^2)

The D50 was then calculated using HEC-23 Volume 2 Equation 4.2.

$$D_{50} = 1.20D_{30}$$

where,

D_{50} = Median stone diameter (ft)

The minimum target D_{50} was determined to be 5.25 inches.

Th extents of the riprap apron were determined using the streambed profile. Natural streambed material over a layer of dumped riprap was proposed such that the scour hole on either side of the bridge would be filled.

Table 12 displays the dimensions for the end transition aprons for the channel armoring on either side of the proposed bridge.

Table 12 – Summary of Countermeasure Design

MassDOT Riprap Size	D_{50} (Inches)	Length of Apron (ft)	Depth of Apron (Feet)
M2.02.2 Dumped Riprap	8	24	2.5

Appendix K includes the scour analysis and countermeasure calculations.

7.0 TEMPORARY COFFERDAMS DURING STAGE CONSTRUCTION

This section presents the results of hydraulic analysis for the placement of the temporary cofferdams required during the stage construction of the bridge to allow for the removal of the existing bridge abutments and the construction of the new bridge foundation. Using HEC-RAS, the bridge hydraulic opening with the proposed temporary cofferdams in place, thereby restricting the flow area at the bridge crossing, was analyzed. It was assumed that the cofferdams on each side the bridge footings for each construction stage will be constructed at the same time. Hydraulic analysis was performed per the LRFD Bridge Manual Section 2.7 Temporary Water Control Measures for temporary water control that will be in place for not more than two years. The 20% Annual Chance (5-Year) flood discharge was used to determine the top of the cofferdam. Under these conditions, the cofferdam should be set at elevation 82.8 ft in order to provide 1 foot of free board.

The temporary cofferdam data is summarized in Table 13. The HEC-RAS output is included as **Appendix L**.

Table 13 – Temporary Water Control Design Data

Flood Frequency	Peak Flow (cfs)	Water Surface Elevation (ft)	Velocity (ft/s)	Free Board (ft)	Recommended Elevation for the Cofferdam (ft)
50% (2-yr)	104	80.05	4.80	1	81.05
20% (5-yr)	171	81.79	5.62	1	82.79

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

- The project hydraulic model indicates that proposed bridge replacement will safely convey the 10-year flood event.
- The project hydraulic model indicates that the 50-year design flood event will overtop the roadway. This is consistent with the effective Flood Insurance Study.
- The hydraulic and hydrology analysis indicates that opening the bridge to meet the Stream Crossing Standards will result in a higher 100-year flood elevation downstream, requiring a CLOMR. In addition, expanding the width of the hydraulic opening to meet the Stream Crossing Standards will be ineffective, due to structures on both the upstream and downstream sides of the bridge constricting the flow.
- The scour analysis calculations indicate a potential scour of 6.8 feet of contraction scour and 8.9 feet of abutment scour under the Design Scour flood event.
- The geometry and hydraulic performance of the bridge will not be impacted by the proposed modification.

8.2 Recommendations

- The bridge will be designed to have a span length of approximately 12 feet. The low chord elevation will match the existing low chord elevation of 78.93’.
- The bridge low chord cannot be raised to meet the required 2’ of freeboard. A freeboard waiver letter will be required.
- As discussed in Section 6.3.3, the top of footings will be constructed 4 feet below the thalweg.
- Natural streambed material and dumped riprap channel armoring countermeasures are proposed to mitigate against the risk of contraction scour. The proposed riprap size has been chosen to exceed the minimum size calculated using readily available MassDOT specified material.
- The abutments will be designed to accommodate the estimated abutment scour.

Table 14 – Hydraulic Data

HYDRAULIC DESIGN DATA			
	CURRENT HYDROLOGY CONDITIONS	**PROJECTED HYDROLOGY CONDITIONS**	
DRAINAGE AREA:	4.1	4.1	SQUARE MILES
DESIGN FLOOD DISCHARGE:	784	784	CFS
DESIGN FLOOD ANNUAL CHANCE (FREQUENCY):	2% (50-YR)	2% (50-YR)	% (YEAR)
DESIGN FLOOD VELOCITY:	9.84	9.84	FT/S
DESIGN FLOOD ELEVATION:	81.70	81.70	FT, NAVD88
BASE (100-YEAR) FLOOD DATA			
BASE FLOOD DISCHARGE:	956	956	CFS
BASE FLOOD ELEVATION:	83.76	83.76	FT, NAVD88
SCOUR DESIGN FLOOD (SDF) EVENT DATA			
SCOUR DESIGN FLOOD ANNUAL CHANCE (RETURN FREQUENCY):	INCIPIENT; Q = 370 CFS		
SCOUR DESIGN FLOOD ELEVATION (IN BRIDGE OPENING IN MAIN CHANNEL):	78.93 FEET		
SCOUR DESIGN FLOOD ABUTMENT SCOUR DEPTH:	8.88 FEET		
SCOUR DESIGN FLOOD PIER SCOUR DEPTH :	N/A		
SCOUR CHECK FLOOD (SCF) EVENT DATA			
SCOUR CHECK FLOOD ANNUAL CHANCE (RETURN FREQUENCY):	INCIPIENT; Q = 370 CFS		
SCOUR CHECK FLOOD ELEVATION (IN BRIDGE OPENING IN MAIN CHANNEL):	78.93 FEET		
SCOUR CHECK FLOOD ABUTMENT SCOUR DEPTH:	8.88 FEET		
SCOUR CHECK FLOOD PIER SCOUR DEPTH :	N/A		
FLOOD OF RECORD			
DISCHARGE:	UNKNOWN		
FREQUENCY (IF KNOWN):	UNKNOWN		
MAXIMUM ELEVATION:	UNKNOWN		
DATE:	UNKNOWN		
HISTORY OF ICE FLOES:	UNKNOWN		
EVIDENCE OF SCOUR AND EROSION:	SCOUR HOLE OBSERVED		

9.0 REFERENCES

1. ASTM International, ASTM D6913-04(2009)e1 "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis," May 2017
2. Commonwealth of Massachusetts Department of Environmental Protection, "MassDEP NOAA14 PLUS – Summary of Technical Review," November 2022.
3. Commonwealth of Massachusetts Department of Fish and Game Division of Ecological Restoration, "Massachusetts Stream Crossings Handbook," Second Edition, June 2012.
4. Commonwealth of Massachusetts Department of Transportation, "MassDOT Bridge Manual," Hundredth Anniversary Edition, June 2024.
5. Commonwealth of Massachusetts Department of Transportation, "Standard Specifications for Highways and Bridges," 2025 Edition, March 2025.
6. Emergency Management Agency, Original HEC-2 Model for Flood Insurance Study-Town of Wilmington, MA, December, 1978.
7. Federal Emergency Management Agency, Flood Insurance Study, Middlesex County, Massachusetts, July 6, 2016.
8. Federal Highway Administration, Publication No. FHWA-HRT-15-033 "Scour in Cohesive Soils," May 2015.
9. Federal Highway Administration, Publication No. FHWA-RD-03-052 "Field Observations and Evaluations of Streambed Scour at Bridges," May 2005.
10. Federal Highway Administration, Hydraulic Engineering Circular No. 17 "Highways in the River Environment - Floodplains, Extreme Events, Risk, and Resilience," Second Edition, June 2016.
11. Federal Highway Administration, Hydraulic Engineering Circular No. 18 "Evaluating Scour at Bridges," Fifth Edition, April 2012.
12. Federal Highway Administration, Hydraulic Engineering Circular No. 23 "Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance," Third Edition, September 2009.
13. National Oceanic and Atmospheric Administration, "Precipitation-Frequency Atlas of the United States," Volume 10 Version 3.0: Northeastern States, 2015, revised 2019.

APPENDIX A

FEMA FLOOD MAP AND FIS OUTPUT

Proposal No. 608051 - 132406

drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' National North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations tables in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations tables should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Massachusetts State Plane - Mainland zone (FIPSZONE 2001), meters. The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Energy and Environmental Affairs. This information was derived from digital orthophotos produced at a scale of 1:5,000 from aerial photography dated April 2005.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://msc.fema.gov.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov.



The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 (EL 987) — Base Flood Elevation line and value; elevation in feet* / Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

- Cross section line
- Transect line
- 87°07'45", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 4476000mN — 1000-meter Universal Transverse Mercator grid values, zone 19
- 600000 FT — 5000-foot grid values: Massachusetts State Plane coordinate system, Mainland zone (FIPSZONE 2001), Lambert Conformal Conic projection
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
June 4, 2010

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
150 0 150 300 METERS

NFIP

PANEL 0291E

FIRM

FLOOD INSURANCE RATE MAP

MIDDLESEX COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 291 OF 656
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
WILMINGTON, TOWN OF	250227	0291	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
25017C0291E

EFFECTIVE DATE

A00882 - 37

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
LUBBERS BROOK - continued					
At Glen Road	3.2	135	215	250	350
At State Route 38 (Main Street)	2.8	80	115	130	180
At State Route 129 (Shawsheen Avenue)	2.0	90	135	150	290
Approximately 2,200 feet upstream of Shawsheen Avenue/ State Route 29	1.5	90	150	180	275
At Billerica/Wilmington corporate limits	1.3	63	106	129	200
At Billerica/Burlington corporate limits	0.7	47	80	98	153
MALDEN RIVER					
At the upstream side of the Amelia Earhart Dam	61.9	4,000	4,000	4,000	4,000
At Medford/Everett corporate limits	9.2	850	1,200	1,410	1,890
MAPLE MEADOW BROOK					
Upstream of confluence with Ipswich River	5.7	230	360	430	620
Upstream of tributary, approximately 525 feet northeast of Paddock Street	5.6	190	290	350	520
Upstream of Main Street bridge	4.1	160	260	310	460
Approximately 1,300 feet upstream of Middlesex Canal	1.5	30	50	60	90
MARGINAL BROOK					
At confluence with Concord River	1.2	70	115	140	220
MARSHALL BROOK					
At confluence with Strong Water Brook	4.0	180	295	350	515
Upstream of confluence of Darby Brook	3.2	150	240	290	425
Upstream of the tributary at station 1.075	2.6	105	170	205	300

TABLE 10 - MANNING'S "n" VALUES - continued

Stream	Channel "n"	Overbank "n"
Little Brook	0.035-0.10	0.014-0.30
Locke Brook	0.035	0.050-0.075
Lower Spot Pond Brook	0.020-0.024	0.044
Lubbers Brook	0.030-0.055	0.075-0.120
Malden River	0.020-0.050	0.020-0.050
Maple Meadow Brook	0.035-0.055	0.065-0.088
Marginal Brook	0.035-0.045	0.045-0.085
Marshall Brook	0.014-0.045	0.060-0.070
Martins Brook	0.040-0.102	0.060-0.090
Martins Pond Brook	0.035-0.040	0.050-0.070
Mascuppic Brook	0.030	0.070
Mason Brook	0.035	0.050-0.075
Meadow Brook	0.024-0.045	0.060-0.070
Meadow River Branch	0.015-0.050	0.100
Merrimack River	0.020-0.055	0.040-0.200
Mill Brook 1	0.035	0.050-0.075
Mill Brook 2	0.030-0.040	0.030-0.080
Mill Brook 3	0.035-0.150	0.014-0.300
Mill Pond Tributary	0.020-0.035	0.080
Mill River	0.045-0.100	0.110
Mineway Brook	0.030-0.045	0.070-0.100
Mongo Brook	0.040-0.050	0.120-0.160
Morse Brook	0.035	0.050-0.070
Mowry Brook	0.015-0.035	0.045-0.080
Mud Pond Brook	*	*
Muddy Brook[1]	0.050	0.050-0.090
Mulpus Brook	0.035	0.050-0.070
Munroe Brook	0.050-0.080	0.060-0.100
Mystic River	0.035	0.014-0.300
Nagog Brook	0.045	0.070
Nashoba Brook	0.015-0.045	0.040-0.120
Nashua River	0.030	0.060-0.070
Nissitissit River	0.040	0.060-0.090
Nonacoicus Brook 1	0.035	0.050
Nonacoicus Brook 2	0.035	0.050
North Lexington Brook	0.050-0.080	0.060-0.100
Pages Brook	0.013-0.050	0.100
Pages Brook Branch	0.024-0.050	0.100
Pantry Brook	0.016-0.040	0.050-0.100
Pearl Hill Brook	0.035	0.050-0.075
Peppermint Brook	0.035	0.070
Pine Brook	0.035	0.050-0.075

*Data not available

[1]Updated values for the July 7, 2014 countywide analyses

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Lubbers Brook (continued)								
AA	27,134	149	322	0.6	99.2	99.2	99.3	0.1
AB	28,380	63	175	1.0	99.7	99.7	99.9	0.2
AC	28,887	10	22	8.3	101.3	101.3	101.4	0.1
AD	29,811	265	993	0.2	102.1	102.1	102.6	0.5
AE	31,131	100	462	0.3	102.4	102.4	103.4	1.0
AF	31,776	80	321	0.4	103.0	103.0	103.5	0.5
AG	33,221	80	178	0.7	103.0	103.0	103.7	0.7
AH	34,306	80	169	0.6	103.3	103.3	104.2	0.9
AI	34,831	80	157	0.6	103.4	103.4	104.3	0.9
Maple Meadow Brook								
A	486	40	105	4.1	79.9	75.9[2]	75.9	0.0
B	1,954	25	110	3.3	79.9	77.0[2]	78.0	1.0
C	3,274	70	280	1.3	79.9	77.8[2]	78.8	1.0
D	4,910	125	450	0.8	79.9	78.2[2]	79.2	1.0
E	5,797	45	275	1.3	81.3	81.3	81.4	0.1
F	6,426	25	165	2.2	81.3	81.3	81.4	0.1
G	7,429	55	515	0.6	82.9	82.9	82.9	0.0
H	8,100	10	90	3.5	83.8	83.8	83.8	0.0
I	10,856	240	1,265	0.0	84.2	84.2	85.0	0.7
J	12,007	260	935	0.1	84.2	84.2	85.0	0.7
K	13,306	60	170	0.3	84.2	84.2	85.0	0.7

[1] Feet above confluence with Ipswich River
[2] Elevation computed without consideration of backwater effects from Ipswich River

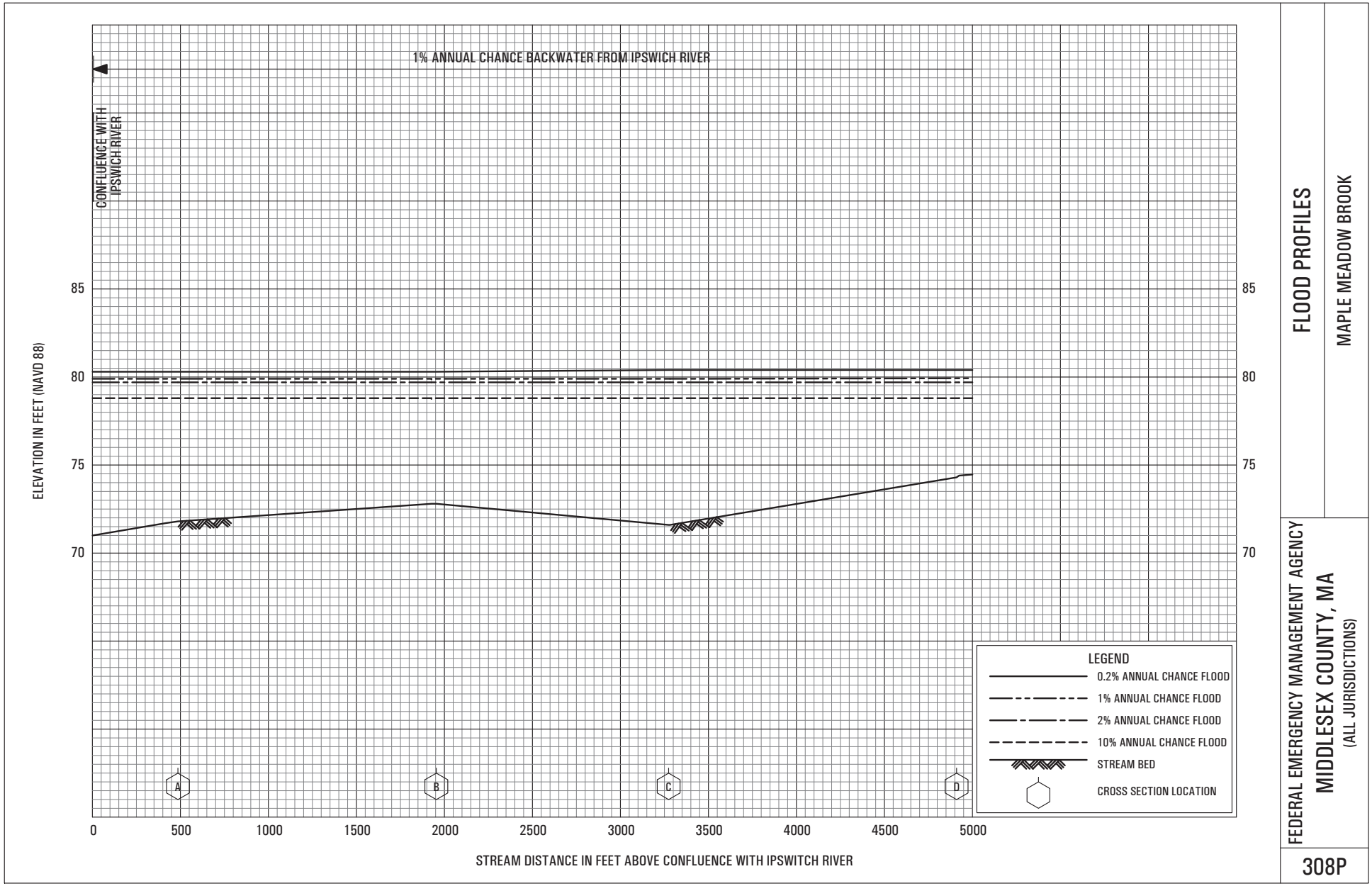
TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)

FLOODWAY DATA

LUBBERS BROOK – MAPLE MEADOW BROOK



FLOOD PROFILES

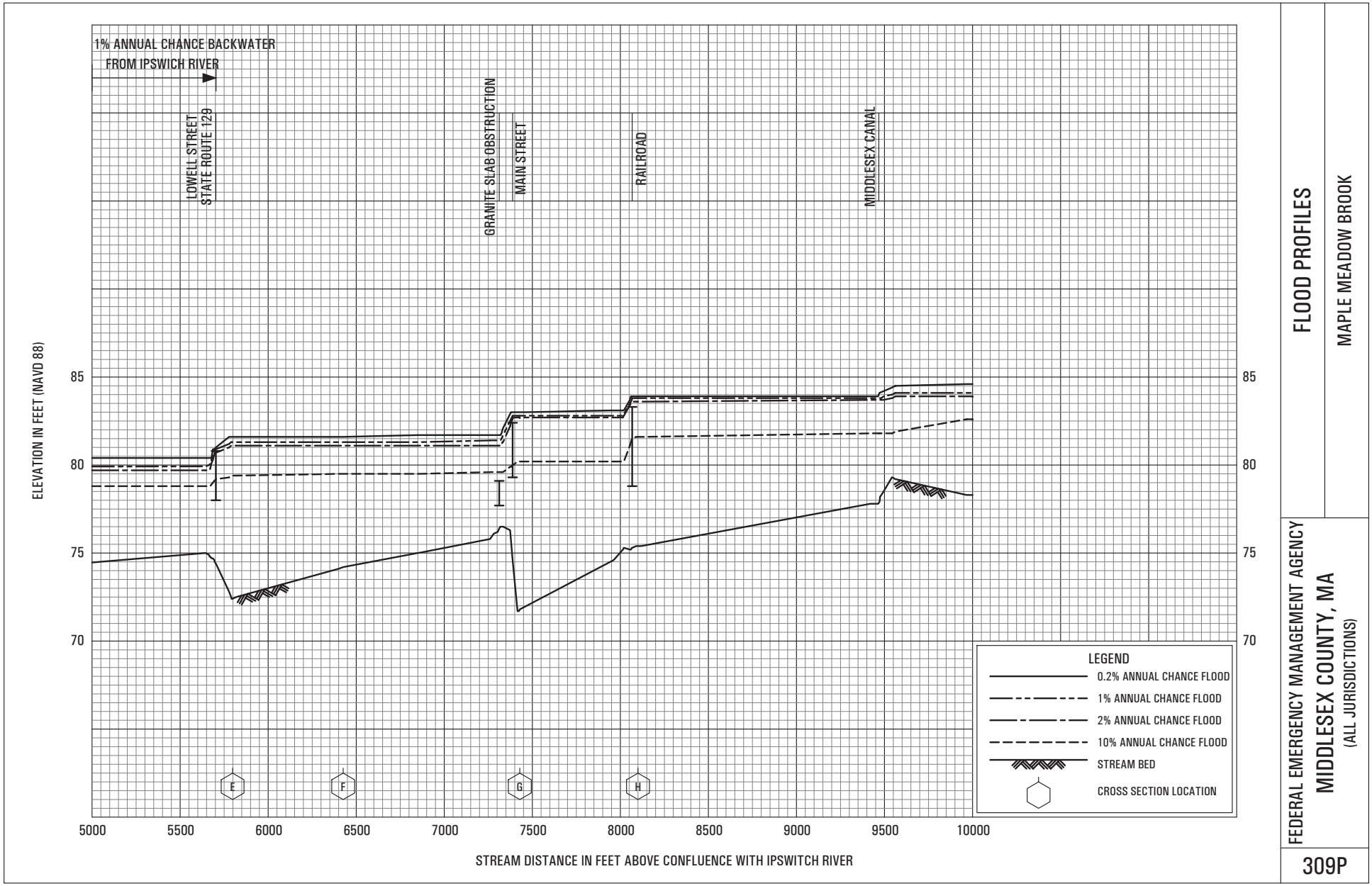
MAPLE MEADOW BROOK

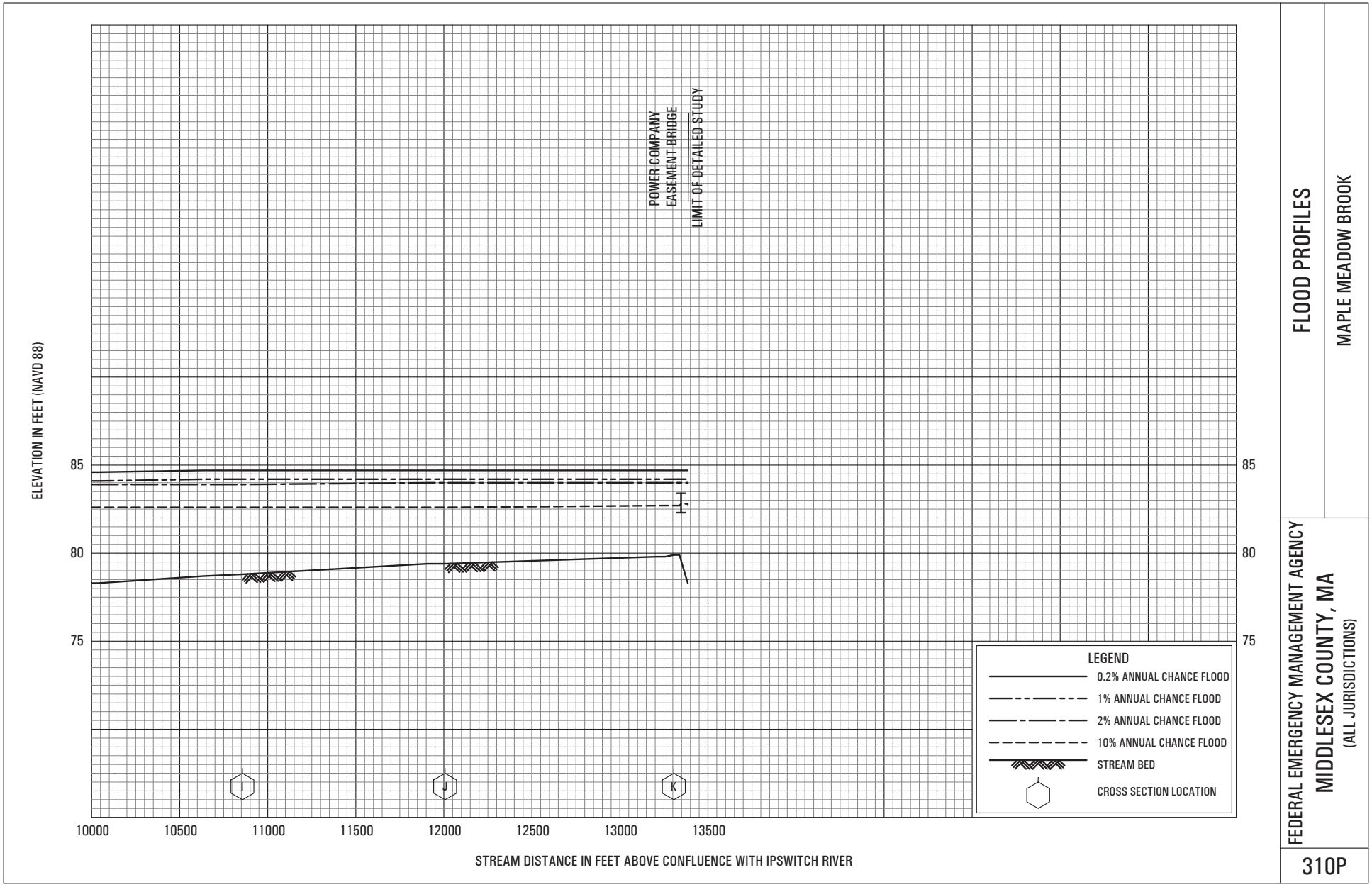
FEDERAL EMERGENCY MANAGEMENT AGENCY

MIDDLESEX COUNTY, MA

(ALL JURISDICTIONS)

308P


1% ANNUAL CHANCE BACKWATER
FROM IPSWICH RIVER
LOWELL STREET
STATE ROUTE 129
GRANITE SLAB OBSTRUCTION
MAIN STREET
RAILROAD
MIDDLESEX CANAL
ELEVATION IN FEET (NAVD 88)
85
80
75
70
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
STREAM DISTANCE IN FEET ABOVE CONFLUENCE WITH IPSWITCH RIVER
F
F
G
H
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
MAPLE MEADOW BROOK
FEDERAL EMERGENCY MANAGEMENT AGENCY
MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)
309P



FLOOD PROFILES

MAPLE MEADOW BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MIDDLESEX COUNTY, MA

(ALL JURISDICTIONS)

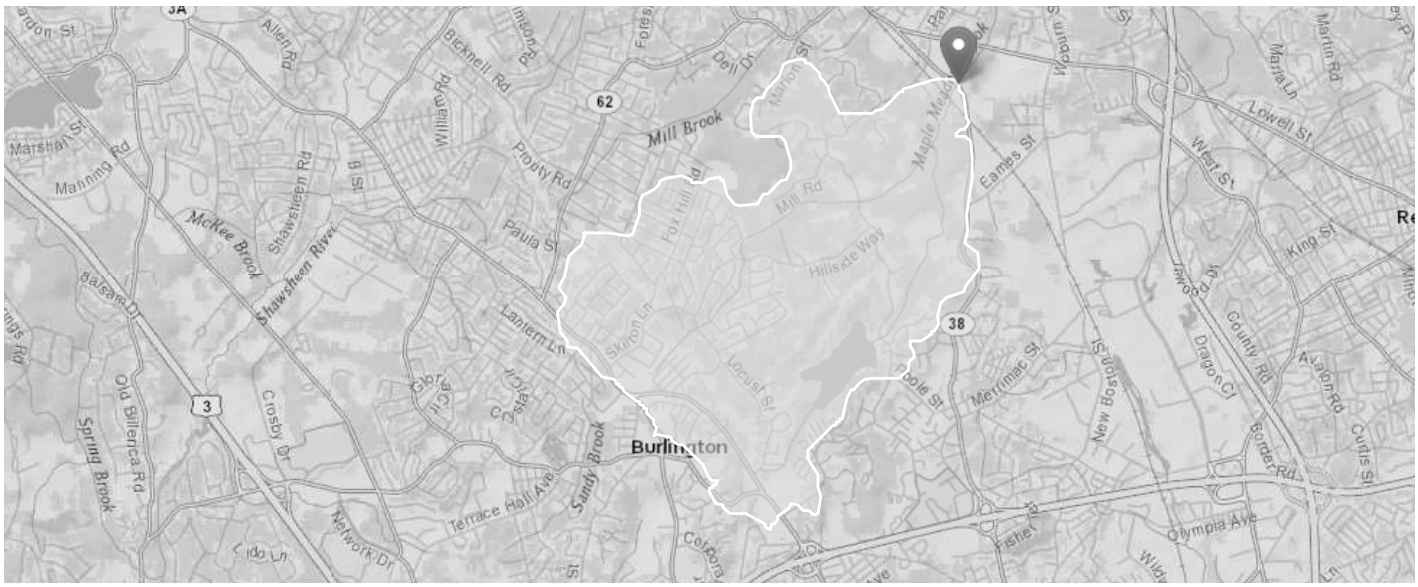
310P

APPENDIX B

USGS STREAMSTATS REPORT

Peak Flows at Maple Meadow Brook, Rte 38, Wilmington, MA

Region ID: MA
Workspace ID: MA20250320160748325000
Clicked Point (Latitude, Longitude): 42.53752, -71.16053
Time: 2025-03-20 12:08:22 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	4.03	square miles
ELEV	Mean Basin Elevation	139	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	10.85	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4.03	square miles	0.16	512
ELEV	Mean Basin Elevation	139	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	10.85	percent	0	32.3

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

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct, RMSE: Root Mean Squared Error, PseudoR^2: Pseudo R Squared (other -- see report)

Statistic	Value	Unit	PIL	PIU	ASEp
50-percent AEP flood	104	ft^3/s	53.1	204	42.3
20-percent AEP flood	171	ft^3/s	86.2	339	43.4
10-percent AEP flood	223	ft^3/s	110	453	44.7

Statistic	Value	Unit	PIL	PIU	ASEp
4-percent AEP flood	299	ft^3/s	142	629	47.1
2-percent AEP flood	361	ft^3/s	166	784	49.4
1-percent AEP flood	427	ft^3/s	191	956	51.8
0.5-percent AEP flood	498	ft^3/s	216	1150	54.1
0.2-percent AEP flood	600	ft^3/s	248	1450	57.6

Peak-Flow Statistics Citations

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

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

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USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.28.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

APPENDIX J

RANDOM FLOWS HEC-RAS ANALYSIS – SUMMARY TABLES AND PLOTS

HEC-RAS Plan: Existing rand Qs River: Maple Meadow Bro Reach: Maple Meadow Bro

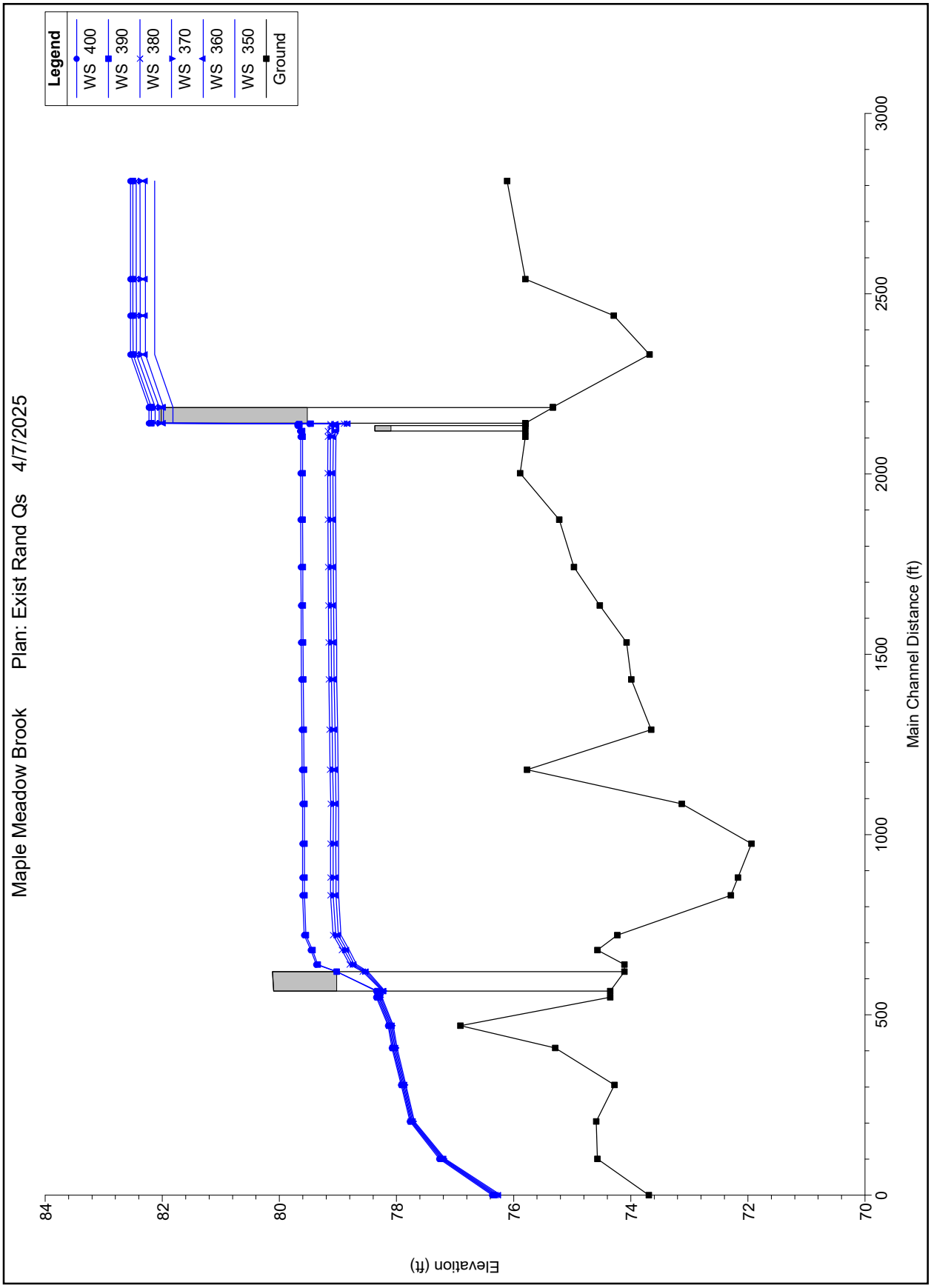
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2284	350	82.13	82.13		0.00	0.07	385.57	4.89	148.42	196.69	0.45
Maple Meadow Bro	2284	360	82.29	82.29		0.00	0.07	397.03	5.00	151.55	203.45	0.45
Maple Meadow Bro	2284	370	82.38	82.38		0.00	0.07	414.24	5.30	156.70	208.00	0.46
Maple Meadow Bro	2284	380	82.44	82.44		0.00	0.07	426.70	5.57	161.54	212.89	0.47
Maple Meadow Bro	2284	390	82.50	82.50		0.00	0.07	495.41	2.84	168.72	218.43	0.49
Maple Meadow Bro	2284	400	82.54	82.54		0.00	0.07	504.69	2.98	172.48	224.53	0.49
Maple Meadow Bro	2194.02	350	82.06	81.82	78.85			666.18	5.89	340.53	3.58	3.97
Maple Meadow Bro	2194.02	360	82.22	81.98	78.92			696.94	6.56	349.16	4.29	3.95
Maple Meadow Bro	2194.02	370	82.30	82.05	78.97			708.93	7.03	361.39	1.58	4.04
Maple Meadow Bro	2194.02	380	82.37	82.12	79.02			719.34	7.35	366.56	6.09	4.05
Maple Meadow Bro	2194.02	390	82.43	82.19	79.07			729.21	7.63	370.03	12.34	4.04
Maple Meadow Bro	2194.02	400	82.47	82.23	79.12			735.64	7.86	374.75	17.38	4.06
Maple Meadow Bro	2164.02 BR U	350	82.06	81.82	78.95					350.00		8.35
Maple Meadow Bro	2164.02 BR U	360	82.22	81.98	79.01					356.42	3.54	8.50
Maple Meadow Bro	2164.02 BR U	370	82.30	82.05	79.07					360.42	8.87	8.60
Maple Meadow Bro	2164.02 BR U	380	82.37	82.12	79.12			23.38		363.20	15.00	8.66
Maple Meadow Bro	2164.02 BR U	390	82.43	82.19	79.18			38.15		365.41	23.77	8.71
Maple Meadow Bro	2164.02 BR U	400	82.47	82.23	79.24			47.77		366.91	32.67	8.75
Maple Meadow Bro	2164.02 BR D	350	82.06	81.82	79.07					350.00		8.63
Maple Meadow Bro	2164.02 BR D	360	82.22	81.98	79.13					356.42	3.54	8.79
Maple Meadow Bro	2164.02 BR D	370	82.30	82.05	79.18					360.42	8.87	8.89
Maple Meadow Bro	2164.02 BR D	380	82.37	82.12	79.24			23.38		363.20	15.00	8.91
Maple Meadow Bro	2164.02 BR D	390	82.43	82.19	79.29			38.15		365.41	23.77	8.93
Maple Meadow Bro	2164.02 BR D	400	82.47	82.23	79.35			47.77		366.91	32.67	8.95
Maple Meadow Bro	2138.106	350	79.32	78.79		0.00	0.19	507.15		350.00		5.80
Maple Meadow Bro	2138.106	360	79.37	78.82		0.00	0.21	510.47		360.00		5.90
Maple Meadow Bro	2138.106	370	79.42	78.86		0.00	0.22	514.34		370.00		5.99
Maple Meadow Bro	2138.106	380	79.47	78.90		0.00	0.23	518.49		380.00		6.07
Maple Meadow Bro	2138.106	390	79.89	79.47		0.00	0.19	579.98		390.00		5.19
Maple Meadow Bro	2138.106	400	79.92	79.49		0.00	0.20	582.01		400.00		5.29
Maple Meadow Bro	2137.106	350	79.12	78.98	78.69			528.09	106.96	243.04		3.55
Maple Meadow Bro	2137.106	360	79.16	79.03	78.70			532.88	116.94	243.06		3.48
Maple Meadow Bro	2137.106	370	79.20	79.08	78.73			538.13	127.57	242.44		3.41
Maple Meadow Bro	2137.106	380	79.24	79.13	78.74			542.95	138.40	241.60		3.33
Maple Meadow Bro	2137.106	390	79.69	79.66	78.76	0.00	0.00	612.46	196.31	178.34	15.34	2.00
Maple Meadow Bro	2137.106	400	79.72	79.69	78.77	0.00	0.00	622.14	202.78	180.16	17.06	1.99

HEC-RAS Plan: Existing rand Qs River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2112.457BR U	350	79.12	78.98	79.08			282.95	294.29	54.75		1.95
Maple Meadow Bro	2112.457BR U	360	79.16	79.03	79.09			294.62	309.26	50.45		1.80
Maple Meadow Bro	2112.457BR U	370	79.20	79.08	79.11			307.44	317.83	47.60		1.70
Maple Meadow Bro	2112.457BR U	380	79.24	79.13	79.12			317.53	331.21	46.11	0.00	1.64
Maple Meadow Bro	2112.457BR U	390	79.68	79.66	79.13	0.04	0.00	445.23	325.89	60.56	3.55	2.15
Maple Meadow Bro	2112.457BR U	400	79.71	79.69	79.14	0.04	0.00	457.57	338.09	57.72	4.19	2.04
Maple Meadow Bro	2112.457BR D	350	79.12	78.98	79.08			282.95	294.29	54.75		1.93
Maple Meadow Bro	2112.457BR D	360	79.16	79.03	79.09			294.62	309.26	50.45		1.78
Maple Meadow Bro	2112.457BR D	370	79.20	79.08	79.10			307.44	317.83	47.60		1.68
Maple Meadow Bro	2112.457BR D	380	79.24	79.17	79.11			328.19	331.21	46.11	0.00	1.63
Maple Meadow Bro	2112.457BR D	390	79.64	79.61	79.12	0.01	0.00	429.12	318.53	68.72	2.74	2.42
Maple Meadow Bro	2112.457BR D	400	79.67	79.64	79.13	0.01	0.00	442.22	331.95	64.69	3.36	2.27
Maple Meadow Bro	2103.11	350	79.09	79.03		0.02	0.03	531.23	148.00	190.99	11.01	2.51
Maple Meadow Bro	2103.11	360	79.13	79.08		0.02	0.02	536.16	155.95	190.73	13.32	2.46
Maple Meadow Bro	2103.11	370	79.17	79.13		0.02	0.02	540.49	163.82	190.39	15.79	2.41
Maple Meadow Bro	2103.11	380	79.22	79.17		0.02	0.02	544.44	171.43	190.30	18.27	2.37
Maple Meadow Bro	2103.11	390	79.63	79.61		0.01	0.01	597.48	196.45	157.30	36.25	1.68
Maple Meadow Bro	2103.11	400	79.66	79.64		0.01	0.01	607.43	202.53	159.18	38.30	1.68
Maple Meadow Bro	2001.98	350	79.04	79.04	76.78	0.01	0.00	802.43	169.58	95.13	85.29	0.82
Maple Meadow Bro	2001.98	360	79.09	79.09	76.80	0.01	0.00	817.40	175.03	96.95	88.03	0.82
Maple Meadow Bro	2001.98	370	79.14	79.13	76.81	0.01	0.00	831.88	182.22	99.68	88.10	0.83
Maple Meadow Bro	2001.98	380	79.18	79.18	76.82	0.01	0.00	844.07	187.53	101.39	91.08	0.83
Maple Meadow Bro	2001.98	390	79.61	79.61	76.82	0.00	0.00	943.86	195.16	96.36	98.48	0.68
Maple Meadow Bro	2001.98	400	79.64	79.64	76.82	0.00	0.00	947.08	200.35	98.34	101.31	0.69
Maple Meadow Bro	679.8376	350	78.95	78.81	77.25	0.05	0.02	76.00	37.81	264.37	47.82	3.51
Maple Meadow Bro	679.8376	360	79.00	78.85	77.29	0.05	0.02	76.42	39.38	270.96	49.66	3.56
Maple Meadow Bro	679.8376	370	79.04	78.89	77.32	0.05	0.02	76.84	40.98	277.50	51.52	3.60
Maple Meadow Bro	679.8376	380	79.09	78.93	77.33	0.05	0.02	77.25	42.58	284.03	53.38	3.64
Maple Meadow Bro	679.8376	390	79.55	79.44	77.36	0.03	0.01	96.96	49.47	280.56	59.97	3.16
Maple Meadow Bro	679.8376	400	79.58	79.46	77.40	0.03	0.01	97.83	51.04	287.20	61.76	3.21
Maple Meadow Bro	639.83	350	78.89	78.68	77.28	0.04	0.04	49.13		350.00		3.64
Maple Meadow Bro	639.83	360	78.93	78.72	77.31	0.04	0.04	50.15		360.00		3.69
Maple Meadow Bro	639.83	370	78.98	78.76	77.33	0.04	0.04	50.72		370.00		3.73
Maple Meadow Bro	639.83	380	79.02	78.80	77.37	0.04	0.04	51.26		380.00		3.78
Maple Meadow Bro	639.83	390	79.51	79.35	77.41			62.83		390.00		3.22
Maple Meadow Bro	639.83	400	79.53	79.37	77.45			63.43		400.00		3.27

HEC-RAS Plan: Existing rand Qs River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	590.17 BR U	350	78.81	78.49	77.31	0.17	0.03	27.31		350.00		4.57
Maple Meadow Bro	590.17 BR U	360	78.85	78.52	77.36	0.18	0.03	27.31		360.00		4.65
Maple Meadow Bro	590.17 BR U	370	78.90	78.55	77.41	0.18	0.03	27.30		370.00		4.73
Maple Meadow Bro	590.17 BR U	380	78.94	78.58	77.45	0.19	0.03	27.30		380.00		4.81
Maple Meadow Bro	590.17 BR U	390	79.51	79.02	77.49					390.00		4.32
Maple Meadow Bro	590.17 BR U	400	79.53	79.02	77.53					400.00		4.44
Maple Meadow Bro	590.17 BR D	350	78.61	78.19	77.44	0.04	0.10	27.33		350.00		5.18
Maple Meadow Bro	590.17 BR D	360	78.65	78.21	77.48	0.04	0.10	27.32		360.00		5.29
Maple Meadow Bro	590.17 BR D	370	78.68	78.23	77.51	0.05	0.11	27.32		370.00		5.40
Maple Meadow Bro	590.17 BR D	380	78.72	78.24	77.54	0.05	0.11	27.32		380.00		5.52
Maple Meadow Bro	590.17 BR D	390	78.58	78.33	77.57			27.32		390.00		5.48
Maple Meadow Bro	590.17 BR D	400	78.61	78.34	77.61			27.32		400.00		5.58
Maple Meadow Bro	548.93	350	78.47	78.25		0.24	0.04	114.71		348.88	1.12	3.77
Maple Meadow Bro	548.93	360	78.50	78.27		0.24	0.04	115.74		358.82	1.18	3.85
Maple Meadow Bro	548.93	370	78.53	78.29		0.24	0.05	116.74		368.76	1.24	3.92
Maple Meadow Bro	548.93	380	78.56	78.31		0.25	0.05	117.65		378.70	1.30	4.00
Maple Meadow Bro	548.93	390	78.58	78.33		0.25	0.06	118.55		388.64	1.36	4.08
Maple Meadow Bro	548.93	400	78.61	78.34		0.26	0.06	119.44		398.58	1.42	4.15
Maple Meadow Bro	469.67	350	78.19	78.05		0.12	0.02	175.91	140.32	145.68	64.00	4.21
Maple Meadow Bro	469.67	360	78.21	78.07		0.12	0.02	176.03	143.76	149.56	66.68	4.25
Maple Meadow Bro	469.67	370	78.23	78.09		0.12	0.02	176.14	147.19	153.44	69.37	4.28
Maple Meadow Bro	469.67	380	78.25	78.11		0.12	0.03	176.25	150.63	157.32	72.05	4.32
Maple Meadow Bro	469.67	390	78.27	78.13		0.12	0.03	176.36	154.07	161.20	74.73	4.36
Maple Meadow Bro	469.67	400	78.29	78.14		0.12	0.03	176.47	157.49	165.07	77.44	4.39


Maple Meadow Brook Plan: Exist Rand Qs 4/7/2025
Legend
WS 400
WS 390
WS 380
WS 370
WS 360
WS 350
Ground
Elevation (ft)
84
82
80
78
76
74
72
70
Main Channel Distance (ft)
0
500
1000
1500
2000
2500
3000

APPENDIX C

DUPLICATE EFFECTIVE MODEL HEC-RAS ANALYSIS – SUMMARY TABLES AND PLOTS

HEC-RAS Plan: hec2 River: maple Reach: Alignment - 5

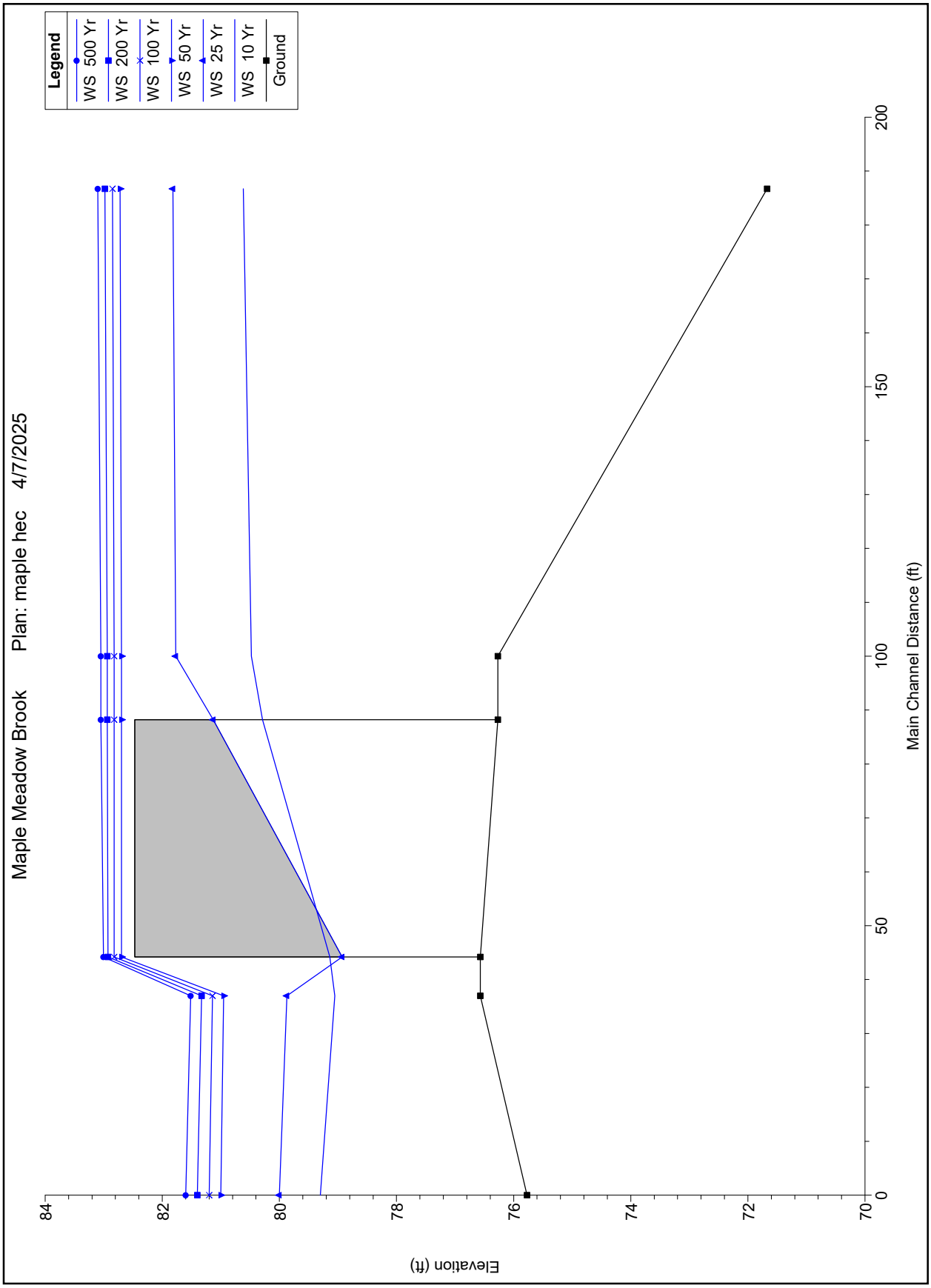
Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Alignment - 5	147.5	10 Yr	80.62	80.62		0.00	0.01	460.22		128.02	31.98	0.23
Alignment - 5	147.5	25 Yr	81.82	81.82		0.00	0.00	570.38	0.06	154.98	62.96	0.22
Alignment - 5	147.5	50 Yr	82.72	82.72		0.00	0.00	704.89	1.59	173.38	85.03	0.21
Alignment - 5	147.5	100 Yr	82.85	82.85		0.00	0.00	724.03	2.36	204.86	102.78	0.24
Alignment - 5	147.5	200 Yr	82.98	82.98		0.00	0.00	742.88	3.47	246.94	126.59	0.29
Alignment - 5	147.5	500 Yr	83.10	83.10		0.00	0.00	760.87	5.01	298.75	156.24	0.34
Alignment - 5	84.5	10 Yr	80.60	80.48	78.47	0.08	0.01	37.84		160.00		2.83
Alignment - 5	84.5	25 Yr	81.82	81.77	78.88			74.80		218.00		1.69
Alignment - 5	84.5	50 Yr	82.72	82.70	79.15			206.34		257.23	2.77	1.22
Alignment - 5	84.5	100 Yr	82.85	82.82	79.40			249.30		302.93	7.07	1.36
Alignment - 5	84.5	200 Yr	82.98	82.94	80.40			290.64		362.37	14.63	1.54
Alignment - 5	84.5	500 Yr	83.10	83.05	80.72			329.03		433.75	26.25	1.76
Alignment - 5	60.8 BR U	10 Yr	80.51	80.29	78.48	0.66	0.04	11.70		160.00		3.78
Alignment - 5	60.8 BR U	25 Yr	81.81	81.13	78.89					218.00		4.18
Alignment - 5	60.8 BR U	50 Yr	82.72	82.70	79.16			206.34		234.81	25.09	3.17
Alignment - 5	60.8 BR U	100 Yr	82.85	82.82	79.47			249.30		253.97	55.72	2.95
Alignment - 5	60.8 BR U	200 Yr	82.97	82.94	79.86			290.64		277.57	99.43	2.82
Alignment - 5	60.8 BR U	500 Yr	83.09	83.05	80.31			329.03		303.81	154.88	2.77
Alignment - 5	60.8 BR D	10 Yr	79.81	79.14	78.65	0.31	0.09			160.00		6.57
Alignment - 5	60.8 BR D	25 Yr	80.06	78.93	82.75					218.00		8.95
Alignment - 5	60.8 BR D	50 Yr	82.72	82.70	82.81			206.34		234.81	25.09	5.18
Alignment - 5	60.8 BR D	100 Yr	82.85	82.82	82.86			249.30		253.97	55.72	4.48
Alignment - 5	60.8 BR D	200 Yr	82.97	82.93	82.93			286.65		277.57	99.43	4.17
Alignment - 5	60.8 BR D	500 Yr	83.09	83.01	83.01			313.91		303.81	154.88	4.12
Alignment - 5	37.01	10 Yr	79.41	79.05		0.00	0.11	28.67		160.00		4.80
Alignment - 5	37.01	25 Yr	80.06	79.87		0.00	0.06	44.29		218.00		3.45
Alignment - 5	37.01	50 Yr	81.02	80.95		0.00	0.02	64.91		260.00		2.13
Alignment - 5	37.01	100 Yr	81.23	81.14		0.00	0.02	68.57		310.00		2.30
Alignment - 5	37.01	200 Yr	81.43	81.33		0.00	0.03	72.15		377.00		2.54
Alignment - 5	37.01	500 Yr	81.64	81.51		0.00	0.04	75.63		460.00		2.85
Alignment - 5	0	10 Yr	79.30	79.30	77.05			1056.12		160.00		0.21
Alignment - 5	0	25 Yr	80.00	80.00	77.24			1142.92		218.00		0.14
Alignment - 5	0	50 Yr	81.00	81.00	77.36			1266.92		260.00		0.09
Alignment - 5	0	100 Yr	81.20	81.20	77.49			1291.72		310.00		0.10
Alignment - 5	0	200 Yr	81.40	81.40	77.83			1316.52		377.00		0.12

HEC-RAS Plan: hec2 River: maple Reach: Alignment - 5 (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Alignment - 5	0	500 Yr	81.60	81.60	77.94			1341.32		460.00		0.13

HEC-RAS Plan: hec2 River: maple Reach: Alignment - 5

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)	
Alignment - 5	147.5	10 Yr	160.00	71.67	80.62		80.62	0.000003	0.23	1176.86	460.22	0.02
Alignment - 5	147.5	25 Yr	218.00	71.67	81.82		81.82	0.000002	0.22	1782.22	570.38	0.02
Alignment - 5	147.5	50 Yr	260.00	71.67	82.72		82.72	0.000002	0.21	2359.13	704.89	0.01
Alignment - 5	147.5	100 Yr	310.00	71.67	82.85		82.85	0.000002	0.24	2451.15	724.03	0.02
Alignment - 5	147.5	200 Yr	377.00	71.67	82.98		82.98	0.000003	0.29	2544.13	742.88	0.02
Alignment - 5	147.5	500 Yr	460.00	71.67	83.10		83.10	0.000004	0.34	2635.10	760.87	0.02
Alignment - 5	84.5	10 Yr	160.00	76.27	80.48	78.47	80.60	0.007564	2.83	56.57	37.84	0.41
Alignment - 5	84.5	25 Yr	218.00	76.27	81.77	78.88	81.82	0.002053	1.69	129.23	74.80	0.23
Alignment - 5	84.5	50 Yr	260.00	76.27	82.70	79.15	82.72	0.000792	1.22	228.20	206.34	0.15
Alignment - 5	84.5	100 Yr	310.00	76.27	82.82	79.40	82.85	0.000938	1.36	256.26	249.30	0.16
Alignment - 5	84.5	200 Yr	377.00	76.27	82.94	80.40	82.98	0.001158	1.54	288.24	290.64	0.18
Alignment - 5	84.5	500 Yr	460.00	76.27	83.05	80.72	83.10	0.001453	1.76	322.34	329.03	0.20
Alignment - 5	60.8		Bridge									
Alignment - 5	37.01	10 Yr	160.00	76.57	79.05		79.41	0.028680	4.80	33.37	28.67	0.78
Alignment - 5	37.01	25 Yr	218.00	76.57	79.87		80.06	0.010915	3.45	63.22	44.29	0.51
Alignment - 5	37.01	50 Yr	260.00	76.57	80.95		81.02	0.002816	2.13	122.16	64.91	0.27
Alignment - 5	37.01	100 Yr	310.00	76.57	81.14		81.23	0.003082	2.30	134.98	68.57	0.29
Alignment - 5	37.01	200 Yr	377.00	76.57	81.33		81.43	0.003570	2.54	148.14	72.15	0.31
Alignment - 5	37.01	500 Yr	460.00	76.57	81.51		81.64	0.004224	2.85	161.63	75.63	0.34
Alignment - 5	0	10 Yr	160.00	75.77	79.30	77.05	79.30	0.000019	0.21	768.25	1056.12	0.04
Alignment - 5	0	25 Yr	218.00	75.77	80.00	77.24	80.00	0.000004	0.14	1537.91	1142.92	0.02
Alignment - 5	0	50 Yr	260.00	75.77	81.00	77.36	81.00	0.000001	0.09	2742.83	1266.92	0.01
Alignment - 5	0	100 Yr	310.00	75.77	81.20	77.49	81.20	0.000001	0.10	2998.69	1291.72	0.01
Alignment - 5	0	200 Yr	377.00	75.77	81.40	77.83	81.40	0.000001	0.12	3259.52	1316.52	0.01
Alignment - 5	0	500 Yr	460.00	75.77	81.60	77.94	81.60	0.000001	0.13	3525.30	1341.32	0.01


Maple Meadow Brook Plan: maple hec 4/7/2025
Legend
WS 500 Yr
WS 200 Yr
WS 100 Yr
WS 50 Yr
WS 25 Yr
WS 10 Yr
Ground
Elevation (ft)
84
82
80
78
76
74
72
70
Main Channel Distance (ft)
0
50
100
150
200

APPENDIX D

EXISTING CONDITIONS MODEL HEC-RAS ANALYSIS – SUMMARY TABLES AND PLOTS

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2284	10-yr	82.50	82.50		0.00	0.11	494.28	3.29	196.06	253.65	0.56
Maple Meadow Bro	2284	25-yr	82.99	82.99		0.01	0.21	601.84	7.80	260.82	360.38	0.71
Maple Meadow Bro	2284	50-yr	83.35	83.34		0.01	0.38	671.93	15.45	316.00	452.55	0.82
Maple Meadow Bro	2284	100-yr	83.84	83.84		0.01	0.02	793.94	31.02	368.40	556.58	0.91
Maple Meadow Bro	2284	200-yr	84.01	84.01		0.01	0.02	862.93	44.48	446.50	659.02	1.08
Maple Meadow Bro	2284	500-yr	84.21	84.20		0.01	0.02	960.89	68.87	574.48	806.65	1.37
Maple Meadow Bro	2284	2-yr	80.22	80.22		0.00	0.06	342.93	3.19	99.97	100.83	0.40
Maple Meadow Bro	2284	5-yr	81.92	81.92		0.00	0.07	378.52	5.00	145.61	188.39	0.45
Maple Meadow Bro	2194.02	10-yr	82.39	82.02	79.36			702.93	8.39	439.04	5.57	4.94
Maple Meadow Bro	2194.02	25-yr	82.77	82.07	80.14			711.50	12.01	612.83	4.16	6.83
Maple Meadow Bro	2194.02	50-yr	82.97	81.70	80.79			623.25	12.37	764.59	7.05	9.13
Maple Meadow Bro	2194.02	100-yr	83.82	83.76	82.87	0.00	0.00	1119.12	242.14	369.04	344.82	3.15
Maple Meadow Bro	2194.02	200-yr	83.99	83.92	83.02	0.00	0.00	1158.77	315.57	404.07	430.36	3.38
Maple Meadow Bro	2194.02	500-yr	84.18	84.11	83.22	0.00	0.00	1164.59	428.86	454.88	566.26	3.71
Maple Meadow Bro	2194.02	2-yr	80.15	79.94	78.01			327.03	0.55	203.45		3.67
Maple Meadow Bro	2194.02	5-yr	81.84	81.59	78.80			559.77	5.03	331.28	2.68	4.04
Maple Meadow Bro	2164.02 BR U	10-yr	82.38	82.02	82.99					434.77	16.88	10.37
Maple Meadow Bro	2164.02 BR U	25-yr	82.78	82.07	83.15				47.88	427.69	150.46	10.20
Maple Meadow Bro	2164.02 BR U	50-yr	82.96	81.70	83.26				114.23	412.43	251.17	9.84
Maple Meadow Bro	2164.02 BR U	100-yr	83.82	83.76	83.26	0.33	0.04	663.50	342.62	172.33	441.04	3.42
Maple Meadow Bro	2164.02 BR U	200-yr	83.98	83.92	83.31	0.40	0.06	793.35	404.12	195.41	550.47	3.69
Maple Meadow Bro	2164.02 BR U	500-yr	84.17	84.11	83.43	0.42	0.08	894.68	536.35	214.74	698.91	3.84
Maple Meadow Bro	2164.02 BR U	2-yr	80.15	79.52	78.03					204.00		4.87
Maple Meadow Bro	2164.02 BR U	5-yr	81.84	79.52	78.89					339.00		8.08
Maple Meadow Bro	2164.02 BR D	10-yr	82.38	82.02	82.94					434.77	16.88	10.72
Maple Meadow Bro	2164.02 BR D	25-yr	82.78	82.07	83.09				47.88	427.69	150.46	10.54
Maple Meadow Bro	2164.02 BR D	50-yr	82.96	81.70	83.18				114.23	412.43	251.17	10.17
Maple Meadow Bro	2164.02 BR D	100-yr	83.45	83.26	83.26	0.01	0.39	533.43	237.06	267.98	450.96	5.52
Maple Meadow Bro	2164.02 BR D	200-yr	83.53	83.26	83.26	0.02	0.58	532.26	284.25	323.38	542.37	6.68
Maple Meadow Bro	2164.02 BR D	500-yr	83.67	83.34	83.34	0.01	0.03	553.34	378.22	386.09	685.68	7.59
Maple Meadow Bro	2164.02 BR D	2-yr	79.21	78.85	78.15			11.60		204.00		6.22
Maple Meadow Bro	2164.02 BR D	5-yr	80.49	79.38	79.00			11.60		339.00		8.69
Maple Meadow Bro	2138.106	10-yr	80.13	79.60		0.00	0.25	596.37		453.00		5.80
Maple Meadow Bro	2138.106	25-yr	80.86	80.07		0.00	0.38	720.91		629.00		7.11
Maple Meadow Bro	2138.106	50-yr	81.48	80.46		0.00	0.50	815.44		784.00		8.08
Maple Meadow Bro	2138.106	100-yr	81.99	80.51		0.00	0.73	819.04		956.00		9.76
Maple Meadow Bro	2138.106	200-yr	82.65	80.45	80.45	0.00	1.09	811.54		1150.00		11.90
Maple Meadow Bro	2138.106	500-yr	82.63	82.36		0.00	0.13	846.54	410.24	824.15	215.61	5.54

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2138.106	2-yr	79.02	78.85		0.00	0.06	512.84		204.00		3.32
Maple Meadow Bro	2138.106	5-yr	79.72	79.38		0.00	0.15	569.07		339.00		4.63
Maple Meadow Bro	2137.106	10-yr	79.88	79.85	78.84	0.00	0.01	654.35	235.35	190.27	27.37	1.99
Maple Meadow Bro	2137.106	25-yr	80.48	80.46	79.04	0.00	0.00	813.82	346.10	209.18	73.72	1.82
Maple Meadow Bro	2137.106	50-yr	80.98	80.96	79.23	0.00	0.00	826.19	444.38	215.16	124.47	1.64
Maple Meadow Bro	2137.106	100-yr	81.25	81.24	79.31	0.00	0.00	830.44	548.58	240.50	166.92	1.72
Maple Meadow Bro	2137.106	200-yr	81.51	81.50	79.46	0.00	0.00	834.50	665.42	269.43	215.15	1.81
Maple Meadow Bro	2137.106	500-yr	82.50	82.49	79.62	0.00	0.00	849.81	853.89	278.95	317.16	1.55
Maple Meadow Bro	2137.106	2-yr	78.96	78.90	77.44			518.92	54.22	149.78		2.26
Maple Meadow Bro	2137.106	5-yr	79.56	79.53	78.00	0.00	0.00	586.41	164.68	165.74	8.58	1.94
Maple Meadow Bro	2112.457BR U	10-yr	79.87	79.85	79.18	0.03	0.00	504.37	394.17	50.33	8.50	1.68
Maple Meadow Bro	2112.457BR U	25-yr	80.47	80.46	79.30	0.01	0.00	711.20	538.55	54.51	35.94	1.18
Maple Meadow Bro	2112.457BR U	50-yr	80.97	80.96	79.38	0.01	0.00	763.17	638.40	65.57	80.03	1.05
Maple Meadow Bro	2112.457BR U	100-yr	81.25	81.24	79.47	0.01	0.00	776.37	758.24	78.23	119.53	1.10
Maple Meadow Bro	2112.457BR U	200-yr	81.51	81.50	79.55	0.01	0.00	788.97	893.03	92.40	164.56	1.16
Maple Meadow Bro	2112.457BR U	500-yr	82.50	82.49	79.70	0.00	0.00	840.26	1064.09	110.58	275.33	0.99
Maple Meadow Bro	2112.457BR U	2-yr	78.96	78.90	77.79			260.59	157.91	36.94		1.32
Maple Meadow Bro	2112.457BR U	5-yr	79.56	79.53	79.06	0.05	0.00	406.98	270.55	67.01	1.44	2.39
Maple Meadow Bro	2112.457BR D	10-yr	79.83	79.82	79.19	0.01	0.00	500.42	391.23	54.10	7.67	1.80
Maple Meadow Bro	2112.457BR D	25-yr	80.46	80.45	79.31	0.01	0.00	706.68	537.67	56.16	35.17	1.21
Maple Meadow Bro	2112.457BR D	50-yr	80.96	80.96	79.39	0.00	0.00	762.83	637.83	66.34	79.82	1.07
Maple Meadow Bro	2112.457BR D	100-yr	81.24	81.23	79.47	0.00	0.00	776.05	757.66	78.63	119.71	1.11
Maple Meadow Bro	2112.457BR D	200-yr	81.50	81.50	79.56	0.00	0.00	788.67	892.42	92.43	165.15	1.17
Maple Meadow Bro	2112.457BR D	500-yr	82.49	82.49	79.70	0.00	0.00	836.28	1063.31	109.26	277.43	1.00
Maple Meadow Bro	2112.457BR D	2-yr	78.94	78.92	77.78			265.21	157.91	36.94		1.30
Maple Meadow Bro	2112.457BR D	5-yr	79.51	79.48	79.07	0.01	0.01	395.04	263.80	74.30	0.90	2.62
Maple Meadow Bro	2103.11	10-yr	79.82	79.81		0.01	0.01	648.04	231.85	170.86	50.29	1.71
Maple Meadow Bro	2103.11	25-yr	80.45	80.43		0.01	0.01	805.18	340.00	195.55	93.45	1.64
Maple Meadow Bro	2103.11	50-yr	80.96	80.95		0.01	0.00	825.15	438.48	203.20	142.32	1.50
Maple Meadow Bro	2103.11	100-yr	81.24	81.22		0.01	0.00	829.56	541.90	228.72	185.38	1.59
Maple Meadow Bro	2103.11	200-yr	81.50	81.49		0.01	0.00	833.76	658.14	257.60	234.27	1.69
Maple Meadow Bro	2103.11	500-yr	82.49	82.48		0.01	0.00	849.19	848.13	269.51	332.35	1.47
Maple Meadow Bro	2103.11	2-yr	78.94	78.92		0.01	0.01	519.17	80.24	120.08	3.68	1.66
Maple Meadow Bro	2103.11	5-yr	79.49	79.47		0.01	0.01	574.39	166.66	145.00	27.34	1.62
Maple Meadow Bro	2001.98	10-yr	79.81	79.81	76.89	0.00	0.00	964.01	228.02	108.63	116.35	0.72
Maple Meadow Bro	2001.98	25-yr	80.44	80.43	76.95	0.00	0.00	1033.76	322.72	139.25	167.03	0.79
Maple Meadow Bro	2001.98	50-yr	80.95	80.95	76.95	0.00	0.00	1047.68	415.39	161.45	207.16	0.81

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2001.98	100-yr	81.23	81.22	77.48	0.00	0.00	1055.12	513.22	190.69	252.09	0.90
Maple Meadow Bro	2001.98	200-yr	81.49	81.48	77.59	0.00	0.00	1095.19	623.99	223.29	302.73	1.00
Maple Meadow Bro	2001.98	500-yr	82.48	82.48	77.73	0.00	0.00	1214.25	810.16	259.68	380.16	0.98
Maple Meadow Bro	2001.98	2-yr	78.92	78.92	76.53	0.00	0.00	744.05	97.87	56.87	49.25	0.51
Maple Meadow Bro	2001.98	5-yr	79.48	79.47	76.76	0.00	0.00	921.79	168.98	85.57	84.45	0.63
Maple Meadow Bro	679.8376	10-yr	79.74	79.61	77.56	0.03	0.02	101.26	59.27	322.29	71.45	3.49
Maple Meadow Bro	679.8376	25-yr	80.36	80.15	78.06	0.04	0.02	184.63	91.59	448.84	88.56	4.31
Maple Meadow Bro	679.8376	50-yr	80.87	80.63	78.39	0.05	0.03	319.35	121.86	542.52	119.63	4.74
Maple Meadow Bro	679.8376	100-yr	81.13	80.74	78.72	0.07	0.03	340.98	137.04	685.62	133.34	5.87
Maple Meadow Bro	679.8376	200-yr	81.36	80.85	79.05	0.09	0.06	359.69	163.36	812.40	174.24	6.82
Maple Meadow Bro	679.8376	500-yr	82.41	82.20	79.52	0.03	0.02	725.14	238.60	751.78	459.62	5.08
Maple Meadow Bro	679.8376	2-yr	78.89	78.84	76.69	0.02	0.00	76.36	22.28	153.61	28.10	2.02
Maple Meadow Bro	679.8376	5-yr	79.43	79.33	77.22	0.02	0.01	93.65	42.03	245.67	51.30	2.84
Maple Meadow Bro	639.83	10-yr	79.69	79.49	77.64			66.68		453.00		3.57
Maple Meadow Bro	639.83	25-yr	80.29	80.01	78.15			84.97		629.00		4.30
Maple Meadow Bro	639.83	50-yr	80.80	80.46	78.51			234.38		774.39	9.61	4.72
Maple Meadow Bro	639.83	100-yr	81.03	80.56	78.85			271.14	0.41	937.17	18.42	5.59
Maple Meadow Bro	639.83	200-yr	81.20	80.47	79.20			237.43		1134.81	15.19	6.90
Maple Meadow Bro	639.83	500-yr	82.36	82.19	79.72	0.03	0.05	815.90	199.44	940.15	310.41	4.07
Maple Meadow Bro	639.83	2-yr	78.87	78.81	76.71	0.01	0.01	51.41		204.00		2.02
Maple Meadow Bro	639.83	5-yr	79.39	79.26	77.24			60.67		339.00		2.87
Maple Meadow Bro	590.17 BR U	10-yr	79.69	79.02	77.73					453.00		5.02
Maple Meadow Bro	590.17 BR U	25-yr	80.29	80.01	78.23					620.81	8.18	6.88
Maple Meadow Bro	590.17 BR U	50-yr	80.80	80.46	78.64			136.86	12.51	607.06	163.94	6.73
Maple Meadow Bro	590.17 BR U	100-yr	81.03	80.56	81.25			177.93	49.35	609.01	296.72	6.75
Maple Meadow Bro	590.17 BR U	200-yr	81.20	80.47	81.39			138.58	101.72	629.34	423.62	6.98
Maple Meadow Bro	590.17 BR U	500-yr	82.29	82.21	81.68	0.31	0.07	748.64	387.42	347.44	715.14	3.85
Maple Meadow Bro	590.17 BR U	2-yr	78.85	78.76	76.68	0.04	0.00	27.29		204.00		2.43
Maple Meadow Bro	590.17 BR U	5-yr	79.39	79.02	77.27					339.00		3.76
Maple Meadow Bro	590.17 BR D	10-yr	79.12	78.89	77.77			27.28		453.00		5.23
Maple Meadow Bro	590.17 BR D	25-yr	80.25	80.01	78.27					620.81	8.18	6.96
Maple Meadow Bro	590.17 BR D	50-yr	80.73	80.46	78.66			155.69	12.51	607.06	163.94	6.81
Maple Meadow Bro	590.17 BR D	100-yr	81.03	80.56	81.20			199.92	49.35	609.01	296.72	6.81
Maple Meadow Bro	590.17 BR D	200-yr	81.20	80.47	81.39			157.60	101.72	629.34	423.62	7.06
Maple Meadow Bro	590.17 BR D	500-yr	81.91	81.59	81.59	0.12	0.18	601.31	182.43	618.58	648.99	6.57
Maple Meadow Bro	590.17 BR D	2-yr	78.81	78.72	76.90	0.01	0.02	27.29		204.00		2.49
Maple Meadow Bro	590.17 BR D	5-yr	78.96	78.82	77.41			27.29		339.00		4.01

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	548.93	10-yr	79.12	78.89		0.11	0.09	132.21		450.61	2.39	3.89
Maple Meadow Bro	548.93	25-yr	79.51	79.12		0.16	0.14	136.14		625.30	3.70	5.04
Maple Meadow Bro	548.93	50-yr	80.13	79.68		0.12	0.19	145.71		779.72	4.28	5.40
Maple Meadow Bro	548.93	100-yr	80.46	79.90	78.47	0.15	0.24	170.03	0.42	934.35	21.23	6.07
Maple Meadow Bro	548.93	200-yr	80.74	79.99	78.84	0.19	0.32	177.34	1.81	1113.47	34.72	7.03
Maple Meadow Bro	548.93	500-yr	81.20	80.30	79.34	0.19	0.39	224.19	12.35	1359.52	78.13	7.88
Maple Meadow Bro	548.93	2-yr	78.78	78.73		0.03	0.02	129.46		203.02	0.98	1.85
Maple Meadow Bro	548.93	5-yr	78.96	78.82		0.07	0.05	131.00		337.28	1.72	2.98
Maple Meadow Bro	469.67	10-yr	78.93	78.86		0.04	0.01	228.79	166.39	177.56	109.05	2.92
Maple Meadow Bro	469.67	25-yr	79.20	79.10		0.05	0.02	272.26	207.71	256.49	164.80	3.74
Maple Meadow Bro	469.67	50-yr	79.82	79.75		0.03	0.01	331.78	276.60	298.75	208.65	3.34
Maple Meadow Bro	469.67	100-yr	80.07	79.99		0.04	0.01	351.91	354.30	351.10	250.60	3.61
Maple Meadow Bro	469.67	200-yr	80.24	80.12		0.05	0.02	360.12	451.08	420.92	278.00	4.14
Maple Meadow Bro	469.67	500-yr	80.62	80.49		0.05	0.02	378.19	617.22	504.81	327.98	4.45
Maple Meadow Bro	469.67	2-yr	78.74	78.72		0.01	0.00	214.83	75.22	80.82	47.97	1.44
Maple Meadow Bro	469.67	5-yr	78.84	78.80		0.02	0.01	221.78	124.68	133.51	80.81	2.27

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro

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)	
Maple Meadow Bro	2765.14	10-yr	453.00	76.11	82.50	77.01	82.50	0.000007	0.44	3883.37	1499.09	0.03
Maple Meadow Bro	2765.14	25-yr	629.00	76.11	83.00	77.14	83.00	0.000008	0.50	4559.60	1560.53	0.03
Maple Meadow Bro	2765.14	50-yr	784.00	76.11	83.35	77.24	83.35	0.000009	0.55	5046.83	1593.35	0.04
Maple Meadow Bro	2765.14	100-yr	956.00	76.11	83.85	77.34	83.85	0.000009	0.58	5733.76	1618.56	0.04
Maple Meadow Bro	2765.14	200-yr	1150.00	76.11	84.02	77.47	84.02	0.000012	0.66	5970.47	1622.83	0.04
Maple Meadow Bro	2765.14	500-yr	1450.00	76.11	84.22	77.61	84.22	0.000016	0.79	6245.32	1627.78	0.05
Maple Meadow Bro	2765.14	2-yr	204.00	76.11	80.22	76.70	80.22	0.000008	0.36	1514.94	732.67	0.03
Maple Meadow Bro	2765.14	5-yr	339.00	76.11	81.92	76.90	81.92	0.000006	0.39	3138.86	1138.56	0.03
Maple Meadow Bro	2492.94	10-yr	453.00	75.80	82.50	76.60	82.50	0.000004	0.32	3340.63	1094.79	0.02
Maple Meadow Bro	2492.94	25-yr	629.00	75.80	82.99	76.75	83.00	0.000006	0.42	3771.22	1326.34	0.03
Maple Meadow Bro	2492.94	50-yr	784.00	75.80	83.35	76.93	83.35	0.000007	0.48	4084.90	1369.26	0.03
Maple Meadow Bro	2492.94	100-yr	956.00	75.80	83.85	76.97	83.85	0.000008	0.53	4529.03	1412.86	0.03
Maple Meadow Bro	2492.94	200-yr	1150.00	75.80	84.01	77.17	84.02	0.000010	0.62	4681.27	1423.41	0.04
Maple Meadow Bro	2492.94	500-yr	1450.00	75.80	84.21	77.31	84.21	0.000015	0.75	4857.45	1461.85	0.05
Maple Meadow Bro	2492.94	2-yr	204.00	75.80	80.22	76.27	80.22	0.000004	0.24	1825.13	540.82	0.02
Maple Meadow Bro	2492.94	5-yr	339.00	75.80	81.92	76.47	81.92	0.000003	0.27	2891.70	929.10	0.02
Maple Meadow Bro	2391.78	10-yr	453.00	74.29	82.50	76.30	82.50	0.000004	0.40	2917.64	902.05	0.03
Maple Meadow Bro	2391.78	25-yr	629.00	74.29	82.99	76.50	82.99	0.000007	0.51	3236.26	1033.58	0.03
Maple Meadow Bro	2391.78	50-yr	784.00	74.29	83.35	76.60	83.35	0.000009	0.61	3472.14	1151.61	0.04
Maple Meadow Bro	2391.78	100-yr	956.00	74.29	83.84	76.79	83.85	0.000010	0.68	3812.66	1214.85	0.04
Maple Meadow Bro	2391.78	200-yr	1150.00	74.29	84.01	76.91	84.02	0.000013	0.79	3928.91	1241.38	0.05
Maple Meadow Bro	2391.78	500-yr	1450.00	74.29	84.21	77.08	84.21	0.000019	0.96	4062.87	1271.94	0.06
Maple Meadow Bro	2391.78	2-yr	204.00	74.29	80.22	75.68	80.22	0.000003	0.28	1766.52	432.97	0.02
Maple Meadow Bro	2391.78	5-yr	339.00	74.29	81.92	76.08	81.92	0.000003	0.34	2554.66	828.86	0.02
Maple Meadow Bro	2284	10-yr	453.00	73.68	82.50		82.50	0.000008	0.56	2060.27	494.28	0.03
Maple Meadow Bro	2284	25-yr	629.00	73.68	82.99		82.99	0.000012	0.71	2331.87	601.84	0.04
Maple Meadow Bro	2284	50-yr	784.00	73.68	83.34		83.35	0.000015	0.82	2556.45	671.93	0.05
Maple Meadow Bro	2284	100-yr	956.00	73.68	83.84		83.84	0.000017	0.91	2917.52	793.94	0.05
Maple Meadow Bro	2284	200-yr	1150.00	73.68	84.01		84.01	0.000023	1.08	3055.01	862.93	0.06
Maple Meadow Bro	2284	500-yr	1450.00	73.68	84.20		84.21	0.000036	1.37	3228.64	960.89	0.08
Maple Meadow Bro	2284	2-yr	204.00	73.68	80.22		80.22	0.000006	0.40	1217.56	342.93	0.03
Maple Meadow Bro	2284	5-yr	339.00	73.68	81.92		81.92	0.000006	0.45	1829.71	378.52	0.03
Maple Meadow Bro	2194.02	10-yr	453.00	75.33	82.02	79.36	82.39	0.001293	4.94	102.95	702.93	0.37
Maple Meadow Bro	2194.02	25-yr	629.00	75.33	82.07	80.14	82.77	0.002438	6.83	122.61	711.50	0.51
Maple Meadow Bro	2194.02	50-yr	784.00	75.33	81.70	80.79	82.97	0.004786	9.13	95.26	623.25	0.71
Maple Meadow Bro	2194.02	100-yr	956.00	75.33	83.76	82.87	83.82	0.000365	3.15	1466.06	1119.12	0.21
Maple Meadow Bro	2194.02	200-yr	1150.00	75.33	83.92	83.02	83.99	0.000406	3.38	1652.72	1158.77	0.22
Maple Meadow Bro	2194.02	500-yr	1450.00	75.33	84.11	83.22	84.18	0.000474	3.71	1867.37	1164.59	0.24

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	2194.02	2-yr	204.00	75.33	79.94	78.01	80.15	0.001321	3.67	56.61	327.03	0.35
Maple Meadow Bro	2194.02	5-yr	339.00	75.33	81.59	78.80	81.84	0.000961	4.04	92.76	559.77	0.32
Maple Meadow Bro	2164.02		Bridge									
Maple Meadow Bro	2138.106	10-yr	453.00	75.80	79.60		80.13	0.002538	5.80	78.10	596.37	0.54
Maple Meadow Bro	2138.106	25-yr	629.00	75.80	80.07		80.86	0.003227	7.11	88.50	720.91	0.62
Maple Meadow Bro	2138.106	50-yr	784.00	75.80	80.46		81.48	0.003685	8.08	97.06	815.44	0.68
Maple Meadow Bro	2138.106	100-yr	956.00	75.80	80.51		81.99	0.005312	9.76	97.96	819.04	0.82
Maple Meadow Bro	2138.106	200-yr	1150.00	75.80	80.45	80.45	82.65	0.008035	11.90	96.67	811.54	1.00
Maple Meadow Bro	2138.106	500-yr	1450.00	75.80	82.36		82.63	0.001633	5.54	943.95	846.54	0.45
Maple Meadow Bro	2138.106	2-yr	204.00	75.80	78.85		79.02	0.001145	3.32	61.45	512.84	0.35
Maple Meadow Bro	2138.106	5-yr	339.00	75.80	79.38		79.72	0.001758	4.63	73.28	569.07	0.45
Maple Meadow Bro	2137.106	10-yr	453.00	75.80	79.85	78.84	79.88	0.000382	1.99	722.87	654.35	0.20
Maple Meadow Bro	2137.106	25-yr	629.00	75.80	80.46	79.04	80.48	0.000248	1.82	1170.38	813.82	0.17
Maple Meadow Bro	2137.106	50-yr	784.00	75.80	80.96	79.23	80.98	0.000169	1.64	1586.21	826.19	0.14
Maple Meadow Bro	2137.106	100-yr	956.00	75.80	81.24	79.31	81.25	0.000169	1.72	1814.00	830.44	0.14
Maple Meadow Bro	2137.106	200-yr	1150.00	75.80	81.50	79.46	81.51	0.000175	1.81	2032.61	834.50	0.15
Maple Meadow Bro	2137.106	500-yr	1450.00	75.80	82.49	79.62	82.50	0.000098	1.55	2865.58	849.81	0.12
Maple Meadow Bro	2137.106	2-yr	204.00	75.80	78.90	77.44	78.96	0.000683	2.26	234.23	518.92	0.26
Maple Meadow Bro	2137.106	5-yr	339.00	75.80	79.53	78.00	79.56	0.000422	1.94	529.38	586.41	0.21
Maple Meadow Bro	2112.457		Bridge									
Maple Meadow Bro	2103.11	10-yr	453.00	75.80	79.81		79.82	0.000251	1.71	860.08	648.04	0.17
Maple Meadow Bro	2103.11	25-yr	629.00	75.80	80.43		80.45	0.000182	1.64	1316.02	805.18	0.15
Maple Meadow Bro	2103.11	50-yr	784.00	75.80	80.95		80.96	0.000129	1.50	1738.49	825.15	0.13
Maple Meadow Bro	2103.11	100-yr	956.00	75.80	81.22		81.24	0.000133	1.59	1966.38	829.56	0.13
Maple Meadow Bro	2103.11	200-yr	1150.00	75.80	81.49		81.50	0.000141	1.69	2184.72	833.76	0.13
Maple Meadow Bro	2103.11	500-yr	1450.00	75.80	82.48		82.49	0.000083	1.47	3022.36	849.19	0.11
Maple Meadow Bro	2103.11	2-yr	204.00	75.80	78.92		78.94	0.000363	1.66	359.20	519.17	0.19
Maple Meadow Bro	2103.11	5-yr	339.00	75.80	79.47		79.49	0.000260	1.62	659.34	574.39	0.17
Maple Meadow Bro	2001.98	10-yr	453.00	75.89	79.81	76.89	79.81	0.000041	0.72	1749.52	964.01	0.07
Maple Meadow Bro	2001.98	25-yr	629.00	75.89	80.43	76.95	80.44	0.000039	0.79	2257.92	1033.76	0.07
Maple Meadow Bro	2001.98	50-yr	784.00	75.89	80.95	76.95	80.95	0.000035	0.81	2689.89	1047.68	0.07
Maple Meadow Bro	2001.98	100-yr	956.00	75.89	81.22	77.48	81.23	0.000040	0.90	2922.91	1055.12	0.07
Maple Meadow Bro	2001.98	200-yr	1150.00	75.89	81.48	77.59	81.49	0.000046	1.00	3146.42	1095.19	0.08
Maple Meadow Bro	2001.98	500-yr	1450.00	75.89	82.48	77.73	82.48	0.000035	0.98	4015.21	1214.25	0.07
Maple Meadow Bro	2001.98	2-yr	204.00	75.89	78.92	76.53	78.92	0.000030	0.51	1107.29	744.05	0.06
Maple Meadow Bro	2001.98	5-yr	339.00	75.89	79.47	76.76	79.48	0.000036	0.63	1499.60	921.79	0.06

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	1873.26	10-yr	453.00	75.22	79.80	76.67	79.80	0.000020	0.55	2216.85	978.48	0.05
Maple Meadow Bro	1873.26	25-yr	629.00	75.22	80.43	76.80	80.43	0.000020	0.62	2750.53	1068.56	0.05
Maple Meadow Bro	1873.26	50-yr	784.00	75.22	80.94	76.91	80.95	0.000020	0.66	3200.60	1096.32	0.05
Maple Meadow Bro	1873.26	100-yr	956.00	75.22	81.22	77.01	81.22	0.000024	0.74	3444.32	1104.81	0.06
Maple Meadow Bro	1873.26	200-yr	1150.00	75.22	81.48	77.10	81.48	0.000028	0.83	3677.26	1111.01	0.06
Maple Meadow Bro	1873.26	500-yr	1450.00	75.22	82.48	77.23	82.48	0.000023	0.84	4583.19	1262.73	0.06
Maple Meadow Bro	1873.26	2-yr	204.00	75.22	78.92	76.39	78.92	0.000011	0.35	1544.29	857.26	0.04
Maple Meadow Bro	1873.26	5-yr	339.00	75.22	79.47	76.57	79.47	0.000015	0.46	1956.50	913.03	0.04
Maple Meadow Bro	1741.68	10-yr	453.00	74.97	79.80	76.47	79.80	0.000018	0.56	2302.52	1065.30	0.05
Maple Meadow Bro	1741.68	25-yr	629.00	74.97	80.43	76.74	80.43	0.000019	0.63	2876.42	1263.86	0.05
Maple Meadow Bro	1741.68	50-yr	784.00	74.97	80.94	76.87	80.94	0.000018	0.66	3356.01	1319.41	0.05
Maple Meadow Bro	1741.68	100-yr	956.00	74.97	81.22	76.98	81.22	0.000022	0.74	3611.89	1334.08	0.05
Maple Meadow Bro	1741.68	200-yr	1150.00	74.97	81.48	77.10	81.48	0.000026	0.83	3856.12	1352.48	0.06
Maple Meadow Bro	1741.68	500-yr	1450.00	74.97	82.47	77.19	82.48	0.000021	0.83	4805.45	1406.29	0.05
Maple Meadow Bro	1741.68	2-yr	204.00	74.97	78.92	76.15	78.92	0.000010	0.36	1575.56	938.42	0.03
Maple Meadow Bro	1741.68	5-yr	339.00	74.97	79.47	76.38	79.47	0.000015	0.48	2018.79	1019.34	0.04
Maple Meadow Bro	1635.31	10-yr	453.00	74.53	79.80	76.62	79.80	0.000019	0.55	2108.07	1270.54	0.05
Maple Meadow Bro	1635.31	25-yr	629.00	74.53	80.42	76.81	80.43	0.000019	0.61	2654.69	1309.40	0.05
Maple Meadow Bro	1635.31	50-yr	784.00	74.53	80.94	76.96	80.94	0.000019	0.64	3107.17	1428.87	0.05
Maple Meadow Bro	1635.31	100-yr	956.00	74.53	81.21	77.10	81.22	0.000022	0.72	3348.94	1468.74	0.05
Maple Meadow Bro	1635.31	200-yr	1150.00	74.53	81.47	77.25	81.48	0.000026	0.81	3579.94	1530.16	0.06
Maple Meadow Bro	1635.31	500-yr	1450.00	74.53	82.47	77.48	82.48	0.000014	0.66	6185.73	1697.74	0.04
Maple Meadow Bro	1635.31	2-yr	204.00	74.53	78.92	76.24	78.92	0.000011	0.36	1404.63	1073.96	0.04
Maple Meadow Bro	1635.31	5-yr	339.00	74.53	79.47	76.46	79.47	0.000015	0.46	1827.59	1216.07	0.04
Maple Meadow Bro	1532.63	10-yr	453.00	74.07	79.79	76.69	79.80	0.000030	0.76	1913.34	1130.35	0.06
Maple Meadow Bro	1532.63	25-yr	629.00	74.07	80.42	76.91	80.42	0.000030	0.82	2461.24	1178.61	0.06
Maple Meadow Bro	1532.63	50-yr	784.00	74.07	80.94	77.09	80.94	0.000028	0.85	2917.12	1310.47	0.06
Maple Meadow Bro	1532.63	100-yr	956.00	74.07	81.21	77.24	81.21	0.000033	0.94	3162.47	1340.95	0.07
Maple Meadow Bro	1532.63	200-yr	1150.00	74.07	81.47	77.34	81.47	0.000038	1.05	3396.23	1437.77	0.07
Maple Meadow Bro	1532.63	500-yr	1450.00	74.07	82.47	77.61	82.47	0.000029	1.00	4299.08	1585.92	0.06
Maple Meadow Bro	1532.63	2-yr	204.00	74.07	78.92	76.21	78.92	0.000019	0.52	1216.70	900.02	0.05
Maple Meadow Bro	1532.63	5-yr	339.00	74.07	79.47	76.50	79.47	0.000025	0.66	1638.50	1091.09	0.06
Maple Meadow Bro	1430.01	10-yr	453.00	73.99	79.79	76.26	79.79	0.000022	0.63	2055.73	848.52	0.05
Maple Meadow Bro	1430.01	25-yr	629.00	73.99	80.42	76.47	80.42	0.000022	0.69	2605.74	903.41	0.05
Maple Meadow Bro	1430.01	50-yr	784.00	73.99	80.93	76.62	80.94	0.000021	0.72	3086.72	1076.01	0.05
Maple Meadow Bro	1430.01	100-yr	956.00	73.99	81.21	76.79	81.21	0.000028	0.86	3396.65	1228.87	0.06
Maple Meadow Bro	1430.01	200-yr	1150.00	73.99	81.47	77.03	81.47	0.000032	0.95	3703.97	1256.24	0.07

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	1430.01	500-yr	1450.00	73.99	82.47	77.25	82.47	0.000023	0.89	4942.56	1433.74	0.06
Maple Meadow Bro	1430.01	2-yr	204.00	73.99	78.91	75.85	78.92	0.000014	0.44	1328.82	798.58	0.04
Maple Meadow Bro	1430.01	5-yr	339.00	73.99	79.46	76.10	79.47	0.000018	0.55	1778.86	833.52	0.05
Maple Meadow Bro	1291.21	10-yr	453.00	73.65	79.78	76.49	79.79	0.000054	1.05	1321.04	667.89	0.08
Maple Meadow Bro	1291.21	25-yr	629.00	73.65	80.41	76.74	80.42	0.000057	1.16	1759.67	778.96	0.09
Maple Meadow Bro	1291.21	50-yr	784.00	73.65	80.92	77.05	80.93	0.000051	1.17	2151.13	829.97	0.08
Maple Meadow Bro	1291.21	100-yr	956.00	73.65	81.19	77.27	81.20	0.000059	1.29	2362.26	896.34	0.09
Maple Meadow Bro	1291.21	200-yr	1150.00	73.65	81.45	77.40	81.46	0.000072	1.47	2573.76	972.76	0.10
Maple Meadow Bro	1291.21	500-yr	1450.00	73.65	82.46	77.81	82.47	0.000049	1.33	3430.71	1161.61	0.09
Maple Meadow Bro	1291.21	2-yr	204.00	73.65	78.91	75.76	78.91	0.000029	0.67	823.95	480.02	0.06
Maple Meadow Bro	1291.21	5-yr	339.00	73.65	79.46	76.18	79.46	0.000044	0.90	1114.32	608.92	0.07
Maple Meadow Bro	1180.19	10-yr	453.00	75.77	79.78		79.78	0.000089	1.01	1373.31	721.65	0.10
Maple Meadow Bro	1180.19	25-yr	629.00	75.77	80.40		80.41	0.000072	1.02	1836.86	757.46	0.09
Maple Meadow Bro	1180.19	50-yr	784.00	75.77	80.92		80.92	0.000066	1.07	2272.06	899.10	0.09
Maple Meadow Bro	1180.19	100-yr	956.00	75.77	81.19		81.20	0.000073	1.17	2516.26	908.08	0.10
Maple Meadow Bro	1180.19	200-yr	1150.00	75.77	81.45		81.45	0.000081	1.27	2750.71	942.30	0.10
Maple Meadow Bro	1180.19	500-yr	1450.00	75.77	82.45		82.46	0.000056	1.20	3825.65	1106.17	0.09
Maple Meadow Bro	1180.19	2-yr	204.00	75.77	78.91		78.91	0.000070	0.72	800.98	548.91	0.08
Maple Meadow Bro	1180.19	5-yr	339.00	75.77	79.45		79.45	0.000085	0.92	1142.19	697.26	0.10
Maple Meadow Bro	1085.1	10-yr	453.00	73.13	79.77	74.56	79.78	0.000024	0.84	1205.27	628.63	0.06
Maple Meadow Bro	1085.1	25-yr	629.00	73.13	80.39	74.84	80.40	0.000029	0.97	1629.60	714.15	0.06
Maple Meadow Bro	1085.1	50-yr	784.00	73.13	80.91	75.07	80.92	0.000030	1.04	2013.91	823.26	0.07
Maple Meadow Bro	1085.1	100-yr	956.00	73.13	81.18	75.30	81.19	0.000037	1.18	2244.95	935.23	0.07
Maple Meadow Bro	1085.1	200-yr	1150.00	73.13	81.43	75.52	81.45	0.000045	1.33	2483.25	1013.12	0.08
Maple Meadow Bro	1085.1	500-yr	1450.00	73.13	82.44	75.93	82.45	0.000034	1.25	3514.26	1107.83	0.07
Maple Meadow Bro	1085.1	2-yr	204.00	73.13	78.90	74.06	78.91	0.000010	0.49	760.42	442.34	0.04
Maple Meadow Bro	1085.1	5-yr	339.00	73.13	79.44	74.35	79.45	0.000018	0.69	1018.22	523.50	0.05
Maple Meadow Bro	974.91	10-yr	453.00	71.94	79.77		79.77	0.000010	0.61	1539.79	448.10	0.04
Maple Meadow Bro	974.91	25-yr	629.00	71.94	80.39		80.40	0.000015	0.79	1862.41	577.07	0.05
Maple Meadow Bro	974.91	50-yr	784.00	71.94	80.91		80.92	0.000019	0.91	2172.71	646.69	0.05
Maple Meadow Bro	974.91	100-yr	956.00	71.94	81.17		81.19	0.000025	1.06	2361.73	756.26	0.06
Maple Meadow Bro	974.91	200-yr	1150.00	71.94	81.43		81.44	0.000031	1.22	2570.17	863.90	0.07
Maple Meadow Bro	974.91	500-yr	1450.00	71.94	82.44		82.45	0.000027	1.21	3475.04	926.31	0.07
Maple Meadow Bro	974.91	2-yr	204.00	71.94	78.90		78.90	0.000003	0.30	1235.27	257.91	0.02
Maple Meadow Bro	974.91	5-yr	339.00	71.94	79.45		79.45	0.000006	0.46	1405.51	395.95	0.03
Maple Meadow Bro	880.98	10-yr	453.00	72.17	79.77	73.35	79.77	0.000008	0.54	1160.48	233.35	0.04
Maple Meadow Bro	880.98	25-yr	629.00	72.17	80.39	73.56	80.40	0.000012	0.68	1312.05	324.31	0.04

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HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

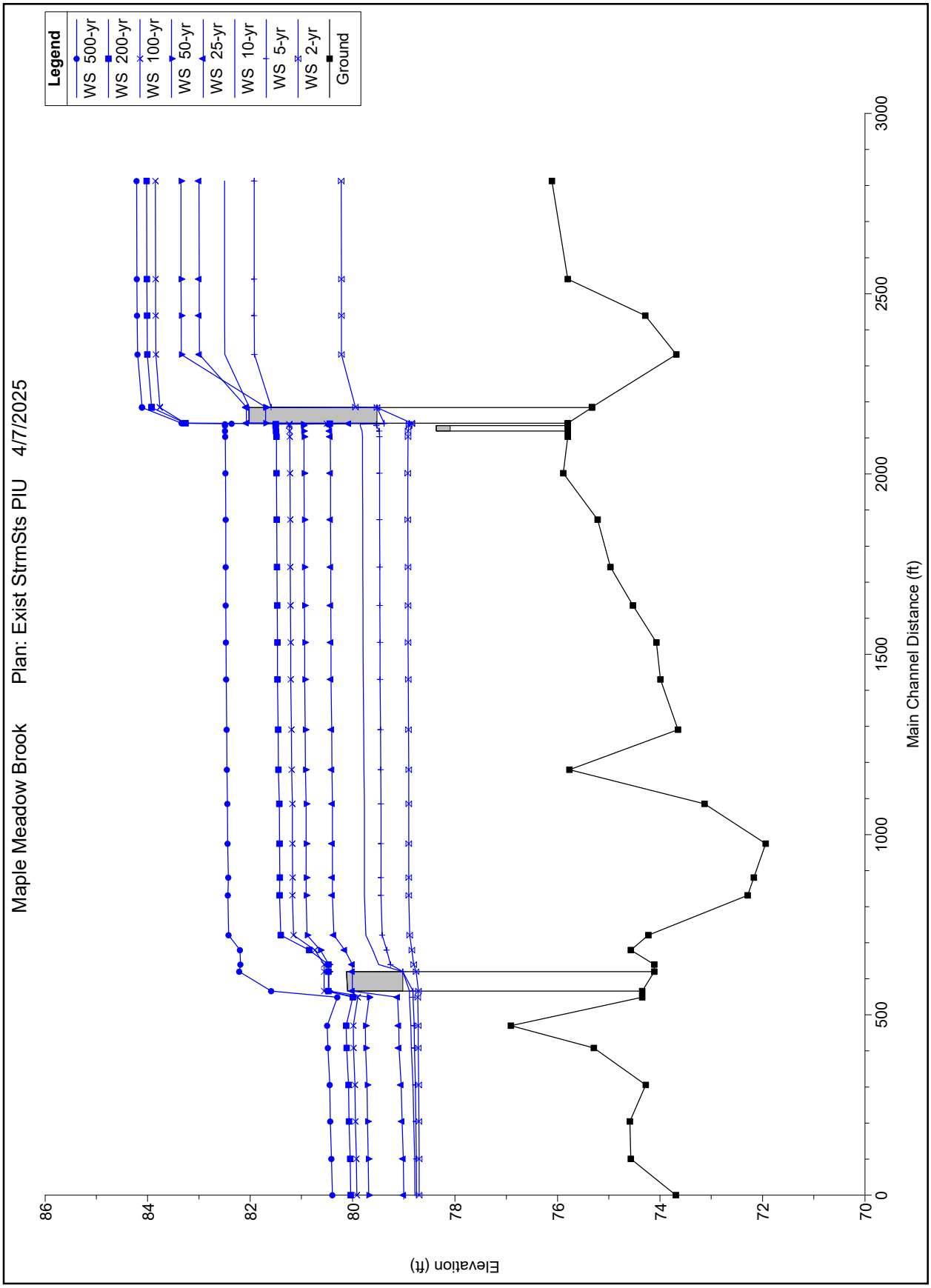
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Maple Meadow Bro	880.98	50-yr	784.00	72.17	80.91	73.72	80.91	0.000015	0.79	1445.31	443.95	0.05
Maple Meadow Bro	880.98	100-yr	956.00	72.17	81.17	73.89	81.18	0.000020	0.93	1519.84	550.70	0.06
Maple Meadow Bro	880.98	200-yr	1150.00	72.17	81.42	74.07	81.44	0.000026	1.09	1597.15	739.18	0.06
Maple Meadow Bro	880.98	500-yr	1450.00	72.17	82.43	74.33	82.45	0.000029	1.23	2030.37	1193.13	0.07
Maple Meadow Bro	880.98	2-yr	204.00	72.17	78.90	73.00	78.90	0.000003	0.27	983.12	190.29	0.02
Maple Meadow Bro	880.98	5-yr	339.00	72.17	79.45	73.19	79.45	0.000005	0.42	1087.63	206.14	0.03
Maple Meadow Bro	831.48	10-yr	453.00	72.29	79.77	73.69	79.77	0.000009	0.54	1990.56	498.70	0.04
Maple Meadow Bro	831.48	25-yr	629.00	72.29	80.39	73.90	80.40	0.000012	0.67	2316.92	554.09	0.04
Maple Meadow Bro	831.48	50-yr	784.00	72.29	80.91	74.07	80.91	0.000014	0.75	2606.46	630.59	0.05
Maple Meadow Bro	831.48	100-yr	956.00	72.29	81.17	74.24	81.18	0.000018	0.87	2759.79	683.86	0.05
Maple Meadow Bro	831.48	200-yr	1150.00	72.29	81.43	74.42	81.43	0.000024	1.03	2908.06	843.00	0.06
Maple Meadow Bro	831.48	500-yr	1450.00	72.29	82.43	74.69	82.44	0.000024	1.10	3656.21	1242.91	0.06
Maple Meadow Bro	831.48	2-yr	204.00	72.29	78.90	73.33	78.90	0.000003	0.30	1569.20	468.71	0.02
Maple Meadow Bro	831.48	5-yr	339.00	72.29	79.45	73.54	79.45	0.000006	0.43	1830.30	490.42	0.03
Maple Meadow Bro	721.16	10-yr	453.00	74.23	79.74	76.73	79.77	0.000164	1.39	589.55	505.55	0.14
Maple Meadow Bro	721.16	25-yr	629.00	74.23	80.37	77.10	80.39	0.000141	1.45	966.95	679.27	0.13
Maple Meadow Bro	721.16	50-yr	784.00	74.23	80.89	77.39	80.91	0.000114	1.42	1343.36	784.73	0.12
Maple Meadow Bro	721.16	100-yr	956.00	74.23	81.15	77.70	81.17	0.000124	1.54	1550.71	858.84	0.13
Maple Meadow Bro	721.16	200-yr	1150.00	74.23	81.40	78.01	81.43	0.000138	1.68	1752.01	986.01	0.13
Maple Meadow Bro	721.16	500-yr	1450.00	74.23	82.42	78.39	82.44	0.000081	1.46	2702.40	1534.62	0.11
Maple Meadow Bro	721.16	2-yr	204.00	74.23	78.89	76.06	78.90	0.000120	0.97	277.70	258.82	0.11
Maple Meadow Bro	721.16	5-yr	339.00	74.23	79.42	76.46	79.44	0.000145	1.22	445.72	383.36	0.13
Maple Meadow Bro	679.8376	10-yr	453.00	74.57	79.61	77.56	79.74	0.000718	3.49	235.30	101.26	0.30
Maple Meadow Bro	679.8376	25-yr	629.00	74.57	80.15	78.06	80.36	0.000935	4.31	291.19	184.63	0.34
Maple Meadow Bro	679.8376	50-yr	784.00	74.57	80.63	78.39	80.87	0.000999	4.74	361.05	319.35	0.36
Maple Meadow Bro	679.8376	100-yr	956.00	74.57	80.74	78.72	81.13	0.001492	5.87	385.63	340.98	0.44
Maple Meadow Bro	679.8376	200-yr	1150.00	74.57	80.85	79.05	81.36	0.001960	6.82	411.87	359.69	0.51
Maple Meadow Bro	679.8376	500-yr	1450.00	74.57	82.20	79.52	82.41	0.000812	5.08	969.28	725.14	0.34
Maple Meadow Bro	679.8376	2-yr	204.00	74.57	78.84	76.69	78.89	0.000313	2.02	174.15	76.36	0.19
Maple Meadow Bro	679.8376	5-yr	339.00	74.57	79.33	77.22	79.43	0.000519	2.84	212.81	93.65	0.25
Maple Meadow Bro	639.83	10-yr	453.00	74.11	79.49	77.64	79.69	0.001063	3.57	126.89	66.68	0.34
Maple Meadow Bro	639.83	25-yr	629.00	74.11	80.01	78.15	80.29	0.001272	4.30	146.38	84.97	0.39
Maple Meadow Bro	639.83	50-yr	784.00	74.11	80.46	78.51	80.80	0.001369	4.72	197.12	234.38	0.41
Maple Meadow Bro	639.83	100-yr	956.00	74.11	80.56	78.85	81.03	0.001863	5.59	218.41	271.14	0.47
Maple Meadow Bro	639.83	200-yr	1150.00	74.11	80.47	79.20	81.20	0.002910	6.90	199.40	237.43	0.59
Maple Meadow Bro	639.83	500-yr	1450.00	74.11	82.19	79.72	82.36	0.000642	4.07	1143.66	815.90	0.29
Maple Meadow Bro	639.83	2-yr	204.00	74.11	78.81	76.71	78.87	0.000461	2.02	100.98	51.41	0.22
Maple Meadow Bro	639.83	5-yr	339.00	74.11	79.26	77.24	79.39	0.000754	2.87	118.18	60.67	0.29

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	590.17		Bridge									
Maple Meadow Bro	548.93	10-yr	453.00	74.35	78.89		79.12	0.001338	3.89	118.28	132.21	0.38
Maple Meadow Bro	548.93	25-yr	629.00	74.35	79.12		79.51	0.002046	5.04	126.95	136.14	0.48
Maple Meadow Bro	548.93	50-yr	784.00	74.35	79.68		80.13	0.001921	5.40	160.24	145.71	0.48
Maple Meadow Bro	548.93	100-yr	956.00	74.35	79.90	78.47	80.46	0.003173	6.07	191.76	170.03	0.59
Maple Meadow Bro	548.93	200-yr	1150.00	74.35	79.99	78.84	80.74	0.004092	7.03	208.47	177.34	0.68
Maple Meadow Bro	548.93	500-yr	1450.00	74.35	80.30	79.34	81.20	0.004583	7.88	266.16	224.19	0.72
Maple Meadow Bro	548.93	2-yr	204.00	74.35	78.73		78.78	0.000323	1.85	112.20	129.46	0.19
Maple Meadow Bro	548.93	5-yr	339.00	74.35	78.82		78.96	0.000808	2.98	115.60	131.00	0.30
Maple Meadow Bro	469.67	10-yr	453.00	76.91	78.86		78.93	0.001494	2.92	323.05	228.79	0.37
Maple Meadow Bro	469.67	25-yr	629.00	76.91	79.10		79.20	0.002103	3.74	381.45	272.26	0.45
Maple Meadow Bro	469.67	50-yr	784.00	76.91	79.75		79.82	0.001171	3.34	587.65	331.78	0.35
Maple Meadow Bro	469.67	100-yr	956.00	76.91	79.99		80.07	0.001228	3.61	668.62	351.91	0.37
Maple Meadow Bro	469.67	200-yr	1150.00	76.91	80.12		80.24	0.001521	4.14	717.53	360.12	0.41
Maple Meadow Bro	469.67	500-yr	1450.00	76.91	80.49		80.62	0.001510	4.45	853.84	378.19	0.42
Maple Meadow Bro	469.67	2-yr	204.00	76.91	78.72		78.74	0.000404	1.44	291.10	214.83	0.19
Maple Meadow Bro	469.67	5-yr	339.00	76.91	78.80		78.84	0.000949	2.27	308.52	221.78	0.30
Maple Meadow Bro	408.43	10-yr	453.00	75.29	78.85	77.08	78.88	0.000330	1.96	599.74	315.35	0.19
Maple Meadow Bro	408.43	25-yr	629.00	75.29	79.09	77.44	79.13	0.000453	2.41	676.14	317.31	0.23
Maple Meadow Bro	408.43	50-yr	784.00	75.29	79.74	77.71	79.78	0.000326	2.29	884.61	325.37	0.20
Maple Meadow Bro	408.43	100-yr	956.00	75.29	79.98	77.81	80.02	0.000384	2.58	962.00	341.07	0.22
Maple Meadow Bro	408.43	200-yr	1150.00	75.29	80.12	78.05	80.17	0.000489	2.97	1007.21	353.44	0.25
Maple Meadow Bro	408.43	500-yr	1450.00	75.29	80.48	78.26	80.55	0.000561	3.35	1130.96	372.02	0.27
Maple Meadow Bro	408.43	2-yr	204.00	75.29	78.72	76.58	78.72	0.000082	0.95	557.14	314.25	0.10
Maple Meadow Bro	408.43	5-yr	339.00	75.29	78.79	76.87	78.81	0.000202	1.51	580.85	314.86	0.15
Maple Meadow Bro	305.54	10-yr	453.00	74.28	78.82	77.39	78.84	0.000306	1.62	615.82	503.89	0.18
Maple Meadow Bro	305.54	25-yr	629.00	74.28	79.05	77.68	79.09	0.000405	1.97	704.12	530.63	0.21
Maple Meadow Bro	305.54	50-yr	784.00	74.28	79.72	77.82	79.75	0.000254	1.80	961.71	653.38	0.17
Maple Meadow Bro	305.54	100-yr	956.00	74.28	79.95	77.97	79.98	0.000287	2.00	1052.51	659.34	0.18
Maple Meadow Bro	305.54	200-yr	1150.00	74.28	80.08	78.11	80.12	0.000361	2.29	1102.75	661.83	0.21
Maple Meadow Bro	305.54	500-yr	1450.00	74.28	80.44	78.32	80.49	0.000396	2.55	1243.96	668.83	0.22
Maple Meadow Bro	305.54	2-yr	204.00	74.28	78.71	76.60	78.71	0.000076	0.78	573.29	493.94	0.09
Maple Meadow Bro	305.54	5-yr	339.00	74.28	78.77	77.18	78.79	0.000186	1.25	597.64	498.80	0.14
Maple Meadow Bro	204.69	10-yr	453.00	74.59	78.81	77.23	78.82	0.000173	1.36	944.64	598.63	0.14
Maple Meadow Bro	204.69	25-yr	629.00	74.59	79.03	77.59	79.05	0.000234	1.65	1076.87	629.81	0.16
Maple Meadow Bro	204.69	50-yr	784.00	74.59	79.71	77.75	79.72	0.000148	1.49	1493.76	675.75	0.13

HEC-RAS Plan: Exist PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	204.69	100-yr	956.00	74.59	79.94	77.85	79.96	0.000166	1.65	1642.23	686.54	0.14
Maple Meadow Bro	204.69	200-yr	1150.00	74.59	80.07	77.95	80.09	0.000209	1.88	1724.22	694.65	0.16
Maple Meadow Bro	204.69	500-yr	1450.00	74.59	80.43	78.09	80.45	0.000225	2.06	1960.85	702.45	0.17
Maple Meadow Bro	204.69	2-yr	204.00	74.59	78.71	76.68	78.71	0.000042	0.65	887.67	591.60	0.07
Maple Meadow Bro	204.69	5-yr	339.00	74.59	78.77	77.01	78.77	0.000104	1.04	920.79	595.57	0.11
Maple Meadow Bro	100.76	10-yr	453.00	74.57	78.79		78.80	0.000152	1.31	992.99	609.58	0.13
Maple Meadow Bro	100.76	25-yr	629.00	74.57	79.01		79.03	0.000204	1.58	1128.77	614.51	0.15
Maple Meadow Bro	100.76	50-yr	784.00	74.57	79.70		79.71	0.000125	1.40	1556.94	657.69	0.12
Maple Meadow Bro	100.76	100-yr	956.00	74.57	79.93		79.94	0.000142	1.55	1713.66	693.64	0.13
Maple Meadow Bro	100.76	200-yr	1150.00	74.57	80.05		80.07	0.000189	1.82	1798.58	701.09	0.15
Maple Meadow Bro	100.76	500-yr	1450.00	74.57	80.41		80.43	0.000204	1.99	2053.77	707.45	0.16
Maple Meadow Bro	100.76	2-yr	204.00	74.57	78.70		78.70	0.000036	0.62	939.12	607.60	0.06
Maple Meadow Bro	100.76	5-yr	339.00	74.57	78.75		78.76	0.000090	1.00	971.36	608.78	0.10
Maple Meadow Bro	0	10-yr	453.00	73.69	78.78	76.48	78.79	0.000080	0.98	1123.81	598.96	0.09
Maple Meadow Bro	0	25-yr	629.00	73.69	79.00	76.84	79.01	0.000114	1.22	1255.22	606.82	0.11
Maple Meadow Bro	0	50-yr	784.00	73.69	79.69	77.07	79.70	0.000078	1.14	1678.52	625.94	0.10
Maple Meadow Bro	0	100-yr	956.00	73.69	79.92	77.23	79.93	0.000092	1.28	1821.33	642.80	0.11
Maple Meadow Bro	0	200-yr	1150.00	73.69	80.04	77.34	80.05	0.000119	1.48	1896.37	650.43	0.12
Maple Meadow Bro	0	500-yr	1450.00	73.69	80.40	77.50	80.42	0.000136	1.67	2125.83	672.90	0.13
Maple Meadow Bro	0	2-yr	204.00	73.69	78.70	75.67	78.70	0.000018	0.46	1074.81	596.12	0.05
Maple Meadow Bro	0	5-yr	339.00	73.69	78.75	76.18	78.75	0.000047	0.74	1104.67	597.85	0.07


Maple Meadow Brook Plan: Exist StrmSts PIU 4/7/2025
Legend
WS 500-yr
WS 200-yr
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 5-yr
WS 2-yr
Ground
Elevation (ft)
Main Channel Distance (ft)
86
84
82
80
78
76
74
72
70
0
500
1000
1500
2000
2500
3000

APPENDIX E

PROPOSED CONDITIONS MODEL HEC-RAS ANALYSIS – SUMMARY TABLES AND PLOTS

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2284	10-yr	82.49	82.49		0.00	0.11	493.22	3.29	196.13	253.58	0.57
Maple Meadow Bro	2284	25-yr	83.00	82.99		0.01	0.21	602.31	7.83	260.77	360.40	0.71
Maple Meadow Bro	2284	50-yr	83.35	83.34		0.01	0.38	671.83	15.44	316.01	452.55	0.82
Maple Meadow Bro	2284	100-yr	83.84	83.84		0.01	0.02	793.91	31.02	368.41	556.58	0.91
Maple Meadow Bro	2284	200-yr	84.01	84.01		0.01	0.02	862.83	44.47	446.49	659.04	1.08
Maple Meadow Bro	2284	500-yr	84.21	84.20		0.01	0.02	960.86	68.86	574.48	806.66	1.37
Maple Meadow Bro	2284	2-yr	80.22	80.22		0.00	0.06	342.93	3.19	99.97	100.83	0.40
Maple Meadow Bro	2284	5-yr	81.90	81.90		0.00	0.07	378.00	5.03	145.75	188.22	0.45
Maple Meadow Bro	2194.02	10-yr	82.39	82.01	79.36			701.96	8.37	439.09	5.54	4.94
Maple Meadow Bro	2194.02	25-yr	82.78	82.08	80.14			713.24	12.05	611.65	5.30	6.80
Maple Meadow Bro	2194.02	50-yr	82.97	81.70	80.79			622.28	12.35	764.62	7.03	9.13
Maple Meadow Bro	2194.02	100-yr	83.82	83.76	82.87	0.00	0.00	1119.10	242.12	369.07	344.81	3.15
Maple Meadow Bro	2194.02	200-yr	83.99	83.92	83.02	0.00	0.00	1158.76	315.53	404.13	430.33	3.38
Maple Meadow Bro	2194.02	500-yr	84.18	84.11	83.22	0.00	0.00	1164.59	428.84	454.91	566.25	3.71
Maple Meadow Bro	2194.02	2-yr	80.15	79.94	78.01			327.03	0.55	203.45		3.67
Maple Meadow Bro	2194.02	5-yr	81.82	81.58	78.80			548.27	4.97	331.41	2.62	4.05
Maple Meadow Bro	2164.02 BR U	10-yr	82.38	82.01	82.99					435.58	16.22	10.36
Maple Meadow Bro	2164.02 BR U	25-yr	82.78	82.08	83.15			14.25	49.13	429.74	152.64	10.22
Maple Meadow Bro	2164.02 BR U	50-yr	82.96	81.70	83.25				113.86	413.48	250.63	9.84
Maple Meadow Bro	2164.02 BR U	100-yr	83.82	83.76	83.26	0.33	0.04	663.38	342.43	172.73	440.84	3.42
Maple Meadow Bro	2164.02 BR U	200-yr	83.98	83.92	83.31	0.39	0.06	793.21	403.92	195.85	550.23	3.69
Maple Meadow Bro	2164.02 BR U	500-yr	84.17	84.11	83.43	0.42	0.08	894.61	536.15	215.17	698.68	3.84
Maple Meadow Bro	2164.02 BR U	2-yr	80.15	79.52	78.03					204.00		4.85
Maple Meadow Bro	2164.02 BR U	5-yr	81.82	79.52	78.88					339.00		8.06
Maple Meadow Bro	2164.02 BR D	10-yr	82.38	82.01	82.95					435.58	16.22	10.70
Maple Meadow Bro	2164.02 BR D	25-yr	82.78	82.08	83.09			14.25	49.13	429.74	152.64	10.52
Maple Meadow Bro	2164.02 BR D	50-yr	82.96	81.70	83.32				113.86	413.48	250.63	10.16
Maple Meadow Bro	2164.02 BR D	100-yr	83.45	83.27	83.27	0.01	0.39	533.59	236.89	268.65	450.46	5.52
Maple Meadow Bro	2164.02 BR D	200-yr	83.53	83.26	83.26	0.02	0.58	532.43	284.06	324.18	541.76	6.68
Maple Meadow Bro	2164.02 BR D	500-yr	83.67	83.34	83.34	0.01	0.03	553.42	377.91	387.11	684.99	7.59
Maple Meadow Bro	2164.02 BR D	2-yr	79.20	78.85	78.14			11.64		204.00		6.20
Maple Meadow Bro	2164.02 BR D	5-yr	80.48	79.38	78.99			11.64		339.00		8.66
Maple Meadow Bro	2138.106	10-yr	80.13	79.60		0.00	0.25	596.37		453.00		5.80
Maple Meadow Bro	2138.106	25-yr	80.86	80.07		0.00	0.38	720.91		629.00		7.11
Maple Meadow Bro	2138.106	50-yr	81.48	80.46		0.00	0.50	815.44		784.00		8.08
Maple Meadow Bro	2138.106	100-yr	81.99	80.51		0.00	0.73	819.04		956.00		9.76
Maple Meadow Bro	2138.106	200-yr	82.65	80.45	80.45	0.00	1.09	811.54		1150.00		11.90
Maple Meadow Bro	2138.106	500-yr	82.63	82.36		0.00	0.13	846.54	410.24	824.15	215.61	5.54

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2138.106	2-yr	79.02	78.85		0.00	0.06	512.84		204.00		3.32
Maple Meadow Bro	2138.106	5-yr	79.72	79.38		0.00	0.15	569.07		339.00		4.63
Maple Meadow Bro	2137.106	10-yr	79.88	79.85	78.84	0.00	0.01	654.35	235.35	190.27	27.37	1.99
Maple Meadow Bro	2137.106	25-yr	80.48	80.46	79.04	0.00	0.00	813.82	346.10	209.18	73.72	1.82
Maple Meadow Bro	2137.106	50-yr	80.98	80.96	79.23	0.00	0.00	826.19	444.38	215.16	124.47	1.64
Maple Meadow Bro	2137.106	100-yr	81.25	81.24	79.31	0.00	0.00	830.44	548.58	240.50	166.92	1.72
Maple Meadow Bro	2137.106	200-yr	81.51	81.50	79.46	0.00	0.00	834.50	665.42	269.43	215.15	1.81
Maple Meadow Bro	2137.106	500-yr	82.50	82.49	79.62	0.00	0.00	849.81	853.89	278.95	317.16	1.55
Maple Meadow Bro	2137.106	2-yr	78.96	78.90	77.44			518.92	54.22	149.78		2.26
Maple Meadow Bro	2137.106	5-yr	79.56	79.53	78.00	0.00	0.00	586.41	164.68	165.74	8.58	1.94
Maple Meadow Bro	2112.457BR U	10-yr	79.87	79.85	79.18	0.03	0.00	504.37	394.17	50.33	8.50	1.68
Maple Meadow Bro	2112.457BR U	25-yr	80.47	80.46	79.30	0.01	0.00	711.20	538.55	54.51	35.94	1.18
Maple Meadow Bro	2112.457BR U	50-yr	80.97	80.96	79.38	0.01	0.00	763.17	638.40	65.57	80.03	1.05
Maple Meadow Bro	2112.457BR U	100-yr	81.25	81.24	79.47	0.01	0.00	776.37	758.24	78.23	119.53	1.10
Maple Meadow Bro	2112.457BR U	200-yr	81.51	81.50	79.55	0.01	0.00	788.97	893.03	92.40	164.56	1.16
Maple Meadow Bro	2112.457BR U	500-yr	82.50	82.49	79.70	0.00	0.00	840.26	1064.09	110.58	275.33	0.99
Maple Meadow Bro	2112.457BR U	2-yr	78.96	78.90	77.79			260.59	157.91	36.94		1.32
Maple Meadow Bro	2112.457BR U	5-yr	79.56	79.53	79.06	0.05	0.00	406.98	270.55	67.01	1.44	2.39
Maple Meadow Bro	2112.457BR D	10-yr	79.83	79.82	79.19	0.01	0.00	500.42	391.23	54.10	7.67	1.80
Maple Meadow Bro	2112.457BR D	25-yr	80.46	80.45	79.31	0.01	0.00	706.68	537.67	56.16	35.17	1.21
Maple Meadow Bro	2112.457BR D	50-yr	80.96	80.96	79.39	0.00	0.00	762.83	637.83	66.34	79.82	1.07
Maple Meadow Bro	2112.457BR D	100-yr	81.24	81.23	79.47	0.00	0.00	776.05	757.66	78.63	119.71	1.11
Maple Meadow Bro	2112.457BR D	200-yr	81.50	81.50	79.56	0.00	0.00	788.67	892.42	92.43	165.15	1.17
Maple Meadow Bro	2112.457BR D	500-yr	82.49	82.49	79.70	0.00	0.00	836.28	1063.31	109.26	277.43	1.00
Maple Meadow Bro	2112.457BR D	2-yr	78.94	78.92	77.78			265.21	157.91	36.94		1.30
Maple Meadow Bro	2112.457BR D	5-yr	79.51	79.48	79.07	0.01	0.01	395.04	263.80	74.30	0.90	2.62
Maple Meadow Bro	2103.11	10-yr	79.82	79.81		0.01	0.01	648.04	231.85	170.86	50.29	1.71
Maple Meadow Bro	2103.11	25-yr	80.45	80.43		0.01	0.01	805.18	340.00	195.55	93.45	1.64
Maple Meadow Bro	2103.11	50-yr	80.96	80.95		0.01	0.00	825.15	438.48	203.20	142.32	1.50
Maple Meadow Bro	2103.11	100-yr	81.24	81.22		0.01	0.00	829.56	541.90	228.72	185.38	1.59
Maple Meadow Bro	2103.11	200-yr	81.50	81.49		0.01	0.00	833.76	658.14	257.60	234.27	1.69
Maple Meadow Bro	2103.11	500-yr	82.49	82.48		0.01	0.00	849.19	848.13	269.51	332.35	1.47
Maple Meadow Bro	2103.11	2-yr	78.94	78.92		0.01	0.01	519.17	80.24	120.08	3.68	1.66
Maple Meadow Bro	2103.11	5-yr	79.49	79.47		0.01	0.01	574.39	166.66	145.00	27.34	1.62
Maple Meadow Bro	2001.98	10-yr	79.81	79.81	76.89	0.00	0.00	964.01	228.02	108.63	116.35	0.72
Maple Meadow Bro	2001.98	25-yr	80.44	80.43	76.95	0.00	0.00	1033.76	322.72	139.25	167.03	0.79
Maple Meadow Bro	2001.98	50-yr	80.95	80.95	76.95	0.00	0.00	1047.68	415.39	161.45	207.16	0.81

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	2001.98	100-yr	81.23	81.22	77.48	0.00	0.00	1055.12	513.22	190.69	252.09	0.90
Maple Meadow Bro	2001.98	200-yr	81.49	81.48	77.59	0.00	0.00	1095.19	623.99	223.29	302.73	1.00
Maple Meadow Bro	2001.98	500-yr	82.48	82.48	77.73	0.00	0.00	1214.25	810.16	259.68	380.16	0.98
Maple Meadow Bro	2001.98	2-yr	78.92	78.92	76.53	0.00	0.00	744.05	97.87	56.87	49.25	0.51
Maple Meadow Bro	2001.98	5-yr	79.48	79.47	76.76	0.00	0.00	921.79	168.98	85.57	84.45	0.63
Maple Meadow Bro	679.8376	10-yr	79.74	79.61	77.56	0.03	0.02	101.26	59.27	322.29	71.45	3.49
Maple Meadow Bro	679.8376	25-yr	80.36	80.15	78.06	0.04	0.02	184.63	91.59	448.84	88.56	4.31
Maple Meadow Bro	679.8376	50-yr	80.87	80.63	78.39	0.05	0.03	319.35	121.86	542.52	119.63	4.74
Maple Meadow Bro	679.8376	100-yr	81.13	80.74	78.72	0.07	0.03	340.98	137.04	685.62	133.34	5.87
Maple Meadow Bro	679.8376	200-yr	81.36	80.85	79.05	0.09	0.06	359.69	163.36	812.40	174.24	6.82
Maple Meadow Bro	679.8376	500-yr	82.41	82.20	79.52	0.03	0.02	725.14	238.60	751.78	459.62	5.08
Maple Meadow Bro	679.8376	2-yr	78.89	78.84	76.69	0.02	0.00	76.36	22.28	153.61	28.10	2.02
Maple Meadow Bro	679.8376	5-yr	79.43	79.33	77.22	0.02	0.01	93.65	42.03	245.67	51.30	2.84
Maple Meadow Bro	639.83	10-yr	79.69	79.49	77.64			66.68		453.00		3.57
Maple Meadow Bro	639.83	25-yr	80.29	80.01	78.15			84.97		629.00		4.30
Maple Meadow Bro	639.83	50-yr	80.80	80.46	78.51			234.38		774.39	9.61	4.72
Maple Meadow Bro	639.83	100-yr	81.03	80.56	78.85			271.14	0.41	937.17	18.42	5.59
Maple Meadow Bro	639.83	200-yr	81.20	80.47	79.20			237.43		1134.81	15.19	6.90
Maple Meadow Bro	639.83	500-yr	82.36	82.19	79.72	0.03	0.05	815.90	199.44	940.15	310.41	4.07
Maple Meadow Bro	639.83	2-yr	78.87	78.81	76.71	0.01	0.01	51.41		204.00		2.02
Maple Meadow Bro	639.83	5-yr	79.39	79.26	77.24			60.67		339.00		2.87
Maple Meadow Bro	590.17 BR U	10-yr	79.69	79.02	77.73					453.00		5.02
Maple Meadow Bro	590.17 BR U	25-yr	80.29	80.01	78.23					620.81	8.18	6.88
Maple Meadow Bro	590.17 BR U	50-yr	80.80	80.46	78.64			136.86	12.51	607.06	163.94	6.73
Maple Meadow Bro	590.17 BR U	100-yr	81.03	80.56	81.25			177.93	49.35	609.01	296.72	6.75
Maple Meadow Bro	590.17 BR U	200-yr	81.20	80.47	81.39			138.58	101.72	629.34	423.62	6.98
Maple Meadow Bro	590.17 BR U	500-yr	82.29	82.21	81.68	0.31	0.07	748.64	387.42	347.44	715.14	3.85
Maple Meadow Bro	590.17 BR U	2-yr	78.85	78.76	76.68	0.04	0.00	27.29		204.00		2.43
Maple Meadow Bro	590.17 BR U	5-yr	79.39	79.02	77.27					339.00		3.76
Maple Meadow Bro	590.17 BR D	10-yr	79.12	78.89	77.77			27.28		453.00		5.23
Maple Meadow Bro	590.17 BR D	25-yr	80.25	80.01	78.27					620.81	8.18	6.96
Maple Meadow Bro	590.17 BR D	50-yr	80.73	80.46	78.66			155.69	12.51	607.06	163.94	6.81
Maple Meadow Bro	590.17 BR D	100-yr	81.03	80.56	81.20			199.92	49.35	609.01	296.72	6.81
Maple Meadow Bro	590.17 BR D	200-yr	81.20	80.47	81.39			157.60	101.72	629.34	423.62	7.06
Maple Meadow Bro	590.17 BR D	500-yr	81.91	81.59	81.59	0.12	0.18	601.31	182.43	618.58	648.99	6.57
Maple Meadow Bro	590.17 BR D	2-yr	78.81	78.72	76.90	0.01	0.02	27.29		204.00		2.49
Maple Meadow Bro	590.17 BR D	5-yr	78.96	78.82	77.41			27.29		339.00		4.01

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Maple Meadow Bro	548.93	10-yr	79.12	78.89		0.11	0.09	132.21		450.61	2.39	3.89
Maple Meadow Bro	548.93	25-yr	79.51	79.12		0.16	0.14	136.14		625.30	3.70	5.04
Maple Meadow Bro	548.93	50-yr	80.13	79.68		0.12	0.19	145.71		779.72	4.28	5.40
Maple Meadow Bro	548.93	100-yr	80.46	79.90	78.47	0.15	0.24	170.03	0.42	934.35	21.23	6.07
Maple Meadow Bro	548.93	200-yr	80.74	79.99	78.84	0.19	0.32	177.34	1.81	1113.47	34.72	7.03
Maple Meadow Bro	548.93	500-yr	81.20	80.30	79.34	0.19	0.39	224.19	12.35	1359.52	78.13	7.88
Maple Meadow Bro	548.93	2-yr	78.78	78.73		0.03	0.02	129.46		203.02	0.98	1.85
Maple Meadow Bro	548.93	5-yr	78.96	78.82		0.07	0.05	131.00		337.28	1.72	2.98
Maple Meadow Bro	469.67	10-yr	78.93	78.86		0.04	0.01	228.79	166.39	177.56	109.05	2.92
Maple Meadow Bro	469.67	25-yr	79.20	79.10		0.05	0.02	272.26	207.71	256.49	164.80	3.74
Maple Meadow Bro	469.67	50-yr	79.82	79.75		0.03	0.01	331.78	276.60	298.75	208.65	3.34
Maple Meadow Bro	469.67	100-yr	80.07	79.99		0.04	0.01	351.91	354.30	351.10	250.60	3.61
Maple Meadow Bro	469.67	200-yr	80.24	80.12		0.05	0.02	360.12	451.08	420.92	278.00	4.14
Maple Meadow Bro	469.67	500-yr	80.62	80.49		0.05	0.02	378.19	617.22	504.81	327.98	4.45
Maple Meadow Bro	469.67	2-yr	78.74	78.72		0.01	0.00	214.83	75.22	80.82	47.97	1.44
Maple Meadow Bro	469.67	5-yr	78.84	78.80		0.02	0.01	221.78	124.68	133.51	80.81	2.27

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro

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)	
Maple Meadow Bro	2765.14	10-yr	453.00	76.11	82.49	77.01	82.50	0.000007	0.44	3877.03	1494.72	0.03
Maple Meadow Bro	2765.14	25-yr	629.00	76.11	83.00	77.14	83.00	0.000008	0.50	4562.82	1560.75	0.03
Maple Meadow Bro	2765.14	50-yr	784.00	76.11	83.35	77.24	83.35	0.000009	0.55	5046.08	1593.30	0.04
Maple Meadow Bro	2765.14	100-yr	956.00	76.11	83.85	77.34	83.85	0.000009	0.58	5733.59	1618.56	0.04
Maple Meadow Bro	2765.14	200-yr	1150.00	76.11	84.02	77.47	84.02	0.000012	0.66	5970.19	1622.83	0.04
Maple Meadow Bro	2765.14	500-yr	1450.00	76.11	84.22	77.61	84.22	0.000016	0.79	6245.23	1627.78	0.05
Maple Meadow Bro	2765.14	2-yr	204.00	76.11	80.22	76.70	80.22	0.000008	0.36	1514.94	732.67	0.03
Maple Meadow Bro	2765.14	5-yr	339.00	76.11	81.90	76.90	81.90	0.000006	0.39	3120.86	1136.68	0.03
Maple Meadow Bro	2492.94	10-yr	453.00	75.80	82.49	76.60	82.49	0.000004	0.32	3336.68	1092.64	0.02
Maple Meadow Bro	2492.94	25-yr	629.00	75.80	83.00	76.75	83.00	0.000006	0.42	3773.28	1333.40	0.03
Maple Meadow Bro	2492.94	50-yr	784.00	75.80	83.35	76.93	83.35	0.000007	0.48	4084.42	1369.23	0.03
Maple Meadow Bro	2492.94	100-yr	956.00	75.80	83.84	76.97	83.85	0.000008	0.53	4528.92	1412.85	0.03
Maple Meadow Bro	2492.94	200-yr	1150.00	75.80	84.01	77.17	84.02	0.000010	0.62	4681.09	1423.40	0.04
Maple Meadow Bro	2492.94	500-yr	1450.00	75.80	84.21	77.31	84.21	0.000015	0.75	4857.38	1461.85	0.05
Maple Meadow Bro	2492.94	2-yr	204.00	75.80	80.22	76.27	80.22	0.000004	0.24	1825.13	540.82	0.02
Maple Meadow Bro	2492.94	5-yr	339.00	75.80	81.90	76.47	81.90	0.000003	0.27	2880.04	927.98	0.02
Maple Meadow Bro	2391.78	10-yr	453.00	74.29	82.49	76.30	82.49	0.000004	0.41	2914.64	901.33	0.03
Maple Meadow Bro	2391.78	25-yr	629.00	74.29	83.00	76.50	83.00	0.000006	0.51	3237.78	1034.17	0.03
Maple Meadow Bro	2391.78	50-yr	784.00	74.29	83.35	76.60	83.35	0.000009	0.61	3471.77	1151.56	0.04
Maple Meadow Bro	2391.78	100-yr	956.00	74.29	83.84	76.79	83.85	0.000010	0.68	3812.58	1214.83	0.04
Maple Meadow Bro	2391.78	200-yr	1150.00	74.29	84.01	76.91	84.02	0.000013	0.79	3928.78	1241.35	0.05
Maple Meadow Bro	2391.78	500-yr	1450.00	74.29	84.21	77.08	84.21	0.000019	0.96	4062.82	1271.93	0.06
Maple Meadow Bro	2391.78	2-yr	204.00	74.29	80.22	75.68	80.22	0.000003	0.28	1766.52	432.97	0.02
Maple Meadow Bro	2391.78	5-yr	339.00	74.29	81.90	76.08	81.90	0.000003	0.34	2544.89	822.64	0.02
Maple Meadow Bro	2284	10-yr	453.00	73.68	82.49		82.49	0.000008	0.57	2057.94	493.22	0.03
Maple Meadow Bro	2284	25-yr	629.00	73.68	82.99		83.00	0.000012	0.71	2333.29	602.31	0.04
Maple Meadow Bro	2284	50-yr	784.00	73.68	83.34		83.35	0.000015	0.82	2556.08	671.83	0.05
Maple Meadow Bro	2284	100-yr	956.00	73.68	83.84		83.84	0.000017	0.91	2917.42	793.91	0.05
Maple Meadow Bro	2284	200-yr	1150.00	73.68	84.01		84.01	0.000023	1.08	3054.84	862.83	0.06
Maple Meadow Bro	2284	500-yr	1450.00	73.68	84.20		84.21	0.000036	1.37	3228.57	960.86	0.08
Maple Meadow Bro	2284	2-yr	204.00	73.68	80.22		80.22	0.000006	0.40	1217.56	342.93	0.03
Maple Meadow Bro	2284	5-yr	339.00	73.68	81.90		81.90	0.000006	0.45	1823.72	378.00	0.03
Maple Meadow Bro	2194.02	10-yr	453.00	75.33	82.01	79.36	82.39	0.001298	4.94	102.80	701.96	0.37
Maple Meadow Bro	2194.02	25-yr	629.00	75.33	82.08	80.14	82.78	0.002412	6.80	127.01	713.24	0.51
Maple Meadow Bro	2194.02	50-yr	784.00	75.33	81.70	80.79	82.97	0.004792	9.13	95.21	622.28	0.71
Maple Meadow Bro	2194.02	100-yr	956.00	75.33	83.76	82.87	83.82	0.000365	3.15	1465.90	1119.10	0.21
Maple Meadow Bro	2194.02	200-yr	1150.00	75.33	83.92	83.02	83.99	0.000406	3.38	1652.44	1158.76	0.22
Maple Meadow Bro	2194.02	500-yr	1450.00	75.33	84.11	83.22	84.18	0.000474	3.71	1867.26	1164.59	0.24

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	2194.02	2-yr	204.00	75.33	79.94	78.01	80.15	0.001321	3.67	56.61	327.03	0.35
Maple Meadow Bro	2194.02	5-yr	339.00	75.33	81.58	78.80	81.82	0.000973	4.05	92.31	548.27	0.32
Maple Meadow Bro	2164.02		Bridge									
Maple Meadow Bro	2138.106	10-yr	453.00	75.80	79.60		80.13	0.002538	5.80	78.10	596.37	0.54
Maple Meadow Bro	2138.106	25-yr	629.00	75.80	80.07		80.86	0.003227	7.11	88.50	720.91	0.62
Maple Meadow Bro	2138.106	50-yr	784.00	75.80	80.46		81.48	0.003685	8.08	97.06	815.44	0.68
Maple Meadow Bro	2138.106	100-yr	956.00	75.80	80.51		81.99	0.005312	9.76	97.96	819.04	0.82
Maple Meadow Bro	2138.106	200-yr	1150.00	75.80	80.45	80.45	82.65	0.008035	11.90	96.67	811.54	1.00
Maple Meadow Bro	2138.106	500-yr	1450.00	75.80	82.36		82.63	0.001633	5.54	943.95	846.54	0.45
Maple Meadow Bro	2138.106	2-yr	204.00	75.80	78.85		79.02	0.001145	3.32	61.45	512.84	0.35
Maple Meadow Bro	2138.106	5-yr	339.00	75.80	79.38		79.72	0.001758	4.63	73.28	569.07	0.45
Maple Meadow Bro	2137.106	10-yr	453.00	75.80	79.85	78.84	79.88	0.000382	1.99	722.87	654.35	0.20
Maple Meadow Bro	2137.106	25-yr	629.00	75.80	80.46	79.04	80.48	0.000248	1.82	1170.38	813.82	0.17
Maple Meadow Bro	2137.106	50-yr	784.00	75.80	80.96	79.23	80.98	0.000169	1.64	1586.21	826.19	0.14
Maple Meadow Bro	2137.106	100-yr	956.00	75.80	81.24	79.31	81.25	0.000169	1.72	1814.00	830.44	0.14
Maple Meadow Bro	2137.106	200-yr	1150.00	75.80	81.50	79.46	81.51	0.000175	1.81	2032.61	834.50	0.15
Maple Meadow Bro	2137.106	500-yr	1450.00	75.80	82.49	79.62	82.50	0.000098	1.55	2865.58	849.81	0.12
Maple Meadow Bro	2137.106	2-yr	204.00	75.80	78.90	77.44	78.96	0.000683	2.26	234.23	518.92	0.26
Maple Meadow Bro	2137.106	5-yr	339.00	75.80	79.53	78.00	79.56	0.000422	1.94	529.38	586.41	0.21
Maple Meadow Bro	2112.457		Bridge									
Maple Meadow Bro	2103.11	10-yr	453.00	75.80	79.81		79.82	0.000251	1.71	860.08	648.04	0.17
Maple Meadow Bro	2103.11	25-yr	629.00	75.80	80.43		80.45	0.000182	1.64	1316.02	805.18	0.15
Maple Meadow Bro	2103.11	50-yr	784.00	75.80	80.95		80.96	0.000129	1.50	1738.49	825.15	0.13
Maple Meadow Bro	2103.11	100-yr	956.00	75.80	81.22		81.24	0.000133	1.59	1966.38	829.56	0.13
Maple Meadow Bro	2103.11	200-yr	1150.00	75.80	81.49		81.50	0.000141	1.69	2184.72	833.76	0.13
Maple Meadow Bro	2103.11	500-yr	1450.00	75.80	82.48		82.49	0.000083	1.47	3022.36	849.19	0.11
Maple Meadow Bro	2103.11	2-yr	204.00	75.80	78.92		78.94	0.000363	1.66	359.20	519.17	0.19
Maple Meadow Bro	2103.11	5-yr	339.00	75.80	79.47		79.49	0.000260	1.62	659.34	574.39	0.17
Maple Meadow Bro	2001.98	10-yr	453.00	75.89	79.81	76.89	79.81	0.000041	0.72	1749.52	964.01	0.07
Maple Meadow Bro	2001.98	25-yr	629.00	75.89	80.43	76.95	80.44	0.000039	0.79	2257.92	1033.76	0.07
Maple Meadow Bro	2001.98	50-yr	784.00	75.89	80.95	76.95	80.95	0.000035	0.81	2689.89	1047.68	0.07
Maple Meadow Bro	2001.98	100-yr	956.00	75.89	81.22	77.48	81.23	0.000040	0.90	2922.91	1055.12	0.07
Maple Meadow Bro	2001.98	200-yr	1150.00	75.89	81.48	77.59	81.49	0.000046	1.00	3146.42	1095.19	0.08
Maple Meadow Bro	2001.98	500-yr	1450.00	75.89	82.48	77.73	82.48	0.000035	0.98	4015.21	1214.25	0.07
Maple Meadow Bro	2001.98	2-yr	204.00	75.89	78.92	76.53	78.92	0.000030	0.51	1107.29	744.05	0.06
Maple Meadow Bro	2001.98	5-yr	339.00	75.89	79.47	76.76	79.48	0.000036	0.63	1499.60	921.79	0.06

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	1873.26	10-yr	453.00	75.22	79.80	76.67	79.80	0.000020	0.55	2216.85	978.48	0.05
Maple Meadow Bro	1873.26	25-yr	629.00	75.22	80.43	76.80	80.43	0.000020	0.62	2750.53	1068.56	0.05
Maple Meadow Bro	1873.26	50-yr	784.00	75.22	80.94	76.91	80.95	0.000020	0.66	3200.60	1096.32	0.05
Maple Meadow Bro	1873.26	100-yr	956.00	75.22	81.22	77.01	81.22	0.000024	0.74	3444.32	1104.81	0.06
Maple Meadow Bro	1873.26	200-yr	1150.00	75.22	81.48	77.10	81.48	0.000028	0.83	3677.26	1111.01	0.06
Maple Meadow Bro	1873.26	500-yr	1450.00	75.22	82.48	77.23	82.48	0.000023	0.84	4583.19	1262.73	0.06
Maple Meadow Bro	1873.26	2-yr	204.00	75.22	78.92	76.39	78.92	0.000011	0.35	1544.29	857.26	0.04
Maple Meadow Bro	1873.26	5-yr	339.00	75.22	79.47	76.57	79.47	0.000015	0.46	1956.50	913.03	0.04
Maple Meadow Bro	1741.68	10-yr	453.00	74.97	79.80	76.47	79.80	0.000018	0.56	2302.52	1065.30	0.05
Maple Meadow Bro	1741.68	25-yr	629.00	74.97	80.43	76.74	80.43	0.000019	0.63	2876.42	1263.86	0.05
Maple Meadow Bro	1741.68	50-yr	784.00	74.97	80.94	76.87	80.94	0.000018	0.66	3356.01	1319.41	0.05
Maple Meadow Bro	1741.68	100-yr	956.00	74.97	81.22	76.98	81.22	0.000022	0.74	3611.89	1334.08	0.05
Maple Meadow Bro	1741.68	200-yr	1150.00	74.97	81.48	77.10	81.48	0.000026	0.83	3856.12	1352.48	0.06
Maple Meadow Bro	1741.68	500-yr	1450.00	74.97	82.47	77.19	82.48	0.000021	0.83	4805.45	1406.29	0.05
Maple Meadow Bro	1741.68	2-yr	204.00	74.97	78.92	76.15	78.92	0.000010	0.36	1575.56	938.42	0.03
Maple Meadow Bro	1741.68	5-yr	339.00	74.97	79.47	76.38	79.47	0.000015	0.48	2018.79	1019.34	0.04
Maple Meadow Bro	1635.31	10-yr	453.00	74.53	79.80	76.62	79.80	0.000019	0.55	2108.07	1270.54	0.05
Maple Meadow Bro	1635.31	25-yr	629.00	74.53	80.42	76.81	80.43	0.000019	0.61	2654.69	1309.40	0.05
Maple Meadow Bro	1635.31	50-yr	784.00	74.53	80.94	76.96	80.94	0.000019	0.64	3107.17	1428.87	0.05
Maple Meadow Bro	1635.31	100-yr	956.00	74.53	81.21	77.10	81.22	0.000022	0.72	3348.94	1468.74	0.05
Maple Meadow Bro	1635.31	200-yr	1150.00	74.53	81.47	77.25	81.48	0.000026	0.81	3579.94	1530.16	0.06
Maple Meadow Bro	1635.31	500-yr	1450.00	74.53	82.47	77.48	82.48	0.000014	0.66	6185.73	1697.74	0.04
Maple Meadow Bro	1635.31	2-yr	204.00	74.53	78.92	76.24	78.92	0.000011	0.36	1404.63	1073.96	0.04
Maple Meadow Bro	1635.31	5-yr	339.00	74.53	79.47	76.46	79.47	0.000015	0.46	1827.59	1216.07	0.04
Maple Meadow Bro	1532.63	10-yr	453.00	74.07	79.79	76.69	79.80	0.000030	0.76	1913.34	1130.35	0.06
Maple Meadow Bro	1532.63	25-yr	629.00	74.07	80.42	76.91	80.42	0.000030	0.82	2461.24	1178.61	0.06
Maple Meadow Bro	1532.63	50-yr	784.00	74.07	80.94	77.09	80.94	0.000028	0.85	2917.12	1310.47	0.06
Maple Meadow Bro	1532.63	100-yr	956.00	74.07	81.21	77.24	81.21	0.000033	0.94	3162.47	1340.95	0.07
Maple Meadow Bro	1532.63	200-yr	1150.00	74.07	81.47	77.34	81.47	0.000038	1.05	3396.23	1437.77	0.07
Maple Meadow Bro	1532.63	500-yr	1450.00	74.07	82.47	77.61	82.47	0.000029	1.00	4299.08	1585.92	0.06
Maple Meadow Bro	1532.63	2-yr	204.00	74.07	78.92	76.21	78.92	0.000019	0.52	1216.70	900.02	0.05
Maple Meadow Bro	1532.63	5-yr	339.00	74.07	79.47	76.50	79.47	0.000025	0.66	1638.50	1091.09	0.06
Maple Meadow Bro	1430.01	10-yr	453.00	73.99	79.79	76.26	79.79	0.000022	0.63	2055.73	848.52	0.05
Maple Meadow Bro	1430.01	25-yr	629.00	73.99	80.42	76.47	80.42	0.000022	0.69	2605.74	903.41	0.05
Maple Meadow Bro	1430.01	50-yr	784.00	73.99	80.93	76.62	80.94	0.000021	0.72	3086.72	1076.01	0.05
Maple Meadow Bro	1430.01	100-yr	956.00	73.99	81.21	76.79	81.21	0.000028	0.86	3396.65	1228.87	0.06
Maple Meadow Bro	1430.01	200-yr	1150.00	73.99	81.47	77.03	81.47	0.000032	0.95	3703.97	1256.24	0.07

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	1430.01	500-yr	1450.00	73.99	82.47	77.25	82.47	0.000023	0.89	4942.56	1433.74	0.06
Maple Meadow Bro	1430.01	2-yr	204.00	73.99	78.91	75.85	78.92	0.000014	0.44	1328.82	798.58	0.04
Maple Meadow Bro	1430.01	5-yr	339.00	73.99	79.46	76.10	79.47	0.000018	0.55	1778.86	833.52	0.05
Maple Meadow Bro	1291.21	10-yr	453.00	73.65	79.78	76.49	79.79	0.000054	1.05	1321.04	667.89	0.08
Maple Meadow Bro	1291.21	25-yr	629.00	73.65	80.41	76.74	80.42	0.000057	1.16	1759.67	778.96	0.09
Maple Meadow Bro	1291.21	50-yr	784.00	73.65	80.92	77.05	80.93	0.000051	1.17	2151.13	829.97	0.08
Maple Meadow Bro	1291.21	100-yr	956.00	73.65	81.19	77.27	81.20	0.000059	1.29	2362.26	896.34	0.09
Maple Meadow Bro	1291.21	200-yr	1150.00	73.65	81.45	77.40	81.46	0.000072	1.47	2573.76	972.76	0.10
Maple Meadow Bro	1291.21	500-yr	1450.00	73.65	82.46	77.81	82.47	0.000049	1.33	3430.71	1161.61	0.09
Maple Meadow Bro	1291.21	2-yr	204.00	73.65	78.91	75.76	78.91	0.000029	0.67	823.95	480.02	0.06
Maple Meadow Bro	1291.21	5-yr	339.00	73.65	79.46	76.18	79.46	0.000044	0.90	1114.32	608.92	0.07
Maple Meadow Bro	1180.19	10-yr	453.00	75.77	79.78		79.78	0.000089	1.01	1373.31	721.65	0.10
Maple Meadow Bro	1180.19	25-yr	629.00	75.77	80.40		80.41	0.000072	1.02	1836.86	757.46	0.09
Maple Meadow Bro	1180.19	50-yr	784.00	75.77	80.92		80.92	0.000066	1.07	2272.06	899.10	0.09
Maple Meadow Bro	1180.19	100-yr	956.00	75.77	81.19		81.20	0.000073	1.17	2516.26	908.08	0.10
Maple Meadow Bro	1180.19	200-yr	1150.00	75.77	81.45		81.45	0.000081	1.27	2750.71	942.30	0.10
Maple Meadow Bro	1180.19	500-yr	1450.00	75.77	82.45		82.46	0.000056	1.20	3825.65	1106.17	0.09
Maple Meadow Bro	1180.19	2-yr	204.00	75.77	78.91		78.91	0.000070	0.72	800.98	548.91	0.08
Maple Meadow Bro	1180.19	5-yr	339.00	75.77	79.45		79.45	0.000085	0.92	1142.19	697.26	0.10
Maple Meadow Bro	1085.1	10-yr	453.00	73.13	79.77	74.56	79.78	0.000024	0.84	1205.27	628.63	0.06
Maple Meadow Bro	1085.1	25-yr	629.00	73.13	80.39	74.84	80.40	0.000029	0.97	1629.60	714.15	0.06
Maple Meadow Bro	1085.1	50-yr	784.00	73.13	80.91	75.07	80.92	0.000030	1.04	2013.91	823.26	0.07
Maple Meadow Bro	1085.1	100-yr	956.00	73.13	81.18	75.30	81.19	0.000037	1.18	2244.95	935.23	0.07
Maple Meadow Bro	1085.1	200-yr	1150.00	73.13	81.43	75.52	81.45	0.000045	1.33	2483.25	1013.12	0.08
Maple Meadow Bro	1085.1	500-yr	1450.00	73.13	82.44	75.93	82.45	0.000034	1.25	3514.26	1107.83	0.07
Maple Meadow Bro	1085.1	2-yr	204.00	73.13	78.90	74.06	78.91	0.000010	0.49	760.42	442.34	0.04
Maple Meadow Bro	1085.1	5-yr	339.00	73.13	79.44	74.35	79.45	0.000018	0.69	1018.22	523.50	0.05
Maple Meadow Bro	974.91	10-yr	453.00	71.94	79.77		79.77	0.000010	0.61	1539.79	448.10	0.04
Maple Meadow Bro	974.91	25-yr	629.00	71.94	80.39		80.40	0.000015	0.79	1862.41	577.07	0.05
Maple Meadow Bro	974.91	50-yr	784.00	71.94	80.91		80.92	0.000019	0.91	2172.71	646.69	0.05
Maple Meadow Bro	974.91	100-yr	956.00	71.94	81.17		81.19	0.000025	1.06	2361.73	756.26	0.06
Maple Meadow Bro	974.91	200-yr	1150.00	71.94	81.43		81.44	0.000031	1.22	2570.17	863.90	0.07
Maple Meadow Bro	974.91	500-yr	1450.00	71.94	82.44		82.45	0.000027	1.21	3475.04	926.31	0.07
Maple Meadow Bro	974.91	2-yr	204.00	71.94	78.90		78.90	0.000003	0.30	1235.27	257.91	0.02
Maple Meadow Bro	974.91	5-yr	339.00	71.94	79.45		79.45	0.000006	0.46	1405.51	395.95	0.03
Maple Meadow Bro	880.98	10-yr	453.00	72.17	79.77	73.35	79.77	0.000008	0.54	1160.48	233.35	0.04
Maple Meadow Bro	880.98	25-yr	629.00	72.17	80.39	73.56	80.40	0.000012	0.68	1312.05	324.31	0.04

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

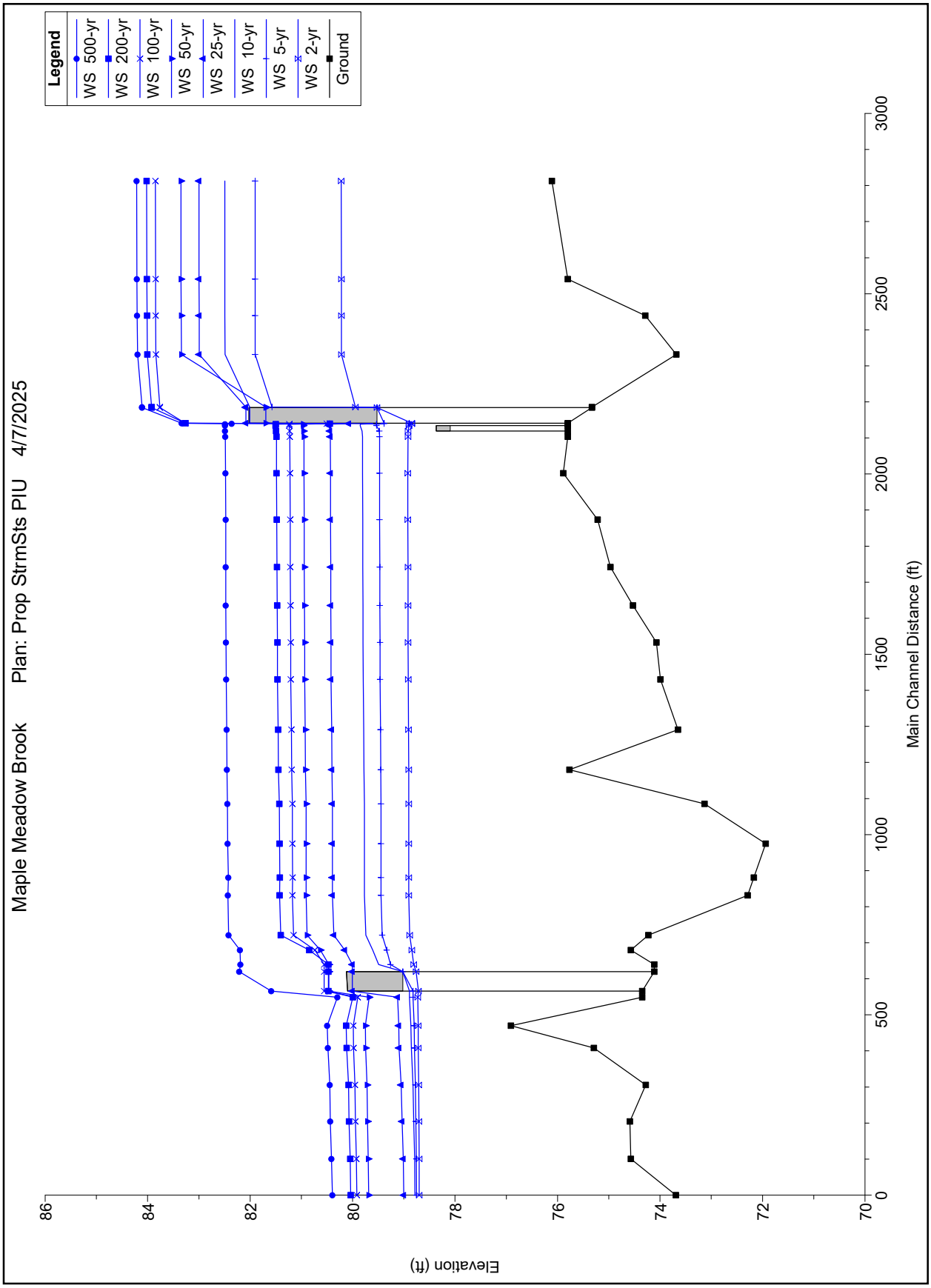
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Maple Meadow Bro	880.98	50-yr	784.00	72.17	80.91	73.72	80.91	0.000015	0.79	1445.31	443.95	0.05
Maple Meadow Bro	880.98	100-yr	956.00	72.17	81.17	73.89	81.18	0.000020	0.93	1519.84	550.70	0.06
Maple Meadow Bro	880.98	200-yr	1150.00	72.17	81.42	74.07	81.44	0.000026	1.09	1597.15	739.18	0.06
Maple Meadow Bro	880.98	500-yr	1450.00	72.17	82.43	74.33	82.45	0.000029	1.23	2030.37	1193.13	0.07
Maple Meadow Bro	880.98	2-yr	204.00	72.17	78.90	73.00	78.90	0.000003	0.27	983.12	190.29	0.02
Maple Meadow Bro	880.98	5-yr	339.00	72.17	79.45	73.19	79.45	0.000005	0.42	1087.63	206.14	0.03
Maple Meadow Bro	831.48	10-yr	453.00	72.29	79.77	73.69	79.77	0.000009	0.54	1990.56	498.70	0.04
Maple Meadow Bro	831.48	25-yr	629.00	72.29	80.39	73.90	80.40	0.000012	0.67	2316.92	554.09	0.04
Maple Meadow Bro	831.48	50-yr	784.00	72.29	80.91	74.07	80.91	0.000014	0.75	2606.46	630.59	0.05
Maple Meadow Bro	831.48	100-yr	956.00	72.29	81.17	74.24	81.18	0.000018	0.87	2759.79	683.86	0.05
Maple Meadow Bro	831.48	200-yr	1150.00	72.29	81.43	74.42	81.43	0.000024	1.03	2908.06	843.00	0.06
Maple Meadow Bro	831.48	500-yr	1450.00	72.29	82.43	74.69	82.44	0.000024	1.10	3656.21	1242.91	0.06
Maple Meadow Bro	831.48	2-yr	204.00	72.29	78.90	73.33	78.90	0.000003	0.30	1569.20	468.71	0.02
Maple Meadow Bro	831.48	5-yr	339.00	72.29	79.45	73.54	79.45	0.000006	0.43	1830.30	490.42	0.03
Maple Meadow Bro	721.16	10-yr	453.00	74.23	79.74	76.73	79.77	0.000164	1.39	589.55	505.55	0.14
Maple Meadow Bro	721.16	25-yr	629.00	74.23	80.37	77.10	80.39	0.000141	1.45	966.95	679.27	0.13
Maple Meadow Bro	721.16	50-yr	784.00	74.23	80.89	77.39	80.91	0.000114	1.42	1343.36	784.73	0.12
Maple Meadow Bro	721.16	100-yr	956.00	74.23	81.15	77.70	81.17	0.000124	1.54	1550.71	858.84	0.13
Maple Meadow Bro	721.16	200-yr	1150.00	74.23	81.40	78.01	81.43	0.000138	1.68	1752.01	986.01	0.13
Maple Meadow Bro	721.16	500-yr	1450.00	74.23	82.42	78.39	82.44	0.000081	1.46	2702.40	1534.62	0.11
Maple Meadow Bro	721.16	2-yr	204.00	74.23	78.89	76.06	78.90	0.000120	0.97	277.70	258.82	0.11
Maple Meadow Bro	721.16	5-yr	339.00	74.23	79.42	76.46	79.44	0.000145	1.22	445.72	383.36	0.13
Maple Meadow Bro	679.8376	10-yr	453.00	74.57	79.61	77.56	79.74	0.000718	3.49	235.30	101.26	0.30
Maple Meadow Bro	679.8376	25-yr	629.00	74.57	80.15	78.06	80.36	0.000935	4.31	291.19	184.63	0.34
Maple Meadow Bro	679.8376	50-yr	784.00	74.57	80.63	78.39	80.87	0.000999	4.74	361.05	319.35	0.36
Maple Meadow Bro	679.8376	100-yr	956.00	74.57	80.74	78.72	81.13	0.001492	5.87	385.63	340.98	0.44
Maple Meadow Bro	679.8376	200-yr	1150.00	74.57	80.85	79.05	81.36	0.001960	6.82	411.87	359.69	0.51
Maple Meadow Bro	679.8376	500-yr	1450.00	74.57	82.20	79.52	82.41	0.000812	5.08	969.28	725.14	0.34
Maple Meadow Bro	679.8376	2-yr	204.00	74.57	78.84	76.69	78.89	0.000313	2.02	174.15	76.36	0.19
Maple Meadow Bro	679.8376	5-yr	339.00	74.57	79.33	77.22	79.43	0.000519	2.84	212.81	93.65	0.25
Maple Meadow Bro	639.83	10-yr	453.00	74.11	79.49	77.64	79.69	0.001063	3.57	126.89	66.68	0.34
Maple Meadow Bro	639.83	25-yr	629.00	74.11	80.01	78.15	80.29	0.001272	4.30	146.38	84.97	0.39
Maple Meadow Bro	639.83	50-yr	784.00	74.11	80.46	78.51	80.80	0.001369	4.72	197.12	234.38	0.41
Maple Meadow Bro	639.83	100-yr	956.00	74.11	80.56	78.85	81.03	0.001863	5.59	218.41	271.14	0.47
Maple Meadow Bro	639.83	200-yr	1150.00	74.11	80.47	79.20	81.20	0.002910	6.90	199.40	237.43	0.59
Maple Meadow Bro	639.83	500-yr	1450.00	74.11	82.19	79.72	82.36	0.000642	4.07	1143.66	815.90	0.29
Maple Meadow Bro	639.83	2-yr	204.00	74.11	78.81	76.71	78.87	0.000461	2.02	100.98	51.41	0.22
Maple Meadow Bro	639.83	5-yr	339.00	74.11	79.26	77.24	79.39	0.000754	2.87	118.18	60.67	0.29

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	590.17		Bridge									
Maple Meadow Bro	548.93	10-yr	453.00	74.35	78.89		79.12	0.001338	3.89	118.28	132.21	0.38
Maple Meadow Bro	548.93	25-yr	629.00	74.35	79.12		79.51	0.002046	5.04	126.95	136.14	0.48
Maple Meadow Bro	548.93	50-yr	784.00	74.35	79.68		80.13	0.001921	5.40	160.24	145.71	0.48
Maple Meadow Bro	548.93	100-yr	956.00	74.35	79.90	78.47	80.46	0.003173	6.07	191.76	170.03	0.59
Maple Meadow Bro	548.93	200-yr	1150.00	74.35	79.99	78.84	80.74	0.004092	7.03	208.47	177.34	0.68
Maple Meadow Bro	548.93	500-yr	1450.00	74.35	80.30	79.34	81.20	0.004583	7.88	266.16	224.19	0.72
Maple Meadow Bro	548.93	2-yr	204.00	74.35	78.73		78.78	0.000323	1.85	112.20	129.46	0.19
Maple Meadow Bro	548.93	5-yr	339.00	74.35	78.82		78.96	0.000808	2.98	115.60	131.00	0.30
Maple Meadow Bro	469.67	10-yr	453.00	76.91	78.86		78.93	0.001494	2.92	323.05	228.79	0.37
Maple Meadow Bro	469.67	25-yr	629.00	76.91	79.10		79.20	0.002103	3.74	381.45	272.26	0.45
Maple Meadow Bro	469.67	50-yr	784.00	76.91	79.75		79.82	0.001171	3.34	587.65	331.78	0.35
Maple Meadow Bro	469.67	100-yr	956.00	76.91	79.99		80.07	0.001228	3.61	668.62	351.91	0.37
Maple Meadow Bro	469.67	200-yr	1150.00	76.91	80.12		80.24	0.001521	4.14	717.53	360.12	0.41
Maple Meadow Bro	469.67	500-yr	1450.00	76.91	80.49		80.62	0.001510	4.45	853.84	378.19	0.42
Maple Meadow Bro	469.67	2-yr	204.00	76.91	78.72		78.74	0.000404	1.44	291.10	214.83	0.19
Maple Meadow Bro	469.67	5-yr	339.00	76.91	78.80		78.84	0.000949	2.27	308.52	221.78	0.30
Maple Meadow Bro	408.43	10-yr	453.00	75.29	78.85	77.08	78.88	0.000330	1.96	599.74	315.35	0.19
Maple Meadow Bro	408.43	25-yr	629.00	75.29	79.09	77.44	79.13	0.000453	2.41	676.14	317.31	0.23
Maple Meadow Bro	408.43	50-yr	784.00	75.29	79.74	77.71	79.78	0.000326	2.29	884.61	325.37	0.20
Maple Meadow Bro	408.43	100-yr	956.00	75.29	79.98	77.81	80.02	0.000384	2.58	962.00	341.07	0.22
Maple Meadow Bro	408.43	200-yr	1150.00	75.29	80.12	78.05	80.17	0.000489	2.97	1007.21	353.44	0.25
Maple Meadow Bro	408.43	500-yr	1450.00	75.29	80.48	78.26	80.55	0.000561	3.35	1130.96	372.02	0.27
Maple Meadow Bro	408.43	2-yr	204.00	75.29	78.72	76.58	78.72	0.000082	0.95	557.14	314.25	0.10
Maple Meadow Bro	408.43	5-yr	339.00	75.29	78.79	76.87	78.81	0.000202	1.51	580.85	314.86	0.15
Maple Meadow Bro	305.54	10-yr	453.00	74.28	78.82	77.39	78.84	0.000306	1.62	615.82	503.89	0.18
Maple Meadow Bro	305.54	25-yr	629.00	74.28	79.05	77.68	79.09	0.000405	1.97	704.12	530.63	0.21
Maple Meadow Bro	305.54	50-yr	784.00	74.28	79.72	77.82	79.75	0.000254	1.80	961.71	653.38	0.17
Maple Meadow Bro	305.54	100-yr	956.00	74.28	79.95	77.97	79.98	0.000287	2.00	1052.51	659.34	0.18
Maple Meadow Bro	305.54	200-yr	1150.00	74.28	80.08	78.11	80.12	0.000361	2.29	1102.75	661.83	0.21
Maple Meadow Bro	305.54	500-yr	1450.00	74.28	80.44	78.32	80.49	0.000396	2.55	1243.96	668.83	0.22
Maple Meadow Bro	305.54	2-yr	204.00	74.28	78.71	76.60	78.71	0.000076	0.78	573.29	493.94	0.09
Maple Meadow Bro	305.54	5-yr	339.00	74.28	78.77	77.18	78.79	0.000186	1.25	597.64	498.80	0.14
Maple Meadow Bro	204.69	10-yr	453.00	74.59	78.81	77.23	78.82	0.000173	1.36	944.64	598.63	0.14
Maple Meadow Bro	204.69	25-yr	629.00	74.59	79.03	77.59	79.05	0.000234	1.65	1076.87	629.81	0.16
Maple Meadow Bro	204.69	50-yr	784.00	74.59	79.71	77.75	79.72	0.000148	1.49	1493.76	675.75	0.13

HEC-RAS Plan: Prop PIU River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	204.69	100-yr	956.00	74.59	79.94	77.85	79.96	0.000166	1.65	1642.23	686.54	0.14
Maple Meadow Bro	204.69	200-yr	1150.00	74.59	80.07	77.95	80.09	0.000209	1.88	1724.22	694.65	0.16
Maple Meadow Bro	204.69	500-yr	1450.00	74.59	80.43	78.09	80.45	0.000225	2.06	1960.85	702.45	0.17
Maple Meadow Bro	204.69	2-yr	204.00	74.59	78.71	76.68	78.71	0.000042	0.65	887.67	591.60	0.07
Maple Meadow Bro	204.69	5-yr	339.00	74.59	78.77	77.01	78.77	0.000104	1.04	920.79	595.57	0.11
Maple Meadow Bro	100.76	10-yr	453.00	74.57	78.79		78.80	0.000152	1.31	992.99	609.58	0.13
Maple Meadow Bro	100.76	25-yr	629.00	74.57	79.01		79.03	0.000204	1.58	1128.77	614.51	0.15
Maple Meadow Bro	100.76	50-yr	784.00	74.57	79.70		79.71	0.000125	1.40	1556.94	657.69	0.12
Maple Meadow Bro	100.76	100-yr	956.00	74.57	79.93		79.94	0.000142	1.55	1713.66	693.64	0.13
Maple Meadow Bro	100.76	200-yr	1150.00	74.57	80.05		80.07	0.000189	1.82	1798.58	701.09	0.15
Maple Meadow Bro	100.76	500-yr	1450.00	74.57	80.41		80.43	0.000204	1.99	2053.77	707.45	0.16
Maple Meadow Bro	100.76	2-yr	204.00	74.57	78.70		78.70	0.000036	0.62	939.12	607.60	0.06
Maple Meadow Bro	100.76	5-yr	339.00	74.57	78.75		78.76	0.000090	1.00	971.36	608.78	0.10
Maple Meadow Bro	0	10-yr	453.00	73.69	78.78	76.48	78.79	0.000080	0.98	1123.81	598.96	0.09
Maple Meadow Bro	0	25-yr	629.00	73.69	79.00	76.84	79.01	0.000114	1.22	1255.22	606.82	0.11
Maple Meadow Bro	0	50-yr	784.00	73.69	79.69	77.07	79.70	0.000078	1.14	1678.52	625.94	0.10
Maple Meadow Bro	0	100-yr	956.00	73.69	79.92	77.23	79.93	0.000092	1.28	1821.33	642.80	0.11
Maple Meadow Bro	0	200-yr	1150.00	73.69	80.04	77.34	80.05	0.000119	1.48	1896.37	650.43	0.12
Maple Meadow Bro	0	500-yr	1450.00	73.69	80.40	77.50	80.42	0.000136	1.67	2125.83	672.90	0.13
Maple Meadow Bro	0	2-yr	204.00	73.69	78.70	75.67	78.70	0.000018	0.46	1074.81	596.12	0.05
Maple Meadow Bro	0	5-yr	339.00	73.69	78.75	76.18	78.75	0.000047	0.74	1104.67	597.85	0.07


Maple Meadow Brook Plan: Prop StrmSts PIU 4/7/2025
Legend
WS 500-yr
WS 200-yr
WS 100-yr
WS 50-yr
WS 25-yr
WS 10-yr
WS 5-yr
WS 2-yr
Ground
Elevation (ft)
86
84
82
80
78
76
74
72
70
Main Channel Distance (ft)
0
500
1000
1500
2000
2500
3000

APPENDIX F

STAGE STORAGE ANALYSIS

HEC-HMS Routing Analysis

Existing and Proposed Conditions

Project: Rte_38_Main_St_Bridge
Simulation Run: 2yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:15

A00882 - 85

Proposal No. 608051 - 132406

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	511.7	04Dec2024, 14:14	0.99
Routing US of Rte 38 Prop	4.03	486.67	04Dec2024, 14:42	0.97
Watershed US of Rte 38 Exist	4.03	511.7	04Dec2024, 14:14	0.99
Routing US of Rte 38 Exist	4.03	259.48	04Dec2024, 16:43	0.97

A00882 - 86

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

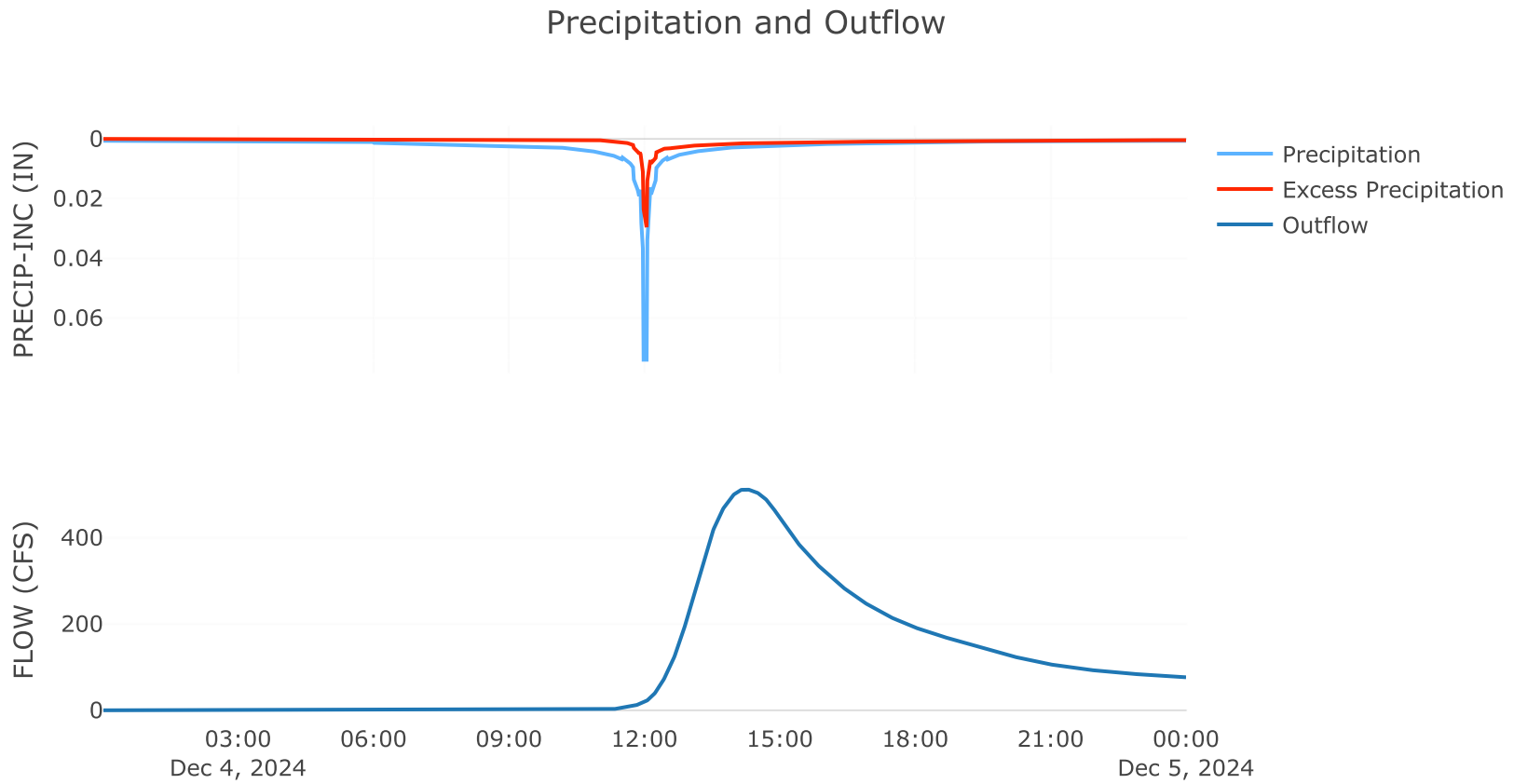
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	511.7
Time of Peak Discharge	04Dec2024, 14:14
Volume (IN)	0.99
Precipitation Volume (AC - FT)	711.43
Loss Volume (AC - FT)	484.93
Excess Volume (AC - FT)	226.5
Direct Runoff Volume (AC - FT)	212.2
Baseflow Volume (AC - FT)	0

A00882 - 87
Proposal No. 608051 - 132406



A00882 - 88

Proposal No. 608051 - 132406

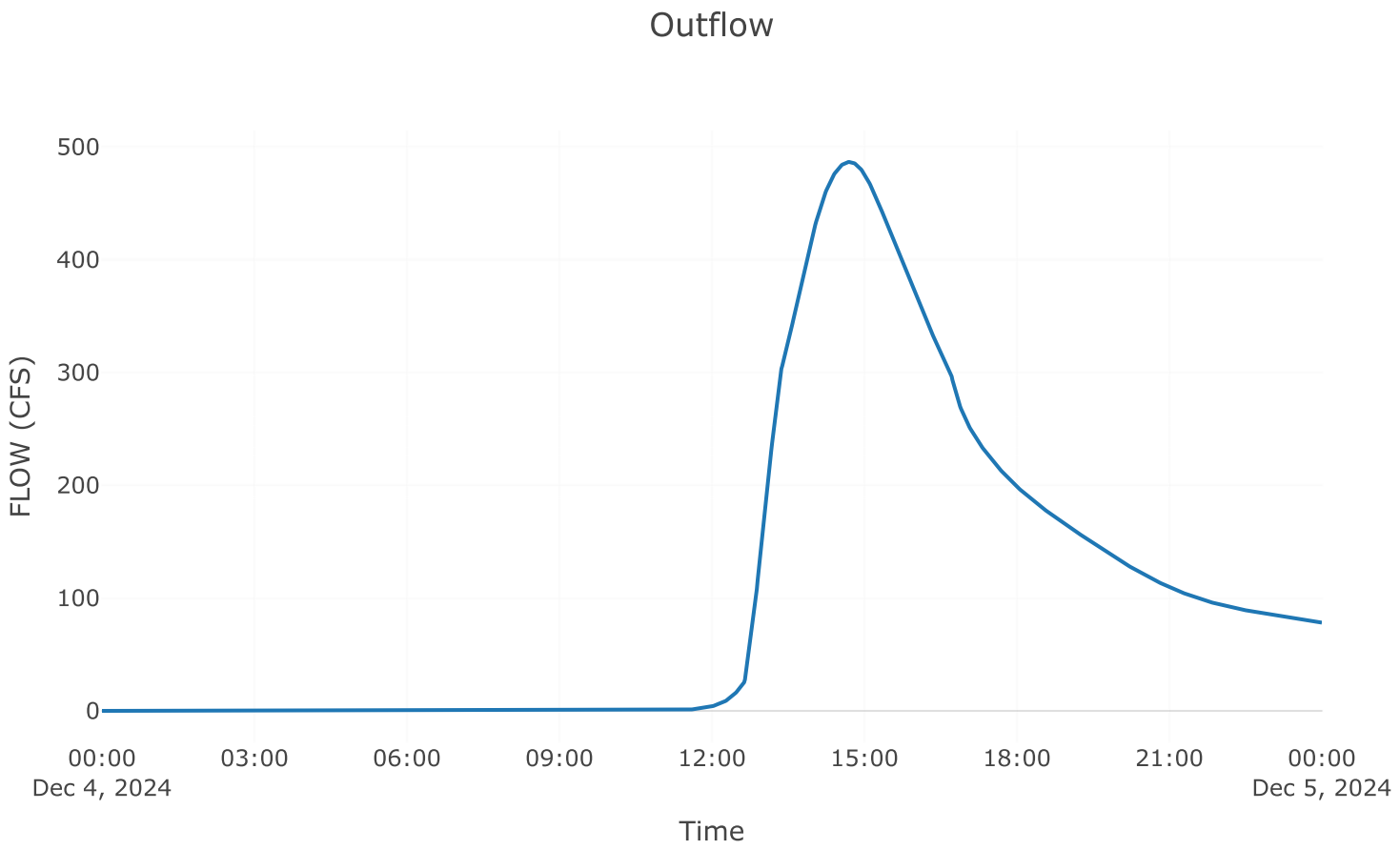
Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	486.67
Time of Peak Discharge	04Dec2024, 14:42
Volume (IN)	0.97
Peak Inflow (CFS)	511.7
Time of Peak Inflow	04Dec2024, 14:14
Inflow Volume (AC - FT)	212.2
Maximum Storage (AC - FT)	14.41
Peak Elevation (FT)	79.62
Discharge Volume (AC - FT)	207.94

A00882 - 89

Proposal No. 608051 - 132406



A00882 - 90

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Exist

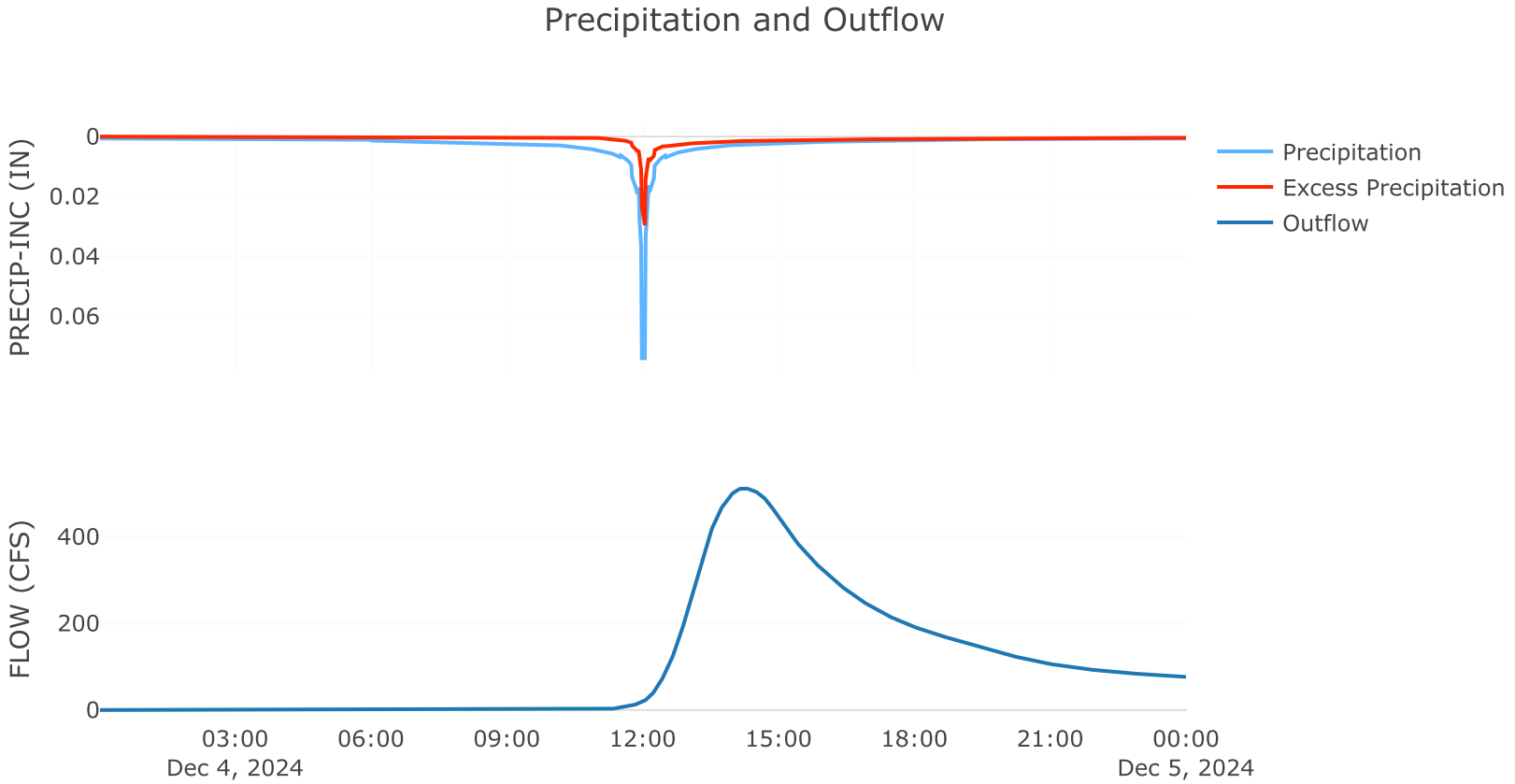
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	511.7
Time of Peak Discharge	04Dec2024, 14:14
Volume (IN)	0.99
Precipitation Volume (AC - FT)	711.43
Loss Volume (AC - FT)	484.93
Excess Volume (AC - FT)	226.5
Direct Runoff Volume (AC - FT)	212.2
Baseflow Volume (AC - FT)	0

A00882 - 91
Proposal No. 608051 - 132406



A00882 - 92

Proposal No. 608051 - 132406

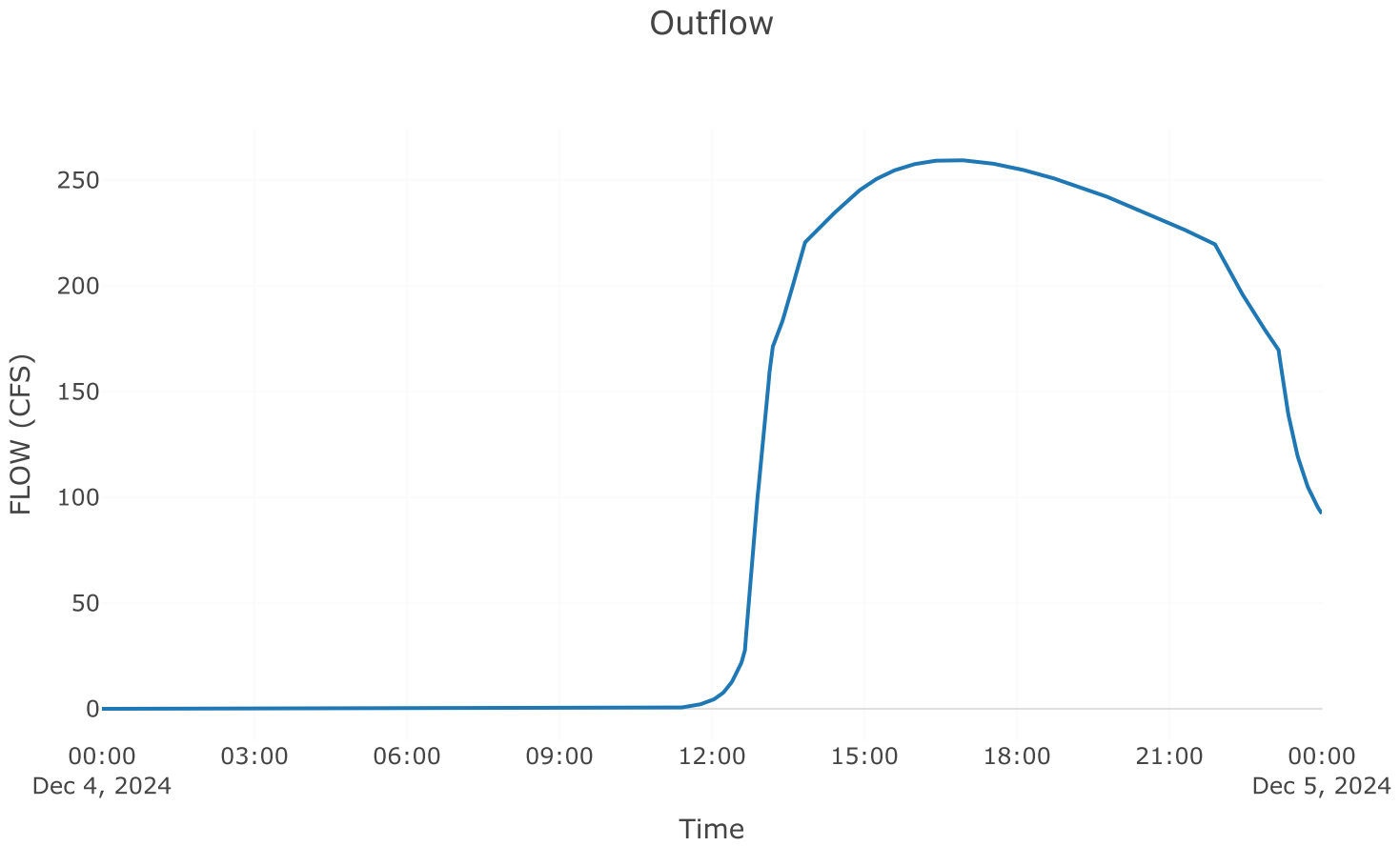
Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	259.48
Time of Peak Discharge	04Dec2024, 16:43
Volume (IN)	0.97
Peak Inflow (CFS)	511.7
Time of Peak Inflow	04Dec2024, 14:14
Inflow Volume (AC - FT)	212.2
Maximum Storage (AC - FT)	56.15
Peak Elevation (FT)	80.44
Discharge Volume (AC - FT)	207.57

A00882 - 93

Proposal No. 608051 - 132406



A00882 - 94

Proposal No. 608051 - 132406

Project: Rte_38_Main_St_Bridge
Simulation Run: 5yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:15

A00882 - 95

Proposal No. 608051 - 132406

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	891.23	04Dec2024, 14:08	1.68
Routing US of Rte 38 Prop	4.03	738.74	04Dec2024, 15:01	1.65
Watershed US of Rte 38 Exist	4.03	891.23	04Dec2024, 14:08	1.68
Routing US of Rte 38 Exist	4.03	319.82	04Dec2024, 17:40	1.33

A00882 - 96

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

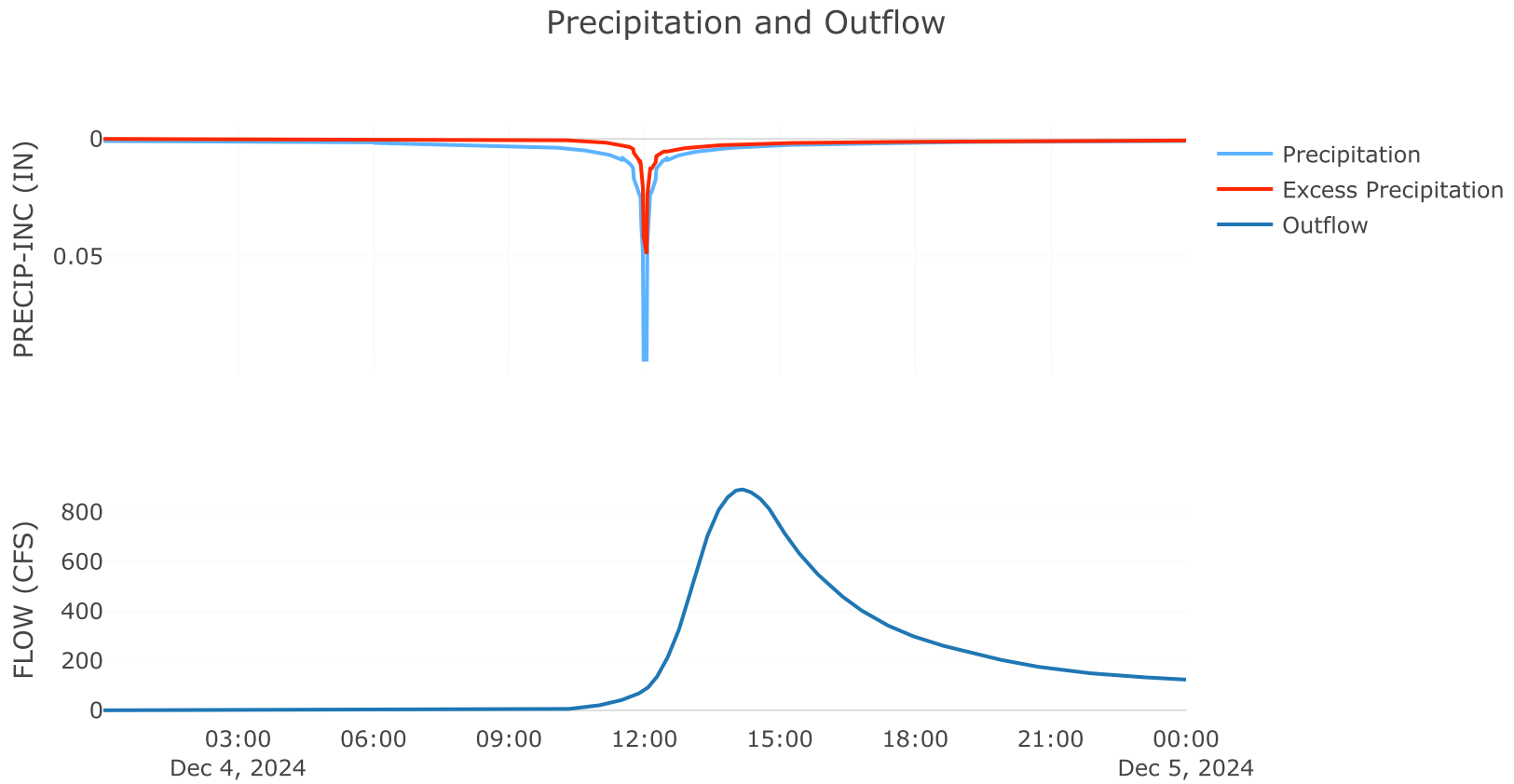
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	891.23
Time of Peak Discharge	04Dec2024, 14:08
Volume (IN)	1.68
Precipitation Volume (AC - FT)	934.96
Loss Volume (AC - FT)	551.67
Excess Volume (AC - FT)	383.29
Direct Runoff Volume (AC - FT)	360.08
Baseflow Volume (AC - FT)	0

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Proposal No. 608051 - 132406



A00882 - 98

Proposal No. 608051 - 132406

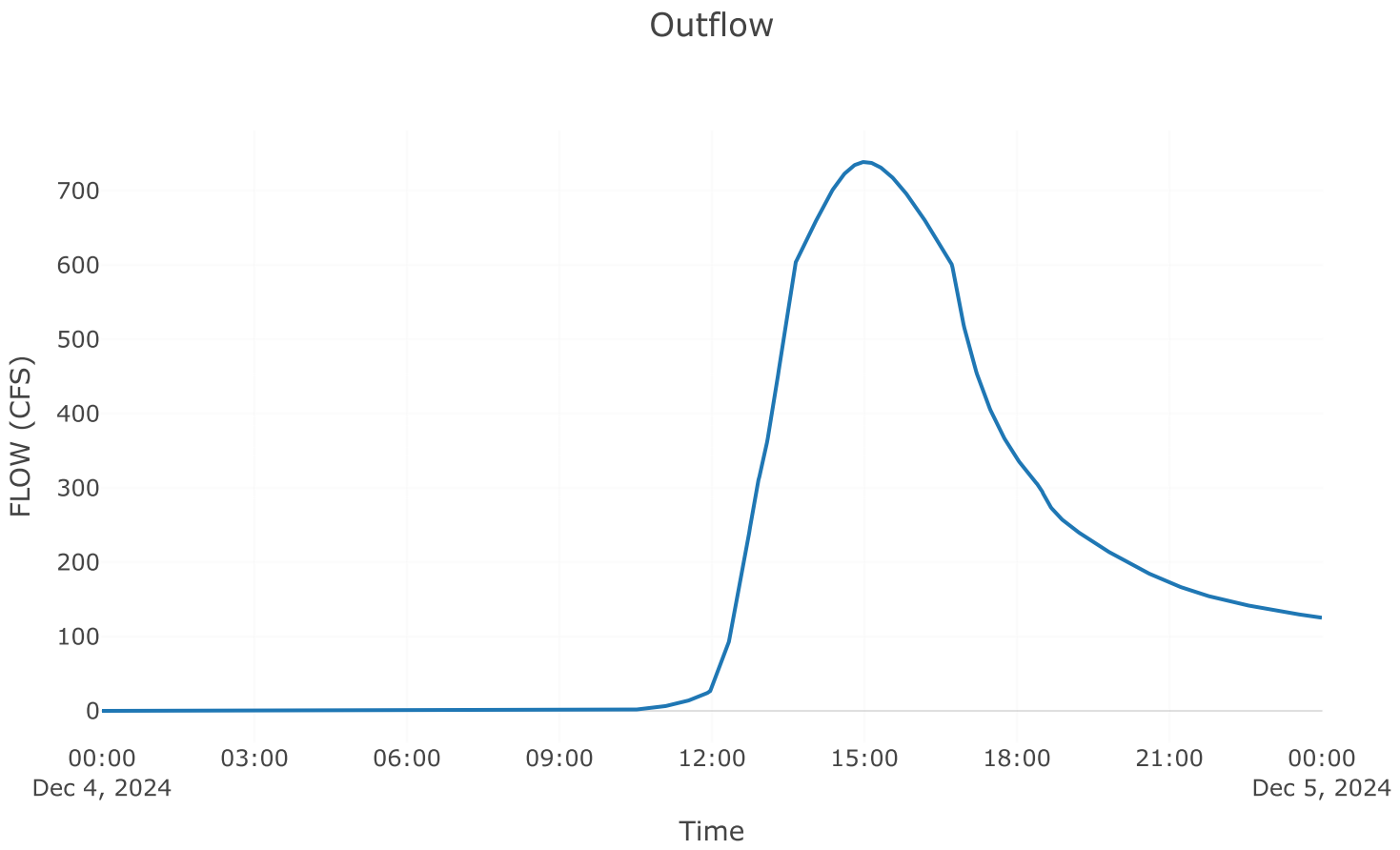
Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	738.74
Time of Peak Discharge	04Dec2024, 15:01
Volume (IN)	1.65
Peak Inflow (CFS)	891.23
Time of Peak Inflow	04Dec2024, 14:08
Inflow Volume (AC - FT)	360.08
Maximum Storage (AC - FT)	37.15
Peak Elevation (FT)	80.22
Discharge Volume (AC - FT)	355.04

A00882 - 99

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A00882 - 100

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Exist

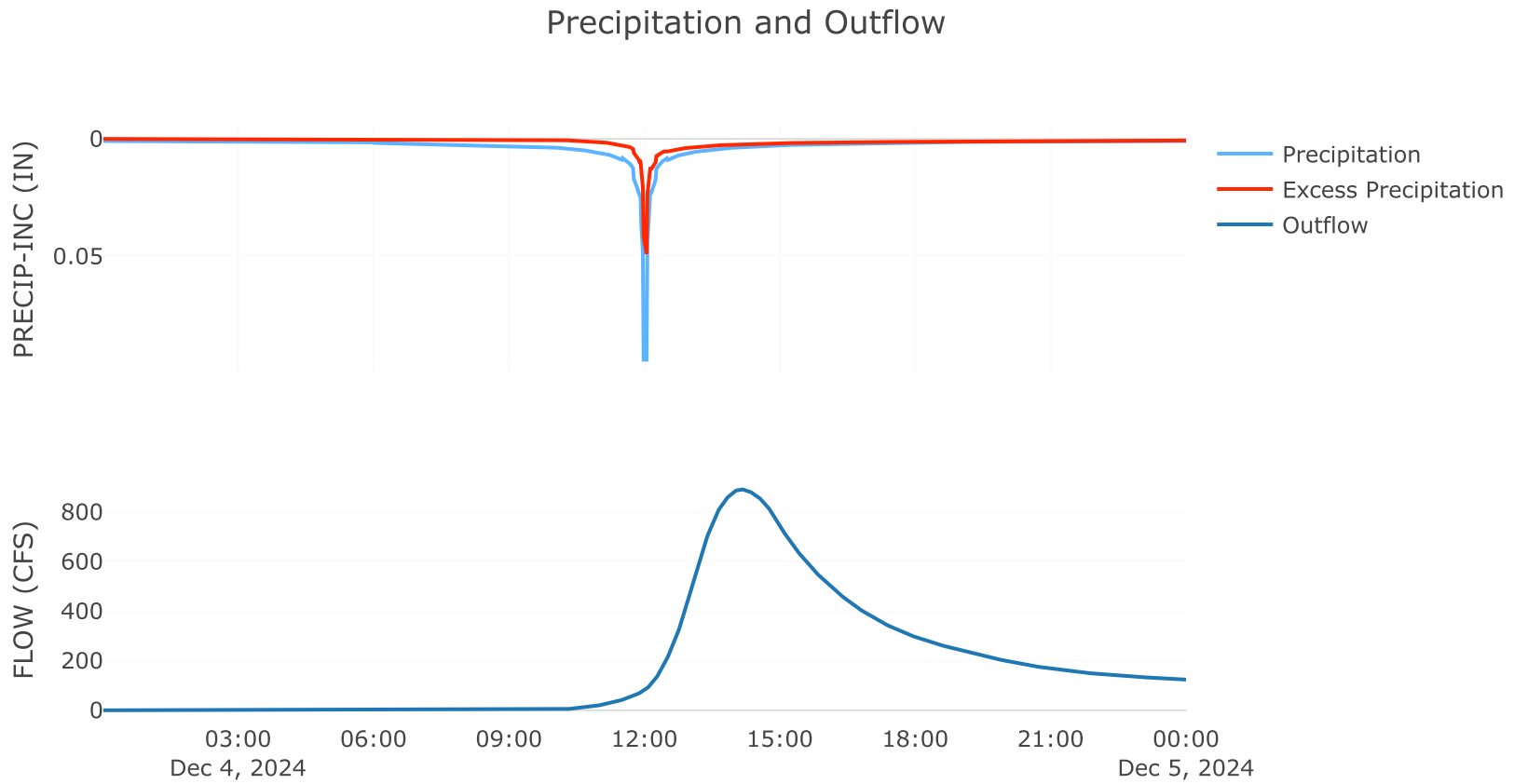
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	891.23
Time of Peak Discharge	04Dec2024, 14:08
Volume (IN)	1.68
Precipitation Volume (AC - FT)	934.96
Loss Volume (AC - FT)	551.67
Excess Volume (AC - FT)	383.29
Direct Runoff Volume (AC - FT)	360.08
Baseflow Volume (AC - FT)	0

A00882 - 101
Proposal No. 608051 - 132406



A00882 - 102

Proposal No. 608051 - 132406

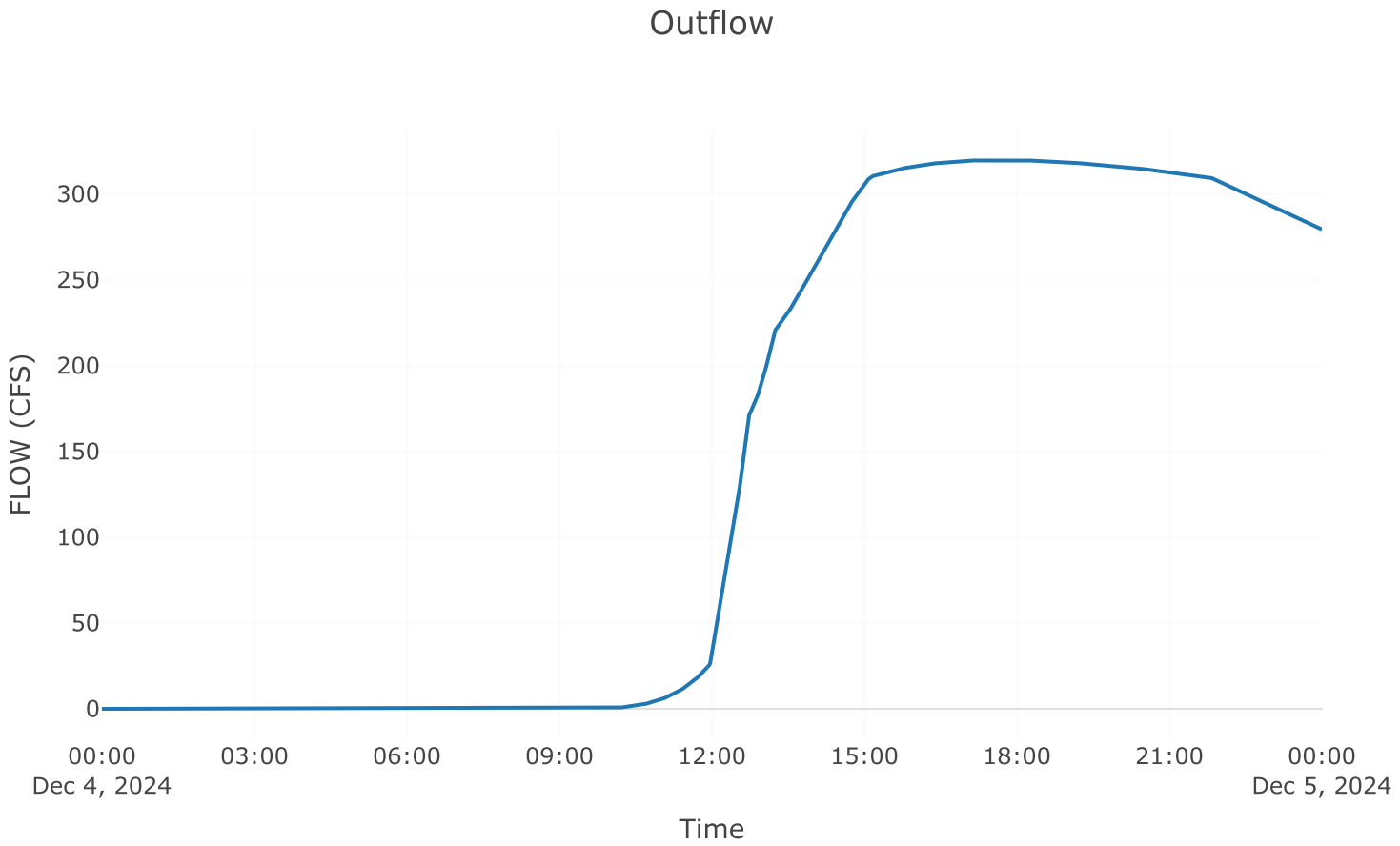
Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	319.82
Time of Peak Discharge	04Dec2024, 17:40
Volume (IN)	1.33
Peak Inflow (CFS)	891.23
Time of Peak Inflow	04Dec2024, 14:08
Inflow Volume (AC - FT)	360.08
Maximum Storage (AC - FT)	137.7
Peak Elevation (FT)	81.2
Discharge Volume (AC - FT)	284.95

A00882 - 103

Proposal No. 608051 - 132406



A00882 - 104

Proposal No. 608051 - 132406

Project: Rte_38_Main_St_Bridge
Simulation Run: 10-yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:15

A00882 - 105

Proposal No. 608051 - 132406

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	1232.59	04Dec2024, 14:06	2.3
Routing US of Rte 38 Prop	4.03	840.76	04Dec2024, 15:28	2.28
Watershed US of Rte 38 Exist	4.03	1232.59	04Dec2024, 14:06	2.3
Routing US of Rte 38 Exist	4.03	345.89	04Dec2024, 18:30	1.49

A00882 - 106

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

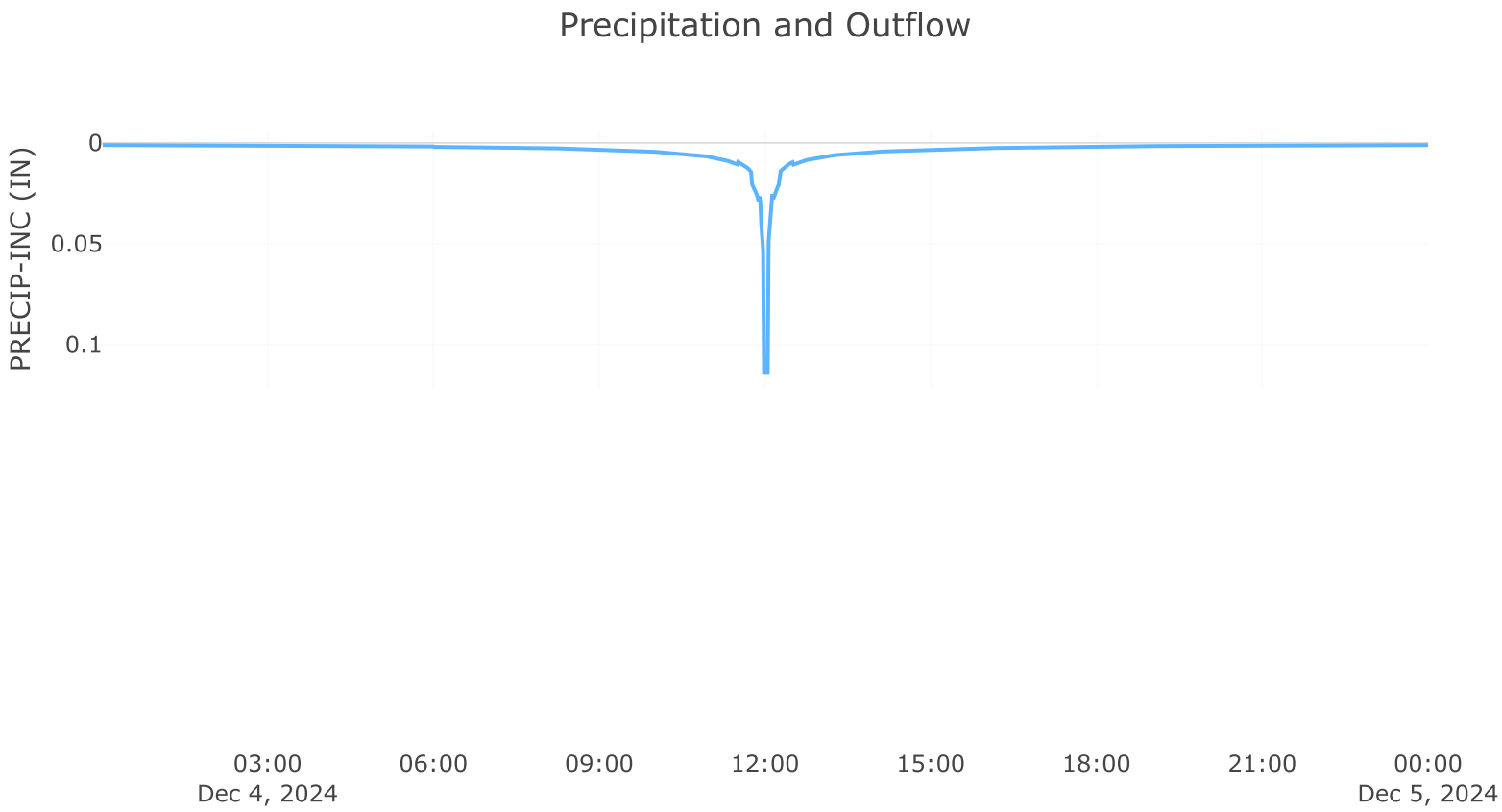
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	1232.59
Time of Peak Discharge	04Dec2024, 14:06
Volume (IN)	2.3
Precipitation Volume (AC - FT)	1119.8
Loss Volume (AC - FT)	594.02
Excess Volume (AC - FT)	525.79
Direct Runoff Volume (AC - FT)	495.14
Baseflow Volume (AC - FT)	0

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Proposal No. 608051 - 132406



A00882 - 108

Proposal No. 608051 - 132406

Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	840.76
Time of Peak Discharge	04Dec2024, 15:28
Volume (IN)	2.28
Peak Inflow (CFS)	1232.59
Time of Peak Inflow	04Dec2024, 14:06
Inflow Volume (AC - FT)	495.14
Maximum Storage (AC - FT)	77.04
Peak Elevation (FT)	80.68
Discharge Volume (AC - FT)	489.52

A00882 - 109

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Exist

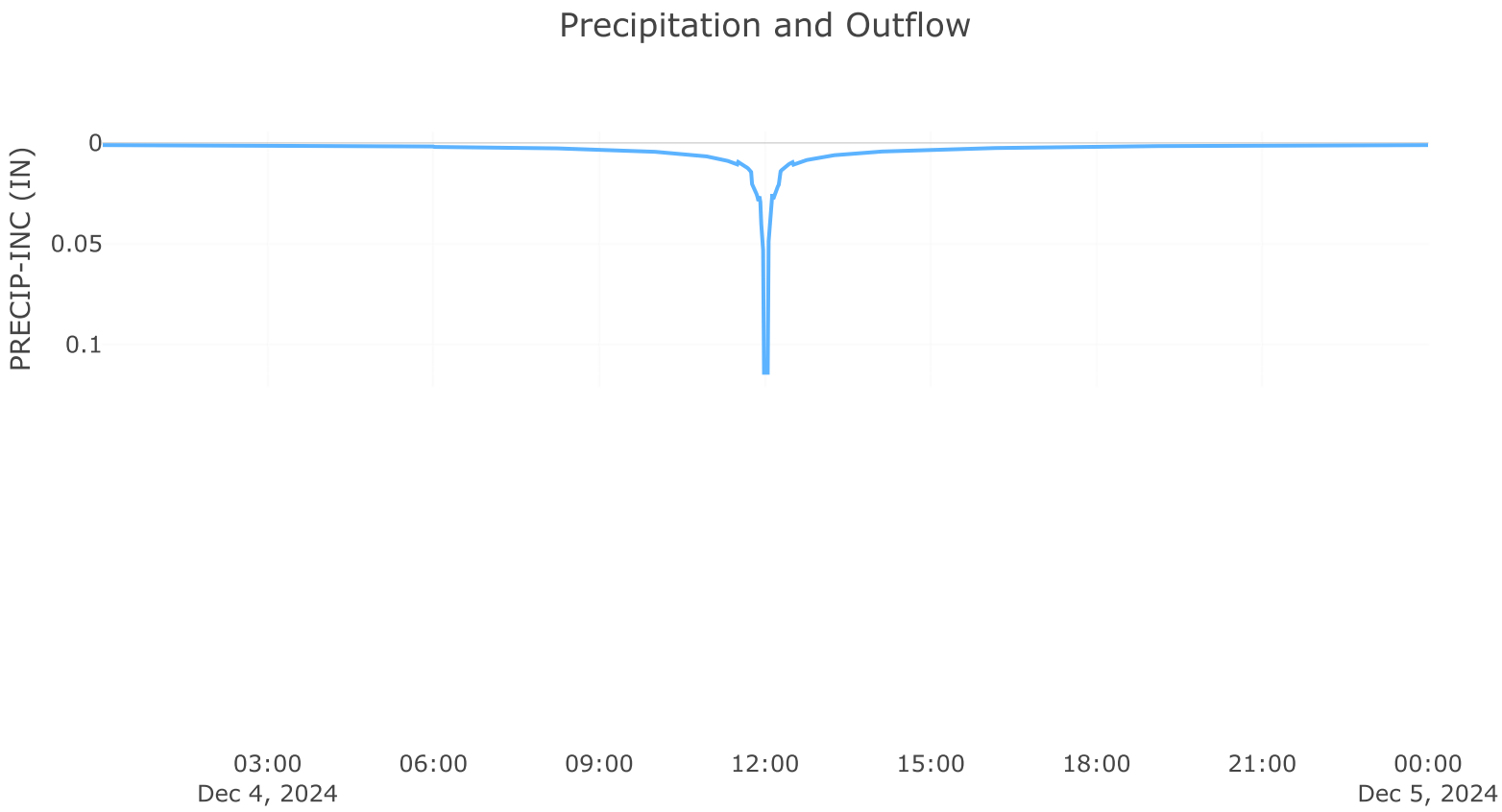
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	1232.59
Time of Peak Discharge	04Dec2024, 14:06
Volume (IN)	2.3
Precipitation Volume (AC - FT)	1119.8
Loss Volume (AC - FT)	594.02
Excess Volume (AC - FT)	525.79
Direct Runoff Volume (AC - FT)	495.14
Baseflow Volume (AC - FT)	0

A00882 - 110
Proposal No. 608051 - 132406



A00882 - 111

Proposal No. 608051 - 132406

Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	345.89
Time of Peak Discharge	04Dec2024, 18:30
Volume (IN)	1.49
Peak Inflow (CFS)	1232.59
Time of Peak Inflow	04Dec2024, 14:06
Inflow Volume (AC - FT)	495.14
Maximum Storage (AC - FT)	226.57
Peak Elevation (FT)	81.72
Discharge Volume (AC - FT)	320.08

A00882 - 112

Proposal No. 608051 - 132406

Project: Rte_38_Main_St_Bridge
Simulation Run: 25yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:15

A00882 - 113

Proposal No. 608051 - 132406

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	1727.8	04Dec2024, 14:05	3.23
Routing US of Rte 38 Prop	4.03	930.9	04Dec2024, 16:02	3.2
Watershed US of Rte 38 Exist	4.03	1727.8	04Dec2024, 14:05	3.23
Routing US of Rte 38 Exist	4.03	477.96	04Dec2024, 18:20	1.85

A00882 - 114

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

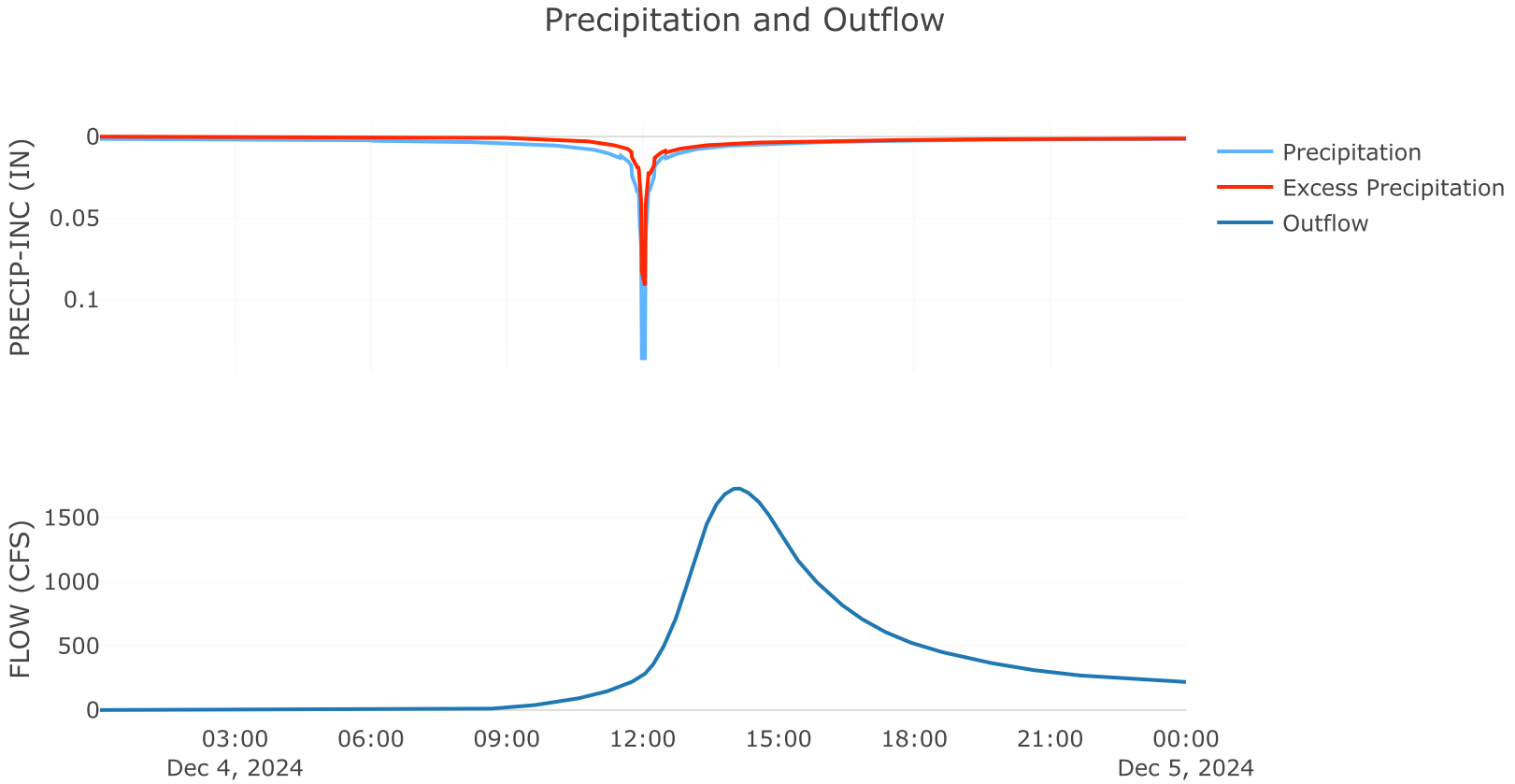
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	1727.8
Time of Peak Discharge	04Dec2024, 14:05
Volume (IN)	3.23
Precipitation Volume (AC - FT)	1375.57
Loss Volume (AC - FT)	639.78
Excess Volume (AC - FT)	735.79
Direct Runoff Volume (AC - FT)	694.76
Baseflow Volume (AC - FT)	0

A00882 - 115
Proposal No. 608051 - 132406



A00882 - 116

Proposal No. 608051 - 132406

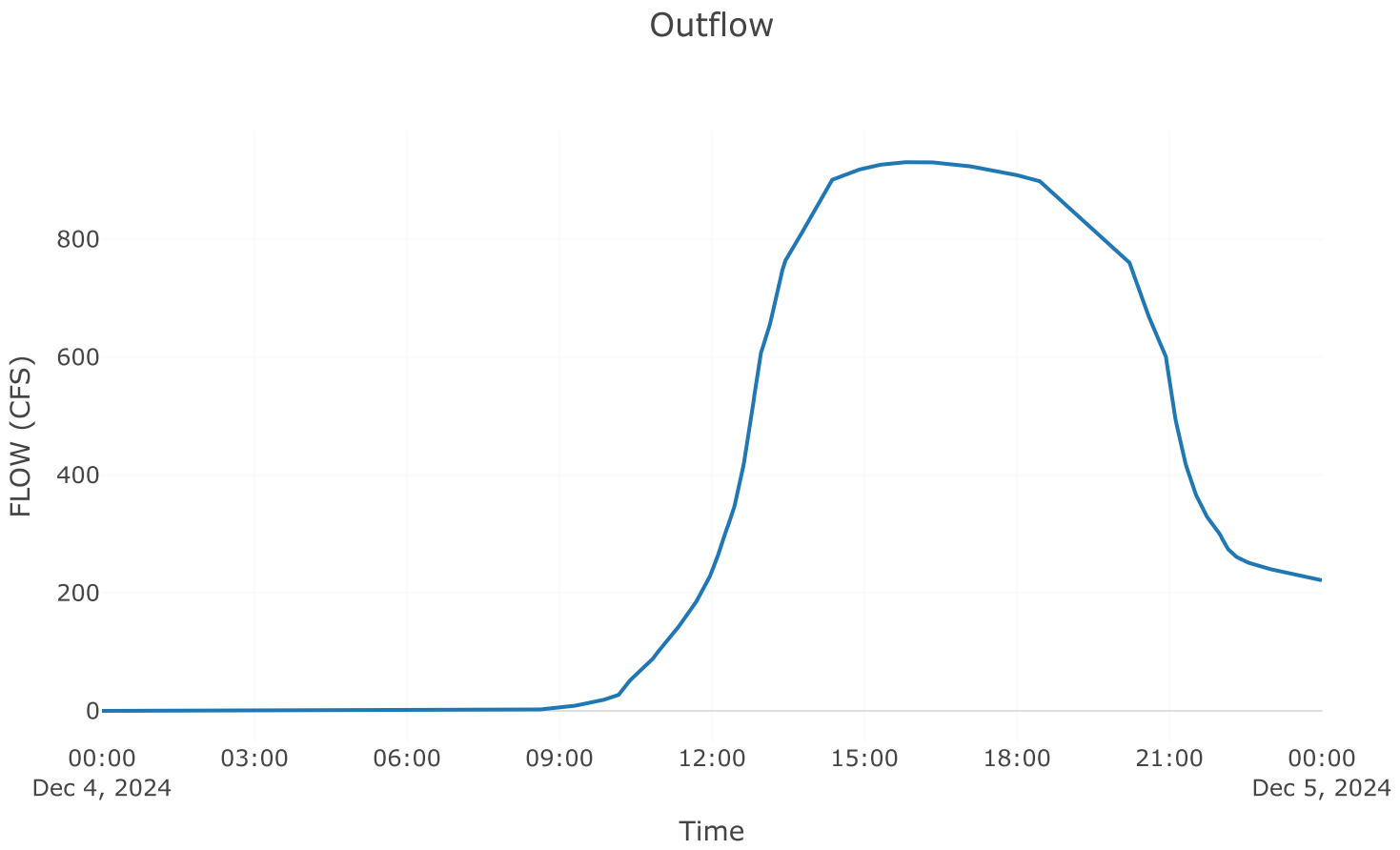
Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	930.9
Time of Peak Discharge	04Dec2024, 16:02
Volume (IN)	3.2
Peak Inflow (CFS)	1727.8
Time of Peak Inflow	04Dec2024, 14:05
Inflow Volume (AC - FT)	694.76
Maximum Storage (AC - FT)	156.88
Peak Elevation (FT)	81.31
Discharge Volume (AC - FT)	688.34

A00882 - 117

Proposal No. 608051 - 132406



A00882 - 118

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Exist

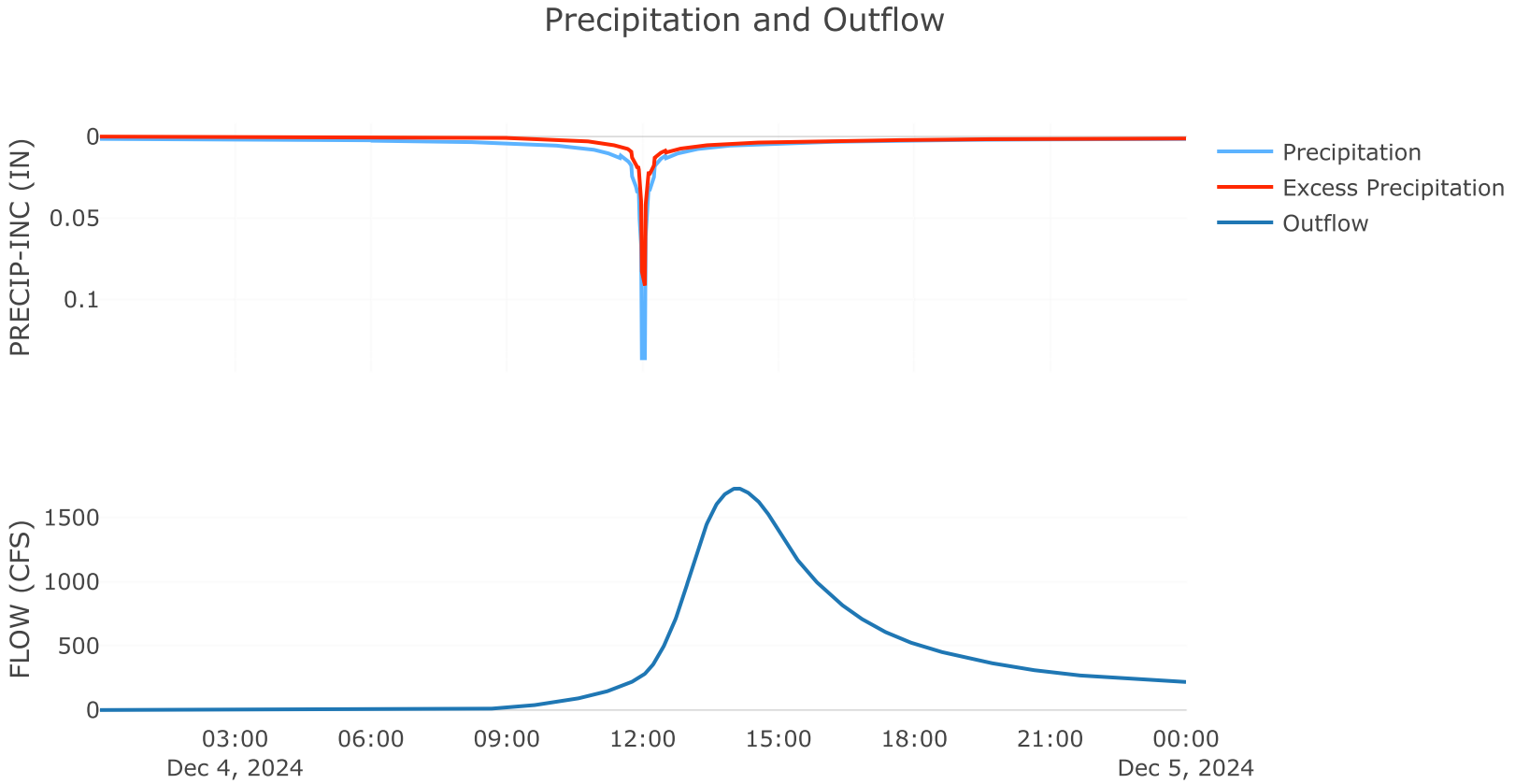
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	1727.8
Time of Peak Discharge	04Dec2024, 14:05
Volume (IN)	3.23
Precipitation Volume (AC - FT)	1375.57
Loss Volume (AC - FT)	639.78
Excess Volume (AC - FT)	735.79
Direct Runoff Volume (AC - FT)	694.76
Baseflow Volume (AC - FT)	0

A00882 - 119
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A00882 - 120

Proposal No. 608051 - 132406

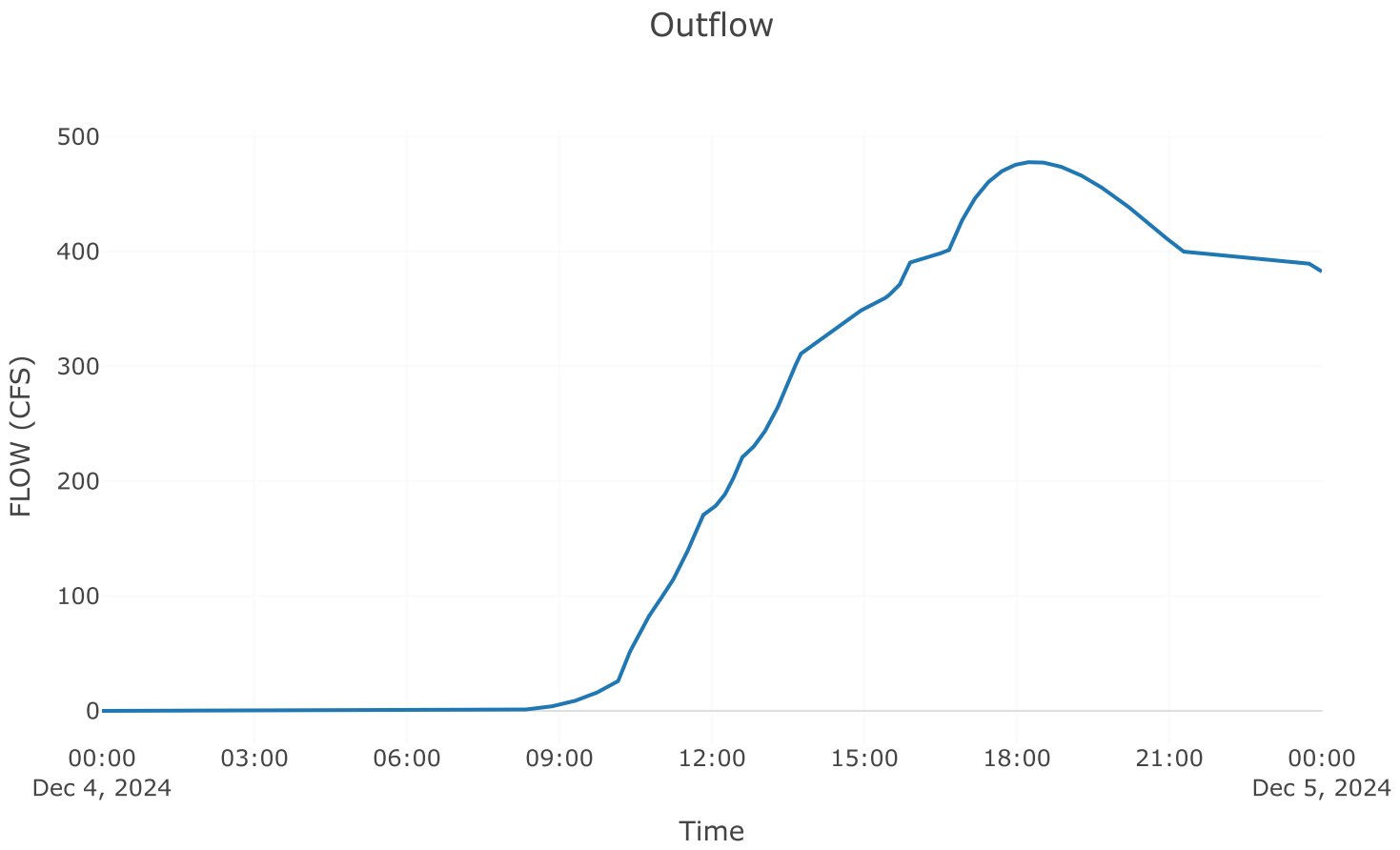
Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	477.96
Time of Peak Discharge	04Dec2024, 18:20
Volume (IN)	1.85
Peak Inflow (CFS)	1727.8
Time of Peak Inflow	04Dec2024, 14:05
Inflow Volume (AC - FT)	694.76
Maximum Storage (AC - FT)	349.49
Peak Elevation (FT)	82.37
Discharge Volume (AC - FT)	398.47

A00882 - 121

Proposal No. 608051 - 132406



A00882 - 122

Proposal No. 608051 - 132406

Project: Rte_38_Main_St_Bridge
Simulation Run: 50yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:21

A00882 - 123

Proposal No. 608051 - 132406

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	2107.09	04Dec2024, 14:04	3.95
Routing US of Rte 38 Prop	4.03	975.04	04Dec2024, 16:24	3.92
Watershed US of Rte 38 Exist	4.03	2107.09	04Dec2024, 14:04	3.95
Routing US of Rte 38 Exist	4.03	722.97	04Dec2024, 17:21	2.46

A00882 - 124

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

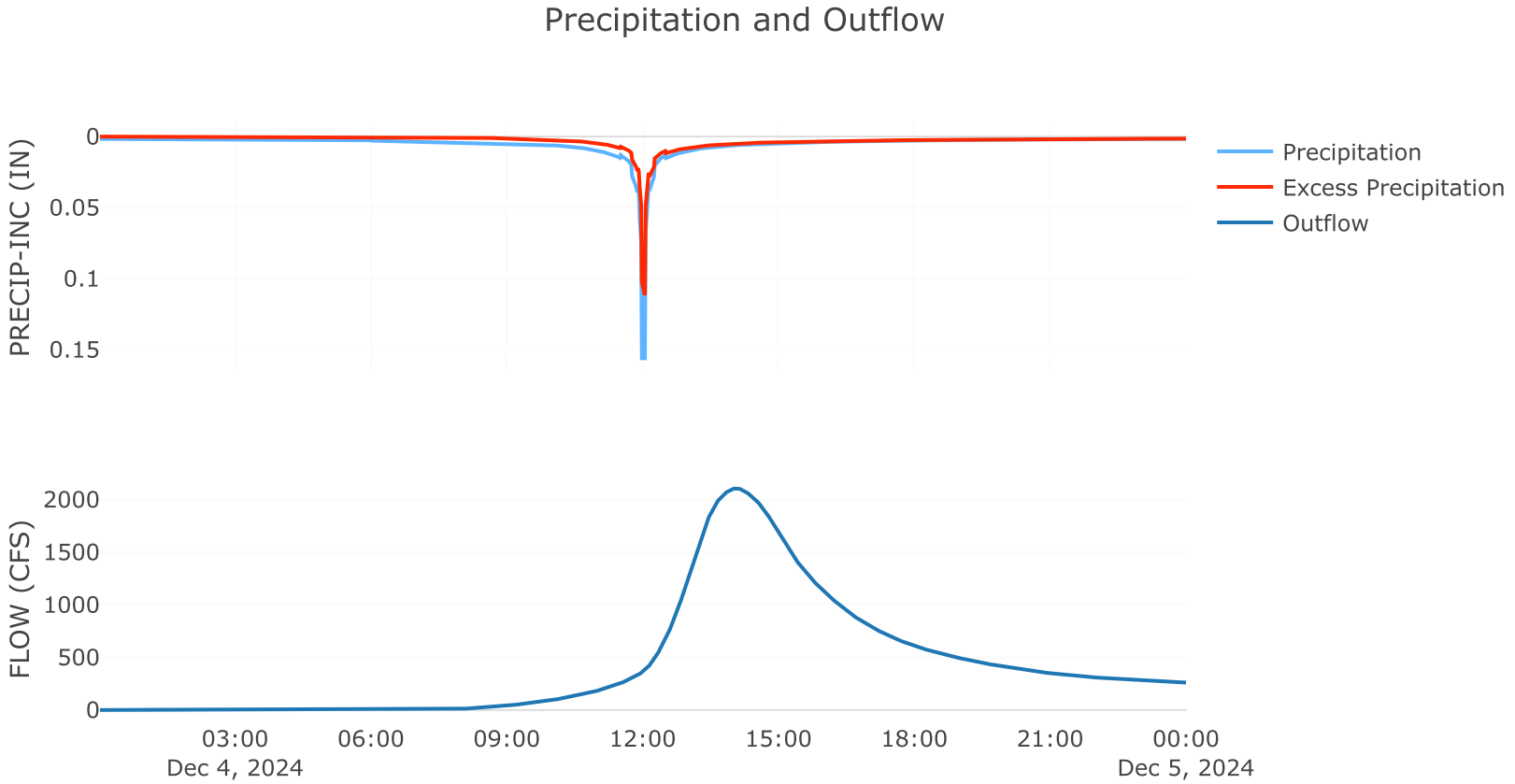
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	2107.09
Time of Peak Discharge	04Dec2024, 14:04
Volume (IN)	3.95
Precipitation Volume (AC - FT)	1564.71
Loss Volume (AC - FT)	666.79
Excess Volume (AC - FT)	897.93
Direct Runoff Volume (AC - FT)	848.91
Baseflow Volume (AC - FT)	0

A00882 - 125
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A00882 - 126

Proposal No. 608051 - 132406

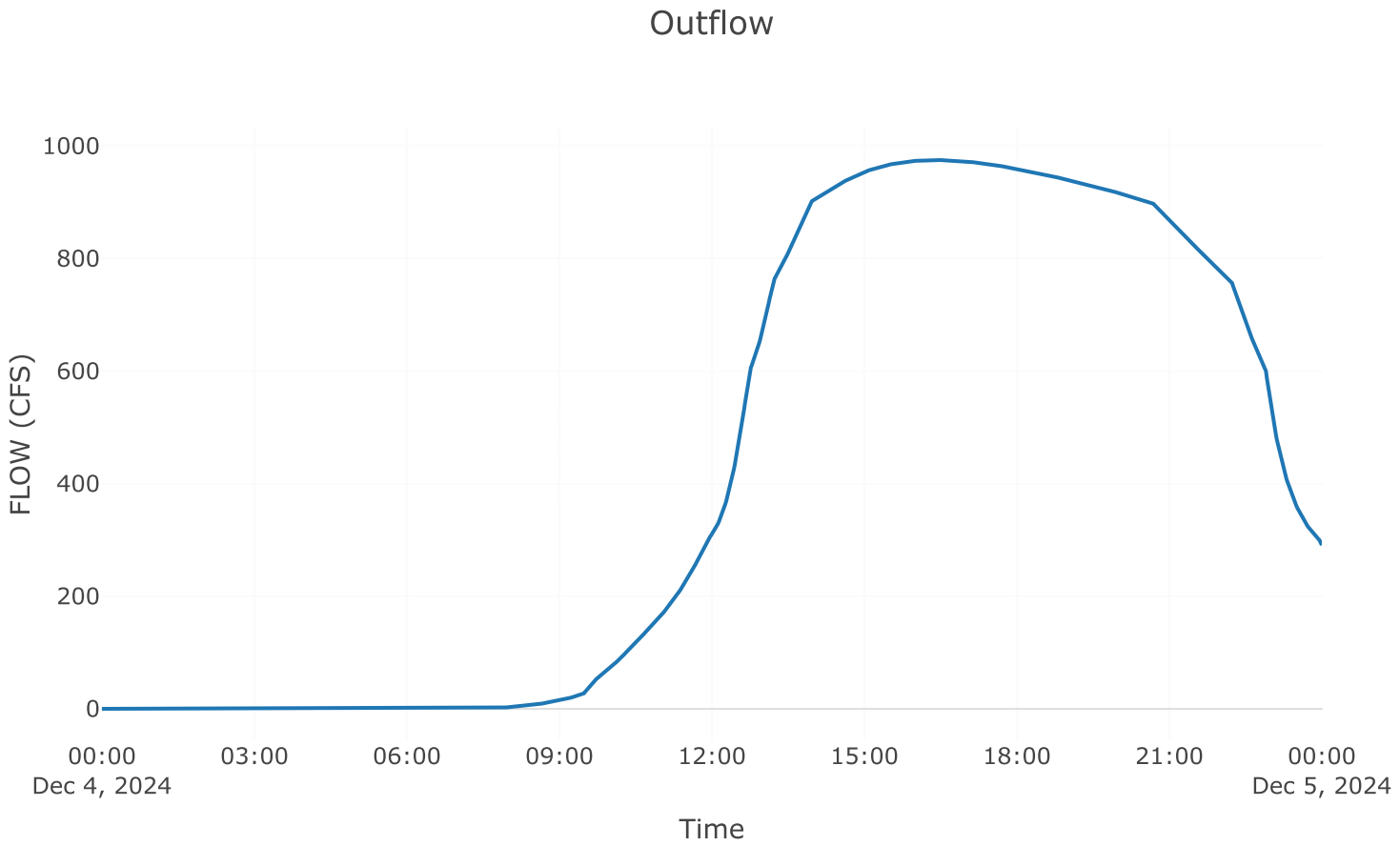
Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	975.04
Time of Peak Discharge	04Dec2024, 16:24
Volume (IN)	3.92
Peak Inflow (CFS)	2107.09
Time of Peak Inflow	04Dec2024, 14:04
Inflow Volume (AC - FT)	848.91
Maximum Storage (AC - FT)	232.12
Peak Elevation (FT)	81.75
Discharge Volume (AC - FT)	841.5

A00882 - 127

Proposal No. 608051 - 132406



A00882 - 128

Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Exist

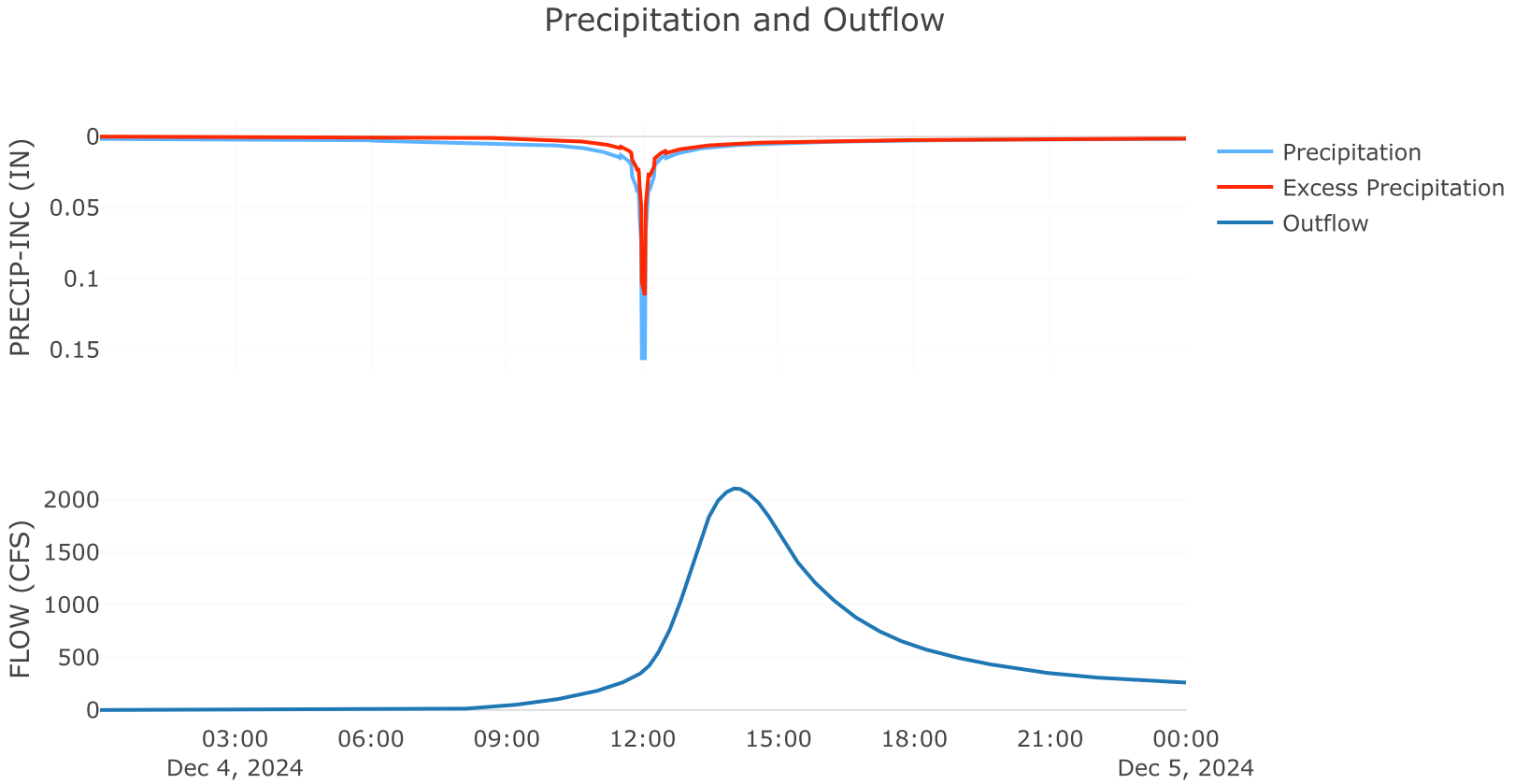
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	2107.09
Time of Peak Discharge	04Dec2024, 14:04
Volume (IN)	3.95
Precipitation Volume (AC - FT)	1564.71
Loss Volume (AC - FT)	666.79
Excess Volume (AC - FT)	897.93
Direct Runoff Volume (AC - FT)	848.91
Baseflow Volume (AC - FT)	0

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A00882 - 130

Proposal No. 608051 - 132406

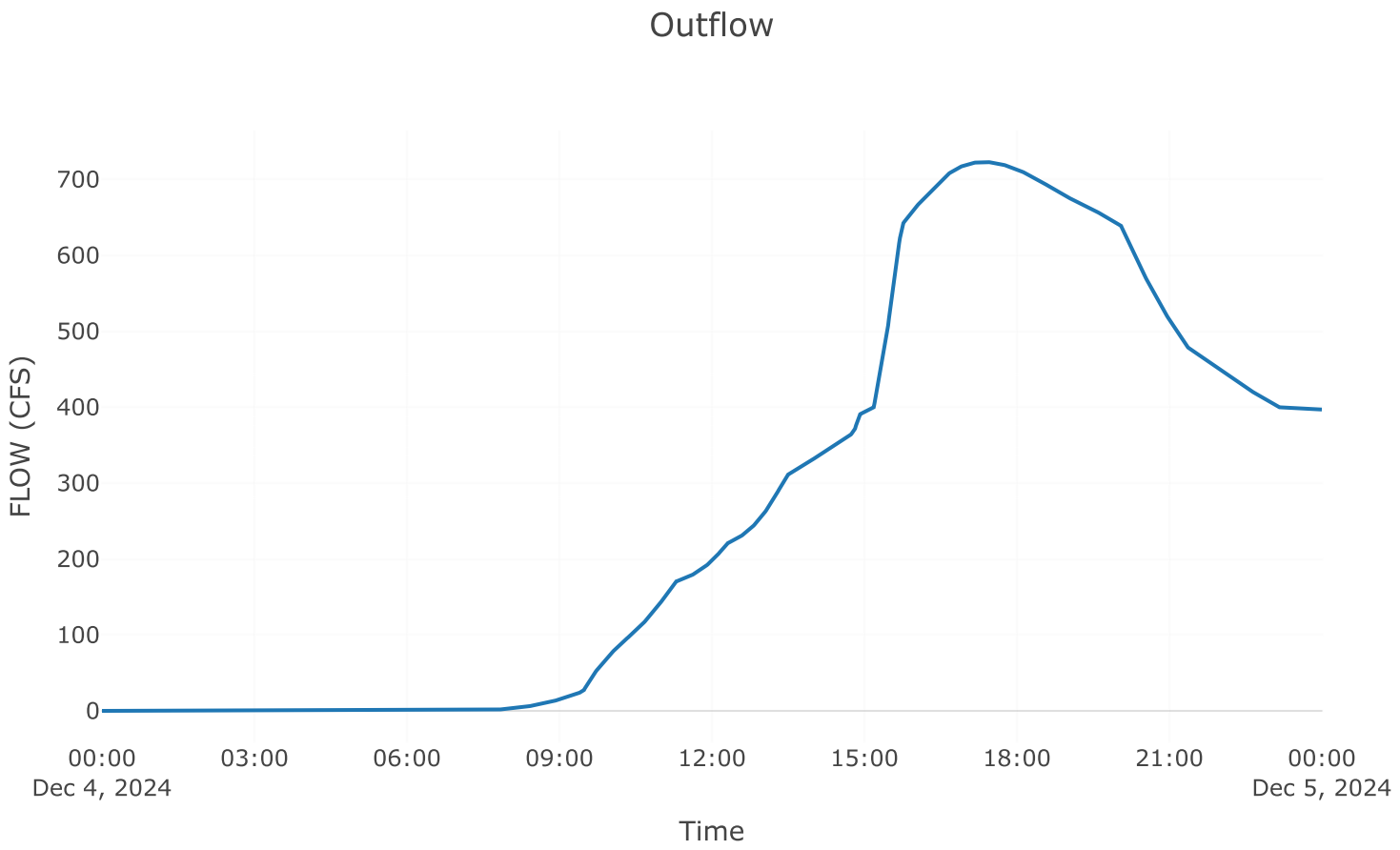
Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	722.97
Time of Peak Discharge	04Dec2024, 17:21
Volume (IN)	2.46
Peak Inflow (CFS)	2107.09
Time of Peak Inflow	04Dec2024, 14:04
Inflow Volume (AC - FT)	848.91
Maximum Storage (AC - FT)	403.53
Peak Elevation (FT)	82.64
Discharge Volume (AC - FT)	528.16

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Proposal No. 608051 - 132406

Project: Rte_38_Main_St_Bridge
Simulation Run: 100yr
Simulation Start: 3 December 2024, 24:00
Simulation End: 4 December 2024, 24:00

HMS Version: 4.12
Executed: 21 March 2025, 12:21

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Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Watershed US of Rte 38 Prop	4.03
Watershed US of Rte 38 Exist	4.03

Downstream

Element Name	Downstream
Watershed US of Rte 38 Prop	Routing US of Rte 38 Prop
Watershed US of Rte 38 Exist	Routing US of Rte 38 Exist

Loss Rate: Scs

Element Name	Percent Impervious Area	Curve Number
Watershed US of Rte 38 Prop	0	73
Watershed US of Rte 38 Exist	0	73

Transform: Scs

Element Name	Lag	Unitgraph Type
Watershed US of Rte 38 Prop	112	Standard
Watershed US of Rte 38 Exist	112	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Watershed US of Rte 38 Prop	4.03	2522.56	04Dec2024, 14:03	4.75
Routing US of Rte 38 Prop	4.03	1197.63	04Dec2024, 16:18	4.57
Watershed US of Rte 38 Exist	4.03	2522.56	04Dec2024, 14:03	4.75
Routing US of Rte 38 Exist	4.03	938.06	04Dec2024, 17:01	3.17

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Proposal No. 608051 - 132406

Subbasin: Watershed US of Rte 38 Prop

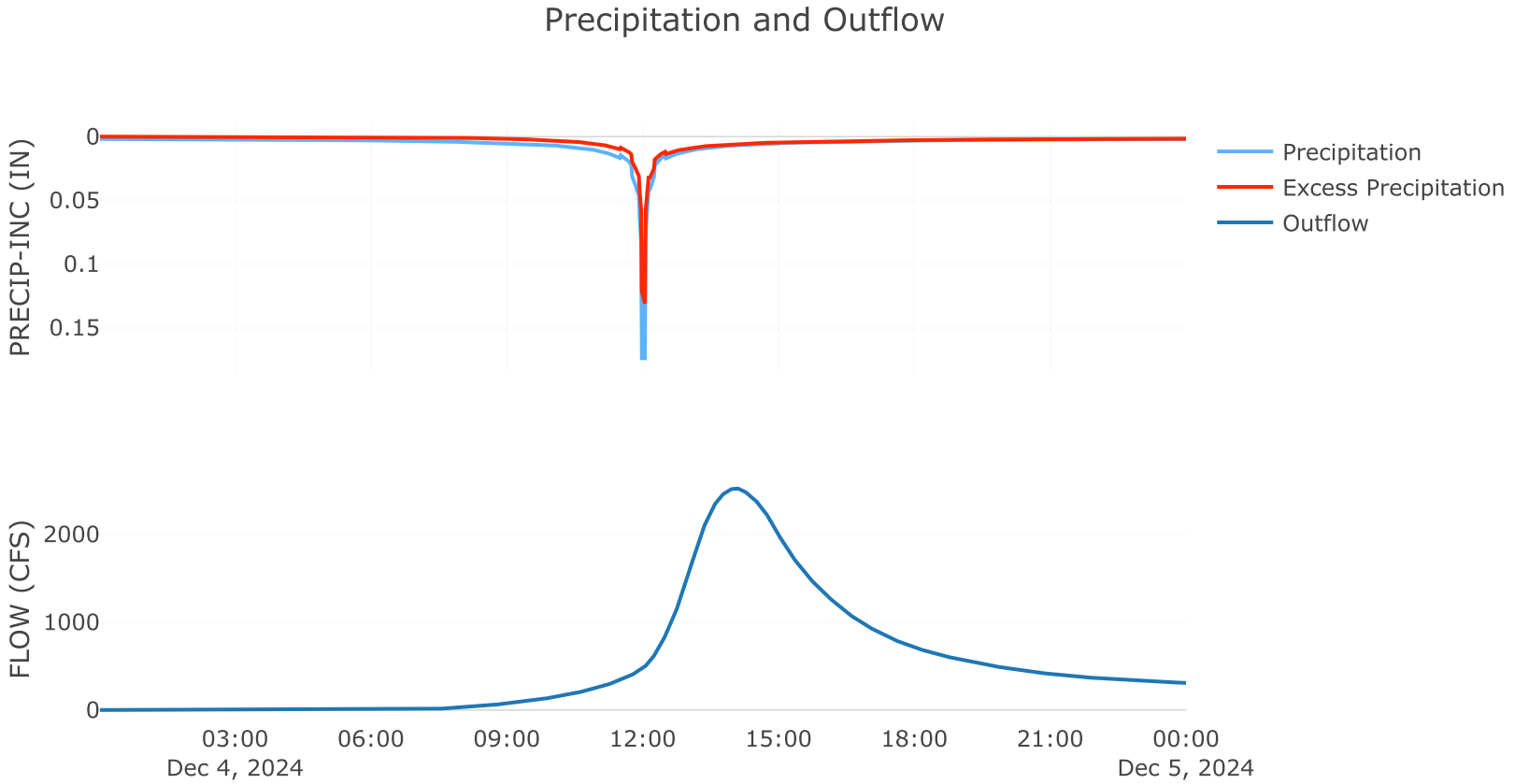
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Prop

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Prop	
Peak Discharge (CFS)	2522.56
Time of Peak Discharge	04Dec2024, 14:03
Volume (IN)	4.75
Precipitation Volume (AC - FT)	1771.05
Loss Volume (AC - FT)	691.4
Excess Volume (AC - FT)	1079.65
Direct Runoff Volume (AC - FT)	1021.81
Baseflow Volume (AC - FT)	0

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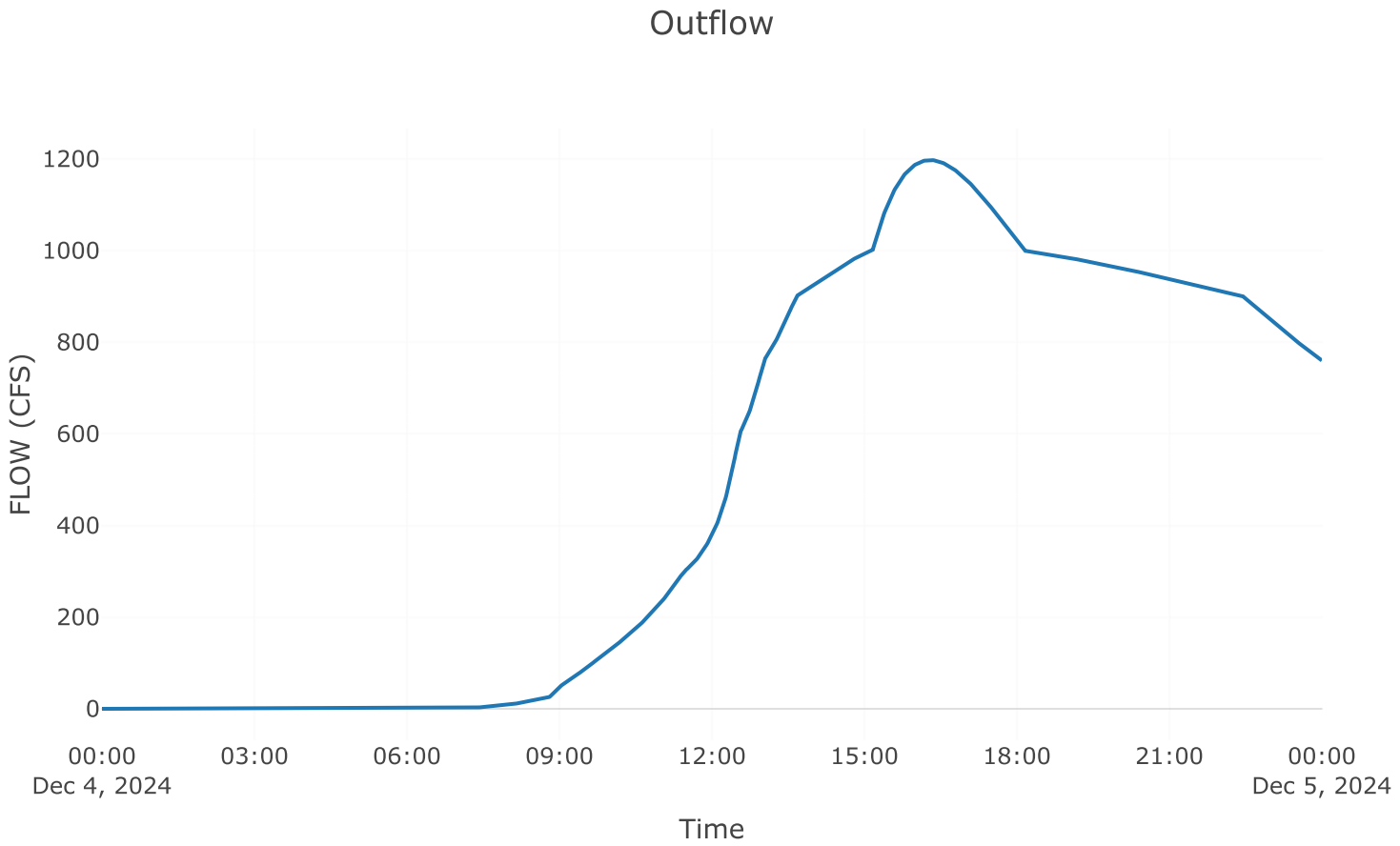
Reservoir: Routing US of Rte 38 Prop

Results: Routing US of Rte 38 Prop

Peak Discharge (CFS)	1197.63
Time of Peak Discharge	04Dec2024, 16:18
Volume (IN)	4.57
Peak Inflow (CFS)	2522.56
Time of Peak Inflow	04Dec2024, 14:03
Inflow Volume (AC - FT)	1021.81
Maximum Storage (AC - FT)	307.76
Peak Elevation (FT)	82.16
Discharge Volume (AC - FT)	981.72

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Subbasin: Watershed US of Rte 38 Exist

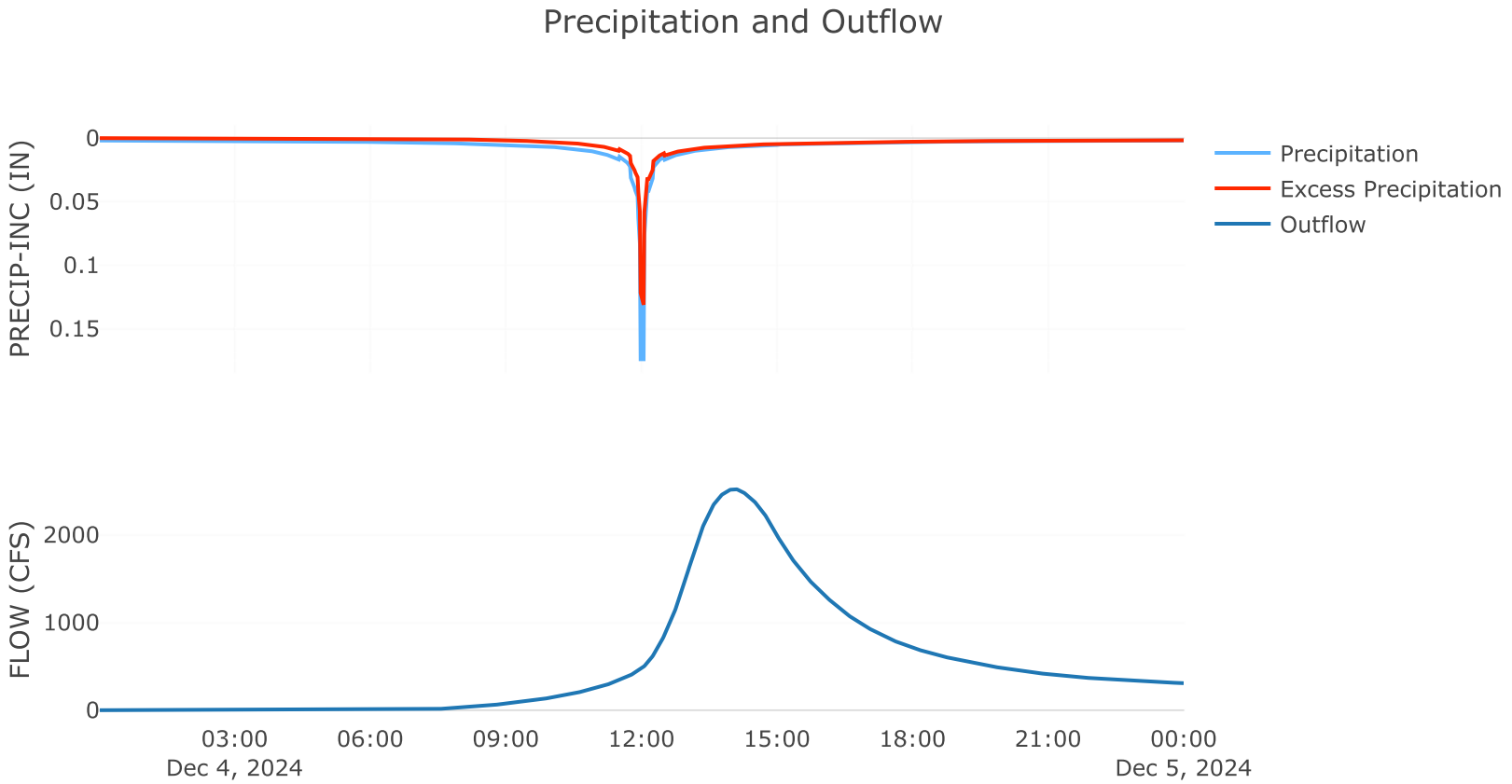
Area (MI2) : 4.03
Downstream : Routing US of Rte 38 Exist

Loss Rate: Scs	
Percent Impervious Area	0
Curve Number	73

Transform: Scs	
Lag	112
Unitgraph Type	Standard

Results: Watershed US of Rte 38 Exist	
Peak Discharge (CFS)	2522.56
Time of Peak Discharge	04Dec2024, 14:03
Volume (IN)	4.75
Precipitation Volume (AC - FT)	1771.05
Loss Volume (AC - FT)	691.4
Excess Volume (AC - FT)	1079.65
Direct Runoff Volume (AC - FT)	1021.81
Baseflow Volume (AC - FT)	0

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Proposal No. 608051 - 132406



A00882 - 140

Proposal No. 608051 - 132406

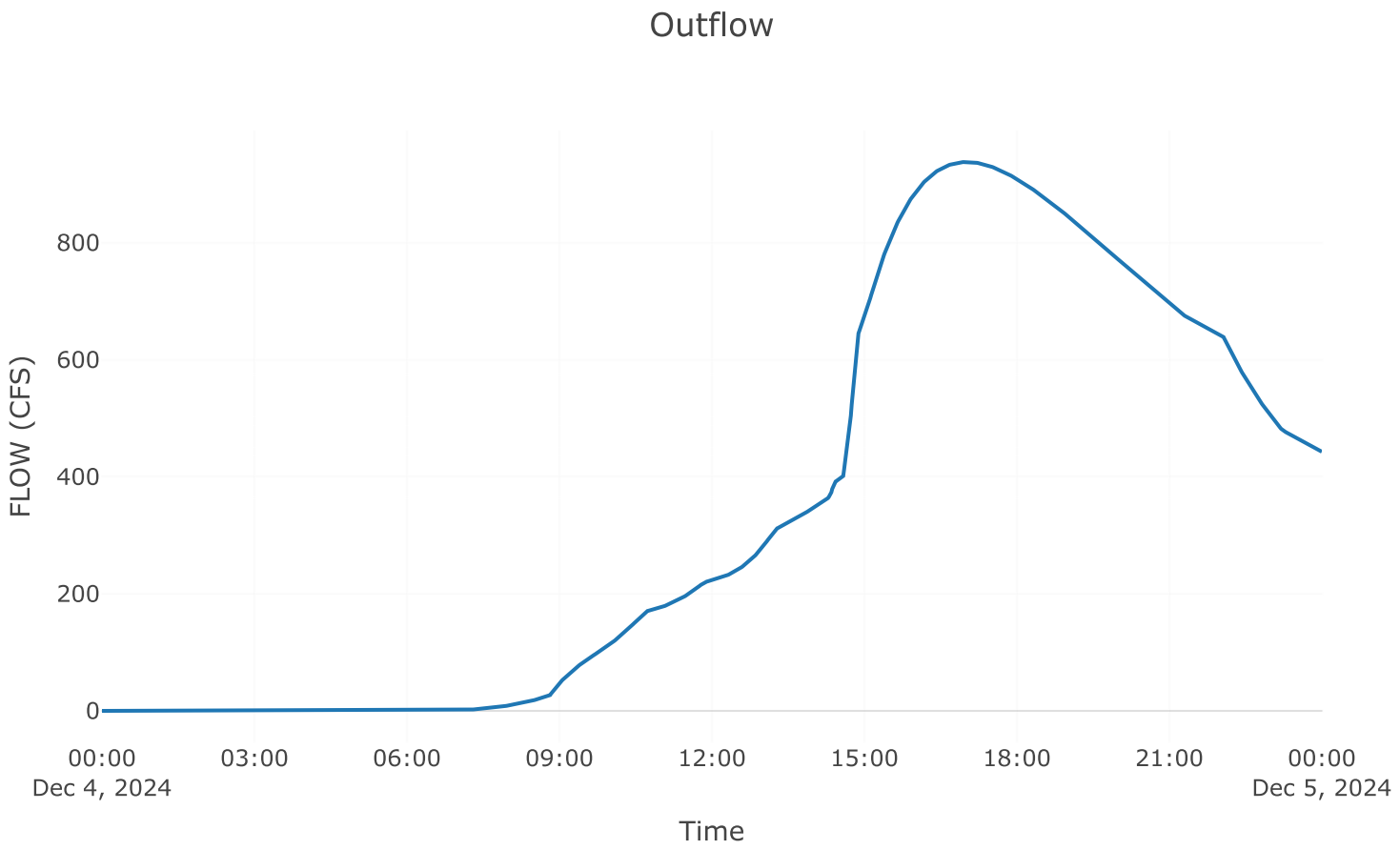
Reservoir: Routing US of Rte 38 Exist

Results: Routing US of Rte 38 Exist

Peak Discharge (CFS)	938.06
Time of Peak Discharge	04Dec2024, 17:01
Volume (IN)	3.17
Peak Inflow (CFS)	2522.56
Time of Peak Inflow	04Dec2024, 14:03
Inflow Volume (AC - FT)	1021.81
Maximum Storage (AC - FT)	471.24
Peak Elevation (FT)	82.98
Discharge Volume (AC - FT)	681.09

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HEC-RAS Routing Analysis

Existing and Proposed Conditions

HEC-RAS Plan: Routing analysis-100yr River: Maple Meadow Bro Reach: Maple Meadow Bro Profile: 100-yr

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)	
Maple Meadow Bro	2765.14	100-yr	938.00	76.11	83.83	77.34	83.84	0.000009	0.57	5714.68	1618.21	0.04
Maple Meadow Bro	2492.94	100-yr	938.00	75.80	83.83	76.97	83.83	0.000008	0.52	4516.77	1412.01	0.03
Maple Meadow Bro	2391.78	100-yr	938.00	74.29	83.83	76.78	83.83	0.000010	0.66	3803.30	1212.72	0.04
Maple Meadow Bro	2284	100-yr	938.00	73.68	83.83		83.83	0.000016	0.90	2906.86	790.20	0.05
Maple Meadow Bro	2194.02	100-yr	938.00	75.33	83.75	82.85	83.81	0.000359	3.12	1451.94	1117.56	0.20
Maple Meadow Bro	2164.02		Bridge									
Maple Meadow Bro	2138.106	100-yr	938.00	75.80	80.51		81.93	0.005090	9.56	98.10	819.15	0.80
Maple Meadow Bro	2137.106	100-yr	938.00	75.80	81.21	79.31	81.23	0.000168	1.70	1794.69	830.08	0.14
Maple Meadow Bro	2112.457		Bridge									
Maple Meadow Bro	2103.11	100-yr	938.00	75.80	81.20		81.21	0.000132	1.58	1947.14	829.19	0.13
Maple Meadow Bro	2001.98	100-yr	938.00	75.89	81.20	77.47	81.20	0.000040	0.89	2903.24	1054.49	0.07
Maple Meadow Bro	1873.26	100-yr	938.00	75.22	81.20	77.00	81.20	0.000023	0.73	3423.78	1104.27	0.06
Maple Meadow Bro	1741.68	100-yr	938.00	74.97	81.19	76.99	81.20	0.000021	0.73	3590.37	1332.75	0.05
Maple Meadow Bro	1635.31	100-yr	938.00	74.53	81.19	77.08	81.19	0.000022	0.71	3328.61	1463.50	0.05
Maple Meadow Bro	1532.63	100-yr	938.00	74.07	81.19	77.22	81.19	0.000032	0.93	3141.87	1338.55	0.07
Maple Meadow Bro	1430.01	100-yr	938.00	73.99	81.18	76.79	81.19	0.000028	0.85	3369.84	1226.49	0.06
Maple Meadow Bro	1291.21	100-yr	938.00	73.65	81.17	77.24	81.18	0.000058	1.28	2344.09	889.74	0.09
Maple Meadow Bro	1180.19	100-yr	938.00	75.77	81.17		81.17	0.000072	1.15	2495.75	907.33	0.10
Maple Meadow Bro	1085.1	100-yr	938.00	73.13	81.15	75.29	81.17	0.000036	1.17	2224.85	928.78	0.07
Maple Meadow Bro	974.91	100-yr	938.00	71.94	81.15		81.16	0.000024	1.05	2345.06	745.25	0.06
Maple Meadow Bro	880.98	100-yr	938.00	72.17	81.15	73.87	81.16	0.000019	0.92	1513.39	544.87	0.06
Maple Meadow Bro	831.48	100-yr	938.00	72.29	81.15	74.23	81.16	0.000017	0.86	2746.94	677.07	0.05
Maple Meadow Bro	721.16	100-yr	938.00	74.23	81.13	77.66	81.15	0.000122	1.52	1533.28	852.71	0.12
Maple Meadow Bro	679.8376	100-yr	938.00	74.57	80.73	78.68	81.10	0.001448	5.78	383.57	339.67	0.44
Maple Meadow Bro	639.83	100-yr	938.00	74.11	80.56	78.81	81.02	0.001791	5.48	218.90	272.02	0.47
Maple Meadow Bro	590.17		Bridge									
Maple Meadow Bro	548.93	100-yr	938.00	74.35	79.90	78.43	80.44	0.003050	5.95	192.00	170.14	0.58
Maple Meadow Bro	469.67	100-yr	938.00	76.91	79.98		80.07	0.001187	3.55	667.70	351.63	0.36
Maple Meadow Bro	408.43	100-yr	938.00	75.29	79.98	77.79	80.02	0.000371	2.54	961.22	340.85	0.21
Maple Meadow Bro	305.54	100-yr	938.00	74.28	79.95	77.96	79.98	0.000277	1.96	1052.00	659.31	0.18
Maple Meadow Bro	204.69	100-yr	938.00	74.59	79.94	77.84	79.96	0.000160	1.62	1641.62	686.50	0.14
Maple Meadow Bro	100.76	100-yr	938.00	74.57	79.93		79.94	0.000137	1.52	1713.39	693.61	0.13
Maple Meadow Bro	0	100-yr	938.00	73.69	79.92	77.22	79.93	0.000089	1.26	1821.33	642.80	0.11

HEC-RAS Plan: Routing analysis Prop NRCS River: Maple Meadow Bro Reach: Maple Meadow Bro Profile: 100-yr

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)	
Maple Meadow Bro	2765.14	100-yr	1198.00	76.11	84.01	77.49	84.01	0.000013	0.69	5951.49	1622.49	0.04
Maple Meadow Bro	2492.94	100-yr	1198.00	75.80	84.00	77.20	84.00	0.000011	0.64	4668.64	1422.53	0.04
Maple Meadow Bro	2391.78	100-yr	1198.00	74.29	84.00	76.94	84.00	0.000014	0.82	3919.10	1239.14	0.05
Maple Meadow Bro	2284	100-yr	1198.00	73.68	83.99		84.00	0.000026	1.13	3042.28	855.31	0.06
Maple Meadow Bro	2194.02	100-yr	1198.00	75.33	83.90	83.03	83.97	0.000441	3.51	1648.84	1153.75	0.23
Maple Meadow Bro	2164.02		Bridge									
Maple Meadow Bro	2138.106	100-yr	1198.00	75.80	81.21	79.56	81.92	0.002296	6.95	193.16	829.98	0.55
Maple Meadow Bro	2137.106	100-yr	1198.00	75.80	81.55	79.49	81.57	0.000178	1.84	2076.71	835.31	0.15
Maple Meadow Bro	2112.457		Bridge									
Maple Meadow Bro	2103.11	100-yr	1198.00	75.80	81.54		81.55	0.000144	1.72	2228.64	834.60	0.14
Maple Meadow Bro	2001.98	100-yr	1198.00	75.89	81.54	77.61	81.54	0.000048	1.03	3191.38	1106.14	0.08
Maple Meadow Bro	1873.26	100-yr	1198.00	75.22	81.53	77.12	81.54	0.000029	0.86	3723.98	1112.26	0.06
Maple Meadow Bro	1741.68	100-yr	1198.00	74.97	81.53	77.11	81.53	0.000027	0.85	3905.16	1357.21	0.06
Maple Meadow Bro	1635.31	100-yr	1198.00	74.53	81.52	77.24	81.53	0.000027	0.83	3626.21	1541.09	0.06
Maple Meadow Bro	1532.63	100-yr	1198.00	74.07	81.52	77.44	81.53	0.000039	1.07	3442.94	1452.54	0.07
Maple Meadow Bro	1430.01	100-yr	1198.00	73.99	81.52	77.08	81.52	0.000034	0.97	3765.96	1265.09	0.07
Maple Meadow Bro	1291.21	100-yr	1198.00	73.65	81.50	77.40	81.51	0.000075	1.51	2617.06	989.17	0.10
Maple Meadow Bro	1180.19	100-yr	1198.00	75.77	81.50		81.50	0.000083	1.30	2799.53	971.89	0.10
Maple Meadow Bro	1085.1	100-yr	1198.00	73.13	81.48	75.57	81.50	0.000047	1.37	2532.54	1024.55	0.08
Maple Meadow Bro	974.91	100-yr	1198.00	71.94	81.48		81.49	0.000033	1.26	2613.47	866.92	0.07
Maple Meadow Bro	880.98	100-yr	1198.00	72.17	81.47	74.11	81.49	0.000028	1.13	1613.41	764.36	0.07
Maple Meadow Bro	831.48	100-yr	1198.00	72.29	81.48	74.48	81.48	0.000025	1.06	2939.87	875.85	0.06
Maple Meadow Bro	721.16	100-yr	1198.00	74.23	81.45	78.07	81.48	0.000142	1.72	1792.43	1001.82	0.14
Maple Meadow Bro	679.8376	100-yr	1198.00	74.57	80.85	79.13	81.41	0.002123	7.10	412.35	359.95	0.53
Maple Meadow Bro	639.83	100-yr	1198.00	74.11	80.36	79.29	81.21	0.003519	7.45	179.15	194.67	0.65
Maple Meadow Bro	590.17		Bridge									
Maple Meadow Bro	548.93	100-yr	1198.00	74.35	79.87	78.93	80.77	0.005173	7.70	186.54	160.18	0.75
Maple Meadow Bro	469.67	100-yr	1198.00	76.91	80.03		80.16	0.001819	4.44	682.54	356.16	0.45
Maple Meadow Bro	408.43	100-yr	1198.00	75.29	80.02	78.09	80.08	0.000584	3.20	973.58	344.36	0.27
Maple Meadow Bro	305.54	100-yr	1198.00	74.28	79.97	78.09	80.02	0.000442	2.49	1060.16	659.72	0.23
Maple Meadow Bro	204.69	100-yr	1198.00	74.59	79.96	77.98	79.98	0.000257	2.05	1651.59	687.22	0.18
Maple Meadow Bro	100.76	100-yr	1198.00	74.57	79.93		79.95	0.000222	1.94	1717.78	694.09	0.16
Maple Meadow Bro	0	100-yr	1198.00	73.69	79.92	77.36	79.94	0.000145	1.61	1821.33	642.80	0.13

APPENDIX G

SEDIMENT SAMPLE ANALYSES – ALPHA ANALYTICAL; APRIL 27, 2023

ANALYTICAL REPORT

Lab Number:	L2321270
Client:	Green International Affiliates 239 Littleton Road Suite 3 Westford, MA 01886
ATTN:	Shahin M. Shahin
Phone:	(978) 923-0400
Project Name:	MASSDOT ROUTE 38
Project Number:	21058.16
Report Date:	04/27/23

The original project report/data package is held by Alpha Analytical. This report/data package is paginated and should be reproduced only in its entirety. Alpha Analytical holds no responsibility for results and/or data that are not consistent with the original.

Certifications & Approvals: MA (M-MA030), NH NELAP (2062), CT (PH-0141), DoD (L2474), FL (E87814), IL (200081), LA (85084), ME (MA00030), MD (350), NJ (MA015), NY (11627), NC (685), OH (CL106), PA (68-02089), RI (LAO00299), TX (T104704419), VT (VT-0015), VA (460194), WA (C954), US Army Corps of Engineers, USDA (Permit #P330-17-00150), USFWS (Permit #206964).

320 Forbes Boulevard, Mansfield, MA 02048-1806
508-822-9300 (Fax) 508-822-3288 800-624-9220 - www.alphalab.com

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16

Lab Number: L2321270
Report Date: 04/27/23

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L2321270-01	LB 1C	SOIL	WILMINGTON, MA	04/20/23 10:30	04/20/23
L2321270-02	RB 3B	SOIL	WILMINGTON, MA	04/20/23 11:30	04/20/23
L2321270-03	CC 2A	SOIL	WILMINGTON, MA	04/20/23 11:00	04/20/23

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Proposal No. 608051 - 132406

Project Name:	MASSDOT ROUTE 38	**Lab Number:**	L2321270
Project Number:	21058.16	**Report Date:**	04/27/23

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet NELAP requirements for all NELAP accredited parameters unless otherwise noted in the following narrative. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively.

When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances, the specific failure is not narrated but noted in the associated QC Outlier Summary Report, located directly after the Case Narrative. QC information is also incorporated in the Data Usability Assessment table (Format 11) of our Data Merger tool, where it can be reviewed in conjunction with the sample result, associated regulatory criteria and any associated data usability implications.

Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

HOLD POLICY - For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Alpha Project Manager and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Project Management at 800-624-9220 with any questions.

Project Name: MASSDOT ROUTE 38 **Lab Number:** L2321270
Project Number: 21058.16 **Report Date:** 04/27/23

Case Narrative (continued)

Sample Receipt

The samples were received at the laboratory above the required temperature range. The samples were delivered directly from the sampling site but were not on ice.

Grain Size Analysis

The WG1769637-1 Laboratory Duplicate RPDs for % coarse gravel (100%), % fine gravel (67%), % medium sand (76%), and % fine sand (40%), performed on L2321270-02, are outside the acceptance criteria. The elevated RPDs have been attributed to the non-homogeneous nature of the native sample.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Michelle M. Morris

Title: Technical Director/Representative Date: 04/27/23

INORGANICS
&
MISCELLANEOUS

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16
Lab Number: L2321270
Report Date: 04/27/23

SAMPLE RESULTS

Lab ID: L2321270-01
Client ID: LB 1C
Sample Location: WILMINGTON, MA
Sample Depth:
Matrix: Soil

Date Collected: 04/20/23 10:30
Date Received: 04/20/23
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Grain Size Analysis - Mansfield Lab										
Cobbles	ND		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Gravel	1.60		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Gravel	1.60		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Sand	4.90		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Medium Sand	5.50		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Sand	1.90		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Total Fines	84.5		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16
Lab Number: L2321270
Report Date: 04/27/23

SAMPLE RESULTS

Lab ID: L2321270-02
Client ID: RB 3B
Sample Location: WILMINGTON, MA
Sample Depth:
Matrix: Soil

Date Collected: 04/20/23 11:30
Date Received: 04/20/23
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Grain Size Analysis - Mansfield Lab										
Cobbles	ND		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Gravel	0.100		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Gravel	0.100		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Sand	1.20		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Medium Sand	5.80		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Sand	12.1		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Total Fines	80.7		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16
Lab Number: L2321270
Report Date: 04/27/23

SAMPLE RESULTS

Lab ID: L2321270-03
Client ID: CC 2A
Sample Location: WILMINGTON, MA
Sample Depth:
Matrix: Soil

Date Collected: 04/20/23 11:00
Date Received: 04/20/23
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Grain Size Analysis - Mansfield Lab										
Cobbles	ND		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Gravel	2.90		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Gravel	3.00		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Coarse Sand	9.60		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Medium Sand	8.80		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Fine Sand	4.40		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK
% Total Fines	71.3		%	0.100	NA	1	-	04/21/23 14:45	12,D6913/D7928	SJK

Lab Duplicate Analysis

Batch Quality Control

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16

Lab Number: L2321270
Report Date: 04/27/23

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Grain Size Analysis - Mansfield Lab Associated sample(s): 01-03 QC Batch ID: WG1769637-1 QC Sample: L2321270-02 Client ID: RB 3B						
Cobbles	ND	ND	%	NC		20
% Coarse Gravel	0.100	0.300	%	**100**	Q	20
% Fine Gravel	0.100	0.200	%	**67**	Q	20
% Coarse Sand	1.20	1.30	%	8		20
% Medium Sand	5.80	2.60	%	**76**	Q	20
% Fine Sand	12.1	8.10	%	**40**	Q	20
% Total Fines	80.7	87.5	%	8		20

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Proposal No. 608051 - 132406

Project Name: MASSDOT ROUTE 38
Project Number: 21058.16

Lab Number: L2321270
Report Date: 04/27/23

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information

Cooler	Custody Seal
A	Absent

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L2321270-01A	Core	A	NA		18.7	Y	Absent		A2-HYDRO-TFINE(),A2-HYDRO-CGRAVEL(),A2-HYDRO-FSAND(),A2-HYDRO-MSAND(),A2-HYDRO-CSAND(),A2-HYDRO-FGRAVEL(),A2-HYDRO-COBBLES()
L2321270-02A	Core	A	NA		18.7	Y	Absent		A2-HYDRO-TFINE(),A2-HYDRO-FSAND(),A2-HYDRO-CGRAVEL(),A2-HYDRO-MSAND(),A2-HYDRO-CSAND(),A2-HYDRO-COBBLES(),A2-HYDRO-FGRAVEL()
L2321270-03A	Core	A	NA		18.7	Y	Absent		A2-HYDRO-TFINE(),A2-HYDRO-CGRAVEL(),A2-HYDRO-FSAND(),A2-HYDRO-MSAND(),A2-HYDRO-CSAND(),A2-HYDRO-COBBLES(),A2-HYDRO-FGRAVEL()

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Proposal No. 608051 - 132406

*Values in parentheses indicate holding time in days

Project Name: MASSDOT ROUTE 38 **Lab Number:** L2321270

Project Number: 21058.16 **Report Date:** 04/27/23

GLOSSARY

Acronyms

DL - Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the limit of quantitation (LOQ). The DL includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)

EDL - Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).

EMPC - Estimated Maximum Possible Concentration: The concentration that results from the signal present at the retention time of an analyte when the ions meet all of the identification criteria except the ion abundance ratio criteria. An EMPC is a worst-case estimate of the concentration.

EPA - Environmental Protection Agency.

LCS - Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

LCSD - Laboratory Control Sample Duplicate: Refer to LCS.

LFB - Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

LOD - Limit of Detection: This value represents the level to which a target analyte can reliably be detected for a specific analyte in a specific matrix by a specific method. The LOD includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)

LOQ - Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)

Limit of Quantitation: The value at which an instrument can accurately measure an analyte at a specific concentration. The LOQ includes any adjustments from dilutions, concentrations or moisture content, where applicable. (DoD report formats only.)

MDL - Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

MS - Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. For Method 332.0, the spike recovery is calculated using the native concentration, including estimated values.

MSD - Matrix Spike Sample Duplicate: Refer to MS.

NA - Not Applicable.

NC - Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.

NDPA/DPA - N-Nitrosodiphenylamine/Diphenylamine.

NI - Not Ignitable.

NP - Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.

NR - No Results: Term is utilized when 'No Target Compounds Requested' is reported for the analysis of Volatile or Semivolatile Organic TIC only requests.

RL - Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

RPD - Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.

SRM - Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.

STLP - Semi-dynamic Tank Leaching Procedure per EPA Method 1315.

TEF - Toxic Equivalency Factors: The values assigned to each dioxin and furan to evaluate their toxicity relative to 2,3,7,8-TCDD.

TEQ - Toxic Equivalent: The measure of a sample's toxicity derived by multiplying each dioxin and furan by its corresponding TEF and then summing the resulting values.

TIC - Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Report Format: Data Usability Report

Project Name:	MASSDOT ROUTE 38	**Lab Number:**	L2321270
Project Number:	21058.16	**Report Date:**	04/27/23

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Chlordane: The target compound Chlordane (CAS No. 57-74-9) is reported for GC ECD analyses. Per EPA,this compound "refers to a mixture of chlordane isomers, other chlorinated hydrocarbons and numerous other components." (Reference: USEPA Toxicological Review of Chlordane, In Support of Summary Information on the Integrated Risk Information System (IRIS), December 1997.)

Difference: With respect to Total Oxidizable Precursor (TOP) Assay analysis, the difference is defined as the Post-Treatment value minus the Pre-Treatment value.

Final pH: As it pertains to Sample Receipt & Container Information section of the report, Final pH reflects pH of container determined after adjustment at the laboratory, if applicable. If no adjustment required, value reflects Initial pH.

Frozen Date/Time: With respect to Volatile Organics in soil, Frozen Date/Time reflects the date/time at which associated Reagent Water-preserved vials were initially frozen. Note: If frozen date/time is beyond 48 hours from sample collection, value will be reflected in 'bold'.

Gasoline Range Organics (GRO): Gasoline Range Organics (GRO) results include all chromatographic peaks eluting from Methyl tert butyl ether through Naphthalene, with the exception of GRO analysis in support of State of Ohio programs, which includes all chromatographic peaks eluting from Hexane through Dodecane.

Initial pH: As it pertains to Sample Receipt & Container Information section of the report, Initial pH reflects pH of container determined upon receipt, if applicable.

PAH Total: With respect to Alkylated PAH analyses, the 'PAHs, Total' result is defined as the summation of results for all or a subset of the following compounds: Naphthalene, C1-C4 Naphthalenes, 2-Methylnaphthalene, 1-Methylnaphthalene, Biphenyl, Acenaphthylene, Acenaphthene, Fluorene, C1-C3 Fluorenes, Phenanthrene, C1-C4 Phenanthrenes/Anthracenes, Anthracene, Fluoranthene, Pyrene, C1-C4 Fluoranthenes/Pyrenes, Benz(a)anthracene, Chrysene, C1-C4 Chrysenes, Benzo(b)fluoranthene, Benzo(j)+(k)fluoranthene, Benzo(e)pyrene, Benzo(a)pyrene, Perylene, Indeno(1,2,3-cd)pyrene, Dibenz(ah)+(ac)anthracene, Benzo(g,h,i)perylene. If a 'Total' result is requested, the results of its individual components will also be reported.

PFAS Total: With respect to PFAS analyses, the 'PFAS, Total (5)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA and PFOS. In addition, the 'PFAS, Total (6)' result is defined as the summation of results for: PFHpA, PFHxS, PFOA, PFNA, PFDA and PFOS. For MassDEP DW compliance analysis only, the 'PFAS, Total (6)' result is defined as the summation of results at or above the RL. Note: If a 'Total' result is requested, the results of its individual components will also be reported.

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Data Qualifiers

A - Spectra identified as "Aldol Condensates" are byproducts of the extraction/concentration procedures when acetone is introduced in the process.

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

F - The ratio of quantifier ion response to qualifier ion response falls outside of the laboratory criteria. Results are considered to be an estimated maximum concentration.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

J - Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

Report Format: Data Usability Report

Project Name:	MASSDOT ROUTE 38	**Lab Number:**	L2321270
Project Number:	21058.16	**Report Date:**	04/27/23

Data Qualifiers

ND - Not detected at the reporting limit (RL) for the sample.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

V - The surrogate associated with this target analyte has a recovery outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

Z - The batch matrix spike and/or duplicate associated with this target analyte has a recovery/RPD outside the QC acceptance limits. (Applicable to MassDEP DW Compliance samples only.)

Report Format: Data Usability Report

Project Name: MASSDOT ROUTE 38 **Lab Number:** L2321270

Project Number: 21058.16 **Report Date:** 04/27/23

REFERENCES

12 Annual Book of ASTM Standards. (American Society for Testing and Materials) ASTM International.

LIMITATION OF LIABILITIES

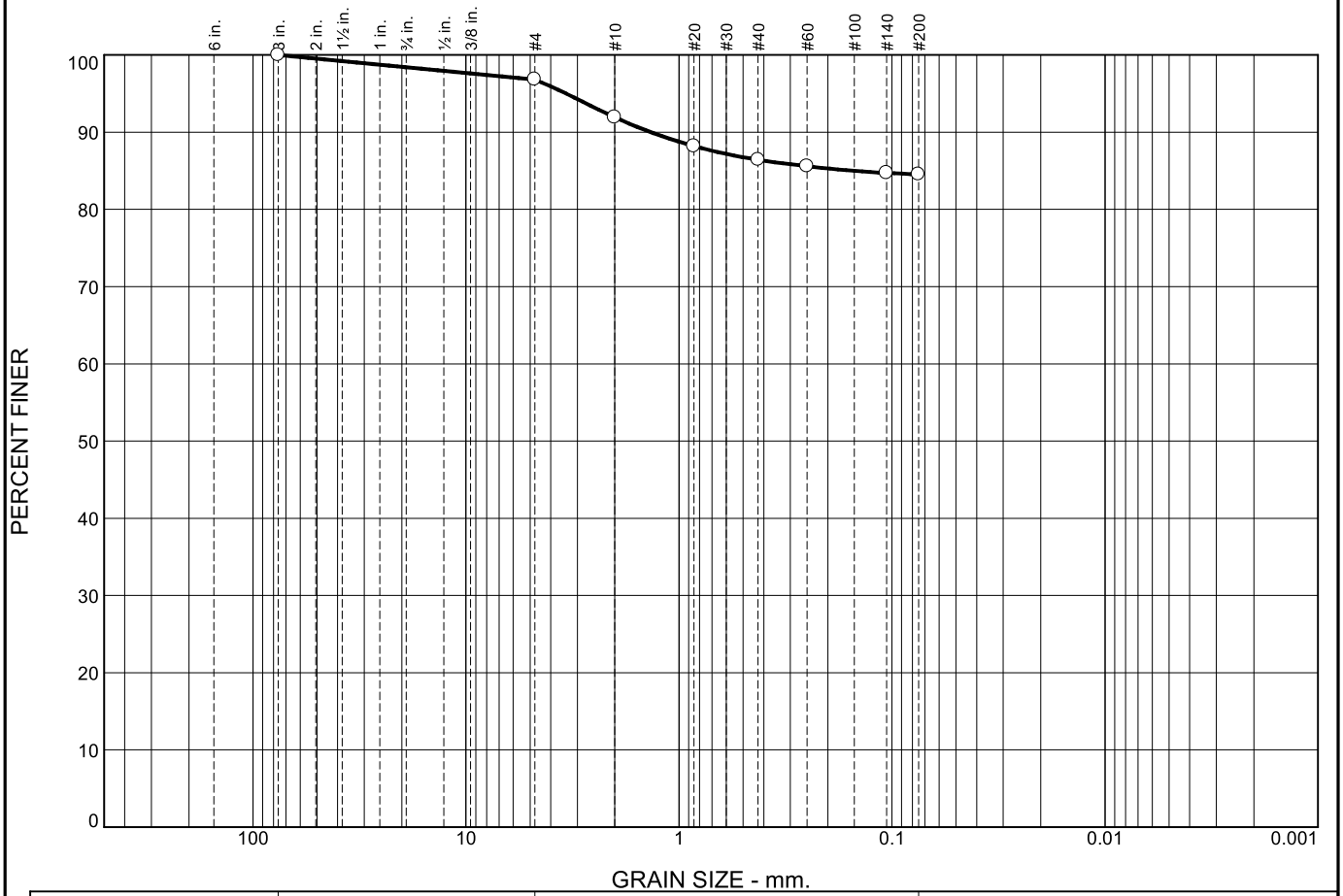
Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

ASTM D6913/D7928

GRAIN SIZE ANALYSIS

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	1.6	1.6	4.9	5.5	1.9	84.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.1497							

	Material Description	USCS	AASHTO
○			

Project No. **Client:**

Project:

○ **Source of Sample:** LB 1C **Sample Number:** L2321270-01

Remarks:

Alpha Analytical

Mansfield, MA

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2023

Location: LB 1C
Sample Number: L2321270-01

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.09
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.09	0.00	3"	0.00	0.00	100.0
		#4	3.18	0.00	96.8
		#10	4.89	0.00	91.9
		#20	3.74	0.00	88.2
		#40	1.77	0.00	86.4
		#60	0.84	0.00	85.6
		#140	0.87	0.00	84.7
		#200	0.18	0.00	84.5

Fractional Components

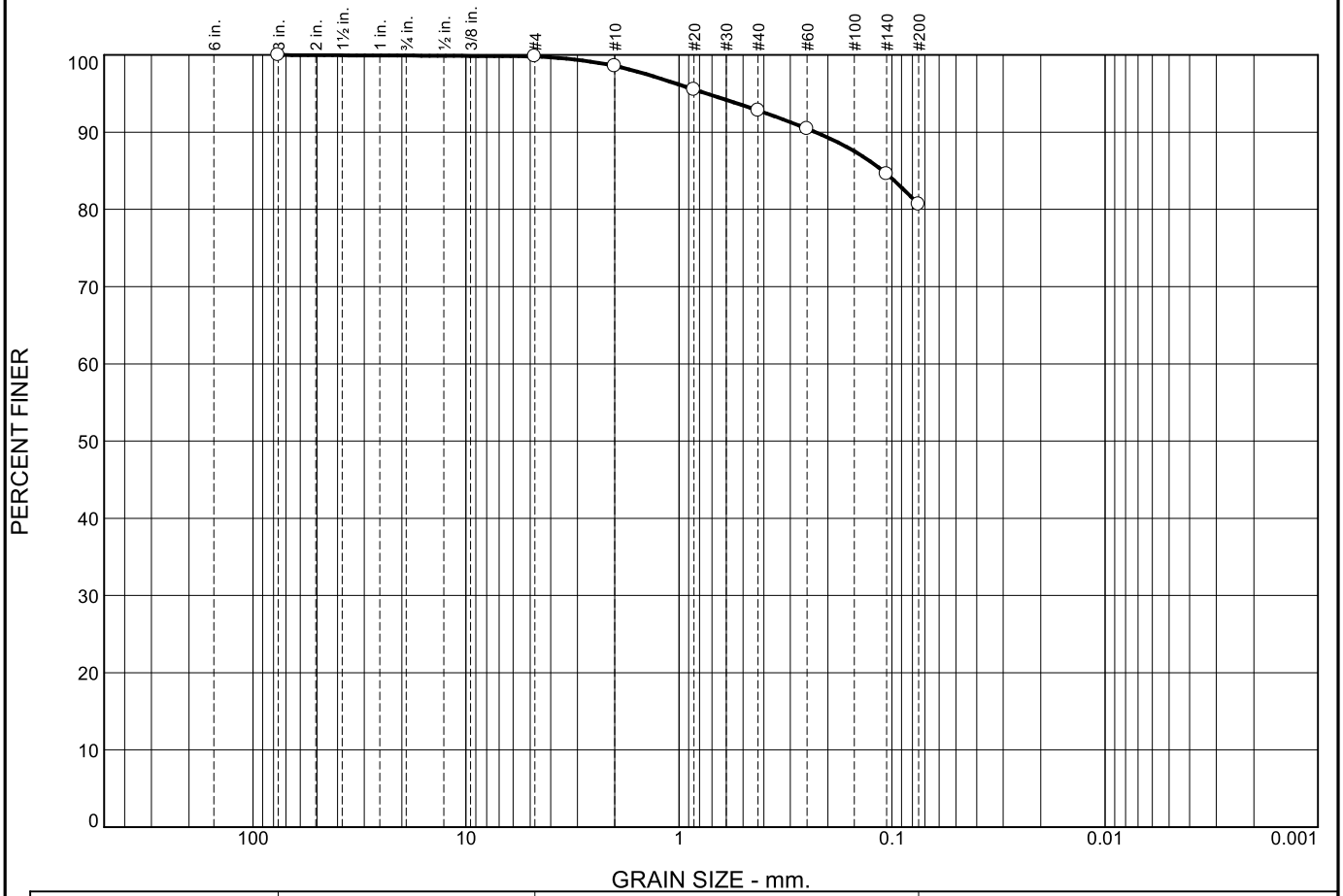
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	1.6	1.6	3.2	4.9	5.5	1.9	12.3			84.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
									0.1497	1.3531	3.3894

Fineness Modulus
0.68

Alpha Analytical

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.1	0.1	1.2	5.8	12.1	80.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.1103							

Material Description	USCS	AASHTO
○		

Project No. **Client:**

Project:

○ **Source of Sample:** RB 3B **Sample Number:** L2321270-02

Remarks:

Alpha Analytical

Mansfield, MA

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2023

Location: RB 3B
Sample Number: L2321270-02

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.79
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.79	0.00	3"	0.00	0.00	100.0
		#4	0.17	0.00	99.8
		#10	1.27	0.00	98.6
		#20	3.06	0.00	95.5
		#40	2.74	0.00	92.8
		#60	2.40	0.00	90.4
		#140	5.88	0.00	84.6
		#200	3.97	0.00	80.7

Fractional Components

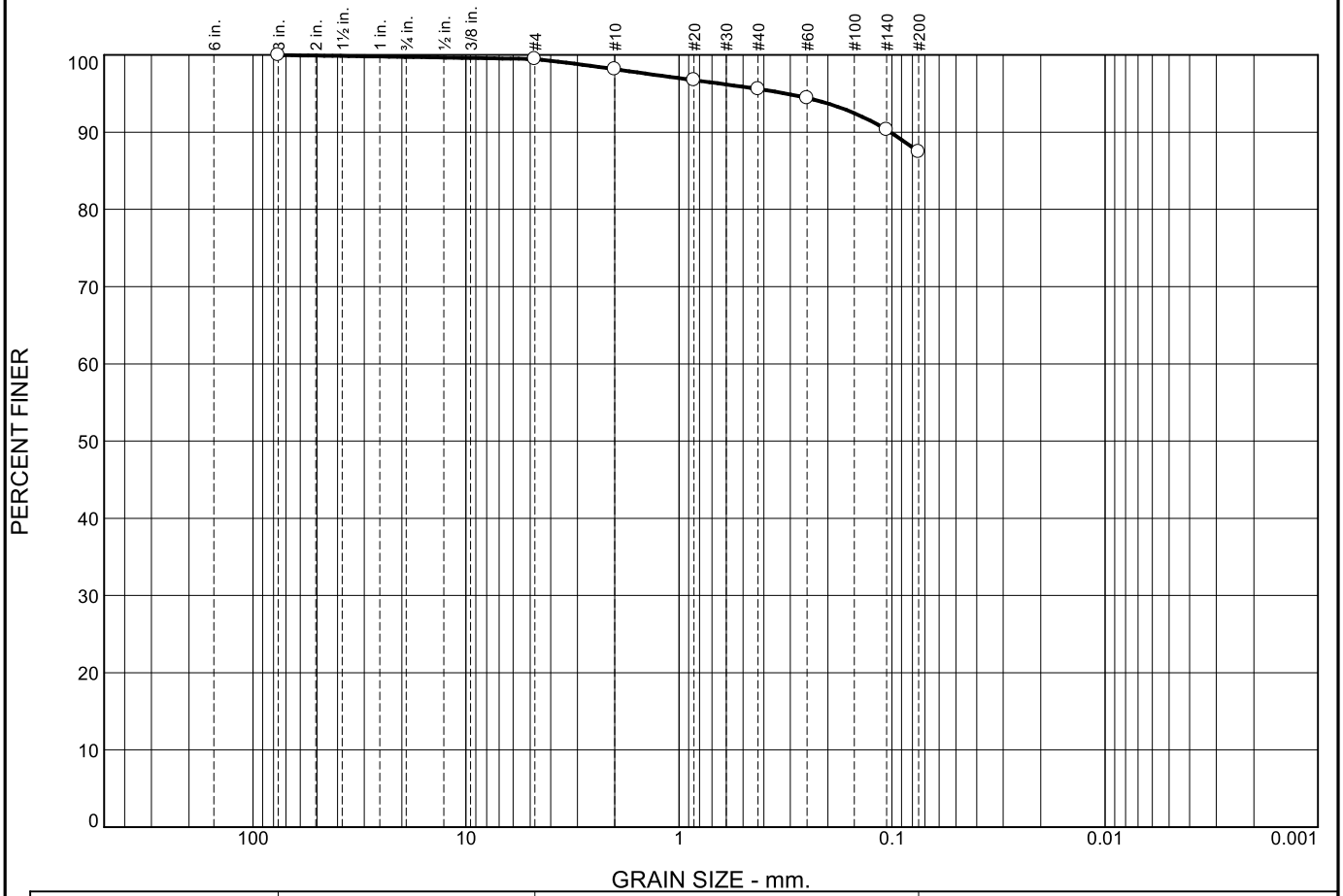
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.1	0.1	0.2	1.2	5.8	12.1	19.1			80.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
									0.1103	0.2288	0.7403

Fineness Modulus
0.32

Alpha Analytical

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.3	0.2	1.3	2.6	8.1	87.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○										

Material Description	USCS	AASHTO
○		

Project No. **Client:**
Project:

○ **Source of Sample:** RB 3B **Sample Number:** WG1769637-1

Alpha Analytical

Mansfield, MA

Remarks:

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2023

Location: RB 3B
Sample Number: WG1769637-1

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.88
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.88	0.00	3"	0.00	0.00	100.0
		#4	0.52	0.00	99.5
		#10	1.34	0.00	98.2
		#20	1.42	0.00	96.7
		#40	1.16	0.00	95.6
		#60	1.18	0.00	94.4
		#140	4.15	0.00	90.3
		#200	2.88	0.00	87.5

Fractional Components

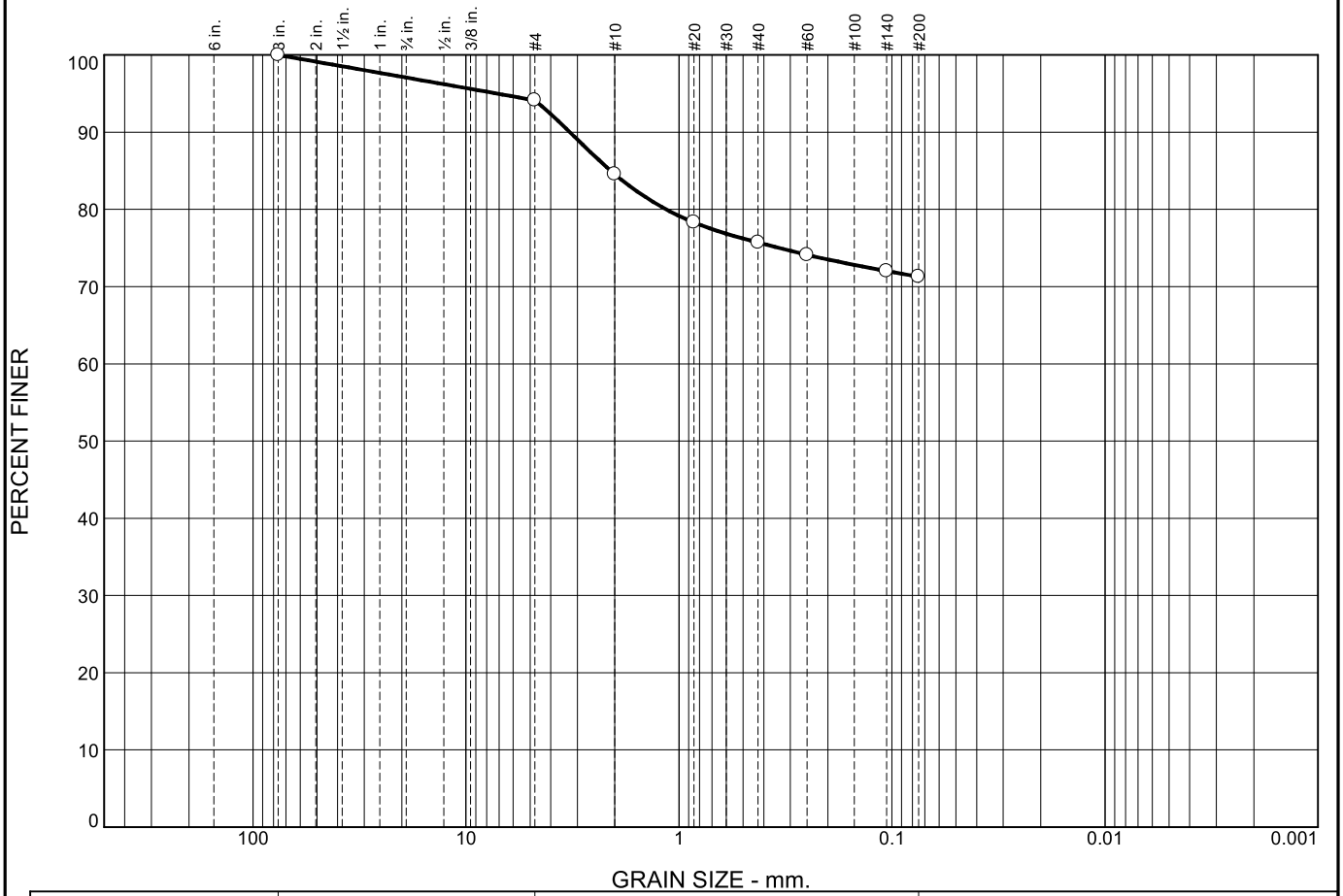
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.3	0.2	0.5	1.3	2.6	8.1	12.0			87.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
										0.1017	0.3141

Fineness Modulus
0.22

Alpha Analytical

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	2.9	3.0	9.6	8.8	4.4	71.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			2.0897							

Material Description	USCS	AASHTO
○		

Project No. **Client:**

Project:

○ **Source of Sample:** CC 2A **Sample Number:** L2321270-03

Alpha Analytical

Mansfield, MA

Remarks:

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2023

Location: CC 2A
Sample Number: L2321270-03

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.84
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.84	0.00	3"	0.00	0.00	100.0
		#4	5.91	0.00	94.1
		#10	9.67	0.00	84.5
		#20	6.28	0.00	78.3
		#40	2.63	0.00	75.7
		#60	1.61	0.00	74.1
		#140	2.11	0.00	72.0
		#200	0.74	0.00	71.3

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	2.9	3.0	5.9	9.6	8.8	4.4	22.8			71.3

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
								1.1459	2.0897	3.2513	7.1402

Fineness Modulus
1.24

Alpha Analytical

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 624/624.1: m/p-xylene, o-xylene, Naphthalene
EPA 625/625.1: alpha-Terpineol
EPA 8260C/8260D: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene; SCM: Iodomethane (methyl iodide), 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D/8270E: NPW: Dimethylnaphthalene,1,4-Diphenylhydrazine, alpha-Terpineol; SCM: Dimethylnaphthalene,1,4-Diphenylhydrazine.
SM4500: NPW: Amenable Cyanide; SCM: Total Phosphorus, TKN, NO2, NO3.

Mansfield Facility
SM 2540D: TSS
EPA 8082A: NPW: PCB: 1, 5, 31, 87,101, 110, 141, 151, 153, 180, 183, 187.
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.
Biological Tissue Matrix: EPA 3050B

The following analytes are included in our Massachusetts DEP Scope of Accreditation

Westborough Facility:

Drinking Water
EPA 300.0: Chloride, Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B, SM4500NO2-B**
EPA 332: Perchlorate; **EPA 524.2:** THMs and VOCs; **EPA 504.1:** EDB, DBCP.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT,SM9222D**.

Non-Potable Water
SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2320B, SM4500CL-E, SM4500F-BC, SM4500NH3-BH: Ammonia-N and Kjeldahl-N, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **EPA 351.1, SM4500NO3-F, EPA 353.2**: Nitrate-N, **SM4500P-E, SM4500P-B, E, SM4500SO4-E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, EPA 420.1, SM4500-CN-CE, SM2540D, EPA 300: Chloride, Sulfate, Nitrate.**
EPA 624.1: Volatile Halocarbons & Aromatics,
EPA 608.3: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625.1: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9221E, EPA 1600, EPA 1603, SM9222D.**

Mansfield Facility:

Drinking Water
EPA 200.7: Al, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Na, Ag, Ca, Zn. **EPA 200.8:** Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag, TL, Zn. **EPA 245.1** Hg.
EPA 522, EPA 537.1.

Non-Potable Water
EPA 200.7: Al, Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, TL, Ti, V, Zn.
EPA 200.8: Al, Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, K, Se, Ag, Na, TL, Zn.
EPA 245.1 Hg.
SM2340B

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

CHAIN OF CUSTODY

PAGE OF

Date Rec'd in Lab: 4/20/23

ALPHA Job #: L2321270

Westborough, MA TEL: 508-898-9220 FAX: 508-898-9193
Mansfield, MA TEL: 508-822-9300 FAX: 508-822-3288

Client Information

Client: Green International Affiliates, Inc.
Address: 100 Ames Pond Road, Suite 200
Tewksbury, MA 01876
Phone: 978-923-0400
Fax:
Email: sshahin@greenintl.com

☐ These samples have been Previously analyzed by Alpha

Project Information

Project Name: MassDOT Route 38
Project Location: Wilmington, MA
Project #: 21058.16
Project Manager: Shahin Shahin
ALPHA Quote #:

Turn-Around Time

☐ Standard ☑ Rush (ONLY IF PRE-APPROVED)

Due Date: 5/4/23 Time:

Report Information Data Deliverables

☐ FAX ☑ EMAIL
☐ ADEx ☐ Add'l Deliverables

Billing Information

☒ Same as Client info PO #:

Regulatory Requirements/Report Limits

State/Fed Program Criteria

Other Project Specific Requirements/Comments/Detection Limits:

Full Sieve Analysis

Requesting testing and report similar to "Particle Size Distribution Report" as received for Lab Number L2015227

ANALYSIS

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler's Initials	Grain Size Analysis
L2321270-01	LB 1C	4/20/23	10:30	Soil	VP	☒
-02	RB 1+3B	4/20/23	11:30	Soil	VP	☒
-03	CL 2A	4/20/23	11:00	Soil	VP	☒
						☐
						☐
						☐
						☐
						☐
						☐
						☐

SAMPLE HANDLIN
Filtration
☐ Done
☐ Not Needed
☐ Lab to do
Preservation
☐ Lab to do
(Please specify below)

Sample Specific Comments

Container Type
Preservative

Relinquished By:	Date/Time	Received By:	Date/Time
	4/20/23 1:15P		4/20/23 1:16
	4/20/23 5:00		4/21/23 15:2
	4/20/23 16:1		4/20/23 16

Please print clearly, and completely. Sa not be logged in an turnaround time clo start until any ambig resolved. All sampl submitted are subje Alpha's Payment Te

FORM NO. 01-01(A42) (rev. 6-JAN-15)

A00882-171

Proposal No. 608051 - 132406

APPENDIX H

SEDIMENT SAMPLE ANALYSES – THIELSCH ENGINEERING;
FEBRUARY 21, 2025

Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:		Project Information:	
TG & B Marine		**Route 38 Bridge over Magic Meadow Brook**	
Monument Beach, MA		**Wilmington, MA**	
508.326.3686		Project Number:	74-25-0002.402
Project Contact:	Camila Knight	Summary Page:	1 of 4
Collected By:	Client	Report Date:	02.21.25

LABORATORY TESTING DATA SHEET, Report No.: 7425-B-128

Boring ID	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Shear / Consolidation / Permeability Tests								Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Torvane or Type Test	Failure Criteria	$\sigma_1 - \sigma_3$ or t psf	Strain %	Permeability cm/sec	EST. Internal Friction Angle	CR / RR	
Onsite	STS-1	2.3	24-S-487		Average Total Unit Weight (2.3') = 90.3 pcf															
		0.0-0.15	Dist																	Disturbed PEAT
		0.15-0.25	W-487a	167									W/C							Brown Fibrous PEAT
		0.25-0.75	SAVED										SAVED							SAVED
		0.75-1.0	S-487	24.6			0.5	64.3	35.2				SIEVE							Brown Organic silty sand
		1.0-1.5	Unc-487	68.7								57.1	UNC	$\sigma_1 - \sigma_3$	1831	20.1				Brown Organic silty sand
		1.5-1.7	L-487	66.5	NV	NP							$\frac{LL}{PL}$							Brown Organic silty sand
		1.7-1.8	W-487b	61.3									W/C							Brown Fibrous PEAT

2.6" poly tube, unable to extract material using mechancial extractor, torvanes could not be collected.
Sample depth measured from top of tube, true depth of sample is unknown.

A00882 - 174

Proposal No. 608051 132406

Date Received: **01.20.25** Reviewed By: Date Reviewed: **02.21.25**

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.5	3.1	14.1	47.1	35.2	

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	99.5		
#10	96.4		
#20	90.7		
#40	82.3		
#60	74.5		
#100	62.8		
#200	35.2		

* (no specification provided)

Soil Description

Brown Organic silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.7902 D_{85}= 0.5199 D_{60}= 0.1380
D_{50}= 0.1068 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Sample contained signifiant amounts of organic material.

Source of Sample: Liner Tubes Depth: 2.3'
Sample Number: STS-1

Date: 02.18.25

Thielsch Engineering Inc.

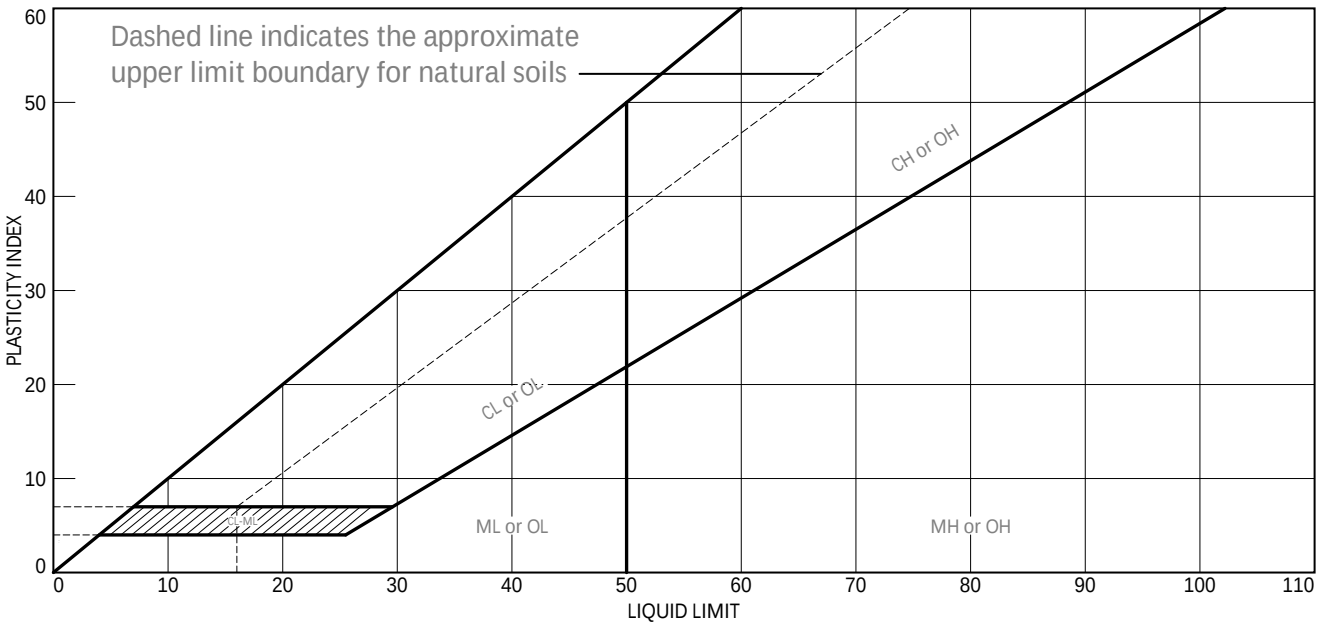
Cranston, RI

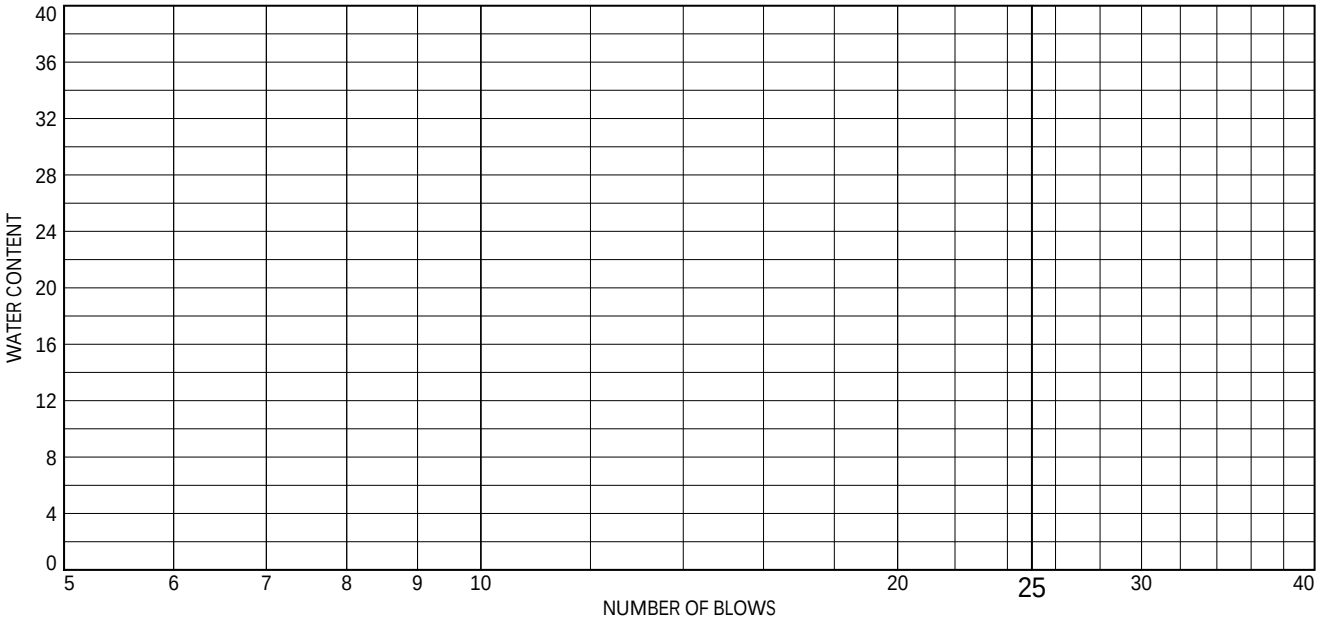
Client: TG&B Marine
Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA
Project No: 74-25-0002.402 Fig. 25-S-487

Tested By: RR/RKO/AV Checked By: Rebecca Roth

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LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Organic silty sand	NV	NP	NP	82.3	35.2	SM

Project No. 74-25-0002.402 Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook

Wilmington, MA

Source of Sample: Liner Tubes Depth: 2.3'

Sample Number: STS-1

Thielsch Engineering Inc.

Cranston, RI

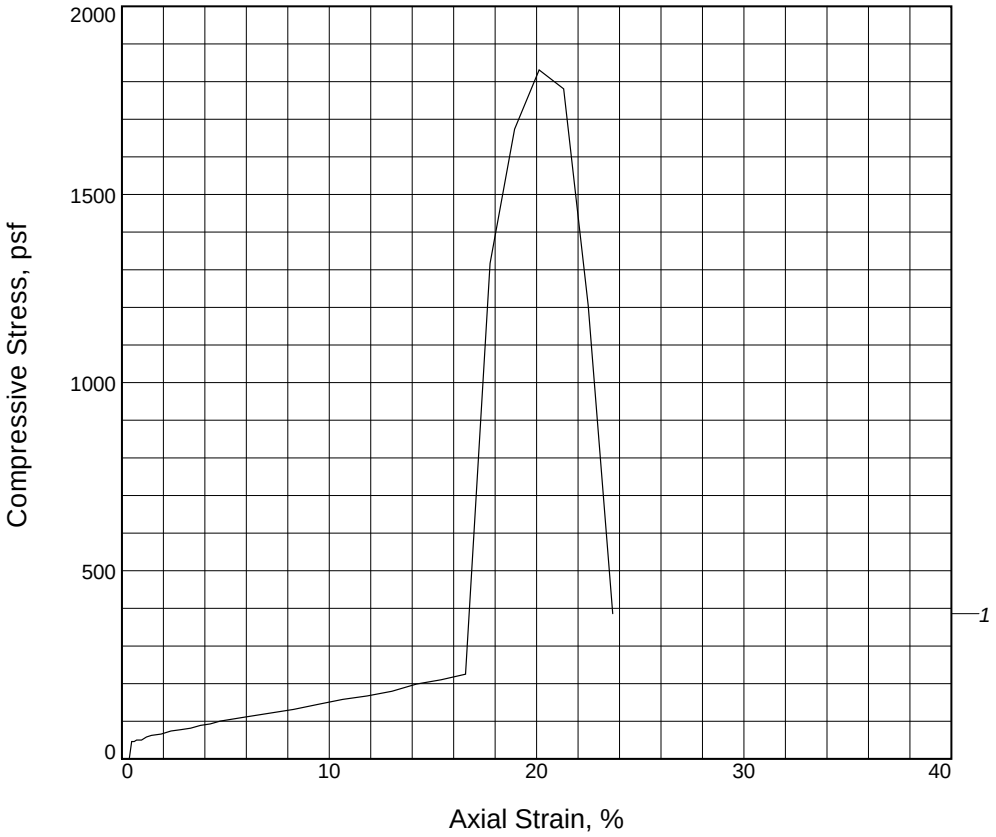
Remarks:

●Sample classified as non-plastic and non-viscous. Sample could not roll past 1/4" and could not achieve more than 25 blows.

Fig. 25-L-487

Tested By: AB Checked By: Rebecca Roth

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1831			
Undrained shear strength, psf	915			
Failure strain, %	20.1			
Strain rate, in./min.	0.030			
Water content, %	68.7			
Wet density, pcf	96.4			
Dry density, pcf	57.1			
Saturation, %	107.6			
Void ratio	1.4045			
Specimen diameter, in.	2.32			
Specimen height, in.	4.22			
Height/diameter ratio	1.82			

Description: Brown Organic silty sand

LL = NV	**PL =**	**PI =** NP	**Assumed GS=** 2.2	**Type:** Intact Tube

Project No.: 74-25-0002.402

Date Sampled: 02.18.25

Remarks:
Poor sample integrity, sample was loosely contained in a membrane. Readings past 0.750 may be due to the membrane holding the sample together.

Fig. Unc-487

Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA

Source of Sample: Liner Tubes **Depth:** 2.3'

Sample Number: STS-1

UNCONFINED COMPRESSION TEST
Thielsch Engineering Inc.
Cranston, RI

Tested By: Rebecca Roth **Checked By:** Rebecca Roth

Thielsch
DIVISION OF THE RISE GROUP



TG& B Marine Services

Route 38 Bridge over Maple Meadow Brook

STS-1, 2.3', T-487







Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:		Project Information:	
TG & B Marine		**Route 38 Bridge over Magic Meadow Brook**	
Monument Beach, MA		**Wilmington, MA**	
508.326.3686		Project Number:	74-25-0002.402
Project Contact:	Camila Knight	Summary Page:	2 of 4
Collected By:	Client	Report Date:	02.21.25

LABORATORY TESTING DATA SHEET, Report No.: 7425-B-128

Boring ID	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Shear / Consolidation / Permeability Tests								Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Torvane or Type Test	Failure Criteria	$\sigma_1 - \sigma_3$ or t psf	Strain %	Permeability cm/sec	EST. Internal Friction Angle	CR / RR	
Onsite	STS-2	3.1	24-S-488		Average Total Unit Weight (3.1') = 95.3 pcf															
		0.0-0.5	Dist																	Disturbed PEAT
		0.6-0.8	W-488a	142									W/C							Brown Fibrous PEAT
		0.8-0.9	H-488	46.1			12.7	72.7	14.6				Hydro							Brown Organic silty sand
		1.2-1.4	W-488b	17.8									W/C							Brown Organic silty sand
		1.4-1.7	K-488	19.0								105.8	PERM				$2.4x10^{-04}$			Brown Organic silty sand
		1.7-2.2	Unc-188	24.0								103.9	UNC	$\sigma_1 - \sigma_3$	511	4.1				Brown Organic silty sand
		2.4-2.6	L-488	43.0	NV	NP														Brown Organic silty sand

2.6" poly tube, unable to extract material using mechancial extractor, torvanes could not be collected.
Sample depth measured from top of tube, true depth of sample is unknown.

A00082 - 180

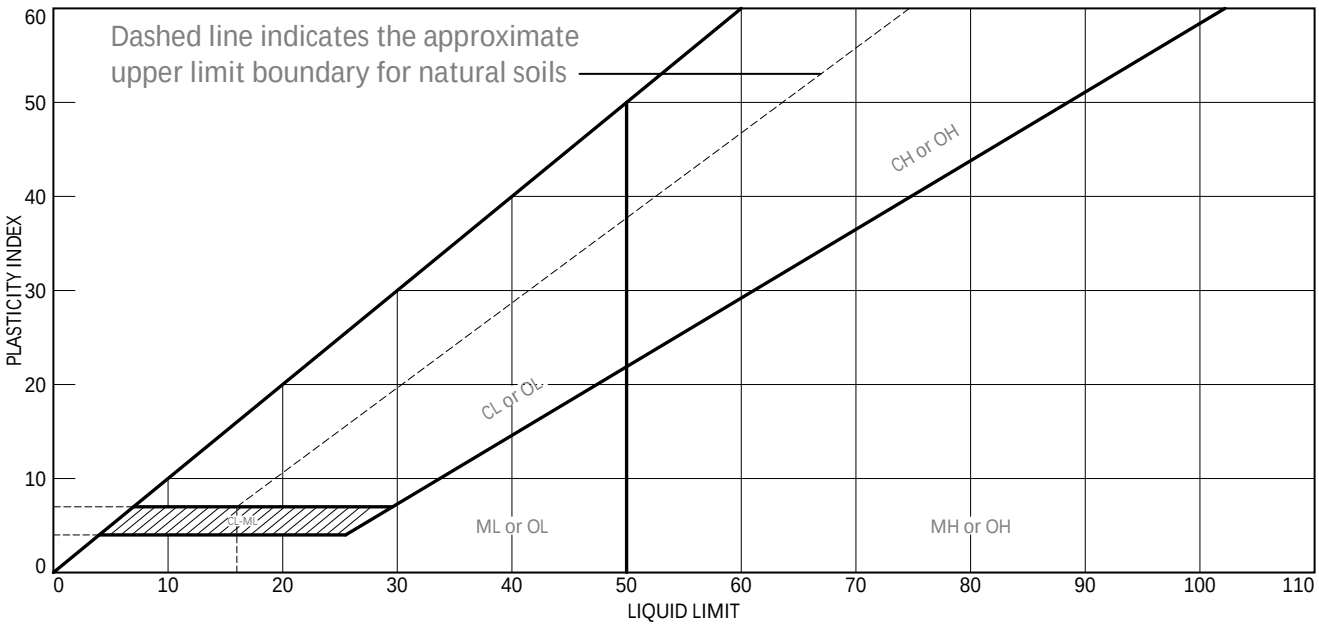
Proposal No. 608051 132406

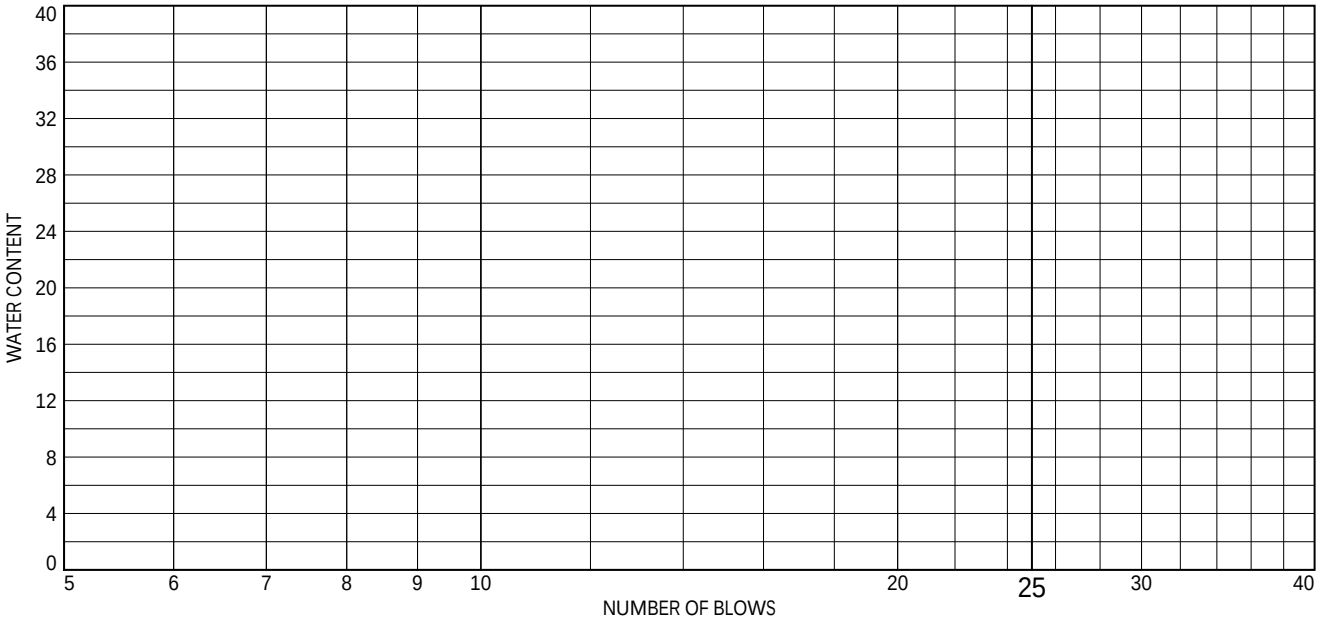
Date Received: **01.20.25** Reviewed By: Date Reviewed: **02.21.25**

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LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Organic silty sand	NV	NP	NP	52.8	14.6	SM

Project No. 74-25-0002.402 Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook

Wilmington, MA

Source of Sample: Liner Tubes Depth: 3.1'

Sample Number: STS-2

Thielsch Engineering Inc.

Cranston, RI

Remarks:

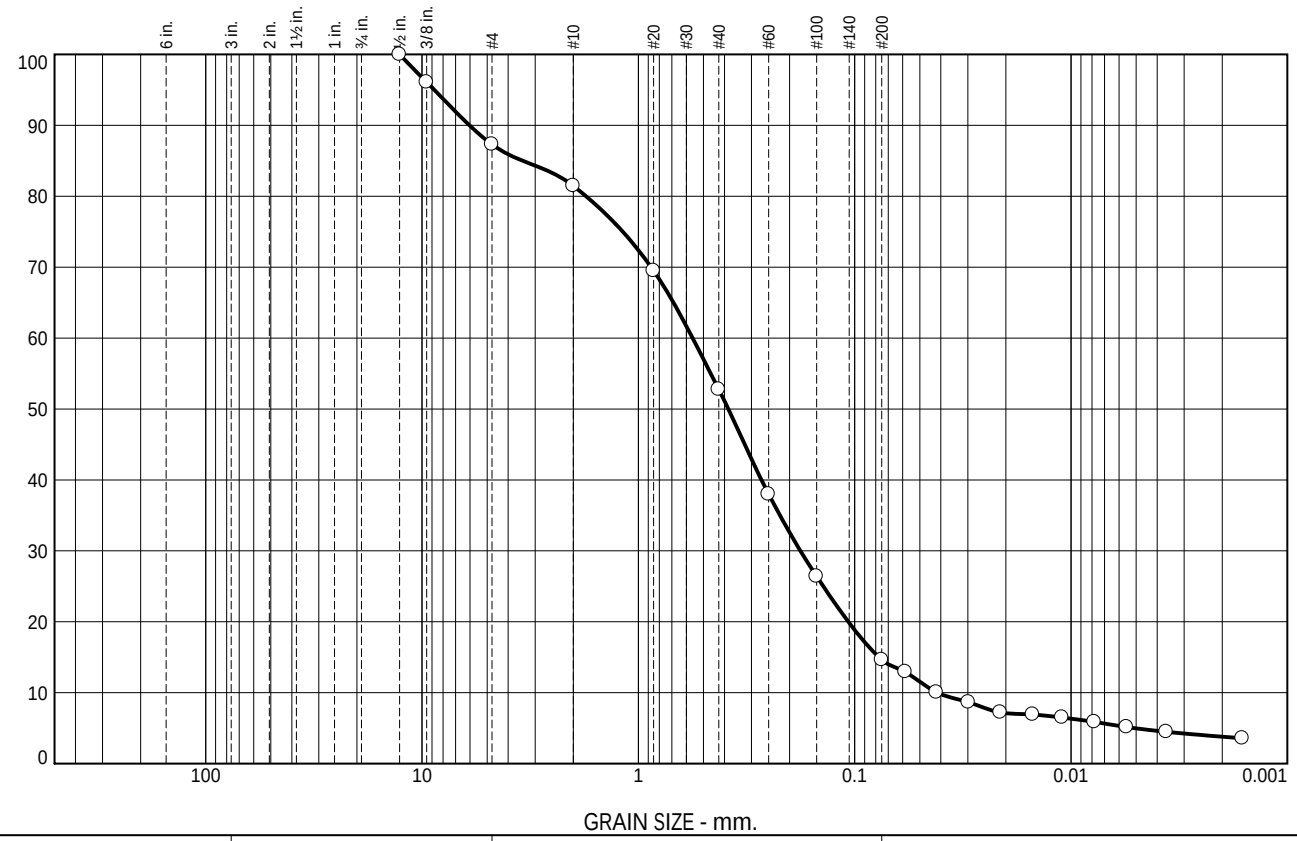
●Sample classified as non-plastic and non-viscous. Sample could not roll past 1/4" and could not achieve more than 25 blows.

Fig. 25-L-488

Tested By: AB Checked By: Rebecca Roth

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	12.7	5.8	28.7	38.2	10.8	3.8

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	96.1		
#4	87.3		
#10	81.5		
#20	69.5		
#40	52.8		
#60	38.0		
#100	26.4		
#200	14.6		
0.0584 mm.	12.9		
0.0419 mm.	10.0		
0.0298 mm.	8.7		
0.0212 mm.	7.2		
0.0150 mm.	6.9		
0.0110 mm.	6.5		
0.0078 mm.	5.9		
0.0055 mm.	5.1		
0.0036 mm.	4.5		
0.0016 mm.	3.6		

* (no specification provided)

Soil Description

Brown Organic silty sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 6.0329 D_{85}= 3.4203 D_{60}= 0.5614
D_{50}= 0.3838 D_{30}= 0.1782 D_{15}= 0.0773
D_{10}= 0.0415 C_u= 13.51 C_c= 1.36

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Sample contained significant amounts of Organic material

Source of Sample: Liner Tubes Depth: 3.1'
Sample Number: STS-2

Date: 02.18.25

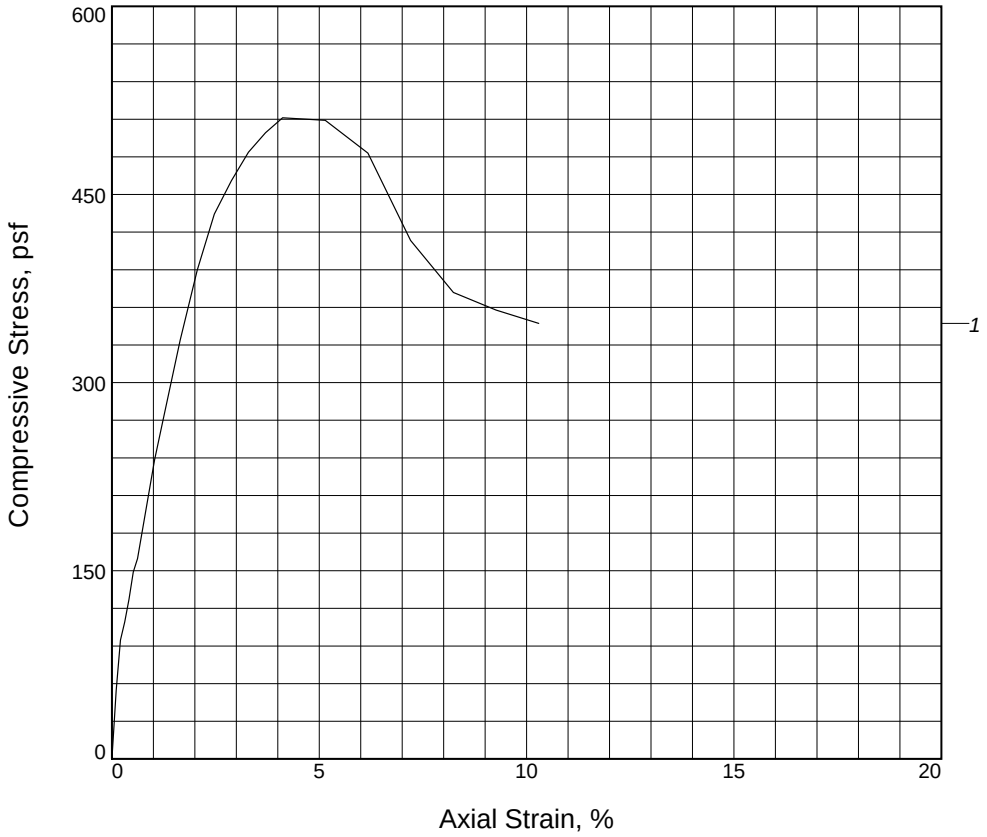
Thielsch Engineering Inc.

Cranston, RI

Client: TG&B Marine
Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA
Project No: 74-25-0002.402 Fig. 25-S-488

Tested By: AB/AV Checked By: Rebecca Roth

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	511			
Undrained shear strength, psf	256			
Failure strain, %	4.1			
Strain rate, in./min.	0.030			
Water content, %	24.0			
Wet density, pcf	128.8			
Dry density, pcf	103.9			
Saturation, %	164.0			
Void ratio	0.3225			
Specimen diameter, in.	2.49			
Specimen height, in.	4.86			
Height/diameter ratio	1.95			

Description: Brown Organic silty sand

LL = NV	**PL =**	**PI =** NP	**Assumed GS=** 2.2	**Type:** Intact Tube

Project No.: 74-25-0002.402

Date Sampled: 02.18.25

Remarks:
Poor sample integrity, sample was loosely contained in a membrane.

Fig. Unc-488

Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA

Source of Sample: Liner Tubes **Depth:** 3.1'

Sample Number: STS-2

UNCONFINED COMPRESSION TEST
Thielsch Engineering Inc.
Cranston, RI

Tested By: Rebecca Roth **Checked By:** Rebecca Roth

Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston, Rhode Island 02910
Phone: 401-467-6454
Fax: 401-467-2398
http://www.Thielsch.com

Client Information:
TG&B Marine

Monument Beach, MA
https://tgandbmarine.com

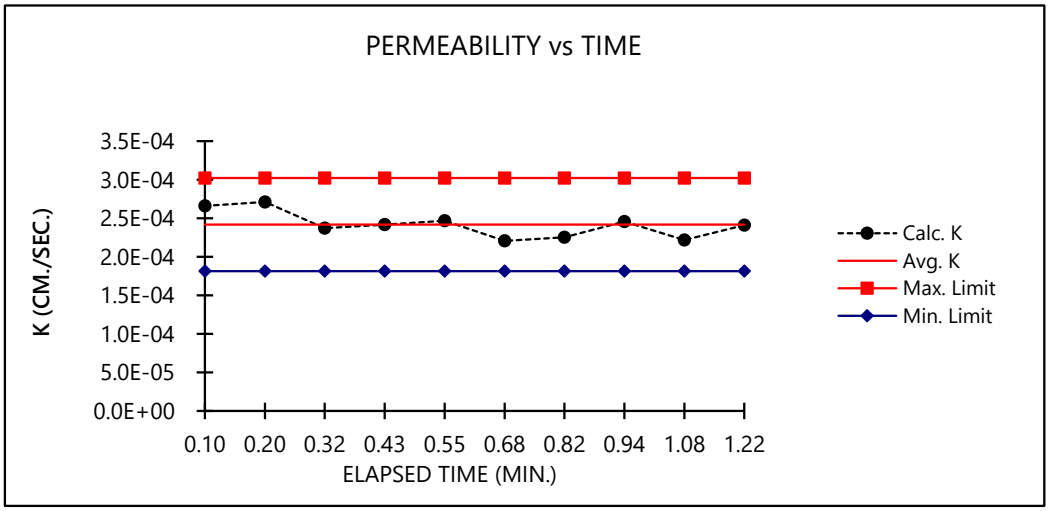
ASTM D5084:
Hydraulic Conductivity using a Flexible Wall Permeameter

2.0" x 2.0" Intact Tube Sample

Project Name:	Rt. 38 Bridge over Mapie Meadow Brook	Lab Number:	K-488
Project Number:	74-25.0002.402	Depth:	3.1'
Material Source:	Onsite	Sample Number:	STS-2
Soil Description:	Brown Organic silty sand		

Sample Data	Initial	Final
Diameter (In):	1.994	1.989
Length (in):	2.050	2.045
Water Content (%):	19.0	20.9
Dry Unit Weight (pcf):	105.8	105.5

Test Parameters	
Total Back Pressure (psi.)	80
Maximum Effective Stress (psi.)	5
Minimum Effective Stress (psi.)	4
Initial Hydraulic Gradient	16
Final Hydraulic Gradient	13



Average K cm/sec **2.4E-04**

Comments
Deaired tap water was used for this test.

Technician:	Sophia Brooks-Randall	**Reviewed By:**	Rebecca Roth
Report Date:	02.13.25	**Review Date:**	02.14.25

Thielsch
DIVISION OF THE RISE GROUP



TG& B Marine Services

Route 38 Bridge over Maple Meadow Brook

STS-2, 3.1', T-488







Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:	Project Information:
TG & B Marine	**Route 38 Bridge over Magic Meadow Brook**
Monument Beach, MA	**Wilmington, MA**
508.326.3686	Project Number: 74-25-0002.402
Project Contact: Camila Knight	Summary Page: 3 of 4
Collected By: Client	Report Date: 02.21.25

LABORATORY TESTING DATA SHEET, Report No.: 7425-B-128

Boring ID	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Shear / Consolidation / Permeability Tests								Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Torvane or Type Test	Failure Criteria	$\sigma_1 - \sigma_3$ or t psf	Strain %	Permeability cm/sec	EST. Internal Friction Angle	CR / RR	
Onsite	STS-3	3.5	24-S-489		Average Total Unit Weight (3.5') = 89.9 pcf															
		0.0-0.8	Dist																	Disturbed PEAT
		0.8-0.9	W-489a	116									W/C							Brown Fibrous PEAT
		0.9-1.1	S-489	79.9			19.4	54.9	25.7				Hydro							Brown Organic silty sand with gravel
		1.1-1.3	L-489	109	NV	NP							LL PL							Brown Organic silty sand with gravel
		1.3-1.8	SAVED										SAVED							Brown Organic silty sand with gravel
		1.8-2.05	K-489	31.7								74.8	Perm				$1.9x10^{-06}$			Brown Organic silty sand
		2.05-2.55	U-489	24.1								106.3	UNC	$\sigma_1 - \sigma_3$	1447	5.4				Brown Organic silty sand
		2.55-3.05	W-489b	45.6									W/C							Brown Fibrous PEAT
2.6" poly tube, unable to extract material using mechancial extractor, torvanes could not be collected. Sample depth measured from top of tube, true depth of sample is unknown.																				

A000082 - 100

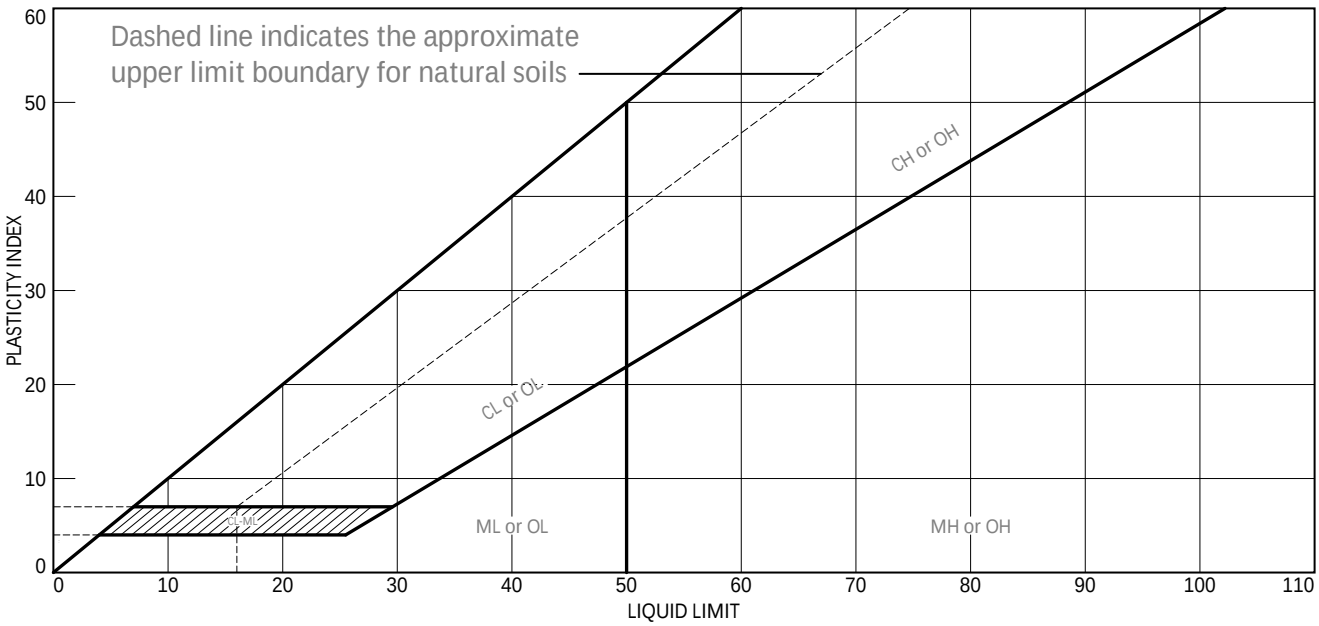
Proposal No. 608051 - 132406

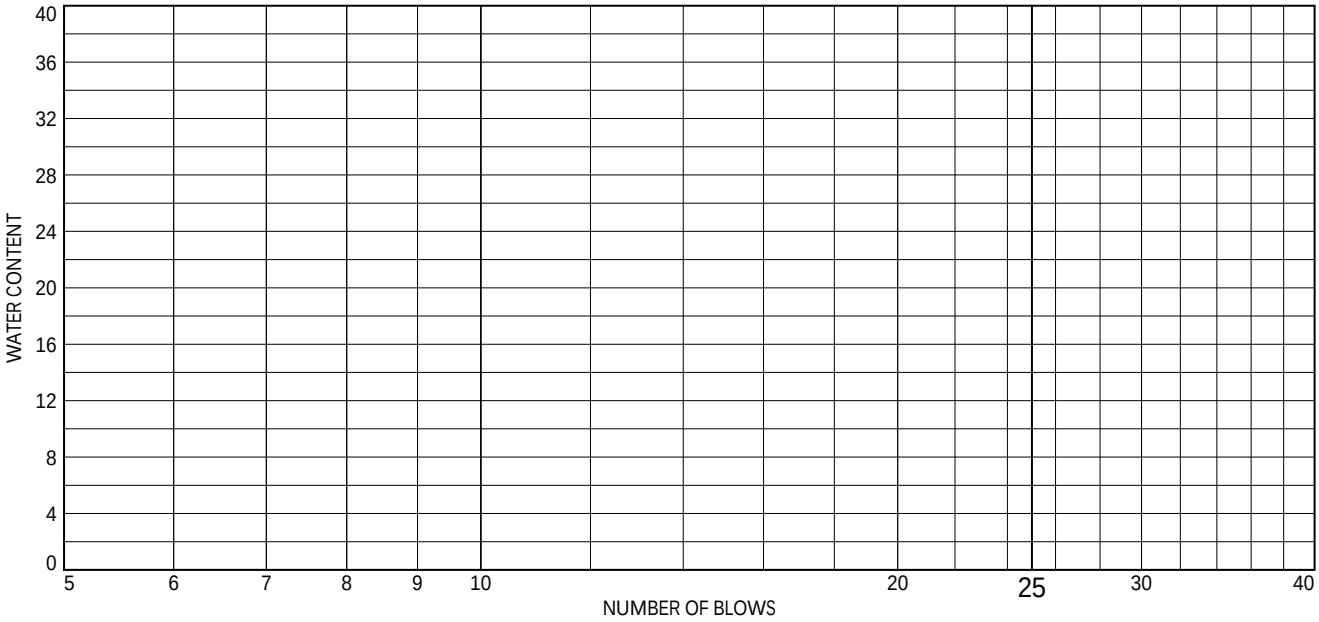
Date Received: **01.20.25** Reviewed By: Date Reviewed: **02.21.25**

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LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Organic silty sand with gravel	NV	NP	NP	63.3	25.7	SM

Project No. 74-25-0002.402 Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook

Wilmington, MA

Source of Sample: Liner Tubes Depth: 3.5'

Sample Number: STS-3

Thielsch Engineering Inc.

Cranston, RI

Remarks:

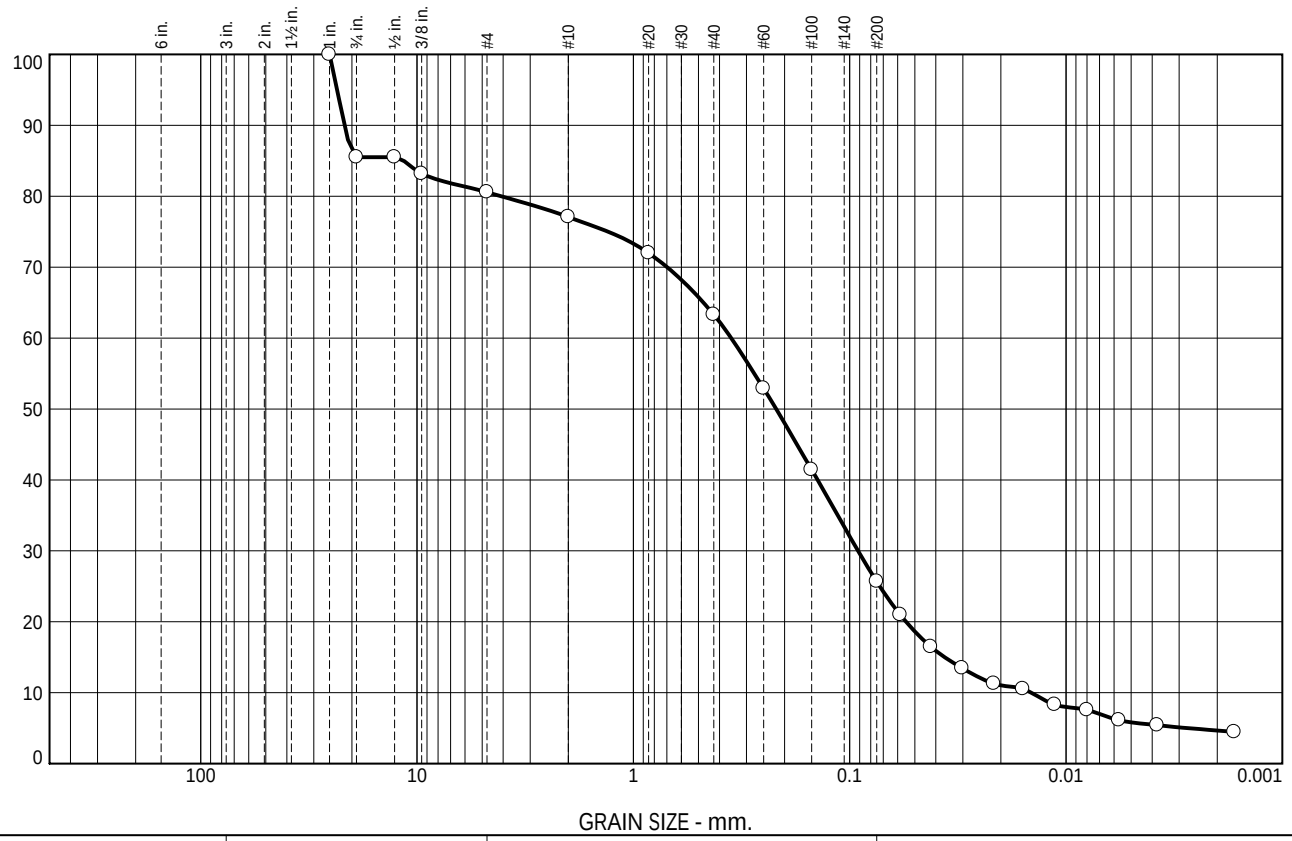
●Sample too fibrous for an atterberg to be tested.

Fig. 25-L-489

Tested By: AB Checked By: Rebecca Roth

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Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	14.5	4.9	3.5	13.8	37.6	21.0	4.7

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	85.5		
1/2"	85.5		
3/8"	83.2		
#4	80.6		
#10	77.1		
#20	72.0		
#40	63.3		
#60	52.9		
#100	41.4		
#200	25.7		
0.0584 mm.	21.0		
0.0422 mm.	16.5		
0.0302 mm.	13.5		
0.0216 mm.	11.3		
0.0158 mm.	10.5		
0.0113 mm.	8.3		
0.0080 mm.	7.6		
0.0057 mm.	6.1		
0.0038 mm.	5.4		
0.0017 mm.	4.5		

* (no specification provided)

Soil Description

Brown Organic silty sand with gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 21.6635 D_{85}= 11.5008 D_{60}= 0.3529
D_{50}= 0.2187 D_{30}= 0.0915 D_{15}= 0.0364
D_{10}= 0.0145 C_u= 24.38 C_c= 1.64

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Sample contains significant Organic material.

Source of Sample: Liner Tubes Depth: 3.5'
Sample Number: STS-3

Date: 02.18.25

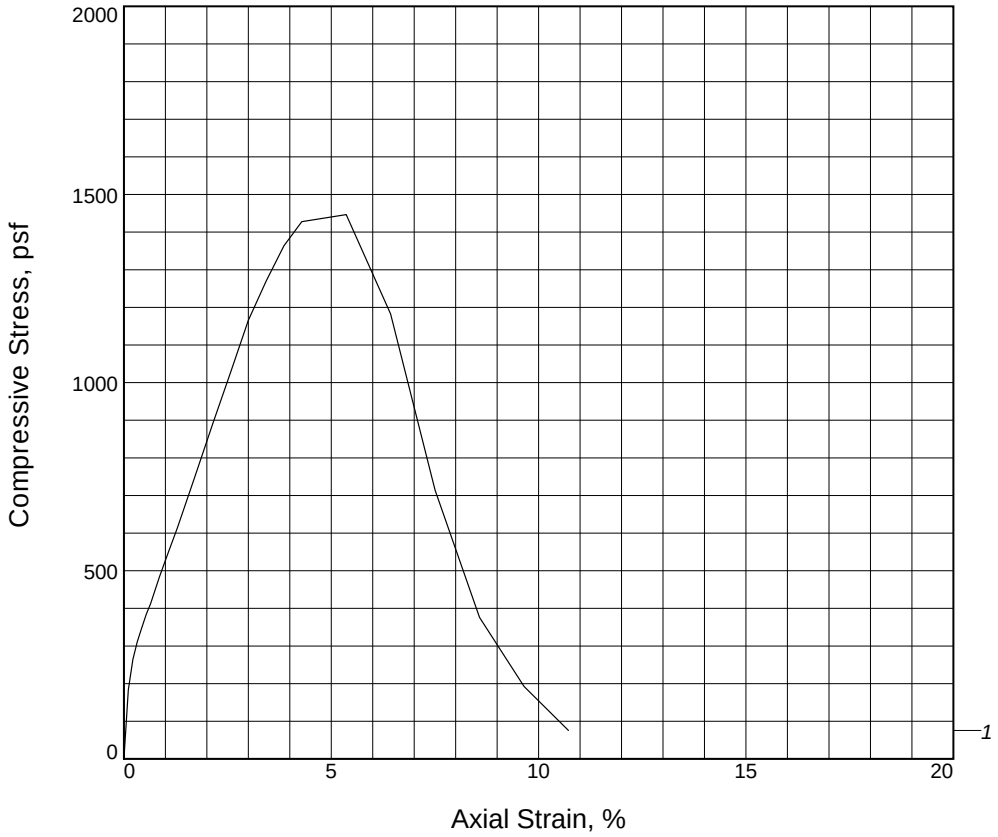
Thielsch Engineering Inc.

Cranston, RI

Client: TG&B Marine
Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA
Project No: 74-25-0002.402 Fig. 25-S-489

Tested By: AB/AV Checked By: Rebecca Roth

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1447			
Undrained shear strength, psf	723			
Failure strain, %	5.4			
Strain rate, in./min.	0.030			
Water content, %	24.1			
Wet density, pcf	132.0			
Dry density, pcf	106.3			
Saturation, %	182.1			
Void ratio	0.2916			
Specimen diameter, in.	2.48			
Specimen height, in.	4.66			
Height/diameter ratio	1.88			

Description: Brown Organic silty sand with gravel

LL = NV	**PL =**	**PI =** NP	**Assumed GS=** 2.2	**Type:** Intact Tube

Project No.: 74-25-0002.402

Date Sampled: 02.18.25

Remarks:
Sample was not contained in a membrane Sample was not contained within a membrane

Fig. Unc-489

Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA

Source of Sample: Liner Tubes **Depth:** 3.5'

Sample Number: STS-3

UNCONFINED COMPRESSION TEST
Thielsch Engineering Inc.
Cranston, RI

Tested By: Sophia Brooks-Randall **Checked By:** Rebecca Roth

Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston, Rhode Island 02910
Phone: 401-467-6454
Fax: 401-467-2398
http://www.Thielsch.com

Client Information:
TG&B Marine

Monument Beach, MA
https://tgandbmarine.com

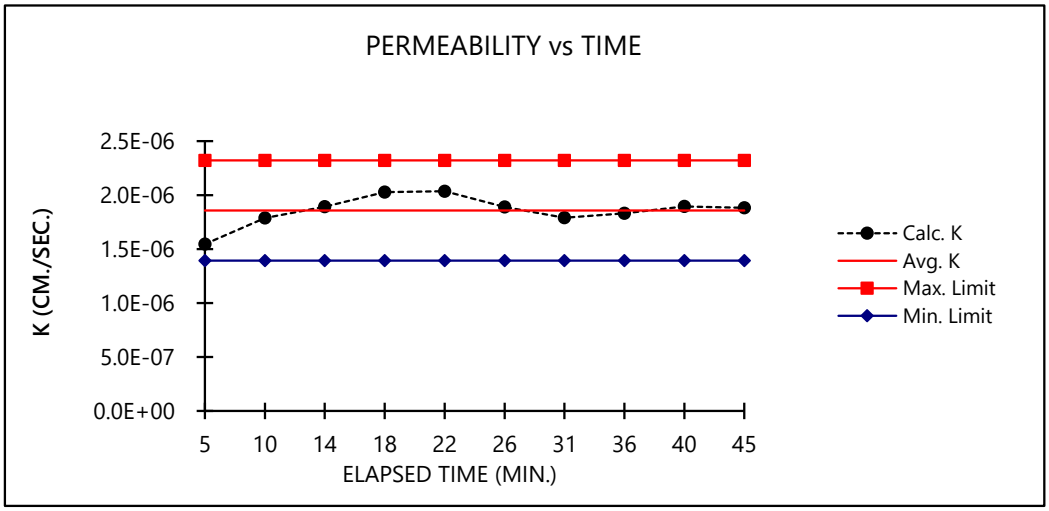
ASTM D5084:
Hydraulic Conductivity using a Flexible Wall Permeameter

2.0" x 2.0" Intact Tube Sample

Project Name:	Rt. 38 Bridge over Mapie Meadow Brook	Lab Number:	K-489
Project Number:	74-25.0002.402	Depth:	3.5'
Material Source:	Onsite	Sample Number:	STS-3
Soil Description:	Brown Organic silty sand with gravel		

Sample Data	Initial	Final
Diameter (In):	2.084	2.060
Length (in):	2.815	2.783
Water Content (%):	31.7	24.5
Dry Unit Weight (pcf):	74.8	80.8

Test Parameters	
Total Back Pressure (psi.)	80
Maximum Effective Stress (psi.)	5
Minimum Effective Stress (psi.)	4
Initial Hydraulic Gradient	10
Final Hydraulic Gradient	9



Average K cm/sec **1.9E-06**

Comments
Deaired tap water was used for this test.

Technician:	Sophia Brooks-Randal	**Reviewed By:**	Rebecca Roth
Report Date:	02.14.25	**Review Date:**	02.18.25

Thielsch
DIVISION OF THE RISE GROUP



TG& B Marine Services

Route 38 Bridge over Maple Meadow Brook

STS-3, 351', T-489





Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
Cranston RI, 02910
Phone: (401)-467-6454
Fax: (401)-467-2398
thielsch.com
Let's Build a Solid Foundation

Client Information:		Project Information:	
TG & B Marine		**Route 38 Bridge over Magic Meadow Brook**	
Monument Beach, MA		**Wilmington, MA**	
508.326.3686		Project Number:	74-25-0002.402
Project Contact:	Camila Knight	Summary Page:	4 of 4
Collected By:	Client	Report Date:	02.21.25

LABORATORY TESTING DATA SHEET, Report No.: 7425-B-128

Boring ID	Sample No.	Depth (ft)	Laboratory No.	Identification Tests								Shear / Consolidation / Permeability Tests								Laboratory Log and Soil Description
				As Rcvd Moisture Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Torvane or Type Test	Failure Criteria	$\sigma_1 - \sigma_3$ or t psf	Strain %	Permeability cm/sec	EST. Internal Friction Angle	CR / RR	
Onsite	STS-3	1.9	24-S-490		Average Total Unit Weight (1.9') = 78.5 pcf															
		0.0-0.15	Dist																	Disturbed PEAT
		0.15-0.25	W-490a	189									W/C							Brown Fibrous PEAT
		0.25-0.5	K-490	106								41.3	Perm				$7.8x10^{-07}$			Brown Organic silty sand
		0.5-0.7	L-490a	126	NV	67							LL / PL							Brown Organic silty sand
		0.7-1.2	U-490	70.9								44.4	UNC	$\sigma_1 - \sigma_3$	238	17.0				Brown Organic silty sand
		1.2-1.35	S-490	81.4			11.5	65.6	22.9				Hydro							Brown Organic silty sand
		1.35-1.4	W-490b	44.8									W/C							Brown Organic silty sand

2.6" poly tube, unable to extract material using mechancial extractor, torvanes could not be collected.
Sample depth measured from top of tube, true depth of sample is unknown.

A00082 - 195

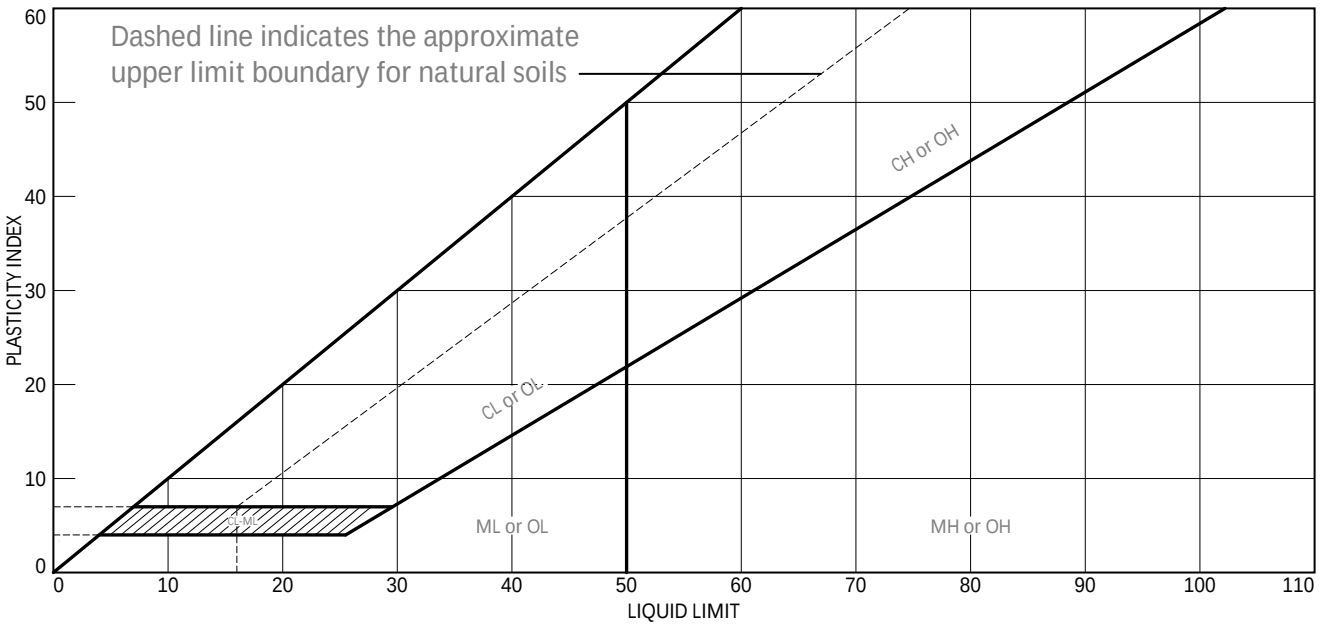
Proposal No. 608051 - 132406

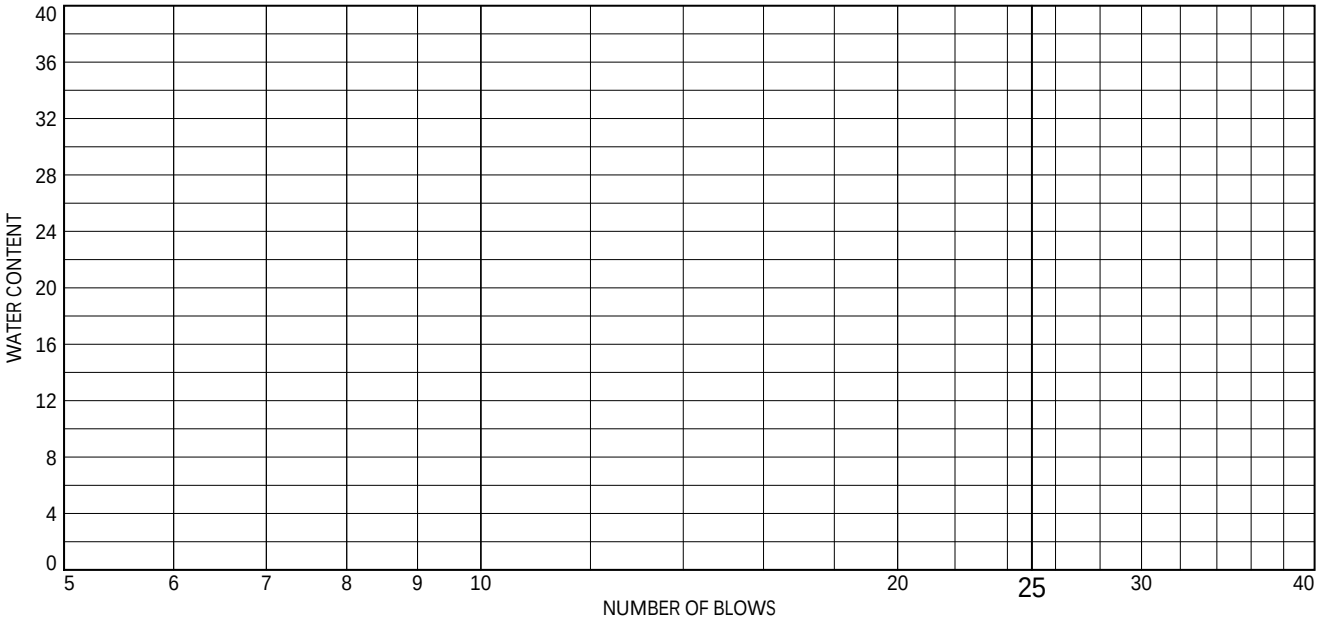
Date Received: **01.20.25** Reviewed By: Date Reviewed: **02.21.25**

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LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown Organic silty sand	NV	67	NP	63.6	22.9	SM

Project No. 74-25-0002.402 Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook

Wilmington, MA

Source of Sample: Liner Tubes Depth: 1.9'

Sample Number: STS-4

Thielsch Engineering Inc.

Cranston, RI

Remarks:

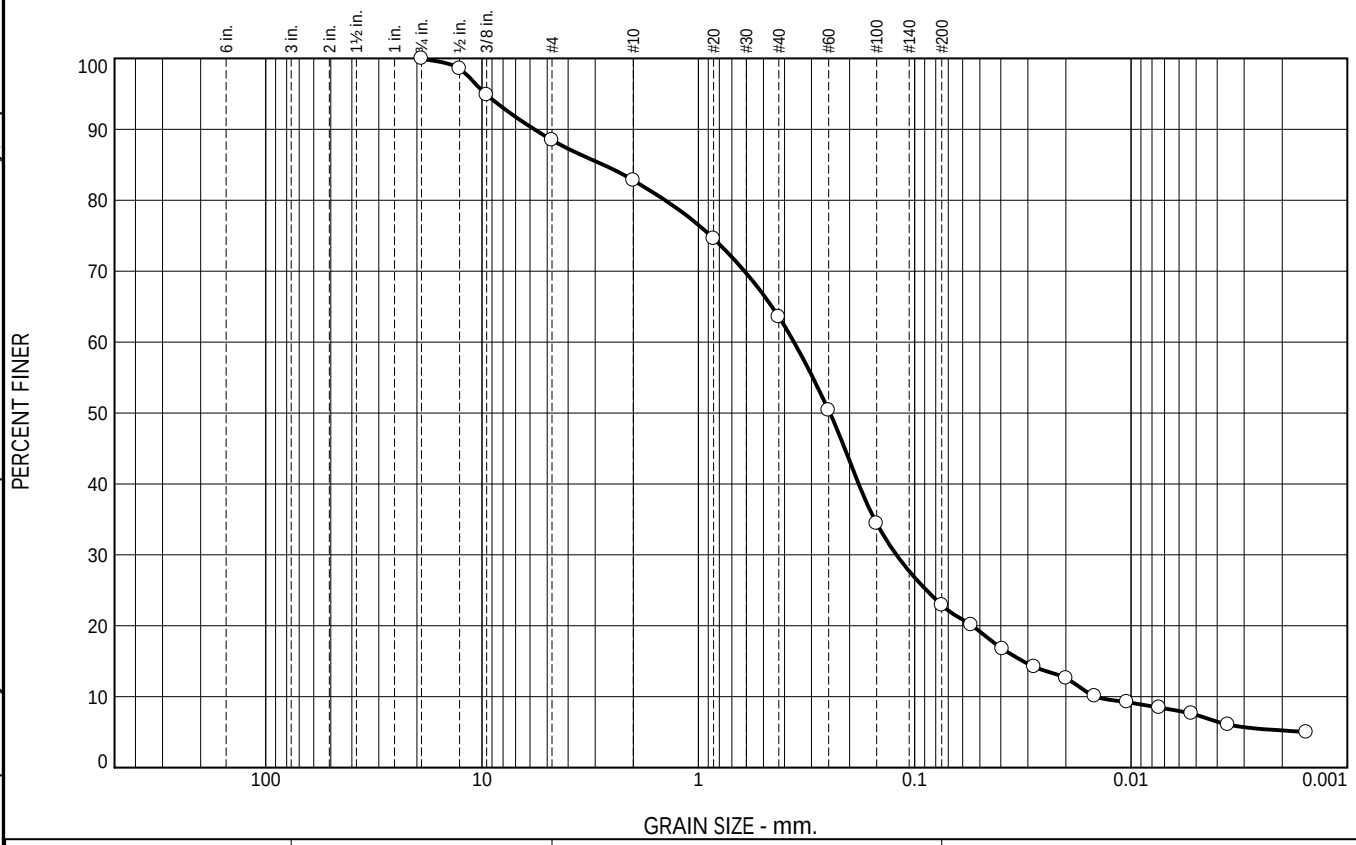
●Sample classified as non-viscous. Sample could not reach 25 blows.

Fig. 25-L-490

Tested By: AB Checked By: Rebecca Roth

These results are for the exclusive use of the client for whom they were obtained. This report only relates to items inspect and/or tested. No warranty, expressed or implied, is made.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	11.5	5.7	19.2	40.7	17.7	5.2

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	98.6		
3/8"	94.9		
#4	88.5		
#10	82.8		
#20	74.6		
#40	63.6		
#60	50.4		
#100	34.4		
#200	22.9		
0.0548 mm.	20.1		
0.0393 mm.	16.7		
0.0281 mm.	14.2		
0.0200 mm.	12.6		
0.0147 mm.	10.1		
0.0104 mm.	9.2		
0.0074 mm.	8.5		
0.0053 mm.	7.6		
0.0036 mm.	6.1		
0.0015 mm.	5.0		

* (no specification provided)

Soil Description

Brown Organic silty sand

Atterberg Limits

PL= 67 LL= NV PI= NP

Coefficients

D_{90}= 5.7233 D_{85}= 2.7470 D_{60}= 0.3614
D_{50}= 0.2465 D_{30}= 0.1215 D_{15}= 0.0316
D_{10}= 0.0145 C_u= 24.93 C_c= 2.82

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Sample contains significant Orgnaic material

Source of Sample: Liner Tubes Depth: 1.9'
Sample Number: STS-4

Date: 02.18.25

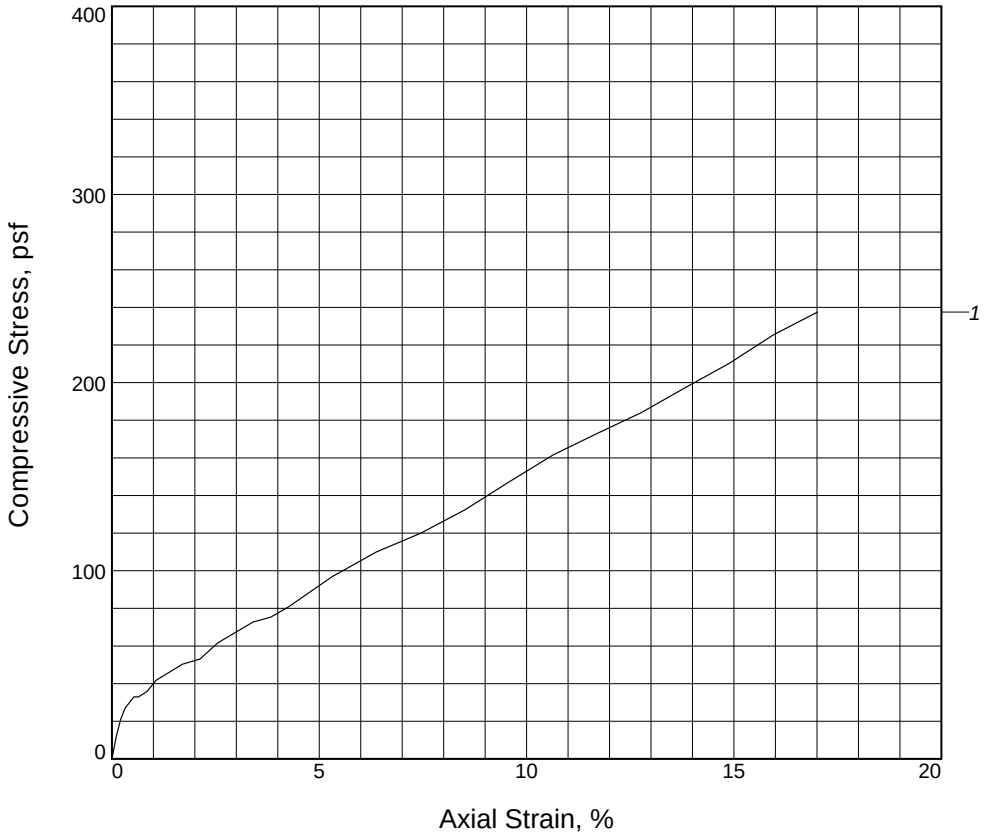
Thielsch Engineering Inc.

Cranston, RI

Client: TG&B Marine
Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA
Project No: 74-25-0002.402 Fig. 25-S-490

Tested By: AB/AV Checked By: Rebecca Roth

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	238			
Undrained shear strength, psf	119			
Failure strain, %	17.0			
Strain rate, in./min.	0.030			
Water content, %	70.9			
Wet density, pcf	75.9			
Dry density, pcf	44.4			
Saturation, %	71.6			
Void ratio	2.3738			
Specimen diameter, in.	2.74			
Specimen height, in.	4.70			
Height/diameter ratio	1.72			

Description: Brown Organic silty sand

LL = NV	**PL =**	**PI =** NP	**Assumed GS=** 2.4	**Type:** Intact Tube

Project No.: 74-25-0002.402

Date Sampled: 02.18.25

Remarks:
Poor sample integrity, sample was loosley contained in a membrane.

Fig. UNC-490

Client: TG&B Marine

Project: Route 38 Bridge over Maple Meadow Brook
Wilmington, MA

Source of Sample: Liner Tubes **Depth:** 1.9'

Sample Number: STS-4

UNCONFINED COMPRESSION TEST
Thielsch Engineering Inc.
Cranston, RI

Tested By: Sophia Brooks-Randall **Checked By:** Rebecca Roth

Thielsch
DIVISION OF THE RISE GROUP

195 Frances Avenue
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Phone: 401-467-6454
Fax: 401-467-2398
http://www.Thielsch.com

Client Information:
TG&B Marine

Monument Beach, MA
https://tgandbmarine.com

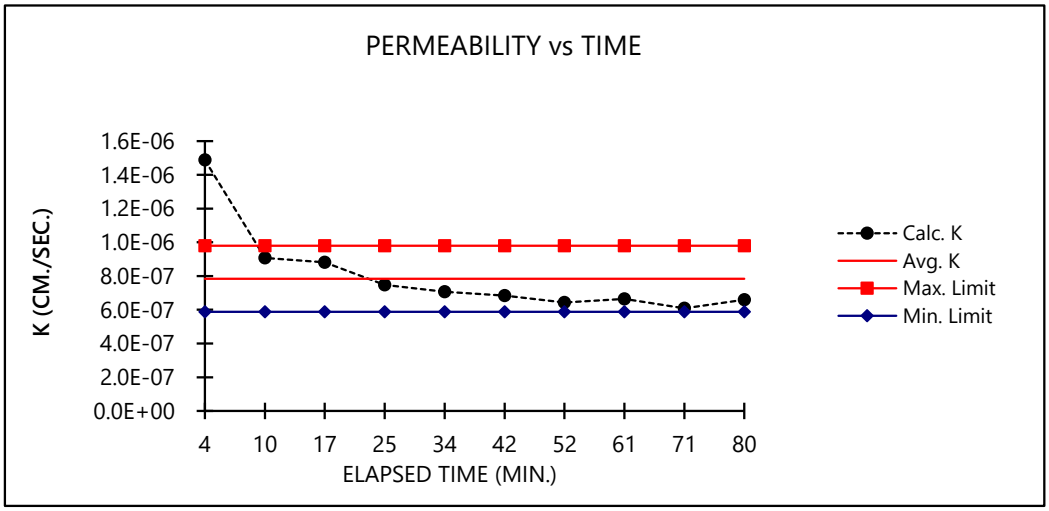
ASTM D5084:
Hydraulic Conductivity using a Flexible Wall Permeameter

2.0" x 2.0" Intact Tube Sample

Project Name:	Rt. 38 Bridge over Mapie Meadow Brook	Lab Number:	K-490
Project Number:	74-25.0002.402	Depth:	1.9'
Material Source:	Onsite	Sample Number:	STS-4
Soil Description:	Brown Organic silty sand		

Sample Data	Initial	Final
Diameter (In):	2.106	2.085
Length (in):	2.097	2.076
Water Content (%):	105.8	106.0
Dry Unit Weight (pcf):	41.3	35.7

Test Parameters	
Total Back Pressure (psi.)	80
Maximum Effective Stress (psi.)	5
Minimum Effective Stress (psi.)	4
Initial Hydraulic Gradient	13
Final Hydraulic Gradient	13



Average K cm/sec **7.8E-07**

Comments
Deaired tap water was used for this test.

Technician:	Sophia Brooks-Randal	**Reviewed By:**	Rebecca Roth
Report Date:	02.14.25	**Review Date:**	02.18.25

Thielsch
DIVISION OF THE RISE GROUP



TG& B Marine Services

Route 38 Bridge over Maple Meadow Brook

STS-4, 1.9', T-490


1 2 3 4 5 6 7 8 9 10
.1 .2 .3 .4 .5 .6 .7 .8


9 10 11 12 13 14 15 16 17 18 19
.8 .9 1 .1 .2 .3 .4 .5 .6

APPENDIX I

BRIDGE BORING LOGS – LAMSON ENGINEERING; JANUARY 2024

massDOT Highway

GREEN INTERNATIONAL AFFILIATES, INC.

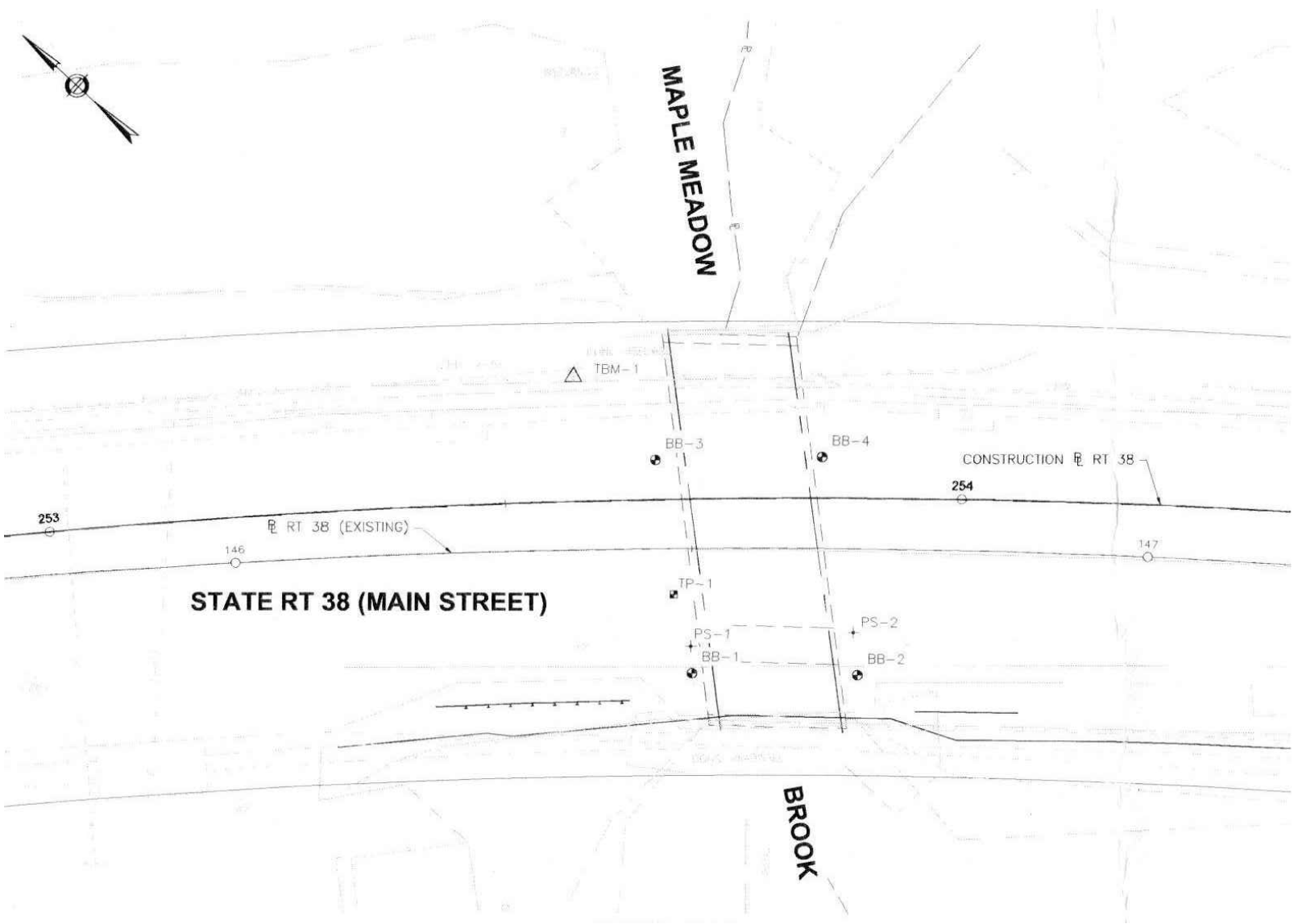
BRIDGE NO. W-38-011 (802)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

2024 BORING LOCATION PLAN

N.T.S.

Fig. 2



Note: Borings BB-3 and BB-4 were not conducted due to overhead electrical wires.

LEGEND:

◕ BRIDGE BORING

\+ PROBE – LOCATION OF THE FIRST IS INDICATED

SOURCE: FROM WILMINGTON BORING PLAN BY GREEN INTERNATIONAL AFFILIATES.

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-1 (Bridge Boring) | Page 1/2 | Scale: 1" = 5'

City/Town: Wilmington, MA	Bridge No.: W-38-011 (802)	Project File No.: 608051	Contract No.: -
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 1/12/24 11:00 AM	Total Hours:
Groundwater Depth (Feet): 2.3' Date & Time: 1/17/24 10:25 AM		Date & Time Completed: 1/17/24 2:00 PM	**9.5
Coordinates: *N 3,021,112.8 *E 747,590.9	Ground Elevation (Feet): *81.1'	Inspector's Name: James Gu	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-1	1' - 3'	17 4 3 2	2"	Dry, loose, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt (with ASPHALT pieces on top).	
S-2	4' - 6'	9 4 4 3	0"	Wet, no recovery.	
S-3	9' - 11'	1 3 5 4	2"	Wet, loose, brown, FINE TO COARSE SAND, trace inorganic silt.	
S-4	14' - 16'	3 6 5 3	10"	Wet, loose, brown, FINE TO COARSE SAND, trace inorganic silt.	18'
S-5	19' - 21'	2 1 1 1	9"	Wet, very loose, gray, FINE SAND AND INORGANIC SILT.	
S-6	24' - 26'	2 3 4 4	11"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-7	29' - 31'	2 3 3 4	10"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	

Notes: * Moved BB-1 4' toward drive way due to underground gas pipe.
**1/12/24 11:00 AM to 3:00 PM, 1/17/24 8:30AM to 2:00 PM
Wilmington PD: 1/12/24 Louis Martignetti #153, Paul Jepson #142
1/17/24 Brian Moon #161, Chris Dindo #170

Arrow-Board: -
Signs: 2
Cones: 11

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: GT8 GtechDrill
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 34' 37'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-1
(Bridge Boring)

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-8	34' - 36'	1 1 1 3	10"	Wet, very loose, gray, FINE SAND AND INORGANIC SILT.	
					37'
C-1	37' - 42'	3 4 11 9 2.5	20"	Hard, slightly fractured, gray, GRANITE Recovery = 20"/ 60" = 33% RQD = 12"/ 60" = 20%	
C-2	42' - 43'2"	3 6/ 2"	6"	Hard. Recovery = 6"/ 14" = 33% RQD = 0"/ 14" = 0%	43'2"
				Bottom of Exploration @ 43'2"	

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-2 (Bridge Boring) | Page 1/2 | Scale: 1" = 5'

City/Town: Wilmington, MA	Bridge No.: W-38-011 (802)	Project File No.: 608051	Contract No.: -
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 1/5/24 8:30 AM	Total Hours:
Groundwater Depth (Feet): 1.75' Date & Time: 1/12/24 9:15 AM		Date & Time Completed: 1/12/24 11:00 AM	**11.5
Coordinates: *N 3,021,101.4 *E 747,605.0	Ground Elevation (Feet): *82.0'	Inspector's Name: James Gu	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Vacuumed and hit ground water stop at 1'-9", no utility found.	
S-1	3' - 5'	6 4 1 1	2"	Wet, loose, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	6.5'
				Roller bit through COBBLE/BOULDER from 6.5' to 9'.	9'
				Core through footing from 9' to 10', 7" recovery.	10'
S-2	10' - 12'	5 7 9 9	17"	Wet, medium dense, gray, FINE TO COARSE SAND, some inorganic silt, trace fine gravel.	11.5'
				Bottom 4", gray, FINE SAND AND INORGANIC SILT.	
S-3	14' - 16'	2 2 2 4	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-4	19' - 21'	2 2 4 3	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-5	24' - 26'	2 2 3 4	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	28'

Notes: * Moved BB-2 6'10" toward drive way due to underground gas pipe.
**Driller: Garrett Peaccok, Helper: Matt Feden on 1/5/24 8:30 AM to 11:00 AM, Rig stop work. Driller: Ken Smith, Helper: Rick Larhette on 1/11/24 8:30 AM to 3:00 PM, 1/12/24 8:30AM to 11:00 AM.
Wilmington PD: 1/5/24 Daryl Ceruolo, John Fortes, 1/11/24 Brian Moon #161, Chris Dindo #170, 1/12/24 Louis Martignetti #153, Paul Jepson #142

Arrow-Board: -
Signs: 2
Cones: 11

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
		Hard	Over 30

N=Sum of Second and Third 6" Blow Counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: GT8 GtechDrill
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 44' 45'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-2
(Bridge Boring)

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-6	29' - 31'	34 17 25 88	10"	Wet, dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-7	34' - 36'	40 48 34 27	13"	Wet, very dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-8	39' - 41'	29 19 42 71	9"	Wet, very dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
					44'
S-9	44' - 44'2"	120/ 2"	2"	Wet, Refusal, WEATHERED BEDROCK	45'
C-1	45' - 50'	2.5 2.5 2.5 2.5 3	58"	Hard, slightly fractured, white-gray, GRANITE Recovery = 58"/ 60" = 97% RQD = 30"/ 60" = 50%	
C-2	50' - 55'	2.5 2.5 2.5 2.5 3	60"	Hard, slightly fractured, white-gray, GRANITE Recovery = 60"/ 60" = 100% RQD = 50"/ 60" = 83%	
					55'
				Bottom of Exploration @ 55'	

APPENDIX K

SCOUR ANALYSIS AND COUNTERMEASURES CALCULATIONS

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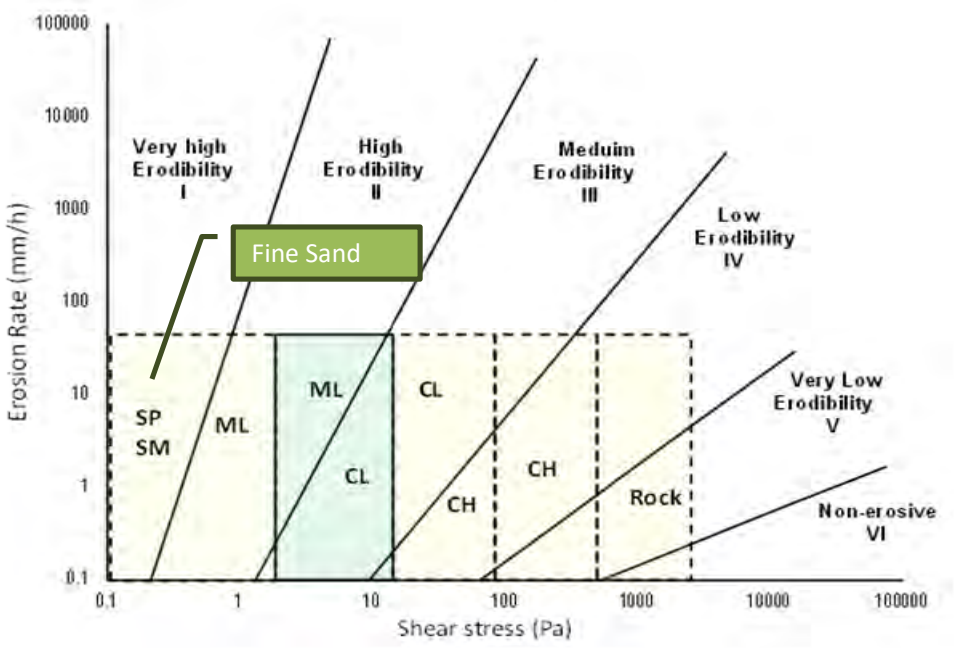
JOB NO.:	MassDOT #608051			SHEET NO.:	1	OF	1
JOB NAME:	Wilmington Route 38 Main Street						
CALCULATED BY:	AAE	DATE:	3/20/2025	CHECKED BY:	AGF	DATE:	4/7/2025
DESCRIPTION:	Critical Shear Stress Estimate; Cohesive Soils						

Estimate critical shear stress τ_c

Due to soil conditions, Atterberg limits were not able to be determined by the lab.

Critical shear stress was instead estimated using the study documented in FHWA-HRT-15-033.

Use FHWA-HRT-15-033 Figure 2 for fine sand, based on sediment sample logs:



Assume minimum critical shear stress is 0.1 Pa and maximum critical shear stress is 0.5 Pa.

τ_c (min)	=	0.10	Pa	=	0.0021 lbf/ft^2
τ_c (max)	=	0.50	Pa	=	0.0104 lbf/ft^2

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JOB NO.: MassDOT #608051 SHEET NO.: 1 OF 1
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 4/2/2025 CHECKED BY: AGF DATE: 4/7/2025
DESCRIPTION: Stream Bed Conditions at Incipient Flow = 370 cfs; Cohesive Soils

Calculate critical velocity for initiation of erosion of cohesive material

Use FHWA-HRT-15-033 Figure 6: Equation for critical velocity and critical shear stress

$$V_c = \frac{K_u}{n}\left(\sqrt{\frac{\tau_c}{\rho g}}\right) y_1^{1/6}$$

FHWA-HRT-15-033 Figure 6

Upstream average flow depth	y_1	=	*6.72*	*ft*
Acceleration due to gravity	**g**	=	*32.2*	*ft/s²*
Manning's n	**n**	=	*0.03*	
Density of water	**ρ**	=	*62.4*	*lb/ft³*
Unit conversion	K_u	=	*1.486*	*for US customary units*

Minimum critical shear stress	τ_c	=	0.0021	lbf/ft²
Maximum critical shear stress	τ_c	=	0.0104	lbf/ft²

Calculate critical velocity	V_c	=	**0.06937**	**ft/s**	minimum critical shear stress
	V_c	=	**0.1551**	**ft/s**	maximum critical shear stress

Compare critical velocity with velocity at the approach section

Velocity at approach section	**V**	=	8.87	ft/s

If V_c > V, then use Clear-Water equations, otherwise use Live-Bed equations

V_c < V; therefore, the streambed is under live bed conditions

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JOB NO.: MassDOT #608051 SHEET NO.: 1 OF 1

JOB NAME: Wilmington Route 38 Main Street

CALCULATED BY: AAE DATE: 5/21/2025 CHECKED BY: AF DATE: 5/28/2025

DESCRIPTION: Stream Bed Conditions at Incipient Flow = 370 cfs; Cohesionless Soils

Calculate critical velocity for initiation of erosion of material V_c

Use HEC-18 Equation 6.1

$$V_c = 11.17 y^{\frac{1}{6}} D^{\frac{1}{3}}$$ HEC-18 Equation 6.1

Upstream average flow depth **y** = *6.72* *ft*

Mean sediment size $\mathbf{D_{50}}$ = *0.107* *mm* = 4E-04 ft

Calculate critical velocity	$\mathbf{V_c}$ =	**1.08**	**ft/s**

Compare critical velocity with velocity at the approach section

Velocity at approach section **V** = *8.87* *ft/s*

If $V_c > V$, then use Clear-Water equations, otherwise use Live-Bed equations

$V_c < V$; therefore, the streambed is under live bed conditions

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JOB NO.: MassDOT #608051 SHEET NO.: 1 OF 4
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 5/21/2025 CHECKED BY: AF DATE: 5/28/2025
DESCRIPTION: Pressure Flow Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions

Calculate average depth in the contracted section y_2

Use HEC-18 Equation 6.2

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

HEC-18 Equation 6.2

Under overtopping conditions, replace Q_1 in Equation 6.2 with effective channel discharge Q_{ue}
Under overtopping conditions, replace y_1 in Equation 6.2 with effective upstream channel flow h_{ue}

$$\frac{y_2}{h_{ue}} = \left(\frac{Q_2}{Q_{ue}}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

HEC-18 Equation 6.2; Modified

Calculate effective channel discharge Q_{ue}

Use HEC-18 Equation 6.15

$$Q_{ue} = Q_1 \left(\frac{h_{ue}}{h_u}\right)^{8/7}$$

HEC-18 Equation 6.15

Upstream flow	Q_1	=	*361.4 cfs*
Average upstream depth	h_u	=	*6.72 ft*

Calculate effective upstream channel flow h_{ue}

$$h_{ue} = h_b + T$$

Bridge opening height	h_b	=	*3.50 ft*
Deck thickness	T	=	*2.00 ft*
Calculate effective upstream channel flow	h_{ue}	=	**5.50 ft**

Calculate effect. channel discharge Q_{ue} = **287 cfs**

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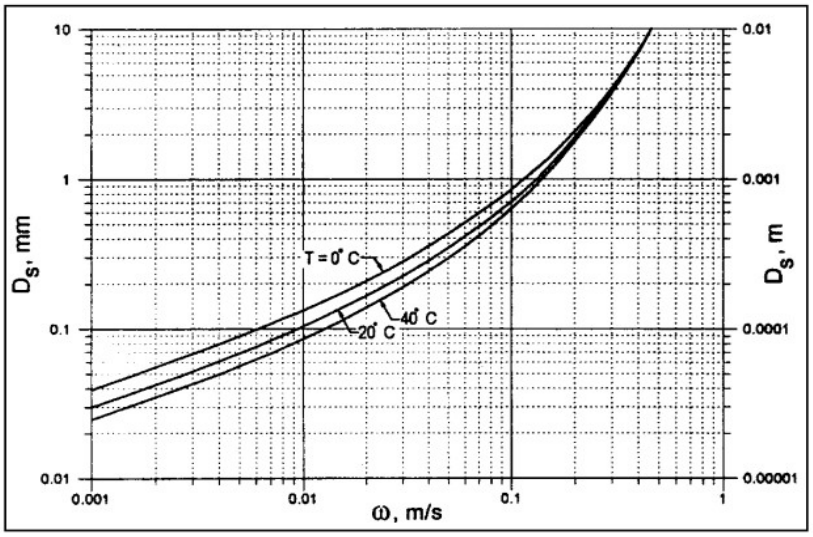
JOB NO.: MassDOT #608051 SHEET NO.: 2 OF 4
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 5/25/2025 CHECKED BY: AF DATE: 5/28/2025
DESCRIPTION: Pressure Flow Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions

Calculate V*/ω to determine exponent k_1

$$V^* = (g * y_1 * S_1)^{\frac{1}{2}}$$

Slope of energy grade line of main channel	S_1	=	*0.0007*	
Acceleration due to gravity	**g**	=	*32.2*	*ft/s²*
Effective upstream flow depth	h_{ue}	=	*5.50*	*ft*
Calculate V*	**V***	=	0.35	ft/s

Use HEC-18 Figure 6.8 to estimate fall velocity ω for D_{50} = 0.1068 mm



Fall velocity at 20° C	**ω**	=	0.01	m/s
			0.03	ft/s
Calculate V*/ω	**V*/ω**	=	10.73	

V*/ω	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material
>2.0	0.69	Mostly suspended bed material

For V*/ω = 10.73 , k_1 = 0.69

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JOB NO.: MassDOT #608051 SHEET NO.: 3 OF 4
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 5/21/2025 CHECKED BY: AF DATE: 5/28/2025
DESCRIPTION: Pressure Flow Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions

Calculate average depth in the contracted section y_2

Use HEC-18 Equation 6.2

$$\frac{y_2}{h_{ue}} = \left(\frac{Q_2}{Q_{ue}}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

HEC-18 Equation 6.2; Modified

Effective upstream flow depth	h_{ue}	=	5.50	ft
Effective upstream discharge	Q_{ue}	=	287	cfs
Contracted section flow	Q_2	=	*360.4*	*cfs*
Upstream bottom width	W_1	=	*16.16*	*ft*
Contracted bottom width	W_2	=	*11.64*	*ft*
Exponent k_1	k_1	=	0.69	

Calculate average depth in the contracted section	y_2	=	**8.37**	**ft**

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JOB NO.: MassDOT #608051 SHEET NO.: 4 OF 4
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 5/21/2025 CHECKED BY: AF DATE: 5/28/2025
DESCRIPTION: Pressure Flow Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions

Calculate separation thickness t

Use HEC-18 Equation 6.16

$$\frac{t}{h_b} = 0.5\left(\frac{h_b h_t}{h_u^2}\right)^{0.2}\left(1-\frac{h_w}{h_t}\right)^{-0.1}$$

HEC-18 Equation 6.16

Bridge opening height h_b = *3.5* *ft*
Average upstream depth h_u = *6.72* *ft*

Calculate distance from the water surface to the lower face of the bridge girders h_t

$$h_t = h_u - h_b$$

h_t = 3.22 ft

Calculate weir flow height h_w

$$h_w = h_t - T$$

Deck thickness **T** = *2.00* *ft*
Calculate weir flow height h_w = 1.22 ft

Calculate separation thickness **t** = **1.39 ft**

Calculate pressure flow scour y_s

Use HEC-18 Equation 6.14

$$y_s = y_2 + t - h_b$$

HEC-18 Equation 6.14

Average depth in the contracted section y_2 = 8.37 ft

Calculate pressure flow scour y_s = **6.26 ft**

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JOB NO.: MassDOT #608051 SHEET NO.: 1 OF 2
JOB NAME: Wilmington Route 38 Main Street
CALCULATED BY: AAE DATE: 5/21/2025 CHECKED BY: AF DATE: 5/28/2025
DESCRIPTION: Abutment Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions

Calculate maximum flow depth resulting from abutment scour under live-bed condition: y_{max}

Use HEC-18 Equations 8.3, 8.4, and 8.5

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

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

$$y_S = y_{max} - y_0$$ HEC-18 Equation 8.4

Upstream average flow depth	y_1	=	*6.72*	*ft*
Upstream flow	Q_1	=	*361*	ft^3/s
Contracted section flow	Q_2	=	*360*	ft^3/s
Upstream bottom width	W_1	=	*16.16*	*ft*
Contracted bottom width	W_2	=	*11.64*	*ft*
Upstream unit discharge	q_1	=	22.34	ft^2/s
Constricted unit discharge	q_{2c}	=	30.93	ft^2/s
Calculate contraction scour	y_c	=	8.88	ft
Calculate q_2/q_1	q_2/q_1	=	1.38	

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JOB NO.:	MassDOT #608051			SHEET NO.:	2	OF	2
JOB NAME:	Wilmington Route 38 Main Street						
CALCULATED BY:	AAE	DATE:	5/21/2025	CHECKED BY:	AF	DATE:	5/28/2025
DESCRIPTION:	Abutment Scour Calculation - Incipient Flow = 370 cfs; Live Bed Conditions						

Use HEC-18 Figure 8.9 to estimate live bed scour amplification factor α_A for q_2/q_1 = 1.38

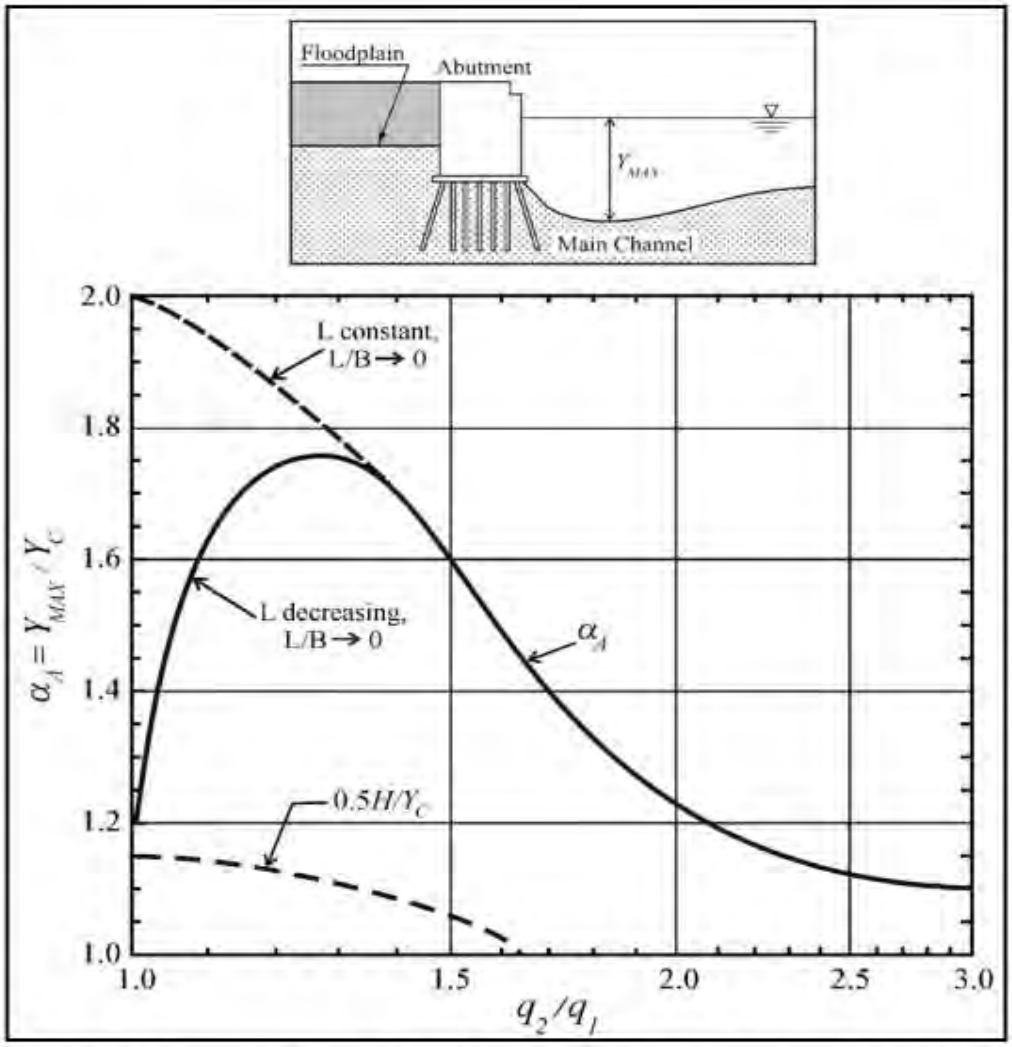


Figure 8.10. Scour amplification factor for wingwall abutments and live-bed conditions (NCHRP 2010b).

Scour amplication factor	α_A	=	1.70	
Contraction scour	y_c	=	8.88	ft
Calculate max flow depth	y_{max}	=	15.10	ft
Flow depth prior to scour	y_0	=	*6.72*	*ft*
Calculate abutment scour	y_s	=	**8.38**	**ft**

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JOB NO.:	MassDOT #608051			SHEET NO.:	1	OF	2
JOB NAME:	Wilmington Route 38 Main Street						
CALCULATED BY:	AAE	DATE:	5/21/2025	CHECKED BY:	AF	DATE:	5/28/2025
DESCRIPTION:	Revetment Riprap Sizing						

Calculate D_{30} of proposed riprap

Use HEC-23 Volume 2 Equation 4.1

$$D_{30} = y(S_f C_S C_V C_T)\left[\frac{V_{des}}{\sqrt{K_1(S_g - 1)gy}}\right]^{2.5}$$

HEC-23 Volume 2 Equation 4.1

Calculate side slope correction factor K_1

$$K_1 = \sqrt{1 - \left(\frac{\sin(\theta - 14°)}{\sin(32°)}\right)^{1.6}}$$

Bank angle	**θ**	=	*42*	°
Calculate correction factor	**K_1**	=	**0.42**	

Calculate characteristic design velocity V_{des}

$$V_{des} = V_{avg}(1.74 - 0.52\log(R_c/W))$$

Average velocity	**V_{avg}**	=	4.34	ft/s
Centerline radius of curvature	**R_c**	=	366	ft
Width of upstream water surface	**W**	=	308.47	ft
Calculate design velocity	**V_{des}**	=	**7.38**	**ft/s**

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JOB NO.:	MassDOT #608051			SHEET NO.:	2	OF	2
JOB NAME:	Wilmington Route 38 Main Street						
CALCULATED BY:	AAE	DATE:	5/21/2025	CHECKED BY:	AF	DATE:	5/28/2025
DESCRIPTION:	Revetment Riprap Sizing						

Calculate D_{30} of proposed riprap

Use HEC-23 Volume 2 Equation 4.1

$$D_{30} = y(S_f C_S C_V C_T)\left[\frac{V_{des}}{\sqrt{K_1(S_g - 1)gy}}\right]^{2.5}$$

HEC-23 Volume 2 Equation 4.1

Local depth of flow	**y**	=	6.99	ft
Safety factor	**S_1**	=	1.1	
Stability coefficient	**C_s**	=	0.3	
Velocity distribution coefficient	**C_v**	=	1	
Blanket thickness coefficient	**C_T**	=	1	
Cross-section average velocity	**V_{avg}**	=	4.34	ft/s
Specific gravity of stone	**S_g**	=	2.65	
Acceleration due to gravity	**g**	=	*32.2*	*ft/s²*
Correction factor	**K_1**	=	0.42	
Characteristic design velocity	**V_{des}**	=	7.38	ft/s

Calculate D_{30}	**D_{30}**	=	**0.62**	**ft**

Calculate D_{50} of proposed riprap

Use HEC-23 Volume 2 Equation 4.2

$$D_{50} = 1.20 D_{30}$$

HEC-23 Volume 2 Equation 4.2

Calculate D_{50}	**D_{50}**	=	**0.74**	**ft**	=	**8.94**	**in**

APPENDIX L

TEMPORARY WATER CONTROL DESIGN HEC-RAS ANALYSIS – SUMMARY TABLES AND PLOTS

HEC-RAS Plan: ExStStsCD River: Maple Meadow Bro Reach: Maple Meadow Bro

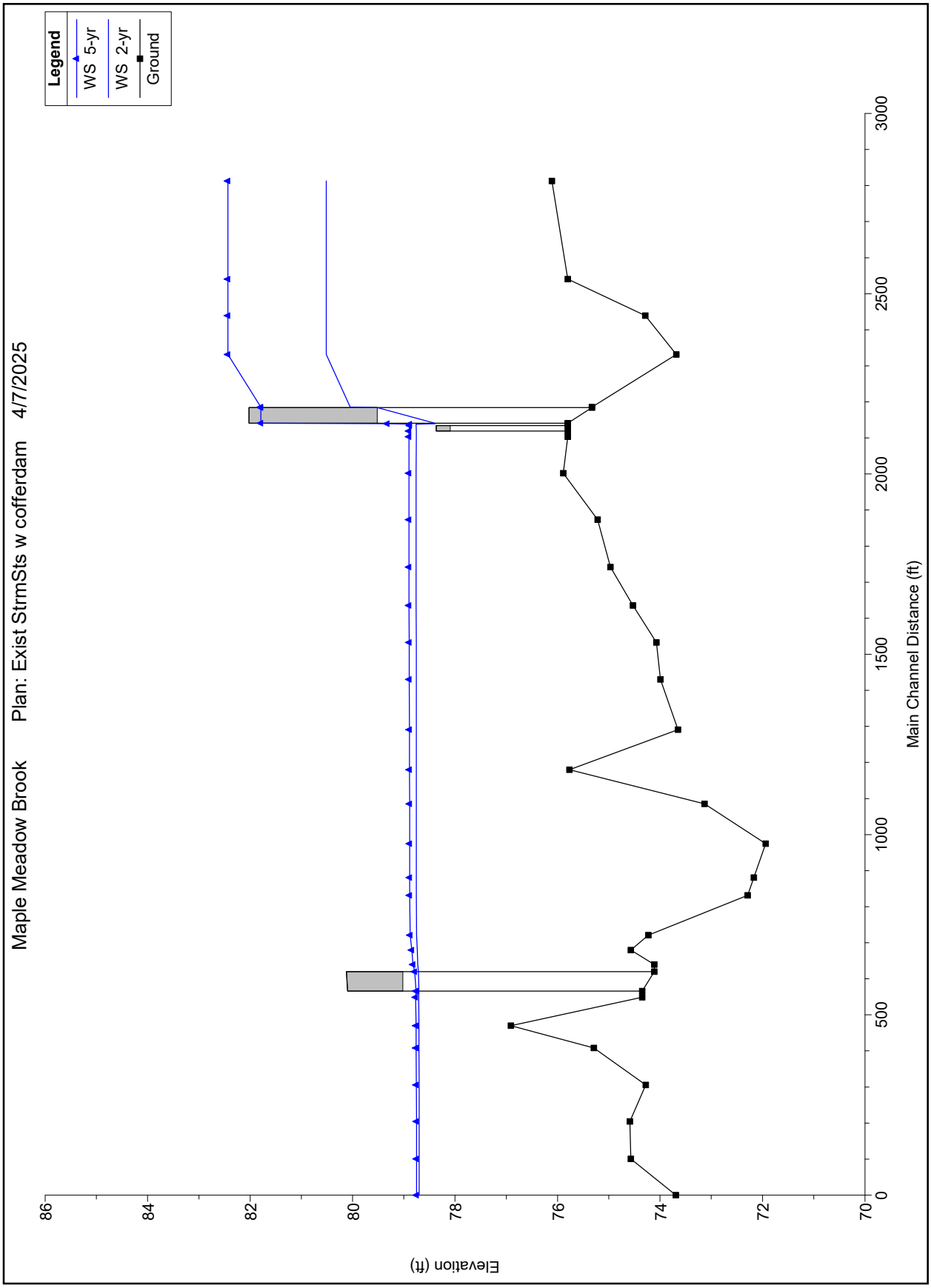
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Maple Meadow Bro	2765.14	2-yr	104.00	76.11	80.51	76.46	80.51	0.000002	0.17	1736.00	780.53	0.01
Maple Meadow Bro	2765.14	5-yr	171.00	76.11	82.43	76.57	82.43	0.000001	0.17	3793.79	1437.26	0.01
Maple Meadow Bro	2492.94	2-yr	104.00	75.80	80.51	76.12	80.51	0.000001	0.11	1985.55	562.69	0.01
Maple Meadow Bro	2492.94	5-yr	171.00	75.80	82.43	76.22	82.43	0.000001	0.12	3286.35	1064.92	0.01
Maple Meadow Bro	2391.78	2-yr	104.00	74.29	80.51	75.34	80.51	0.000001	0.13	1894.45	442.28	0.01
Maple Meadow Bro	2391.78	5-yr	171.00	74.29	82.43	75.57	82.43	0.000001	0.15	2876.55	892.22	0.01
Maple Meadow Bro	2284	2-yr	104.00	73.68	80.51		80.51	0.000001	0.19	1319.75	349.04	0.01
Maple Meadow Bro	2284	5-yr	171.00	73.68	82.43		82.43	0.000001	0.21	2032.07	424.81	0.01
Maple Meadow Bro	2194.02	2-yr	104.00	75.33	80.05	78.08	80.41	0.005218	4.80	21.68	5.00	0.41
Maple Meadow Bro	2194.02	5-yr	171.00	75.33	81.79	79.01	82.28	0.006151	5.62	30.40	5.00	0.40
Maple Meadow Bro	2164.02		Bridge									
Maple Meadow Bro	2138.106	2-yr	104.00	75.95	78.39	78.39	79.59	0.024209	8.78	11.84	5.00	1.01
Maple Meadow Bro	2138.106	5-yr	171.00	75.95	79.32	79.32	80.99	0.027269	10.35	16.52	5.00	1.00
Maple Meadow Bro	2137.106	2-yr	104.00	75.80	78.76	76.94	78.78	0.000268	1.36	182.10	503.28	0.16
Maple Meadow Bro	2137.106	5-yr	171.00	75.80	78.89	77.28	78.93	0.000500	1.93	228.91	517.34	0.22
Maple Meadow Bro	2112.457		Bridge									
Maple Meadow Bro	2103.11	2-yr	104.00	75.80	78.76		78.77	0.000144	1.00	280.47	484.91	0.12
Maple Meadow Bro	2103.11	5-yr	171.00	75.80	78.90		78.92	0.000270	1.42	348.63	516.99	0.16
Maple Meadow Bro	2001.98	2-yr	104.00	75.89	78.76	76.30	78.76	0.000011	0.29	998.41	697.83	0.03
Maple Meadow Bro	2001.98	5-yr	171.00	75.89	78.90	76.47	78.90	0.000022	0.43	1092.49	737.78	0.05
Maple Meadow Bro	1873.26	2-yr	104.00	75.22	78.76	76.15	78.76	0.000004	0.19	1426.44	843.26	0.02
Maple Meadow Bro	1873.26	5-yr	171.00	75.22	78.90	76.32	78.90	0.000008	0.30	1528.68	855.44	0.03
Maple Meadow Bro	1741.68	2-yr	104.00	74.97	78.76	75.87	78.76	0.000003	0.20	1453.66	915.49	0.02
Maple Meadow Bro	1741.68	5-yr	171.00	74.97	78.90	76.07	78.90	0.000007	0.31	1559.50	935.48	0.03
Maple Meadow Bro	1635.31	2-yr	104.00	74.53	78.76	75.99	78.76	0.000004	0.20	1286.59	1000.66	0.02
Maple Meadow Bro	1635.31	5-yr	171.00	74.53	78.90	76.18	78.90	0.000008	0.31	1389.42	1065.87	0.03
Maple Meadow Bro	1532.63	2-yr	104.00	74.07	78.76	75.62	78.76	0.000006	0.29	1105.78	796.81	0.03
Maple Meadow Bro	1532.63	5-yr	171.00	74.07	78.90	76.04	78.90	0.000014	0.44	1202.56	887.41	0.04

HEC-RAS Plan: ExStStsCD River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	1430.01	2-yr	104.00	73.99	78.76	75.63	78.76	0.000004	0.23	1206.88	754.63	0.02
Maple Meadow Bro	1430.01	5-yr	171.00	73.99	78.90	75.78	78.90	0.000010	0.37	1313.33	793.65	0.03
Maple Meadow Bro	1291.21	2-yr	104.00	73.65	78.76	75.23	78.76	0.000009	0.37	752.37	455.00	0.03
Maple Meadow Bro	1291.21	5-yr	171.00	73.65	78.89	75.61	78.89	0.000021	0.57	815.33	476.82	0.05
Maple Meadow Bro	1180.19	2-yr	104.00	75.77	78.76		78.76	0.000024	0.41	719.34	534.96	0.05
Maple Meadow Bro	1180.19	5-yr	171.00	75.77	78.89		78.89	0.000051	0.61	791.69	547.34	0.07
Maple Meadow Bro	1085.1	2-yr	104.00	73.13	78.75	73.78	78.76	0.000003	0.26	697.00	404.59	0.02
Maple Meadow Bro	1085.1	5-yr	171.00	73.13	78.89	73.98	78.89	0.000007	0.41	753.32	439.57	0.03
Maple Meadow Bro	974.91	2-yr	104.00	71.94	78.75		78.75	0.000001	0.16	1199.63	220.57	0.01
Maple Meadow Bro	974.91	5-yr	171.00	71.94	78.89		78.89	0.000002	0.25	1231.06	256.55	0.02
Maple Meadow Bro	880.98	2-yr	104.00	72.17	78.75	72.79	78.75	0.000001	0.14	954.85	189.14	0.01
Maple Meadow Bro	880.98	5-yr	171.00	72.17	78.89	72.94	78.89	0.000002	0.23	980.02	190.16	0.02
Maple Meadow Bro	831.48	2-yr	104.00	72.29	78.75	73.09	78.75	0.000001	0.16	1499.96	460.71	0.01
Maple Meadow Bro	831.48	5-yr	171.00	72.29	78.89	73.26	78.89	0.000002	0.25	1561.57	467.84	0.02
Maple Meadow Bro	721.16	2-yr	104.00	74.23	78.75	75.63	78.75	0.000039	0.54	243.19	222.63	0.06
Maple Meadow Bro	721.16	5-yr	171.00	74.23	78.88	75.94	78.89	0.000086	0.82	274.63	258.07	0.09
Maple Meadow Bro	679.8376	2-yr	104.00	74.57	78.74	76.21	78.75	0.000091	1.07	166.16	75.32	0.10
Maple Meadow Bro	679.8376	5-yr	171.00	74.57	78.84	76.54	78.88	0.000219	1.69	174.30	76.38	0.16
Maple Meadow Bro	639.83	2-yr	104.00	74.11	78.73	76.11	78.75	0.000133	1.06	97.93	50.25	0.12
Maple Meadow Bro	639.83	5-yr	171.00	74.11	78.82	76.53	78.86	0.000319	1.69	101.45	51.59	0.18
Maple Meadow Bro	590.17		Bridge									
Maple Meadow Bro	548.93	2-yr	104.00	74.35	78.71		78.72	0.000086	0.95	111.37	129.08	0.10
Maple Meadow Bro	548.93	5-yr	171.00	74.35	78.77		78.80	0.000217	1.53	113.67	130.13	0.15
Maple Meadow Bro	469.67	2-yr	104.00	76.91	78.71		78.71	0.000108	0.74	287.89	213.54	0.10
Maple Meadow Bro	469.67	5-yr	171.00	76.91	78.76		78.77	0.000260	1.17	300.37	218.49	0.15
Maple Meadow Bro	408.43	2-yr	104.00	75.29	78.70	76.25	78.71	0.000022	0.49	553.19	314.14	0.05
Maple Meadow Bro	408.43	5-yr	171.00	75.29	78.76	76.47	78.77	0.000054	0.78	570.96	314.60	0.08

HEC-RAS Plan: ExStStsCD River: Maple Meadow Bro Reach: Maple Meadow Bro (Continued)

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)	
Maple Meadow Bro	305.54	2-yr	104.00	74.28	78.70	76.07	78.70	0.000020	0.40	570.65	493.53	0.05
Maple Meadow Bro	305.54	5-yr	171.00	74.28	78.76	76.44	78.76	0.000049	0.63	590.99	496.94	0.07
Maple Meadow Bro	204.69	2-yr	104.00	74.59	78.70	76.24	78.70	0.000011	0.33	885.22	591.30	0.03
Maple Meadow Bro	204.69	5-yr	171.00	74.59	78.75	76.56	78.76	0.000027	0.53	914.49	594.82	0.05
Maple Meadow Bro	100.76	2-yr	104.00	74.57	78.70		78.70	0.000009	0.32	938.26	607.57	0.03
Maple Meadow Bro	100.76	5-yr	171.00	74.57	78.75		78.75	0.000023	0.51	969.13	608.70	0.05
Maple Meadow Bro	0	2-yr	104.00	73.69	78.70	75.20	78.70	0.000005	0.23	1074.81	596.12	0.02
Maple Meadow Bro	0	5-yr	171.00	73.69	78.75	75.54	78.75	0.000012	0.38	1104.67	597.85	0.04


Legend
WS 5-yr
WS 2-yr
Ground
Maple Meadow Brook Plan: Exist StrmSts w cofferdam 4/7/2025
Elevation (ft)
Main Channel Distance (ft)
86
84
82
80
78
76
74
72
70
0
500
1000
1500
2000
2500
3000

DOCUMENT A00883

MASSDOT WATER QUALITY DATA FORM (WQDF)

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MassDOT Water Quality Data Form (WQDF)

Project Information:

This sheet collects general project information, such as contact information, project location, and project ownership, in addition to information about the regulatory jurisdiction of the Project. It is crucial for MassDOT to understand the regulatory jurisdiction of each Project so that appropriate stormwater design requirements may be made.

User Instructions:

Use this sheet to enter project information at the time of this submittal. Additional instructions will appear for certain fields when the field is clicked. **Certain questions are required for generating MassDOT SCM Design Requirements. These required fields are marked with an * and must be completed at each Design Stage.** For all other fields, if information is unknown at the current Design Stage, leave that field blank. At the 75% Design Stage and beyond, all fields must be completed. Cells requiring user input are highlighted blue. Grey cells contain formulas and have been locked.

Key:

User Input
Calculations (locked)

General Information

Please enter general project information to the best of your ability at the time of this submittal.

Project Name:	WILMINGTON - RECONSTRUCTION ON ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L.
MassDOT Project Number:	608051
*Design Stage:	PS&E Design
Project Type:	Roadway Reconstruction
DEP Project Development Type:	Redevelopment
MassDOT Project Manager:	Eamon Kernan

Contact Information

Please enter contact information for the project designer. MassDOT will reach out to this individual if any questions arise concerning information provided on the form. Be sure to update contact information if it has changed since the previous submittal.

Design Firm:	Green International Affiliates, Inc.
Primary Contact Person:	Oxana Fartushnaya
Primary Contact Email:	ofartushnaya@greenintl.com
Primary Contact Phone Number:	978-923-0400

Project Location and Ownership

Please enter project location and ownership information. MassDOT will use the project number to develop stormwater treatment requirement depending on the project's location relative to priority watersheds. Please review the Reference Map to determine if the project location is correct. If the location shown is not correct please provide a narrative description of the correct Project Limits in the appropriate box below.

Reference Map Questions

See Reference Map Help tab for information on how to use Reference Map to answer the questions below.

Verify Project Limits in Reference Map:	Project Limits Correct

If Project Limits displayed are incorrect, please describe the correct Project Limits for this Project, including Mile Marker terminus locations and cross roads as necessary.	N/A
Are there any existing SCMs within the Project Limits?	No
If there are existing SCMs within the Project Limits, does this Project propose to alter any existing SCMs?	NA
If this Project proposes to alter any existing SCMs, explain.	N/A
*Primary Project MassDOT Impaired Waters Watershed:	IWP Priority #4: Ipswich
Secondary Project MassDOT Impaired Waters Watershed:	IWP Priority #1: Mystic River
*Is the Project within an Urbanized Area?	Yes

Project Location and Ownership Questions

Project Roads:	ROUTE 38 (MAIN STREET), FROM ROUTE 62 TO THE WOBURN C.L.
Project City/Town:	Wilmington
District Number:	District 4
*Road/Bridge Ownership upon Project Completion:	MassDOT
If the primary owner of the project area upon project completion is NOT MassDOT, enter the owner and any other relevant ownership information.	N/A

Regulatory Jurisdiction, Permits, and Special Design Considerations

Please enter information about the project's regulatory jurisdiction, required permits, and other special design considerations (if applicable). Chapter 2 of the SDG describes regulatory programs and how they apply to MassDOT project as they relate to stormwater. Please refer to Chapter 2 for more details if you are unsure about how to answer the questions below.

Note: This form is used for information collection and tracking purposes only and does not provide permit requirements for the permits mentioned below. Please be sure that your project complies with all relevant permits below.

*Existing Impervious Area (sq. ft.):	506,710
*Proposed Impervious Area (sq. ft.):	567,432
Net Change in Impervious Area (sq. ft.):	60722
Does the Project disturb more than 1.0 acre?	Yes
Does the project exclusively consist of a minor activity or routine roadway maintenance? See SDG Section 2.4.1 for guidance.	No
Is the Project exclusively a roadway improvement project?	Yes

Is the Project exclusively a footpath, bike path or other path for pedestrian and/or nonmotorized vehicle access project?	No

WPA (i)

Is the Project subject to the Wetlands Protection Act (WPA) (310.00 CMR 10.00)?	Yes
Is a Notice of Intent (NOI) required for the Project?	Yes
Is this project using the MassDOT Macro Approach for Stormwater Standards Compliance? (See SDG Chapter 2.3.4 for more information)	Yes
List any stormwater-related special conditions from the WPA Order of Conditions (if NOI has been filed).	For special conditions see OOC for DEP File No. 3441566 issued on 7/17/2025

401 WQC (i)

Is a 401 WQC required for this Project?	Yes
List any stormwater-related considerations from the 401 WQC (if WQC has been filed for/granted).	For special conditions related to Stormwater see 401 WQC (Transmittal No. 25-WW26-0013-APP), issued on 8/5/2025

Other Permits

Are any other stormwater-related permits anticipated for this project?	Yes
List the additional anticipated permits and stormwater-related considerations, if applicable.	NPDES CGP

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MassDOT Water Quality Data Form (WQDF)

MassDOT SCM Requirements:

Based on the project location relative to priority watersheds and project type, MassDOT has developed requirements for stormwater improvements for your project. These requirements are automatically generated and are subject to change, pending MassDOT review.

The stormwater improvement requirements are **IN ADDITION** to those required as part of regulatory compliance for MassDEP Stormwater Standard 4. Please refer to SDG Chapter 2, Section 2, to understand those base requirements. MassDOT Environmental Services Section may adjust these requirements based on project specifics.

User Instructions:

Use this sheet to review MassDOT treatment requirements. You may provide comments on the automatically generated MassDOT treatment requirements, if applicable. Cells for (optional) user input are highlighted blue. Grey cells contain formulas and have been locked. You must certify that you have reviewed the MassDOT treatment requirements before proceeding to the remaining tabs. **The designer will not be able to edit subsequent sheets until the certification box has been checked.**

Key:

User Input
Calculations (locked)

Note:

MassDOT Treatment requirements change based on information entered in Project Information tab. Be sure to review MassDOT Treatment Requirements if any information on Project Information tab is updated.

MassDOT Treatment Requirements

- Follow MassDEP regulatory standards if within MassDEP jurisdiction.
- Your project is located within a high priority watershed with TMDL pollutant load reduction targets and structural SCMs incorporated into your project are required for MassDOT to meet their TS4 requirements.
- Implement MassDOT's Integrated Site Design approach outlined in the Stormwater Design Guide Chapter 3.
- Implement structural SCMs to treat all project impervious cover to the maximum extent practical to achieve MassDOT's target load reduction to achieve 65% phopshorus load reduction for your project following guidance in the Stormwater Design Guide Chapters 3 and 4.
- Please be diligent in inputting your SCMs so that MassDOT can take credit for the positive stormwater improvements as part of your project.

Designer Comments on MassDOT Treatment Requirements (Optional)

☑ By checking this box, the designer certifies that they have reviewed MassDOT Treatment requirements and will propose SCMs to meet these requirements to the MEP. **The designer will not be able to edit any subsequent sheets until this box has been checked.**

MassDOT Water Quality Data Form (WQDF)

Integrated Site Design Data:

Chapter 3 of the SDG explains MassDOT's Integrated Site Design (ISD) approach to incorporating stormwater treatment in typical MassDOT projects. Examples of this approach for the roadway setting are shown on the next tab Integrated Site Design Examples. Matching the approach, this form starts with asking about Low Impact Development (LID) practices to minimize runoff and pollutants on this sheet, then structural stormwater control measures (SCMs) as needed to fully meet requirements on subsequent sheets.

User Instructions:

Use this sheet to enter information about the applicability of the Integrated Site Design approach to this Project at the time of this submittal. If information is unknown at the current Design Stage, select "Unknown at Current Design Stage". At the 75% Design Stage and beyond, all fields must be completed. Cells requiring user input are highlighted blue. Grey cells contain formulas and have been locked.

Key:

User Input
Calculations (locked)

LID Measure	Has this measure been incorporated into this project? If yes, explain in the next column.	If the measure has been incorporated into the project, please explain. If measure has not been included, explain why it was infeasible.
Enhance and Preserve Existing Vegetation Has existing vegetation been identified, protected and/or enhanced? Vegetation performs many functions and plays a critical supportive role in stormwater management, including the reduction of runoff volume, soil erosion, and pollutant transport.	Incorporated	Existing vegetation has been identified and will be maintained and protected, when feasible. In addition, replanting of native vegetation/tree planting is proposed within selected areas along the project corridor.
Reduce Impervious Cover Is post-construction impervious cover less than pre-construction? Reducing impervious cover improves stormwater management by increasing opportunities for recharge and infiltration and decreasing runoff volume and peak flow rates.	Considered but not feasible	The addition of sidewalks in various locations and roadway geometry improvements along the project corridor result in a net increase in impervious area. Stormwater Control Measures (SCMs) are proposed to mitigate the increase in peak rates due to this newly proposed impervious area.
Maintain Pre-Development Drainage Patterns Are natural hydrologic patterns on site maintained? Maintaining existing drainage patterns reduces a project's potential to increase the site's time of concentration (TOC) and runoff velocities and volumes, while sustaining groundwater recharge.	Considered but not feasible	New closed drainage systems are proposed throughout the roadway in order to increase drainage efficiency and increase roadway safety. In some locations, stormwater is rerouted to new SCMs, or rerouted to new outfalls due to site constraints such as utility conflicts, right-of-way limitations, and roadway geometry improvements.

Disconnect Pavement:

Pavement disconnection is a stormwater management measure that diverts stormwater runoff from impervious cover to a vegetated upland area (natural or constructed) where treatment and recharge will occur. This is a cost-effective and low maintenance measure that designers can use to reduce the effects of impervious cover. See Section 3.3.2.3 of the SDG for more information.

If Pavement Disconnection has been incorporated, please enter "Incorporated" below. **If "Incorporated" is selected, "Pavement Disconnection Data" Tab will automatically appear in the navigator ribbon at the bottom of the sheet. Please enter design data on the "Pavement Disconnection Data" sheet for each location to the best of your knowledge at your given design stage.**

Has Pavement Disconnection been incorporated into this project?	Considered but not feasible

Structural SCMs:

Unless the LID practices, as incorporated into the project design, have fully met the project's stormwater objectives, structural SCMs (including retrofits to existing SCMs) should be considered. See Section 3.3 of the SDG for more information about considerations and constraints.

If Structural SCM Measures have been incorporated, including existing SCM retrofits, please enter "Incorporated" below. **If "Incorporated" is selected, "Structural SCM Data" Tab will automatically appear in the navigator ribbon at the bottom of the sheet. Please enter design data on the "Structural SCM Data" sheet for each SCM to the best of your knowledge at your given design stage.**

Have Structural SCMs been incorporated into this project?	Incorporated

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MassDOT Water Quality Data Form (WQDF)

Structural SCM Data:

Structural SCM Data is essential for MassDOT to demonstrate compliance on their regulatory programs and to create an inventory of SCMs. Please enter data to the best of your knowledge at the given design stage. Refer to Chapter 4 of the SDG which details the SCM types. Refer to the SCM Definitions tab for descriptions of how to calculate design storage volume for each SCM type. It is expected that deep sump catch basins are incorporated as part of every MassDOT project, therefore, data regarding deep sump catch basins does not need to be entered.

Phosphorus, Nitrogen, TSS, and Impervious Cover Removal Credits are calculated using the EPA SCM Water Quality Curves. For more information on the SCM Water Quality Curves and how MassDOT uses them, see MassDOT's SCM Water Quality Accounting Methodology Report. TSS Reduction values from this calculator can NOT be used for DEP Stormwater Standard 4 Compliance at this time.

User Instructions:

Use this sheet to enter design data and calculate water quality treatment credit for structural SCMs. Cells requiring user input (i.e., SCM design parameters) are highlighted blue. Grey cells contain formulas and have been locked. Click each input column header for more detailed instructions.

Key:
User Input
Calculations (locked)

Note 1: For SCM type Pavement Disconnection, use the Pavement Disconnection tab (see sheet summary on coversheet). Pavement Disconnection tab will only appear if user has indicated on the Integrated Site Design tab that Pavement Disconnection measures have been included as part of this Project.
Note 2: Refer to the SCM Definitions tab for descriptions of how to calculate design storage volume for each SCM type.
Note 3: Constructed stormwater wetlands are not specifically listed as a SCM type in Appendix F of the MS4. Crediting approach for this SCM type is based on VHB discussions with EPA.
Note 4: Choose the SCM type that most closely matches the function of your SCM (e.g. infiltration vs. filtration). If you are unsure of which SCM type to choose for your design please discuss with MassDOT.
Note 5: Populating the "Does the SCM Exist in the Reference Map?" and "Existing MassDOT SCM Asset ID" fields is critical for reconciling the data entered in this form with the MassDOT drainage inventory database. Please see the Reference Map Help Page for instructions on how to populate these fields.
Note 6: For each SCM, all user input fields must be populated with the exception of "Notes (Optional)" and "Existing MassDOT SCM Asset ID" if "Does the SCM exist in the Reference Map?" is "No." If any of the Catchment Areas for an SCM are equal to zero, enter "0" in the field and populate the corresponding catchment's Land Use field as "Not Applicable". Similarly, if there is no Non-MassDOT area draining to the SCM, make sure to populate the "Non-MassDOT Catchment Primary HSG" as "Not Applicable."

User Inputs																													Phosphorus			Nitrogen			Total Suspended Solids (TSS Reduction values can NOT be used for DEP Stormwater Standard 4 Compliance at this time.)			Effective Impervious Cover (IC)		
Designer SCM ID (Consistent with Plans)	Does the SCM exist in the Reference Map?	Existing MassDOT SCM Asset ID	Latitude	Longitude	SCM Owner	Maintenance Responsible Party	Does the SCM have any accessories?	SCM Type	SCM Soil Type	SCM Design Storage Volume (ft³)	MassDOT Impervious Catchment Area (ft²)	MassDOT Pervious Catchment Area (ft²)	Non-MassDOT Impervious Catchment Area (ft²)	Non-MassDOT Pervious Catchment Area (ft²)	MassDOT Impervious Catchment Primary Land Use	MassDOT Pervious Catchment Primary Land Use	Non-MassDOT Impervious Catchment Primary Land Use	Non-MassDOT Pervious Catchment Primary Land Use	MassDOT Catchment Primary HSG	Non-MassDOT Catchment Primary HSG	Is the SCM lined?	Does the SCM have an underdrain?	Does the SCM have a staff gauge?	Notes (Optional)	Runoff Depth from Impervious Area (in)	EPA Water Quality Curve	Total P Load to SCM (lb/yr)	P Removal Credit (%)	P Load Reduction (lb/yr)	Total N Load to SCM (lb/yr)	N Removal Credit (%)	N Load Reduction (lb/yr)	Total TSS Load to SCM (lb/yr)	TSS Removal Credit (%)	TSS Load Reduction (lb/yr)	Total IC Area Contributing to SCM (ac)	Effective IC Removal Credit (%)	Effective IC Reduction (ac)
SCM-1	Yes	SCM-43017	42.53320	-71.15940	MassDOT	MassDOT	No	Subsurface Infiltration System	Loamy Sand (2.41 in/hr)	1,511	23,330	0	0	7,816	Highway	Low Density Residential	Highway	Low Density Residential	HSG A	HSG A	No	No	No		1.0	Infiltration Trench	0.72	100%	0.72	5.68	100%	5.68	792	100%	792	0.54	100%	0.54
SCM-2	Yes	SCM-43018	42.52374	-71.16019	MassDOT	MassDOT	Yes	Infiltration Basin	Loamy Sand (2.41 in/hr)	955	9,233	0	0	69,454	Highway	Low Density Residential	Highway	Low Density Residential	HSG A	HSG A	No	No	No		1.2	Surface Infiltration	0.33	99%	0.33	2.70	100%	2.70	324	100%	324	0.21	100%	0.21
SCM-3	Yes	SCM-43019	42.52140	-71.15890	MassDOT	MassDOT	No	Subsurface Infiltration System	Silt Loam (0.27 in/hr)	2,453	12,499	0	0	71,272	Highway	Low Density Residential	Highway	Low Density Residential	HSG C	HSG C	No	No	No		2.4	Infiltration Trench	0.73	99%	0.72	6.94	100%	6.94	522	100%	522	0.29	100%	0.29

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MassDOT Water Quality Data Form (WQDF)

SCM Accessories Structures Data:

SCM Accessory Data is essential for MassDOT to create and maintain an inventory of SCMs and their associated structures, which is necessary for asset management and maintenance. SCM Accessories are additional structures associated with SCMs and include (but are not limited to):

- sediment forebays
- check dams
- auxiliary spillways
- level spreaders
- vegetated riprap
- gabions
- tide gates

Please enter data and submit spatial records to the best of your knowledge at the given design stage. Refer to Chapter 4 of the SDG which details the SCM Accessory types.

User Instructions:

Use this sheet to enter information about SCM accessories (i.e. sediment forebays, check dams, level spreaders, etc.) associated with the proposed structural SCMs. The SCM ID column will automatically populate with SCM ID's entered in the Structural SCM Data tab where the user indicated that the SCM has accessories. If an SCM has multiple accessories, fill out information for each structure across the associated SCM row. Additional stand-alone accessories that are not associated with Structural SCMs should be filled out in the rows below the SCM IDs.
Cells requiring user input are highlighted blue. Grey cells contain formulas and have been locked. Click each input column header for more detailed instructions.

Note 1: Populating the "Does the SCM Accessory Exist in the Reference Map?" and "Existing MassDOT Asset ID" fields is critical for reconciling the data entered in this form with the MassDOT drainage inventory database. Please see the Reference Map Help Page for instructions on how to populate these fields.

Key:
User Input
Calculations (locked)

	SCM Accessory 1								SCM Accessory 2								SCM Accessory 3							
Designer SCM ID (Consistent with Plans)	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID (Consistent with Plans)	Structure Type	Notes (Optional)	Latitude	Longitude	Owner	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID (Consistent with Plans)	Structure Type	Notes (Optional)	Latitude	Longitude	Owner	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID (Consistent with Plans)	Structure Type	Notes (Optional)	Latitude	Longitude	Owner
SCM-2	Yes	SWMS-71007	SCM-2-1	Sediment Forebay	N/A	42.52374	-71.16019	MassDOT																

	SCM Accessory 4								SCM Accessory 5								SCM Accessory 6								SCM Accessory 7							
Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID	Structure Type	Notes (Optional)	Latitude	Longitude	Owner	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID	Structure Type	Notes (Optional)	Latitude	Longitude	Owner	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID	Structure Type	Notes (Optional)	Latitude	Longitude	Owner	Does the SCM Accessory exist in the Reference Map?	Existing MassDOT Asset ID	Designer Structure ID	Structure Type	Notes (Optional)	Latitude	Longitude

MassDOT Water Quality Data Form (WQDF)

Designer Review & Certification:

For MassDOT to meet its regulatory obligations, please certify your submittal. By certifying your submittal you attest that you have met the relevant stormwater requirements and have provided accurate information to the best of your ability.
Once your form has been submitted, MassDOT will begin review. If more information is required you will have the opportunity to update this form and resubmit for the given Design Stage. Additional WQDF submissions will be required at subsequent Design Stages.

User Instructions:

Use this sheet to certify information entered in this Form at the time of this submittal. If the design does not meet or plan to meet DOT treatment requirements, you must provide more information as to why these requirements are not being met. **Use the Tab Review table to determine if all tabs have been satisfactorily completed. If the table indicates that a tab is not complete, you must return and complete that tab before submitting the WQDF.** See the WQDF Training Video for more information on how to accurately and completely fill out the form. Contact the MassDOT Stormwater Unit for additional support, if needed.

Once the WQDF has been satisfactorily completed, use the Print Form for Submission to MassDOT button at the bottom of this tab to export the form to a PDF for inclusion in the Bluebeam session for this project. **Be sure to also include the Excel version of the WQDF in the submission package for this project.**

Key:

User Input
Calculations (locked)

Does this design fully meet or plan to meet the DOT treatment requirements presented earlier in this Form?	Yes
If this design does NOT fully meet or plan to meet the DOT design requirements, provide more information as to why the design requirements are not being met.	N/A
If a WQDF has previously been submitted for this Project, explain any significant changes to the form since the previous submission.	No significant changes since 100%.

Tab Review Table

Tab	Complete?
Project Information	Yes
DOT SCM Design Requirements	Yes
Integrated Site Design Data	Yes
Pavement Disconnection Data	Tab not required.
Structural SCM Data	Yes
SCM Accessories Data	Yes
Designer Review & Certification	Yes

☑ By checking this box, the Designer certifies that all information entered in this Form is accurate and complete.

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GEOTECHNICAL REPORT

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Geotechnical Report

(Proposed Bridge and Temporary Pedestrian Bridge)

for

Massachusetts Department of Transportation – Highway Division

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Project File No. 608051

Bridge Complete Replacement Project

for

Bridge No. W-38-011 (CVE)

Route 38 (Main Street) over Maple Meadow Brook

Wilmington, Massachusetts



6th Submission: 11/24/2025
5th Submission: 11/3/2025
4th Submission: 9/15/2025
3rd Submission: 7/25/2025
2nd Submission: 7/7/2025
1st Submission: 4/15/2025

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1.0 EXECUTIVE SUMMARY

Based on the 2023-2025 boring exploration results, Green International Affiliates, Inc. (Green) provided loads and our investigation, the proposed single span 3-sided rigid frame structure can be supported by two (2) rows of micropiles each socketed into intact bedrock. Also, the proposed single span prefabricated truss temporary pedestrian bridge can be supported by a single micropile socketed into intact bedrock at each temporary pedestrian bridge abutment.

The bottom of the proposed bridge pile cap is estimated at Elev. 67.5'. Each micropile is socketed 8 feet minimum into intact bedrock comprising of 1.0-ft minimum plunge length and 7.0-ft minimum bonded length. The tip of the micropile is estimated to vary from Elev. 36.1' to 26.8' and should be adjusted according to the actual top of intact bedrock elevation variation.

The bottom of the proposed temporary pedestrian bridge pile cap is estimated at Elev. 78.1' and 78.3' for north abutment and south abutment, respectively. Each micropile is socketed 3 feet minimum into intact bedrock comprising of 1.0-ft minimum plunge length and 2.0-ft minimum bonded length. The tip of the micropile is estimated to be at Elev. 41.1' and Elev. 34.0' for north abutment and south abutment, respectively. The tip of micropile should be adjusted according to the actual top of intact bedrock elevation variation.

The nominal and the factored micropile resistance values for bridge foundation are included in Section 6.0, 'Summary' of this report.

The current design is based on 1988 North American Vertical Datum (NAVD).

2.0 INTRODUCTION

2.1 Scope of Report

The purpose of this report is to evaluate the substructure foundation types for the proposed superstructure system based on the 2023-2025 site exploration results, make recommendations for the foundation, develop engineering design values, and identify possible construction issues. The design values are prepared in AASHTO LRFD format to be compatible with the current bridge design approach.

2.2 Existing Bridge & Foundation

Bridge No. W-38-011 (802), carries Route 38 (Main Street) over Maple Meadow Brook in the Town of Wilmington, as illustrated in Figure 1 'Project Location Plan'.

The bridge was originally constructed circa 1911 and rehabilitated in 2000. The structure consists of single-span concrete deck slab with two encased steel beams on the west side of the bridge. The overall 42'-8" ± width of the superstructure includes a 33'-1" ± roadway, a 7'-9" ± grass strip with highway guardrail posts, and two 1'-0'' ± parapet/curbs of differing heights. The roadway consists of two 12'-0" wide travel lanes, a 2'-3" shoulder on the west side of the bridge, and a 5'-8" shoulder

on the east side of the bridge. The existing superstructure comprises a 13" thick concrete deck slab with two encased steel beams on the west side of the bridge, which are assumed to be W14 x 50 shapes. The bridge has a skew angle of 7°.

According to DOT Structures Inspection Field Report, dated April 24, 2023, the bridge Deck, Superstructure, and Substructure were rated at N (not applicable), 5 (fair condition), and 6 (satisfactory condition), respectively.

2.3 Proposed Replacement Bridge

The design concept of the proposed single span bridge structure can be found on the Bridge Plan Submittal prepared by Green, who is the Prime Design Engineer for the project. Lamson Engineering Corporation (LEC) is a sub-consultant to Green, responsible for the geotechnical design of the project.

The proposed bridge is a 3-sided rigid frame structure with a clear span of 11'-8 7/8" (square) and out-to-out width of 41'-10 1/2". The superstructure is composed of wearing surface and one sidewalk with S3-MTL4 railings on eight (8) frame segments.

The proposed bridge will be designed according to AASHTO LRFD requirements with a vehicular live loading of HL-93. The geotechnical design values to be provided will be nominal geotechnical resistance and factored geotechnical resistance values.

2.4 Temporary Pedestrian Bridge

Prior to the construction of a new replacement bridge, a temporary pedestrian bridge will be built. The proposed temporary prefabricated truss bridge is constructed on the upstream side of the existing bridge. The design concept of the proposed single span temporary pedestrian bridge structure can be found on the Bridge Plan Submittal prepared by Green.

The proposed bridge is a prefabricated truss bridge with a centerline of bearing to centerline of bearing span length of 60'-0" and centerline of truss panel to centerline of truss panel width of 5'-10". The clear walkway width is 5'-0".

The proposed temporary pedestrian bridge will be designed according to AASHTO LRFD requirements with pedestrian live loading. The geotechnical design values to be provided will be nominal geotechnical resistance and factored geotechnical resistance values.

2.5 References

The following references were used in the preparation of this report:

- MassDOT 2025 Standard Specifications for Highway and Bridges, 2025.
- MassDOT LRFD Bridge Manual, Hundredth Anniversary Edition, 2024.
- AASHTO LRFD Bridge Design Specifications, 2020, 9th Edition

- AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2011, 2nd Edition with 2012, 2014, 2015, and 2022 Interim Revisions.
- "Surficial Geology of the Wilmington Quadrangle, Massachusetts" by Robert O. Castle, 1959.
- "Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts" by Robert O. Castle, J. Christopher Hepburn, and Joseph P. Kopera, 2005.

3.0 SUBSURFACE CONDITIONS

3.1 Local Geology

According to the Surficial Geology Map of the Wilmington Quadrangle, Massachusetts, surficial geologic deposits above the bedrock at the site consist of swamp deposit materials of mainly peat; and commonly overlying undifferentiated sand and gravel deposits.

Based on the Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts, the bedrock consists of Siliceous Schist. The Siliceous Schist can be described as "Chiefly fine-grained, foliated and locally layered, greenish-gray to black biotite-quartz-homeblende-plagioclase schists locally interlayered with ultra-fine-grained siliceous schists. The siliceous schists commonly are chloritic and epidotitic and crop out most conspicuously along the flanks of the Waltham Melange, commonly mylonitic or sheared, with interlayered quartzite and quartz-feldspar gneiss occurring locally."

3.2 2023-2025 Subsurface Exploration Program

A subsurface exploration program consisting of four (4) test borings, two (2) probe lines and three (3) vacuum holes was completed between December 2023 and February 2025 for the proposed bridge, as indicated on Figure 2 '2023-2025 As-Drilled Boring Location Plan'.

Borings BB-1 and BB-3 were drilled in the existing roadway for the North Abutment of the proposed bridge. The boring logs are included in Appendix 1.

Borings BB-2 and BB-4 were drilled in the existing roadway for the South Abutment of the proposed bridge. The boring logs are included in Appendix 1.

Probes PS-1A to PS-1D were conducted for the existing north abutment. Probes PS-2A to PS-2H were conducted for the existing south abutment. The probes lines were performed to determine the approximate configuration of the back of the existing abutments. The results of the probe lines are included on Figures 5 and 6 of this report. The probe logs are included in Appendix 1.

Vacuum Holes VH-1 to VH-3 were conducted to locate the top of the existing slab. The test pit logs are included in Appendix 1.

The explorations were performed by New England Boring Contractors of Derry, New Hampshire between December 19, 2023, and February 14, 2025, and the monitoring was performed by Lamson

Engineering Corporation. Materials recorded on the boring logs, probe logs and test pit logs were visually identified at the site by geotechnical professionals from Lamson Engineering, who were also involved in the preparation of this report.

The soil samples were taken using 2 inches outside diameter split spoon sampler driven 24 inches into the soil by a 140-pound hammer falling 30 inches. Blows per 6 inches were recorded. The materials at the site were included on the boring logs and are also included on the 2023-2025 soil profile in Figures 3 to 4 of this report.

The test pits were conducted using a vacuum truck with an approximately 6" diameter vacuum hose. The pavement was sawcut using a jackhammer prior to the vacuum operation. The probe lines were conducted using a 1.5" diameter drilled rod driven to the required depth or refusal. The information for the probe logs and test pit logs is included in Appendix 1.

3.3 2023-2025 Subsurface Profiles

The soil profiles of the site, as reflected in the 2023-2025 boring exploration results, are included in Figures 3 to 4 of the report.

The boring information shows 37' to 45.5' thick fine to coarse sand materials with some inorganic silt and fine to coarse gravel materials on top of bedrock at the site. No clay materials were encountered during the 2023-2025 subsurface exploration program. Peat materials were encountered in Boring BB-4. For detailed information on each boring, refer to the boring logs included in Appendix 1 of this report.

3.4 Peat Materials Information

Based on the boring logs, information on peat materials was found as shown below:

Table 1 – Peat Materials Information

Boring No.	Ground Elev. (Feet)	Top of Peat Depth/ (Elev.)	Bottom of Peat Depth/ (Elev.)	Peat Layer Thickness (Feet)
BB-4	82.4	7' (75.4')	10.5' (71.9')	3.5

3.5 Cobble/ Boulder Information

Based on the boring logs, information on cobbles or boulder materials was found as shown below.

Table 2: Cobbles / Boulders Information

Boring No.	Ground Elev. (Feet)	Type of Materials	Top of Cobble / Boulder Depth/ (Elev.)	Bot. of Cobble / Boulder Depth/ (Elev.)	Layer Thickness (Feet)
BB-2	Elev. 82.0	Cobbles and Boulders	6.5’ (75.5’)	9.0’ (73.0’)	2.5

3.6 Bedrock Information

The top of weathered bedrock was encountered during the 2023-2025 boring exploration ranging from Elev. 42.1’ to Elev. 36.3’ with an average at Elev. 38.8’. The top intact bedrock was encountered ranging from Elev. 44.1’ to Elev. 34.8’ with an average at Elev. 38.9’.

Table 3: Bedrock Information

Boring No.	Ground Elev. (Feet)	Depth to Weathered Bedrock from Existing Ground	Depth to Intact Bedrock from Existing Ground	Top of Weathered Bedrock Elev. (Feet)	Top of Intact Bedrock Elev.** (Feet)	Recovery Ratio % (RQD %)	Bedrock Type
BB-1	81.1	- ***	37’-0”	- ***	44.1	Core 1: 33% (20%) Core 2: 33% (0%)*	Diorite
BB-2	82.0	44’-0”	45’-0”	38.0	37.0	Core 1: 97% (50%) Core 2: 100% (83%)	Diorite
BB-3	81.8	45’-6”	47’-0”	36.3	34.8	Core 1: 92% (30%) Core 2: 100% (0%)	Sandstone-Diorite
BB-4	82.6	40’-6”	43’-0”	42.1	39.6	Core 1: 100% (95%) Core 2: 97% (42%)	Diorite

*Core barrel is jammed with incomplete 5-foot core run. RQD values recorded are not representative.
**The top of intact rock is based upon the top of the initial rock core run.
*** ‘-’ indicates weathered bedrock is not encountered.

3.7 Existing Footing Core Information

The existing footing core was obtained in Boring BB-2. The information for the footing core is shown in Table 3.7.

Table 4: Existing Bottom of Footing Information

Boring No.	Ground Elev. (Feet)	Depth to the Top of Footing from Ground Surface (Feet)	Depth to the Bottom of Footing from Ground Surface (Feet)	Estimated Bottom of Existing Footing Elev. (Feet)	Remark
BB-2	82.0	9.0	10.0	72.0	For existing south abutment

3.8 Groundwater Information

Based on the boring logs, groundwater information can be obtained. However, the obtained groundwater information from the washed boring operation is presented for preliminary reference only.

Table 5: 2024 Groundwater Information Measured after Washed Boring Operation

Boring No.	Ground Elev. (Feet)	Groundwater Depth (Feet)	Estimated Groundwater Elev. (Feet)	Remark
BB-1	81.1	2’-4”	79.4	For North Abutment
BB-2	82.0	1’-9”	80.3	For South Abutment
BB-3	81.8	4’-3”	77.5	For North Abutment
BB-4	82.6	8’-3”	74.3	For South Abutment

The observed river water surface level was at Elev. 78.0’ on 1/10/2025.

3.9 Seismic Design Category Evaluation

Based on the 2024 M*assDOT* Bridge Manual 3.4.1, all seismic analysis and design of bridges shall be performed in accordance with the ‘AASHTO Guide Specifications for LRFD Seismic Bridge Design’. Based on 2011 Guide Specifications, Table 3.4.2.1-1 (same as AASHTO Table 3.10.3.1-1) for site soil type and profile, the site class is E (F_{pga} = 2.5, F_a = 2.5, F_v = 3.5).
This structure is considered a non-critical/non-essential bridge, and a 1,000-year return period is used. With these results and Appendix 3, ‘AASHTO Guide Specifications for LRFD Seismic Bridge Design, Figure 3.4.1-2b to Figure 3.4.1-4b for the 1,000-year return period’, the following can be obtained:

Acceleration Coefficient (A_s) = 0.200g
Design Spectral Acceleration Coefficient at 0.2-sec Period (S_{DS}) = 0.400g
Design Spectral Acceleration Coefficient at 1.0-sec Period (S_{D1}) = 0.140g

Since S_{D1} is less than 0.15g, the Seismic Design Category (SDC) is A. This is based on Guide Specifications Table 3.5-1 (same as AASHTO Table 4.7.4.3.1-1).

3.10 Liquefaction Potential

A liquefaction assessment is not required for structures in Seismic Design Category (SDC) A. Furthermore, the proposed footings are supported by micropiles socketed into intact bedrock. This type of foundation helps to maintain the integrity of the structure in a seismic event.

4.0 FOUNDATION RECOMMENDATIONS

4.1 Proposed Bridge Foundation

Shallow Foundation
Based on the Summary from the Hydraulic Report prepared by Green (Appendix 5), the design/check scour depth is 8.88'. The thalweg is approximately at Elev. 74.4'. Therefore, the design/check scour at Elev. 65.5'. Due to the potential scour, a shallow spread footing foundation type is not recommended for this bridge project.

Deep Foundation
The proposed bridge can be supported by 2 rows of micropiles socketed into intact bedrock. Other types of deep foundation, such as steel H-pile is not preferred to be used at this location due to the insufficient depth and low blow counts of the subsoil to develop the pile fixity at top of bedrock. Also, larger pile driver is not preferred at the project site with restrictive site constraints and site access constraints. Drilled shaft is also not suitable for this project because of its high cost, requirement for large equipment and small load demand for the proposed bridge. Furthermore, the proposed bridge will be constructed in phases. A small micropile rig is easier to phase layout the micropiles for phased construction than the drilled shaft.

The proposed bottom of the tremie seal is at Elev. 65.5', which is at the design and check scour elevation. Therefore, no scour effect needs to be considered for the proposed micropiles.

Based on MassDOT Bridge Manual Article 3.2.4.2 'Design', the permanent micropile steel casing shall be new prime steel meeting the requirements of API 5L PSL1 pipe with a yield strength of 52 ksi and SR15 supplemental requirements.

The proposed abutments and wingwalls can be supported by two rows of micropiles. The bottom of pile cap is at Elev. 67.5' for both abutments. Each micropile is socketed 8 feet into intact bedrock comprising of 1-ft plunge length and 7-ft bonded length. Based on the Lpile results, the design point of fixity is at Elev. 43.5'. The tip of the micropile is estimated to vary from Elev. 36.1' to 26.8', and should be adjusted according to the actual top of intact bedrock elevation variation.

The strength and material properties, nominal and factored micropile resistance values are included in Section 6.0, 'Summary' of this report.

Pile Group Effect
Based on the pile spacing and configuration from the bridge plans, a group reduction factor (P-multiplier) of 0.85 is considered in the lateral analysis.

Casing Joint Location: No threaded casing joints shall be located within 3 feet of the bottom of the pile cap/ footing.

Pile Head Embedment: The piles are embedded 24-in into the footing/cap.

Settlement: Since the micropile is socketed into an intact bedrock, settlement is negligible.

Load Test
Based on AASHTO 10.9.3.5.4, a 'Micropile Verification Load Test' (Item 948.60) is recommended on a sacrificial pile prior to ordering of production piles. The minimum number of sacrificial pile should be one (1) for the site. It shall be within 10 feet of the footprint of a substructure unit, but at least 5 feet from any production pile as selected by the Contractor and accepted by the Engineer. Also, a 'Micropile Proof Load Test' (Item 948.61) is recommended on two production piles, one at each abutment.

The rebar size used for the test should be greater than the Design Load (DL) for 'Micropile Proof Load Test' and 1.5 times the Design Load for 'Micropile Verification Load Test'.

Table 6: Load Test

Location of Testing Pile	**Pile Type**	**Micropile Verification Load Test (Item 948.60)**	**Micropile Proof Load Test (Item 948.61)**	**Remark**
North Abutment/ Wingwalls	Sacrificial Pile	1	-	Prior to ordering production piles
	Production Pile	-	1	1st production pile for North Abutment/ Wingwalls
South Abutment/ Wingwalls	Sacrificial Pile	-	-	-
	Production Pile	-	1	1st production pile for South Abutment/ Wingwalls
Total:		1	2	

Resistance Factor and Pile Length Discussion
Since the micropiles are socketed into bedrock, a side resistance factor of 0.55 was used in the calculations of this Report. Based on MassDOT Special Provisions for Item 948.60 - Micropile

Verification Load Test, a side resistance factor of 0.70 may be used upon successful completion of a micropile verification load test on a sacrificial pile.

Pile Corrosion Protection

It is our opinion that pile corrosion protection is not needed due to the following reason: In our analysis, a 1/16" sacrificial section loss around the proposed pile outside perimeter is assumed in the calculations. The assumption is based on the following condition:

- This bridge site is not in a marine environment.
- The top portion of the micropile is protected by tremie concrete.

4.2 Temporary Pedestrian Bridge Foundation

Each proposed temporary pedestrian bridge abutment can be supported by a single micropile socketed 3 feet into intact bedrock comprising of 1-ft plunge length and 2-ft bonded length. Based on the Lpile results, the design point of fixity is at Elev. 51.1'. The tip of the micropile is estimated to be at Elev. 41.1' and Elev. 34.0' for temporary pedestrian bridge north abutment and south abutment, respectively.

Refer to Sections 4.1 and 6.3 for micropile design parameters, dimensions and properties. Based on temporary pedestrian bridge loads provided by Green, the loads on the temporary pedestrian bridge micropile are much less than the ones on the proposed bridge. The micropile structural resistance is much larger than Green's loads. Also, since the tip of the micropile is deeper than the design point of fixity, there are no issues for micropile lateral resistance for the temporary pedestrian bridge. Furthermore, the temporary pedestrian bridge micropile foundation meets the edge distance requirements based on the MassDOT Bridge Manual. No scour effect needs to be considered for the temporary pedestrian bridge foundation design. Therefore, a single micropile at the center of each abutment can be used to support the temporary pedestrian bridge.

4.3 Proposed Abutment Design Parameters

The following parameters are recommended for design at the back of the micropile abutment:

Moist Unit Weight of Soil = 120 pcf
Soil Friction Angle = 32°
Active Lateral Earth Pressure Coefficient = 0.275
At-Rest Lateral Soil Pressure Coefficient = 0.470
(Based on AASHTO Table 10.5.5.2.2-1)

Lateral earth pressure values used for design shall be in conformance with *MassDOT* BM 3.1.6 and AASHTO LRFD Bridge Design Specification C3.11.1.

4.4 Recommended Geotechnical Design Parameters by Soil Types – For Deep Foundation

Table 7: Geotechnical Design Parameters – for deep foundation

Soil Type for p-y curve	Density	Friction Angle, φ (degree)	Unconfined Compressive Strength of Rock (psi)	p-y Modulus, k Above water/ (below water) (pci)	Soil Unit Weight, γ (pcf)	Secant Modulus, E50	Remark
Sand (Reese)	Very Loose	28	-	25 (20)	110	-	For sand, inorganic silt and gravel materials.
	Loose	30	-	35 (30)	115	-	
	Medium Dense	32	-	90 (60)	120	-	
	Dense	35	-	200 (100)	125	-	
	Very Dense	38	-	225 (125)	130	-	
Sand (Reese)	Very Dense	43	-	250 (150)	135	-	For cobble, weathered bedrock materials
Sand (Reese)	Very Loose	20	-	15 (10)	100	-	For Peat materials
Strong Rock (Vuggy Limestone)	-	-	12,630*	-	168	-	For bedrock materials

***** Geologically, diorite is between gabbro and granite. Based on 2002 AASHTO Table 4.4.8.1.2B, the uniaxial compressive strength of diorite rock can range from 2,100 psi to 49,000 psi (large range) with average value of 25,550 psi. However, based on a recent diorite rock core lab testing in the MassDOT Bridge No. B-11-005=S-01-013 bridge replacement project that we are involved in, the unconfined compressive strength is 12,630 psi. This value is much below the average value and is used for conservative purpose.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Water Control

The groundwater level at the site is likely to be influenced by the Maple Meadow Brook water level. Groundwater and river water levels fluctuate over time due to seasonal changes and storm events. Water control is needed for any excavation below the groundwater or river water surface elevation.

The following factors should be taken into consideration for the recorded water levels:

- Groundwater levels obtained from the washed boring exploration operation are generally unreliable and are provided for reference only.
- Groundwater level fluctuates over time due to seasonal changes and storm events.

5.2 Cofferdam/ Temporary Earth Support System

A cofferdam/ temporary earth support system will be needed for the proposed bridge staged construction and temporary pedestrian abutment construction. The earth support system is to be designed by the Contractor in accordance with the MassDOT Standard Specifications Section 950, 'Sheeting'. The cofferdam is to be designed by the Contractor in accordance with the MassDOT Standard Specifications Section 140, 'Excavation for Structures'. Also related is the Specifications Section 148, 'Dredging'.

In addition to earth and hydrostatic loadings, the Contractor's intended construction equipment to be used during excavation and construction should be considered.

Based on the sketch plans, the cofferdam in front of the proposed bridge pile cap is to be cut to a minimum of 18" below riverbed and the cofferdam at the back of the pile cap is to be cut to Elev. 77.5' (a minimum of 12" below the bottom of the approach slab).

5.3 Utilities

There are overhead wires and maybe underground utilities within the limit of the bridge site. The contractor should ensure all existing utilities that will conflict with the proposed construction are relocated prior to the proposed construction.

5.4 Obstructions

Underground utilities, cobbles, boulders, and unknown previous construction materials are potential obstruction materials that may be encountered at the site during construction. Contractor should prepare for these potential obstructions during the proposed foundation excavation and pile driving.

5.5 Subgrade Preparation

Excavation during the bridge foundation construction should be in accordance with MassDOT Standard Specifications Section 140 'Excavation for Structures'. Backfilling during the bridge foundation construction should be in accordance with MassDOT Standard Specifications Section 150 'Embankment'.

6.0 SUMMARY

6.1 Abutments and Wingwalls
2 rows of micropiles with 3'-6" spacing between rows and 7'-0" horizontal spacing between piles

Design Factor Axial Load per Pile = 195.3 kips

Steel Casing: 10.75" O.D. x 0.595", API PSL 1 Grade 52 (F_y = 52 ksi),
Original Casing Thickness = 0.595-in, Area = 19.0 in^2
Consider 1/16" Potential Corrosion, Reduced Casing Thickness = 0.5325-in,
Reduced Area = 16.9 in^2

Steel Reinforcing Bar: #14, Threaded, ASTM A615/AASHTO M31 Grade 60
Cement Grout: Neat Mix of Portland Cement (Type I or II), M85 (ASTM C150), f'_c = 5,000 psi

Rock Socket Diameter = 9.3-in min.

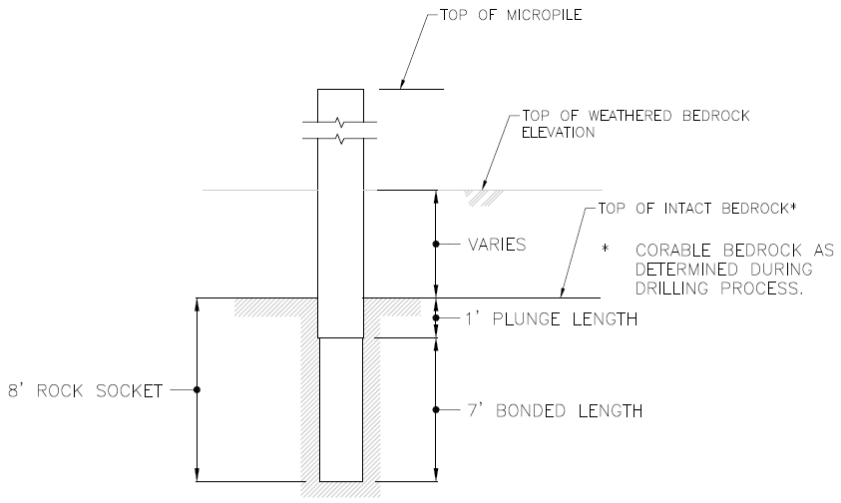
Estimated Bonded Length into Intact Bedrock (Grout into Bedrock)	7-ft
Plunge Length (Casing into Intact Bedrock)	1-ft
Nominal Geotechnical Pile Resistance per Pile	491 kips
Side Resistance Factor, φ_{stat}	0.55
Factored Geotechnical Pile Resistance per Pile	270 kips
Nominal Uplift Resistance per Pile	245 kips
Resistance Factor, φ_{up}	0.55
Factored Uplift Resistance per Pile	135 kips

Nominal Structural Pile Resistance per Pile = 1,097 kips (Portion of Cased Length)
Nominal Structural Pile Resistance per Pile = 352 kips (Portion of Uncased Length)
Compression Resistance Factor, φ_C = 0.75

Factored Structural Pile Resistance per Pile = 823 kips (Portion of Cased Length)
Factored Structural Pile Resistance per Pile = 264 kips (Portion of Uncased Length)

Nominal Tension Resistance = 995 kips (Portion of Cased Length)
Nominal Tension Resistance = 135 kips (Portion of Uncased Length)
Tension Resistance Factor, φ_T = 0.80

Factored Tension Resistance = 796 kips (Portion of Cased Length)
Factored Tension Resistance = 108 kips (Portion of Uncased Length)



SCHEMATIC MICROPILE
(NOT TO SCALE)

6.2 Lateral Pile Resistance – Proposed Bridge Abutments and Wingwalls

Table 6.2A: Pile-Head Deflection and Lateral Load Resistance at Service Limit State – Fixed Head

Substructure	Allowable Service Load Pile-Head Deflection	Unfactored Lateral Resistance per Pile
Abutments and Wingwalls	1.0”	27.6 kips

Table 6.2B: Lateral Load Resistance at Strength Limit States – Fixed Head

Substructures	Factored Lateral Resistance per Pile
Abutments	37.7 kips
Wingwalls	38.2 kips

Note: The factored lateral resistance is based on the micropile structural capacity.

Table 6.2C: Lateral Load Resistance at Extreme Limit States – Fixed Head

Substructures	Factored Lateral Resistance per Pile
Abutments	42.0 kips
Wingwalls	42.0 kips

Note: The factored lateral resistance is based on the micropile structural capacity.

6.3 Temporary Pedestrian Abutments
1 micropile at the center of each abutment

Design Factor Axial Load per Pile = 60 kips

Steel Casing: 10.75" O.D. x 0.595", API PSL 1 Grade 52 (F_y = 52 ksi),
Original Casing Thickness = 0.595-in, Area = 19.0 in^2
Consider 1/16" Potential Corrosion, Reduced Casing Thickness = 0.5325-in,
Reduced Area = 16.9 in^2

Steel Reinforcing Bar: #14, Threaded, ASTM A615/AASHTO M31 Grade 60
Cement Grout: Neat Mix of Portland Cement (Type I or II), M85 (ASTM C150), f'_c = 5,000 psi

Rock Socket Diameter = 9.3-in min.

Estimated Bonded Length into Intact Bedrock (Grout into Bedrock)	2-ft
Plunge Length (Casing into Intact Bedrock)	1-ft
Nominal Geotechnical Pile Resistance per Pile	140 kips
Side Resistance Factor, φ_{stat}	0.55
Factored Geotechnical Pile Resistance per Pile	77 kips
Nominal Uplift Resistance per Pile	70 kips
Resistance Factor, φ_{up}	0.55
Factored Uplift Resistance per Pile	39 kips

Nominal Structural Pile Resistance per Pile = 1,097 kips (Portion of Cased Length)
Nominal Structural Pile Resistance per Pile = 352 kips (Portion of Uncased Length)
Compression Resistance Factor, φ_C = 0.75

Factored Structural Pile Resistance per Pile = 823 kips (Portion of Cased Length)
Factored Structural Pile Resistance per Pile = 264 kips (Portion of Uncased Length)

Nominal Tension Resistance = 995 kips (Portion of Cased Length)
Nominal Tension Resistance = 135 kips (Portion of Uncased Length)
Tension Resistance Factor, φ_T = 0.80

Factored Tension Resistance = 796 kips (Portion of Cased Length)
Factored Tension Resistance = 108 kips (Portion of Uncased Length)

6.4 Lateral Pile Resistance – Temporary Bridge Abutments

Table 6.4A: Pile-Head Deflection and Lateral Load Resistance at Service Limit State – Fixed Head

Substructure	Allowable Service Load Pile-Head Deflection	Unfactored Lateral Resistance per Pile
Temporary Bridge Abutments	1.0”	31.9 kips

Table 6.4B: Lateral Load Resistance at Strength Limit States – Fixed Head

Substructures	Factored Lateral Resistance per Pile
Temporary Bridge Abutments	41.8 kips

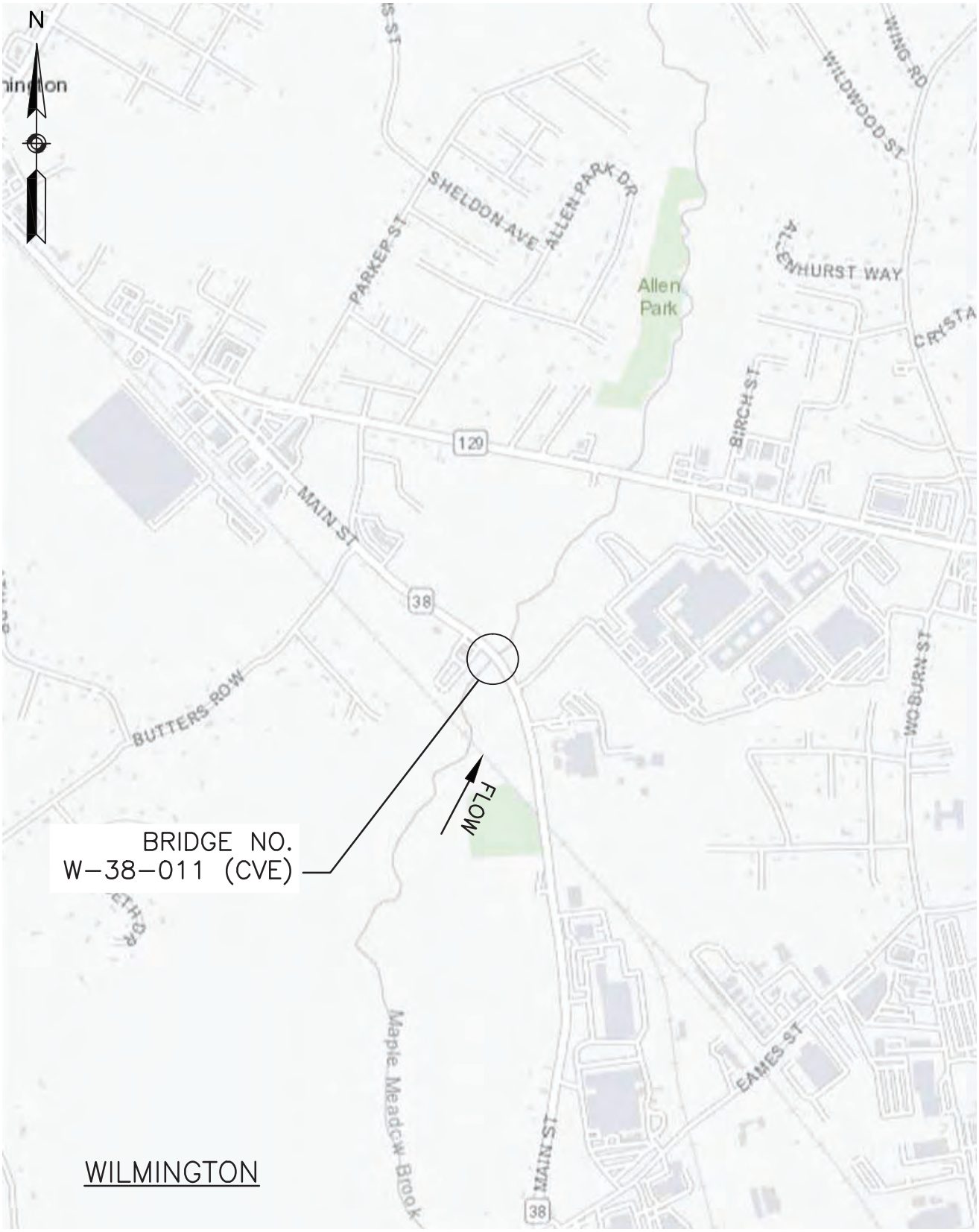
Note: The factored lateral resistance is based on the micropile structural capacity.

Table 6.4C: Lateral Load Resistance at Extreme Limit States – Fixed Head

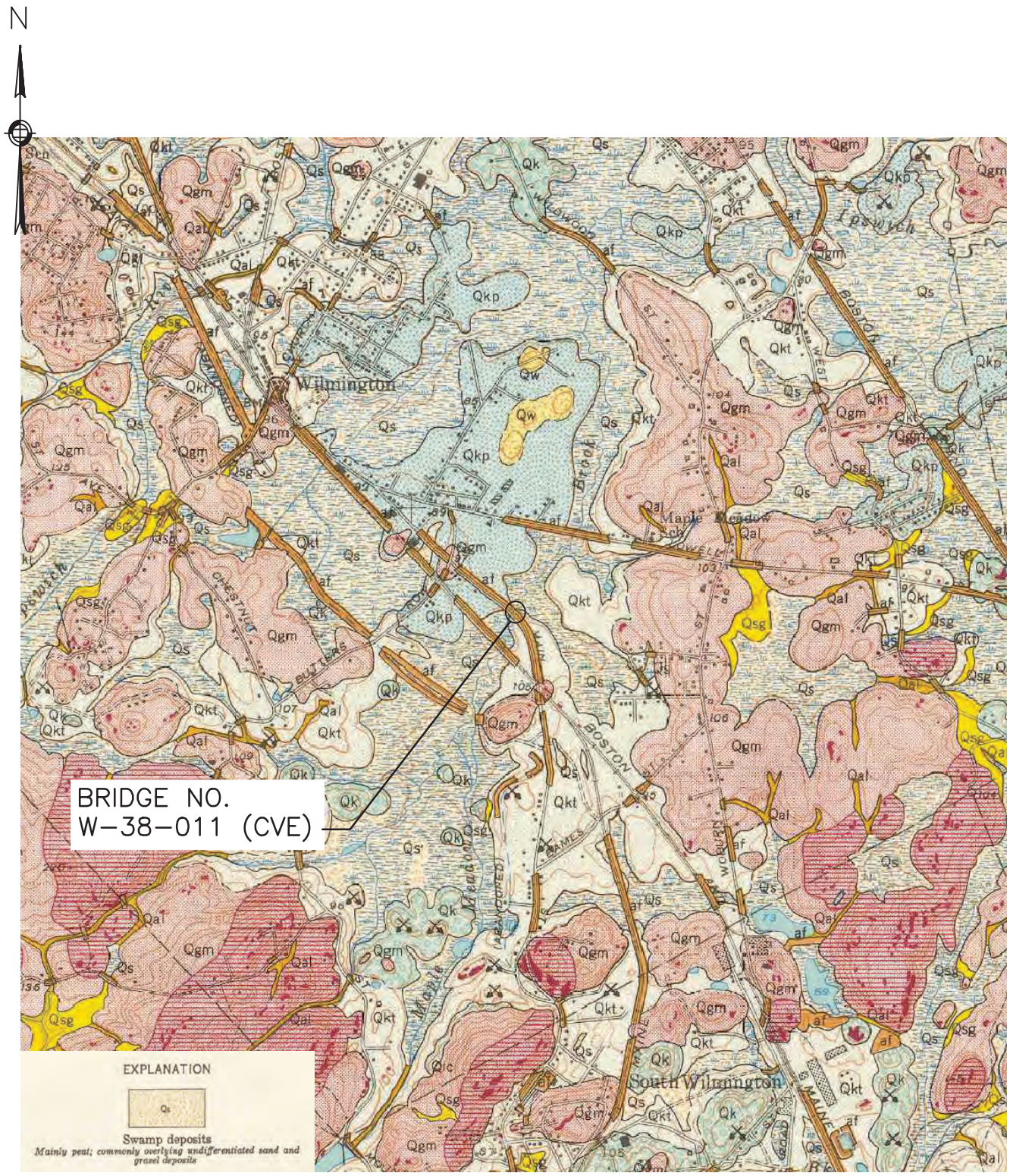
Substructures	Factored Lateral Resistance per Pile
Temporary Bridge Abutments	46.0 kips

Note: The factored lateral resistance is based on the micropile structural capacity.

FIGURES

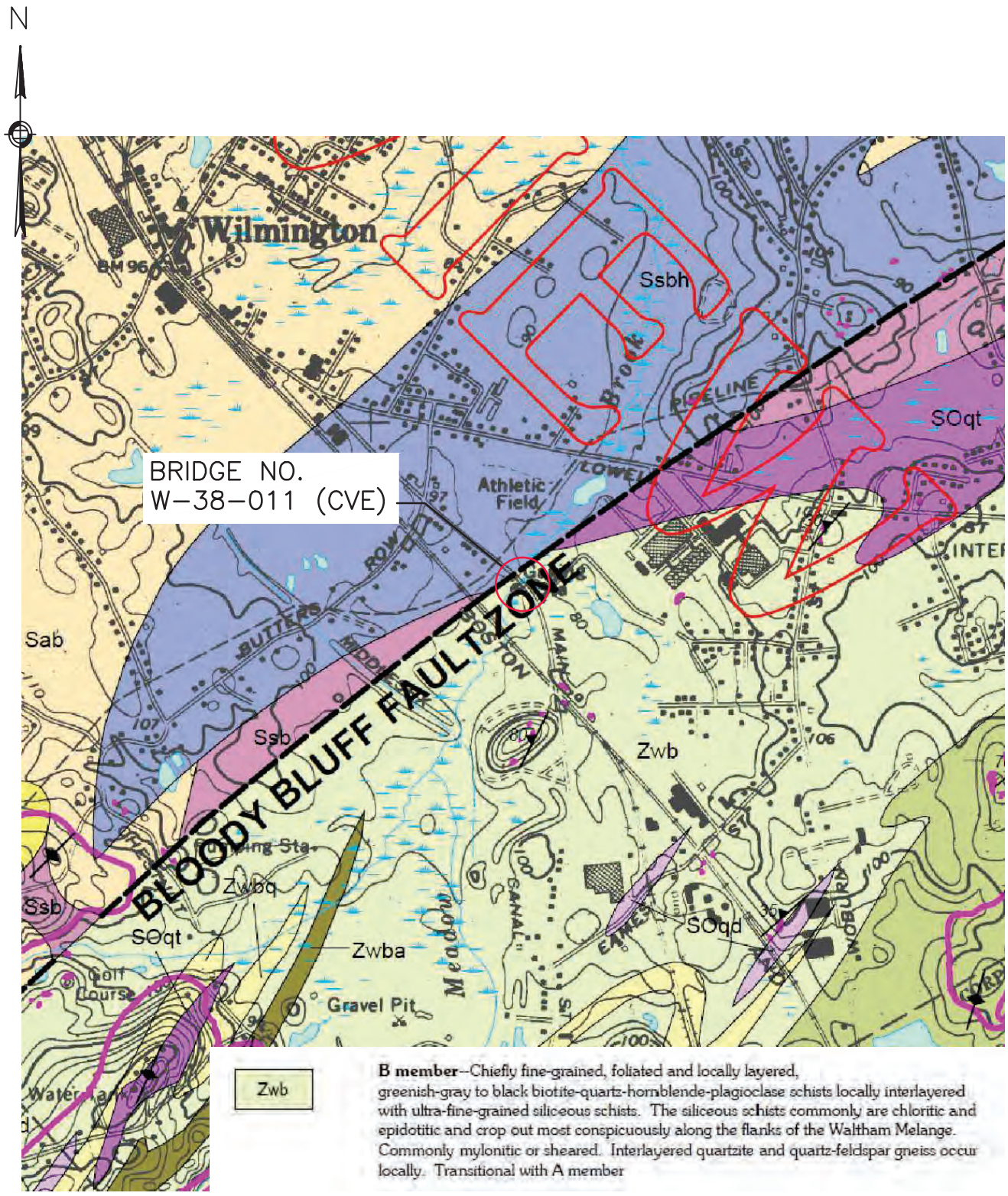


BRIDGE NO. W-38-011 (CVE) ROUTE 38 OVER MAPLE MEADOW BROOK WILMINGTON, MASSACHUSETTS		PROJECT LOCATION PLAN NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 1A



SOURCE: FROM SURFICIAL GEOLOGY OF THE WILMINGTON QUADRANGLE, MASSACHUSETTS BY ROBERT O. CASTLE, 1959

BRIDGE NO. W-38-011 (CVE) ROUTE 38 OVER MAPLE MEADOW BROOK WILMINGTON, MASSACHUSETTS		SURFICIAL GEOLOGICAL MAP NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 1B



SOURCE: FROM BEDROCK GEOLOGIC MAP OF THE WILMINGTON QUADRANGLE, MASSACHUSETTS BY ROBERT O. CASTLE, J. CHRISTOPHER HEPBURN, AND JOSEPH P. KOPERA, 2005

BRIDGE NO. W-38-011 (CVE) ROUTE 38 OVER MAPLE MEADOW BROOK WILMINGTON, MASSACHUSETTS		BEDROCK GEOLOGICAL MAP NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 1C

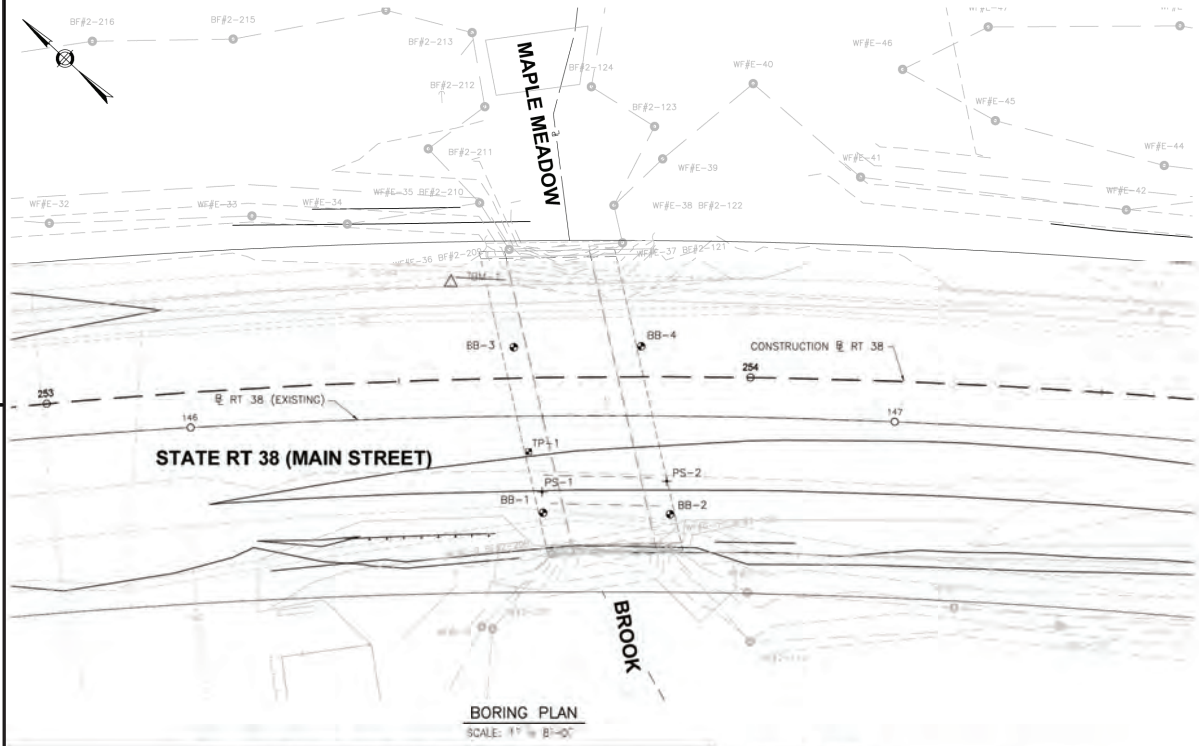
BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

2023-2025 AS-DRILLED BORING LOCATION PLAN

N.T.S.

PREPARED BY
LAWSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 2



BORING PLAN
SCALE: 1" = 8'-0"

PROPOSED BORING & PROBE LOCATIONS (FEET)

BORING	NORTHING	EASTING	STATION	OFFSET	SURFACE ELEVATION	H.B.E	ESTIMATED REQUIRED DEPTH
BB-1	3021110.0361	747588.0849	253+70.31	19.19' RT	81.00	BEDROCK	10' ROCK CORE
BB-2	3021096.6234	747600.1772	253+88.75	19.52' RT	81.88	59.88	–
BB-3	3021129.0150	747602.5250	253+66.54	4.35' LT	81.82	BEDROCK	–
BB-4	3021115.8700	747615.1060	253+84.56	4.31' LT	82.64	BEDROCK	–
PS-1	3021112.1334	747590.1546	253+70.22	16.25' RT	81.90	–	REFUSAL
PS-2	3021100.1619	747603.3054	253+88.24	14.82' RT	81.97	–	REFUSAL

PROPOSED TEST PIT LOCATIONS (FEET)

TEST PIT	NORTHING	EASTING	STATION	OFFSET	SURFACE ELEVATION	H.B.E	ESTIMATED REQUIRED DEPTH
TP-1	3021117.4012	747593.0758	253+57.81	13.77' LT	82.12	–	6'-0"

GENERAL NOTES:

1. BORINGS WILL BE MARKED ON THE GROUND AND OFF ROAD BY THE ENGINEER.
2. BORING CONTRACTOR TO ENSURE TRAFFIC CONTROL NECESSARY TO PERFORM THE WORK IS IN ACCORDANCE WITH APPROVED ACCESS PERMIT. IT IS THE CONTRACTOR'S RESPONSIBILITY FOR COORDINATING WITH DIG SAFE AND POLICE DETAILS, AND APPLYING FOR THE NECESSARY PERMITS FROM THE TOWN AND MASSDOT DISTRICT OFFICE.
3. DISTRICT 4 UTILITY AND CONSTRUCTIBILITY ENGINEER SHALL BE CONTACTED FOR ANY UTILITIES INCLUDING HIGHWAY DRAINAGE UNITS AND LIGHTING DUCTS LOCATED AT THE BRIDGE SITE BEFORE EXPLORATION.
4. SOIL SAMPLES SHALL BE PLACED IN 4 OZ. JARS PROVIDED BY THE CONTRACTOR.
5. BEDROCK CORE SAMPLES SHALL BE PLACED IN WOODEN BOXES FURNISHED BY THE CONTRACTOR. PHOTOS SHALL BE TAKEN OF COMPLETED BOXED CORES PROPERLY IDENTIFIED AND SUBMITTED TO THE GEOTECHNICAL SECTION.
6. THE ENGINEER WILL RETAIN THE SOIL SAMPLES AND THE BEDROCK CORE BOXES TO AID IN PREPARING THE GEOTECHNICAL REPORT. THE BORING SAMPLE BOXES WILL THEN BE DELIVERED TO MASSDOT'S STORAGE FACILITY AT 219 WINTHROP AVENUE (ROUTE 114) LAWRENCE, MA.
7. THIS BORING PLAN IS TO SUPPLEMENT A PREVIOUSLY APPROVED BORING PLAN.

BORING & PROBE NOTES:

1. LOCATION OF BORINGS ARE SHOWN THUS: ⊕ BB-#
2. LOCATION OF PROBES ARE SHOWN THUS: + PS-#
3. SEE THE BORING LOCATIONS TABLE FOR THE SPECIFIED HIGHEST BOTTOM ELEVATION (H.B.E.) OF EACH BORING.
4. BORING BB-4 SHALL BE MADE INTO BEDROCK AND A 10' BEDROCK CORE WILL BE TAKEN AND THE BOREHOLE TERMINATED, UNLESS OTHERWISE NOTED BY THE ENGINEER. THIS BORING SHALL BE TAKEN FIRST.
5. BORING BB-3 SHALL EXTEND TO THE SPECIFIED HIGHEST BOTTOM ELEVATION OR TO REFUSAL BELOW THE H.B.E., WHICHEVER IS DEEPER AS DECIDED BY THE ENGINEER. SHOULD BEDROCK BE ENCOUNTERED AT OR ABOVE THE SPECIFIED HIGHEST BOTTOM ELEVATION, THE BORING SHALL BE CONTINUED AS A ROCK CORE BORING FOR A DEPTH OF 10' THEN TERMINATED.
6. BENCH MARK: TBM 1
   MAG NAIL SET 2' UP IN UTILITY POLE UP 12-64
   ST 38 ℄ STA. 146+37.30 – 19.10' LT
   N3021141.8931 E747603.1422 EL. 85.16' (NAVD 88)
7. BORINGS ARE LOCATED FROM THE CONSTRUCTION BASELINE OF ST 38 (MAIN STREET).
8. ADDITIONAL BORINGS MAY BE REQUESTED BY THE ENGINEER IF NECESSARY.
9. AT THE WEST AND EAST ABUTMENT, PROBING SHALL BE CONDUCTED PRIOR TO THE BORING, TO DETERMINE GEOMETRY AND LOCATION.
10. PROBE SERIES BORINGS SHALL CONSIST OF UP TO THREE (3) PROBES CONDUCTED WITH A SOLID-STEM AUGER ADVANCED TO REFUSAL. PROBE BORINGS SHALL BE MADE IN A DIRECTION PERPENDICULAR TO THE FACE OF THE STRUCTURE AT 12 INCH INCREMENTS AWAY FROM THE STRUCTURE. IF NECESSARY, ONE ADDITIONAL PROBE SHALL BE TAKEN AT 6 INCH INCREMENTS BACK TOWARDS THE STRUCTURE FROM THE PROBE IN WHICH THERE WAS NO REFUSAL.
11. ELEVATION, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
12. HORIZONTAL COORDINATES, IN U.S. SURVEY FEET, ARE REFERENCED TO THE NORTH AMERICAN DATUM OF 1983 (NAD83).
13. THE CONTRACTOR SHALL BE RESPONSIBLE FOR WORK REQUIRED TO ACCESS THE SITE.

TEST PIT NOTES:

1. LOCATION OF TEST PIT IS SHOWN THUS: ⊕ TP-#
2. DEPTH OF TEST PIT IS EXPECTED TO BE APPROXMATELY 6'.
3. THE TEST PIT IS FOR GATHERING EXISTING SUBSTRUCTURE INFORMATION AND SPECIMENS FOR GEOPHYSICAL TESTING TO CLEARLY IDENTIFY THE LIMITS OF EXISTING DECK SLAB ON TOP OF EXISTING ABUTMENT.
4. IT IS THE TEST PIT EXCAVATOR'S RESPONSIBILITY TO OBTAIN NECESSARY PERMITS AND WORK REQUIRED TO ACCESS THE STE.
5. THE TEST PIT IS LOCATED IN THE RIGHT TRAVEL LANE OF STATE ROUTE 38 (MAIN STREET), THEREFORE THE EXCAVATION WORK MAY NEED TO BE PERFORMED DURING THE NIGHT TIME IF PROPER TRAFFIC CONTROL CANNOT BE ESTABLISHED.
6. CONSULT WITH MASSDOT D4 TRAFFIC SECTION PRIOR TO START OF WORK.

NOTE: 3 VACUUMED HOLES WERE PERFORMED INSTEAD OF A TEST PIT. SEE APPENDIX 1 FOR LOCATIONS OF THE VACUUMED HOLES VH-1 TO VH-3.

SOURCE: FROM WILMINGTON BORING PLAN BY GREEN INTERNATIONAL AFFILIATES.

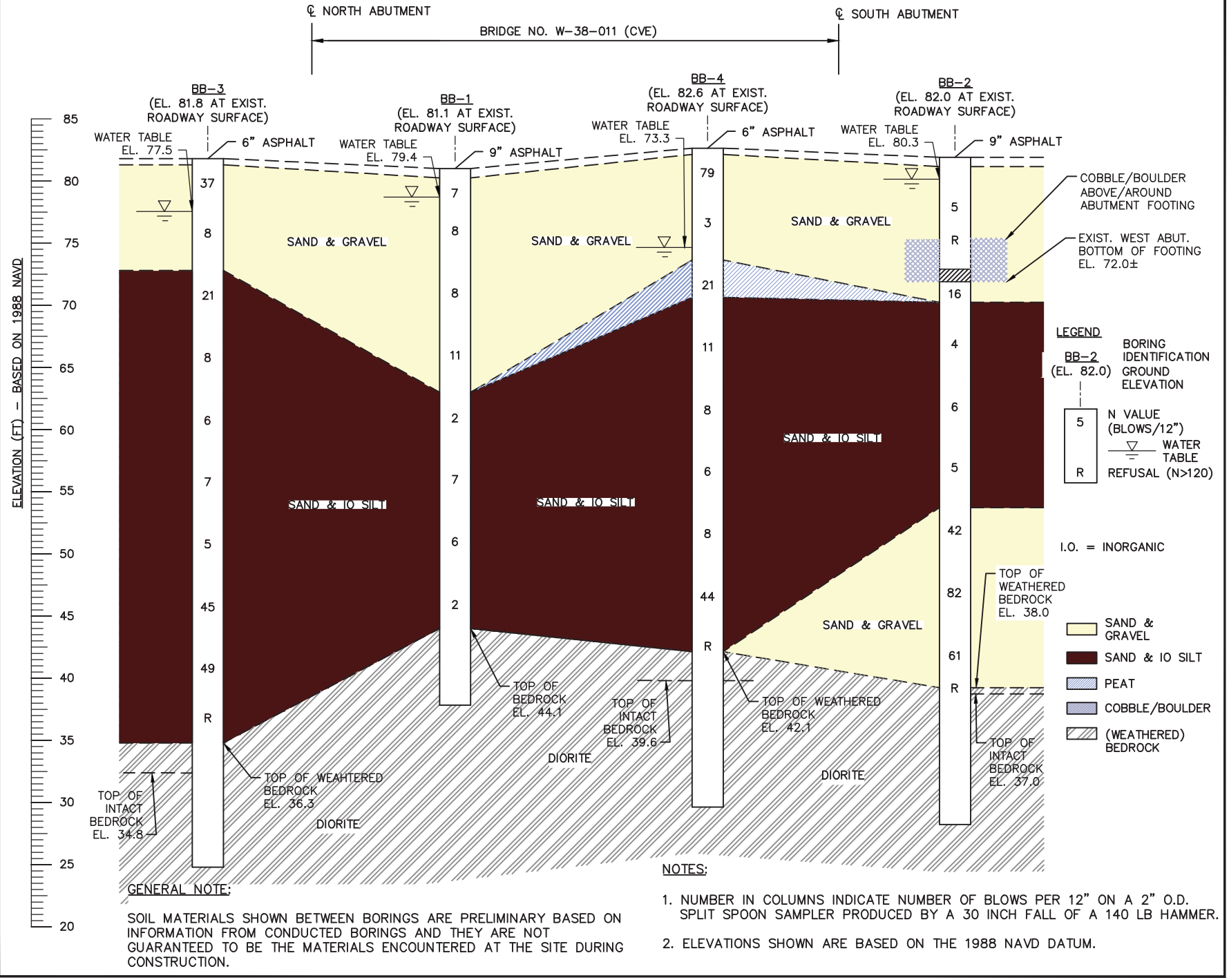
BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

SOIL PROFILE (1/2) - PICTORIAL VIEW

SCALE: 3/64" = 1'-0"

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 3



GENERAL NOTE:

SOIL MATERIALS SHOWN BETWEEN BORINGS ARE PRELIMINARY BASED ON INFORMATION FROM CONDUCTED BORINGS AND THEY ARE NOT GUARANTEED TO BE THE MATERIALS ENCOUNTERED AT THE SITE DURING CONSTRUCTION.

NOTES:

1. NUMBER IN COLUMNS INDICATE NUMBER OF BLOWS PER 12" ON A 2" O.D. SPLIT SPOON SAMPLER PRODUCED BY A 30 INCH FALL OF A 140 LB HAMMER.
2. ELEVATIONS SHOWN ARE BASED ON THE 1988 NAVD DATUM.

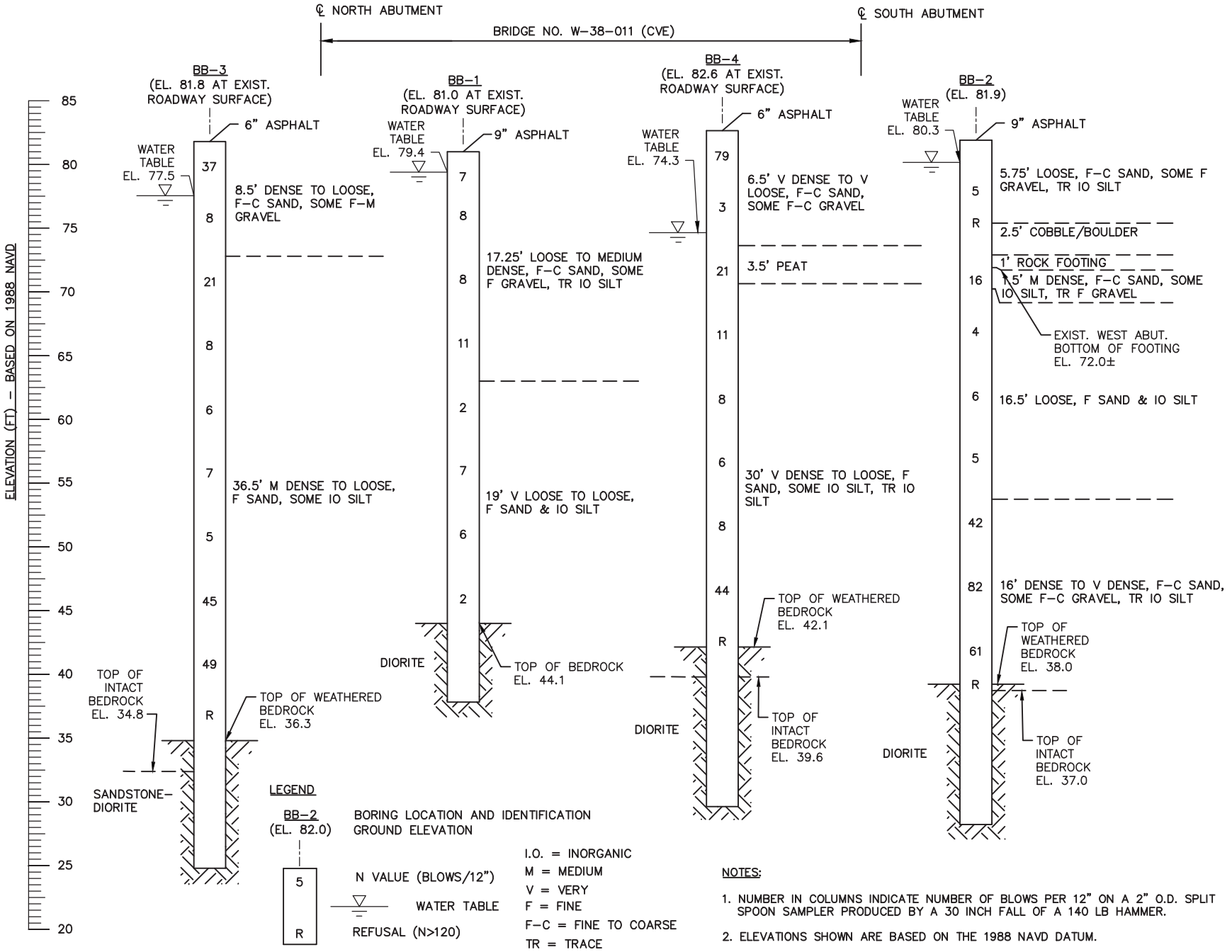
BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

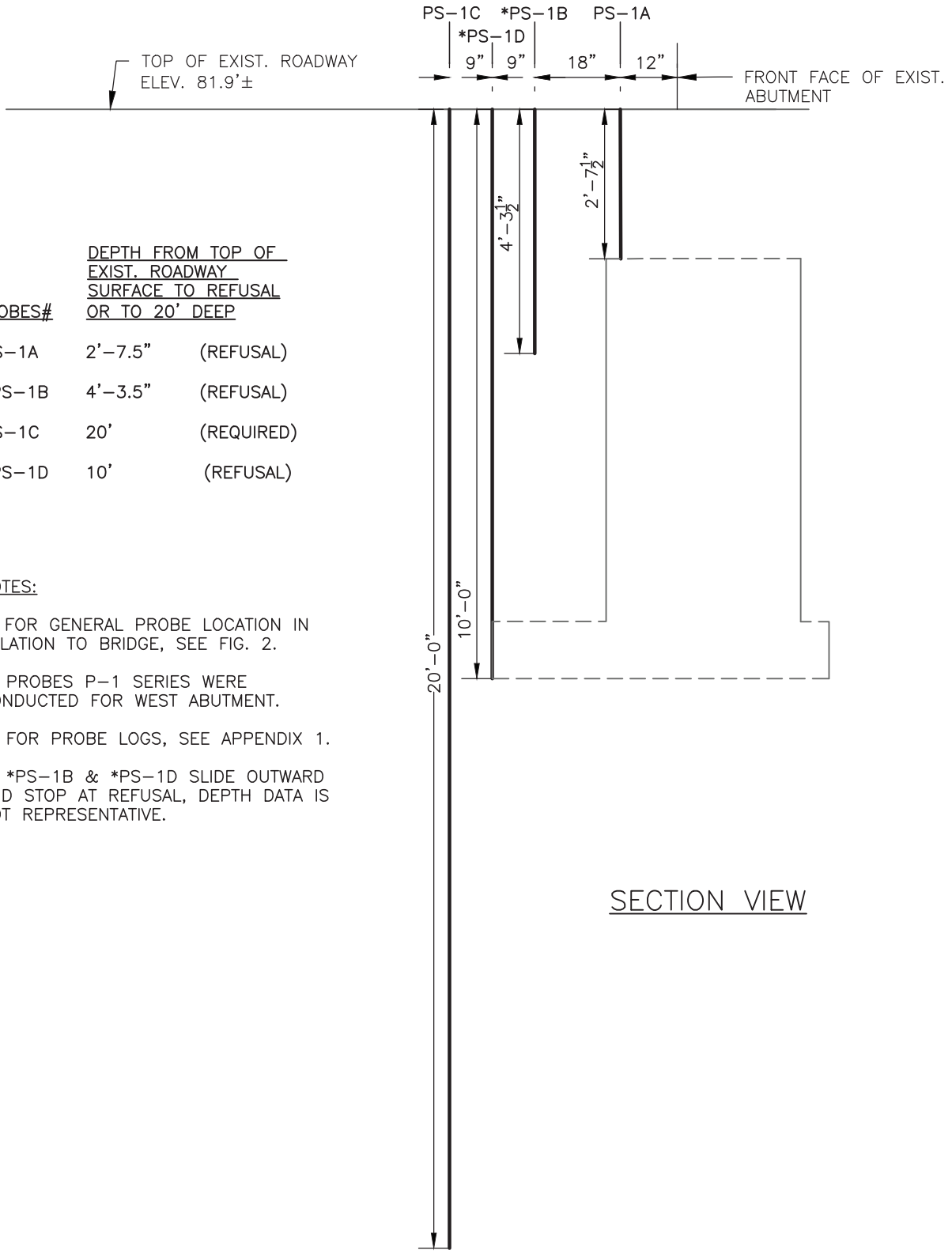
SOIL PROFILE (2/2) - DESCRIPTIVE VIEW

SCALE: 3/64" = 1'-0"

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 4





PROBES#	DEPTH FROM TOP OF EXIST. ROADWAY SURFACE TO REFUSAL OR TO 20' DEEP	
PS–1A	2'–7.5"	(REFUSAL)
*PS–1B	4'–3.5"	(REFUSAL)
PS–1C	20'	(REQUIRED)
*PS–1D	10'	(REFUSAL)

NOTES:

1. FOR GENERAL PROBE LOCATION IN RELATION TO BRIDGE, SEE FIG. 2.
2. PROBES P–1 SERIES WERE CONDUCTED FOR WEST ABUTMENT.
3. FOR PROBE LOGS, SEE APPENDIX 1.
4. *PS–1B & *PS–1D SLIDE OUTWARD AND STOP AT REFUSAL, DEPTH DATA IS NOT REPRESENTATIVE.

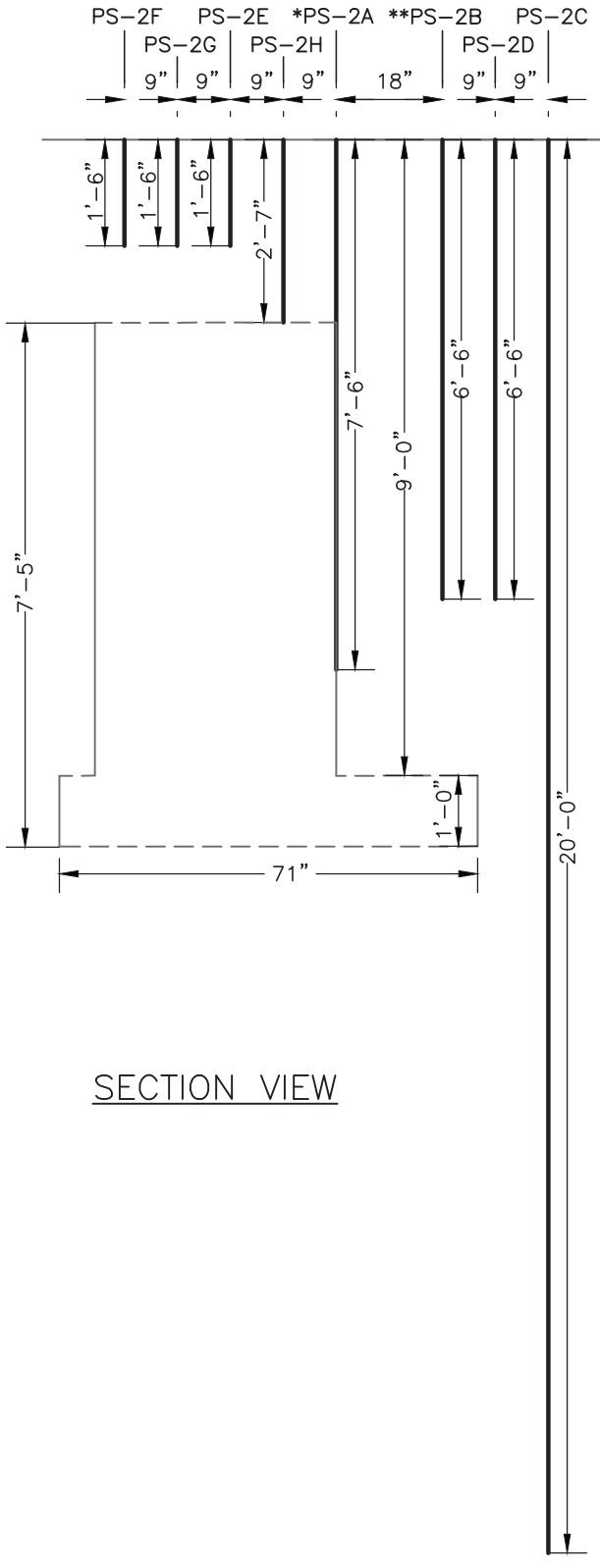
SECTION VIEW

BRIDGE NO. W–38–011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PROBE PS–1
(EXISTING NORTH ABUTMENT)
NOT TO SCALE

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

FIG. 5



SECTION VIEW

PROBES#	DEPTH FROM TOP OF EXIST. ROADWAY SURFACE TO REFUSAL OR TO 20’ DEEP	
*PS–2A	7’–6”	(REFUSAL)
**PS–2B	6’–6”	(REFUSAL)
PS–2C	20’	(REQUIRED)
PS–2D	6’–6”	(REFUSAL)
PS–2E	1’–6”	(REFUSAL)
PS–2F	1’–6”	(REFUSAL)
PS–2G	1’–6”	(REFUSAL)
PS–2H	2’–7”	(REFUSAL)

NOTES:

1. FOR GENERAL PROBE LOCATION IN RELATION TO BRIDGE, SEE FIG. 2.

2. PROBES P–2 SERIES WERE CONDUCTED FOR EAST ABUTMENT.

3. FOR PROBE LOGS, SEE APPENDIX 1.

4. *PS–2A SLIDE OUTWARD AND STOP AT REFUSAL, DEPTH DATA IS NOT REPRESENTATIVE.

5. **PS–2B ENCOUNTERED BOULDER AT 6’–6” DEPTH. BORING BB–2 WAS PERFORMED AT APPROXIMATELY THIS PROBE HOLE LOCATION.

BRIDGE NO. W–38–011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PROBE PS–2
(EXISTING SOUTH ABUTMENT)
NOT TO SCALE

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

FIG. 6

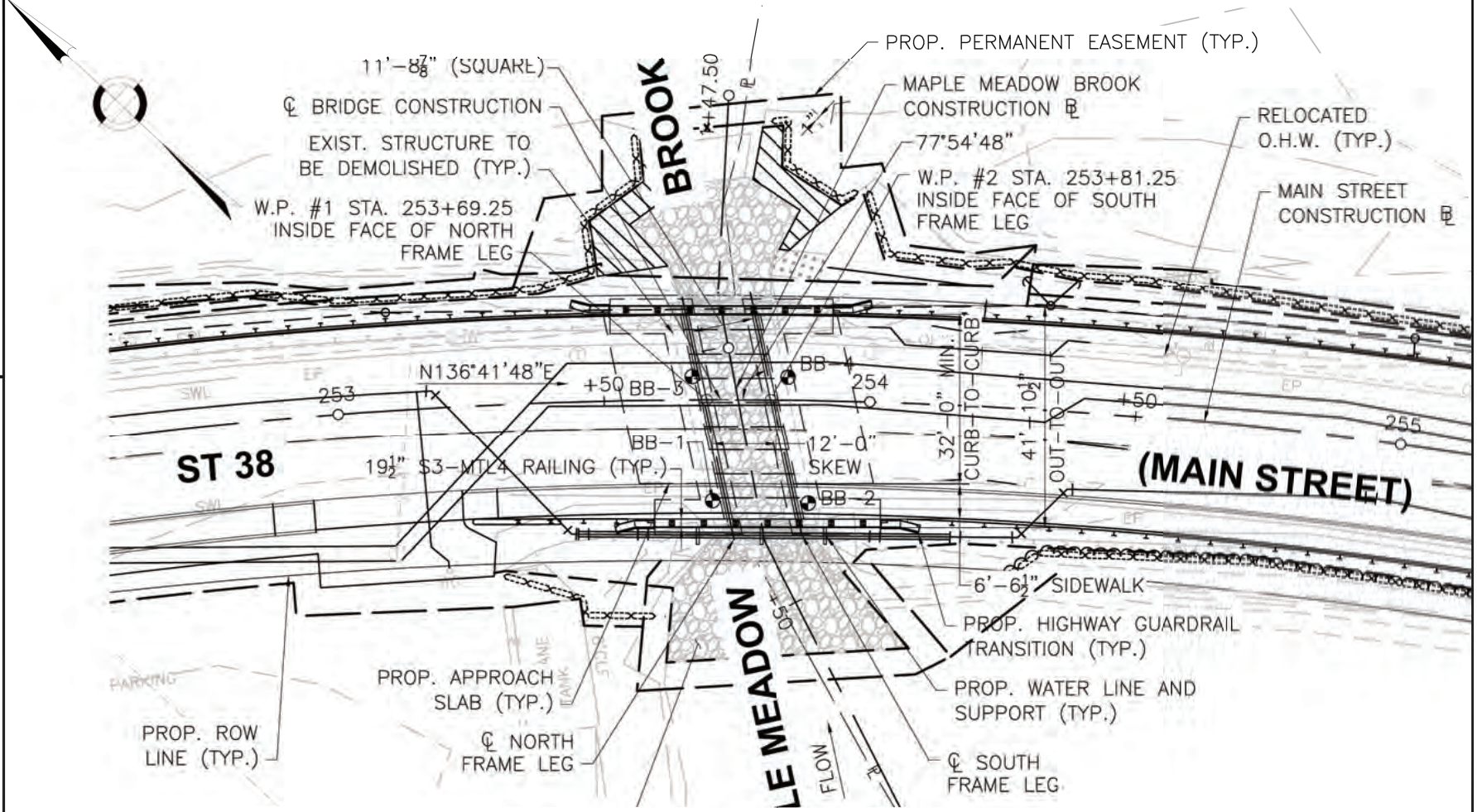
BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PREPARED BY
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NEWTON, MASS.

PROPOSED BRIDGE PLAN

NOT TO SCALE

Fig. 7



PROPOSED BRIDGE PLAN

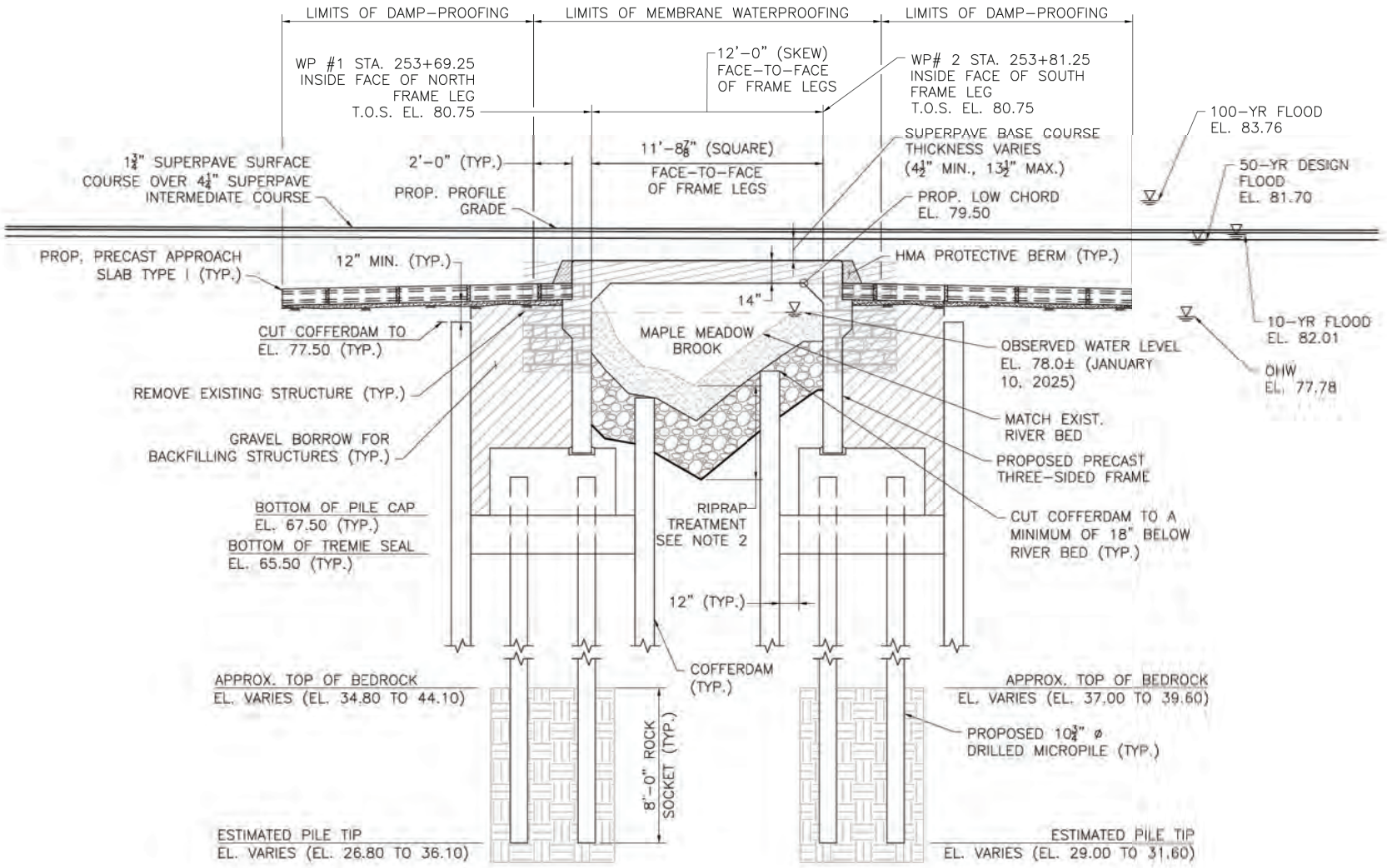
SOURCE: FROM BRIDGE PLANS BY GREEN.

BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

PROPOSED BRIDGE LONGITUDINAL SECTION
NOT TO SCALE

Fig. 8



PROPOSED BRIDGE LONGITUDINAL SECTION

SOURCE: FROM BRIDGE PLANS BY GREEN.

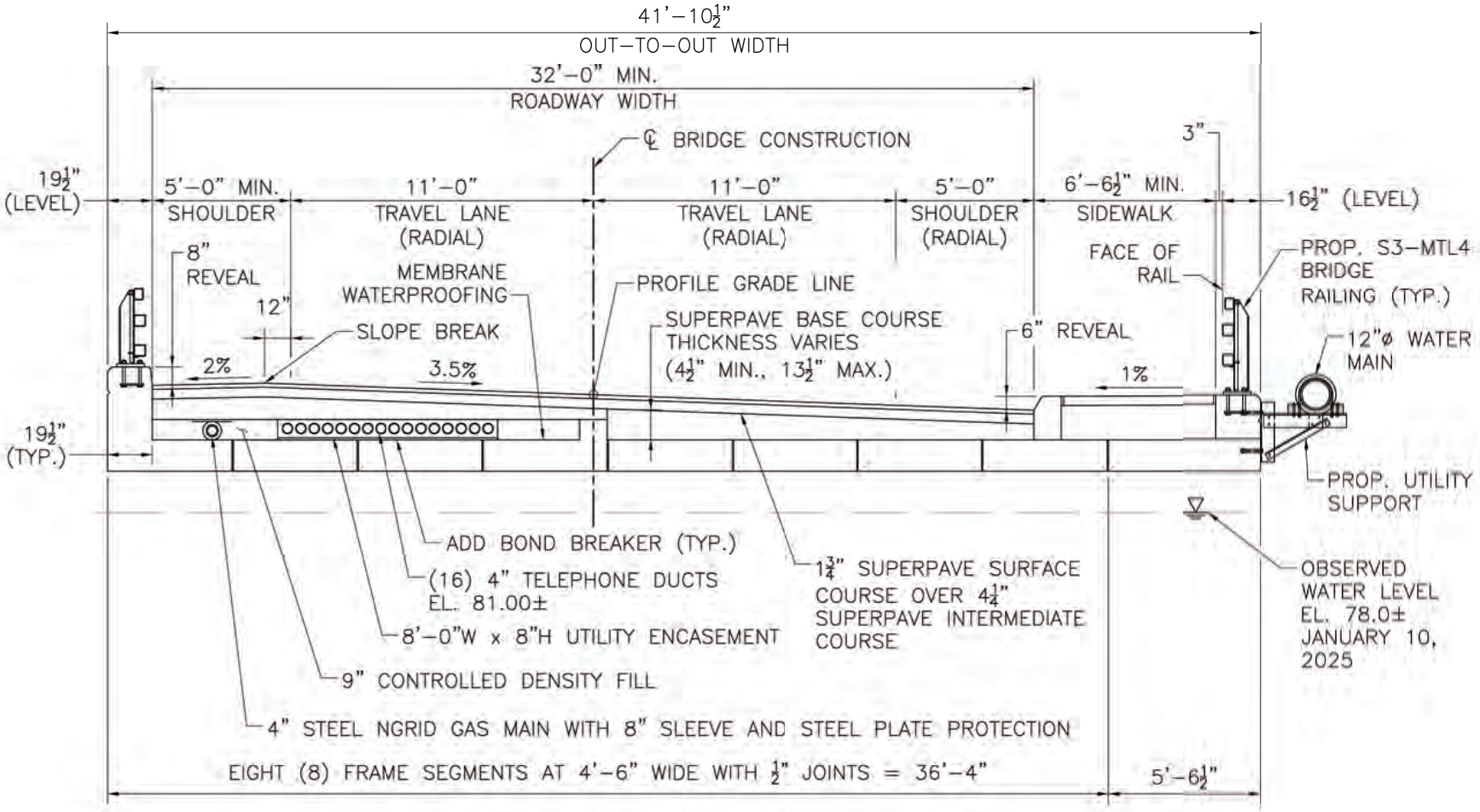
BRIDGE NO. W-38-011 (CVE)
ROUTE 38 OVER MAPLE MEADOW BROOK
WILMINGTON, MASSACHUSETTS

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

PROPOSED BRIDGE CROSS SECTION

NOT TO SCALE

Fig. 9



PROPOSED BRIDGE CROSS SECTION

SOURCE: FROM BRIDGE PLANS BY GREEN.

APPENDIX 1

2023-2025 Subsurface Exploration Results

(14 sheets)

Notes:

1. For 2023-2025 boring locations, see Figure 2.
2. There are 9 sheets for Borings BB-1 to BB-2, Probe Lines PS-1 to PS-2 and Vacuum Holes VH-1 to VH-3.
3. The elevations shown on the attached 2023-2025 logs are based on 1988 NAVD datum.

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-1 (Bridge Boring) | Page 1/2 | Scale: 1" = 5'

City/Town: Wilmington, MA	Bridge No.: W-38-011	Project File No.: 608051	Contract No.: -
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 1/12/24 11:00 AM	Total Hours:
Groundwater Depth (Feet): 2.3' Date & Time: 1/17/24 10:25 AM		Date & Time Completed: 1/17/24 2:00 PM	**9.5
Coordinates: *N 3,021,112.8 *E 747,590.9	Ground Elevation (Feet): *81.1'	Inspector's Name: James Gu	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-1	1' - 3'	17 4 3 2	2"	Dry, loose, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt (with ASPHALT pieces on top).	
S-2	4' - 6'	9 4 4 3	0"	Wet, no recovery.	
S-3	9' - 11'	1 3 5 4	2"	Wet, loose, brown, FINE TO COARSE SAND, trace inorganic silt.	
S-4	14' - 16'	3 6 5 3	10"	Wet, loose, brown, FINE TO COARSE SAND, trace inorganic silt.	18'
S-5	19' - 21'	2 1 1 1	9"	Wet, very loose, gray, FINE SAND AND INORGANIC SILT.	
S-6	24' - 26'	2 3 4 4	11"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-7	29' - 31'	2 3 3 4	10"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	

Notes: * Moved BB-1 4' toward drive way due to underground gas pipe.
**1/12/24 11:00 AM to 3:00 PM, 1/17/24 8:30AM to 2:00 PM
Wilmington PD: 1/12/24 Louis Martignetti #153, Paul Jepson #142
1/17/24 Brian Moon #161, Chris Dindo #170

Arrow-Board: -
Signs: 2
Cones: 11

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: GT8 GtechDrill
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 34' 37'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-1
(Bridge Boring)

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-8	34' - 36'	1 1 1 3	10"	Wet, very loose, gray, FINE SAND AND INORGANIC SILT.	
					37'
C-1	37' - 42'	3 4 11 9 2.5	20"	Hard, slightly fractured, gray, DIORITE Recovery = 20"/ 60" = 33% RQD = 12"/ 60" = 20%	
C-2	42' - 43'2"	3 6/ 2"	6"	Hard, high fractured, gray, DIORITE Recovery = 6"/ 14" = 33% RQD = 0"/ 14" = 0% Core barrel jammed. RQD value is not representative. Boring terminated at 43'2".	43'2"
				Bottom of Exploration @ 43'2"	

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-2 (Bridge Boring) | Page 1/2 | Scale: 1" = 5'

City/Town: Wilmington, MA	Bridge No.: W-38-011	Project File No.: 608051	Contract No.: -
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 1/5/24 8:30 AM	Total Hours:
Groundwater Depth (Feet): 1.75' Date & Time: 1/12/24 9:15 AM		Date & Time Completed: 1/12/24 11:00 AM	**11.5
Coordinates: *N 3,021,101.4 *E 747,605.0	Ground Elevation (Feet): *82.0'	Inspector's Name: James Gu	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Vacuumed and hit ground water stop at 1'-9", no utility found.	
S-1	3' - 5'	6 4 1 1	2"	Wet, loose, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	6.5'
				Roller bit through COBBLE/BOULDER from 6.5' to 9'.	9'
				Core through footing from 9' to 10', 7" recovery.	10'
S-2	10' - 12'	5 7 9 9	17"	Wet, medium dense, gray, FINE TO COARSE SAND, some inorganic silt, trace fine gravel.	11.5'
				Bottom 4", gray, FINE SAND AND INORGANIC SILT.	
S-3	14' - 16'	2 2 2 4	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-4	19' - 21'	2 2 4 3	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	
S-5	24' - 26'	2 2 3 4	16"	Wet, loose, gray, FINE SAND AND INORGANIC SILT.	28'

Notes: * Moved BB-2 6'10" toward drive way due to underground gas pipe.
**Driller: Garrett Peaccok, Helper: Matt Feden on 1/5/24 8:30 AM to 11:00 AM, Rig stop work. Driller: Ken Smith, Helper: Rick Larhette on 1/11/24 8:30 AM to 3:00 PM, 1/12/24 8:30AM to 11:00 AM.
Wilmington PD: 1/5/24 Daryl Ceruolo, John Fortes, 1/11/24 Brian Moon #161, Chris Dindo #170, 1/12/24 Louis Martignetti #153, Paul Jepson #142

Arrow-Board: -
Signs: 2
Cones: 11

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: GT8 GtechDrill
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 44' 45'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, Suite #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Klam@lamsonengineering.com

Boring No. BB-2
(Bridge Boring)

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
S-6	29' - 31'	34 17 25 88	10"	Wet, dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-7	34' - 36'	40 48 34 27	13"	Wet, very dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-8	39' - 41'	29 19 42 71	9"	Wet, very dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
					44'
S-9	44' - 44'2"	120/ 2"	2"	Wet, Refusal, WEATHERED BEDROCK	45'
C-1	45' - 50'	2.5 2.5 2.5 2.5 3	58"	Hard, slightly fractured, white-gray, GRANITE Recovery = 58"/ 60" = 97% RQD = 30"/ 60" = 50%	
C-2	50' - 55'	2.5 2.5 2.5 2.5 3	60"	Hard, slightly fractured, white-gray, GRANITE Recovery = 60"/ 60" = 100% RQD = 50"/ 60" = 83%	
					55'
				Bottom of Exploration @ 55'	

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101

Boring No. BB-3 | Page 1/2

Scale 1" = 5

City/Town: Wilmington	Bridge No.: W-38-011	Project File No: 608051	Contract No.:
Location: Rt 38 over Maple Meadow Brook		Date & Time Started: 2/12/25 12:30 PM	Total Hours:
Groundwater Depth: 4.25'	Date & Time: 2/14/25 1:30 PM	Date & Time Completed: 2/14/25 2:00 PM	12.5
Coordinates: N 3021129.015 E 747602.525	Ground Elevation (Feet): 81.82	Inspector's Name: Edward Mahoney	
Drilling Company: New England Boring Contractors	Driller's Name: Mark D'Ambrosio	Helper's Name: Jack Lefebvre	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes	Elev.
	0'-6"			ASPHALT	6"	
S-1	1'-3'	33 22 15 11	15"	Dry, dense, brown, FINE TO COARSE SAND, some fine to medium gravel (Top 6" Subbase)		80
S-2	5'-7'	4 6 2 2	15"	Moist, loose, brown-dark brown, FINE SAND, some fine to medium gravel, some coarse sand		75
					9'	
S-3	10'-12'	9 11 10 12	7"	Wet, medium dense, gray, FINE SAND, some inorganic silt		70
S-4	15'-17'	3 4 4 5	12"	Wet, loose, gray, FINE SAND, some inorganic silt		65
S-5	20'-21'10"	2 3 3 3	14"	Wet, loose, gray, FINE SAND, some inorganic silt		60
S-6	25'-27'	3 4 3 5	13"	Wet, loose, gray, FINE SAND, some inorganic silt		55
S-7	30'-32'	2 2 3 3	15"	Wet, loose, gray, FINE SAND, some inorganic silt		

Notes: 2-Wilmington police details on 2/13/25 & 2/14/25

Arrow Board:-
Signs:-
Cones:- 10

Protective Device Stand:- Box:-
Well Depth:- Solid Pipe:-
Stick Up Pipe:- Screen Pipe:-

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and=40-50%,some=10-40%,trace=10% or less

Type of Drill Rig: GT8 (Truck)
Hammer Weight: 140 lbs Fall: 30"
Casing Types: Drive Spin
Size: 4" 3"
Depth: 40' 47'
Sampler Type: SS Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15"

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101

Boring No. BB-3

Scale 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes	Elev.
S-8	35'-37'	22 24 21 17	13"	Wet, dense, gray, FINE TO COARSE SAND, some fine to medium gravel, trace of inorganic silt		50
S-9	40'-42'	32 21 28 72	12"	Wet, dense, brown-black, FINE SAND, some coarse sand, trace of inorganic silt		45
				Top of Weathered Bedrock	45'6"	40
S-10	45'6"-45'9"	50/3	3"	Wet, very dense, gray-black, WEATHERED BEDROCK Rollerbit to 47'	47'	
C-1	47'-52'	3 4 4 4 5	55"	Moderately hard, highly fractured (angular) and core breaks, black-gray, SANDSTONE-DIORITE Recovery - 55"/60" = 92% RQD - 18"/60" = 30%		35
C-2	52'-57'	3.5 3.5 3.5 7 4.5	60"	Moderately hard, highly fractured and core breaks, gray-brown, DIORITE Recovery - 60"/60" = 100% RQD - 0"/60" = 0%		30
					57'	25
				Bottom of Exploration @ 57'		20
						15
						10
						5

massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101

Boring No. BB-4 | Page 1/2

Scale 1" = 5 '

City/Town: Wilmington	Bridge No.:W-38-011	Project File No: 608051	Contract No.:
Location: Rt 38 over Maple Meadow Brook		Date & Time Started: 2/11/25 9:30 AM	Total Hours:
Groundwater Depth: 8.25'	Date & Time: 2/12/25 12:00 PM	Date & Time Completed: 2/12/25 12:30PM	8.5
Coordinates:N 3021115.870 E 747615.106	Ground Elevation (Feet): 82.64	Inspector's Name: Edward Mahoney	
Drilling Company: New England Boring Contractors	Driller's Name: Mark D'Ambrosio	Helper's Name: Tyler Vigeant	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes	Elev.
	0'-6"			ASPHALT	6"	
S-1	1'-3'	74 53 26 18	16"	Moist, very dense (frozen), brown, FINE TO COARSE SAND, some fine to coarse gravel (Top 6" Subbase)		80
S-2	5'-7'	3 1 2 1	19"	Wet, very loose, brown-dark brown, FINE SAND, trace of fine gravel, (Pockets of Peat and Wood)	7'	
				Peat in wash		75 ▽
S-3	10'-12'	4 10 11 7	17"		10'6"	
				Wet, medium dense, gray, FINE SAND (Top 6" brown Peat)		70
S-4	15'-17'	4 6 5 5	13"	Wet, medium dense, gray, FINE SAND, some inorganic silt		65
S-5	20'-22'	3 4 4 4	14"	Wet, loose, gray, FINE SAND, some inorganic silt		60
S-6	25'-27'	3 3 3 2	14"	Wet, loose, gray, FINE SAND, some inorganic silt		55
S-7	30'-32'	2 2 6 11	10"	Wet, loose, gray, FINE SAND, some inorganic silt		

Notes: Changed location from N:3021115.870 E:747603.305 to N: E: due to culvert & overhead wires
2-Wilmington police details on 2/11/25 & 2/12/25 Helper - Garrett Peacock

Arrow Board:-
Signs:-
Cones:- 10

Protective Device Stand:- Box:-
Well Depth:- Solid Pipe:-
Stick Up Pipe:- Screen Pipe:-

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and=40-50%,some=10-40%,trace=10% or less

Type of Drill Rig: GT8 (Truck)

Hammer Weight: 140 lbs Fall: 30"
Casing Types: Drive Spin
Size: 4" 3"
Depth: 40' 43'

Sampler Type: SS Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"

Core Barrel Type: NX Size: 2.15"

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101

Boring No. BB-4

Scale 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes	Elev.
S-8	35'-37'	22 29 15 14	7"	Wet, dense, gray, FINE TO COARSE SAND, trace of fine to medium gravel, trace of inorganic silt		50 45
S-9	40'-40'6"	38 60/0	6"	Wet, very dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, some inorganic silt Top of Bedrock Rollerbit to 43'	40'6"	40
C-1	43'-48'	3.5 3.5 3.5 4 5	60"	Hard, slight angular fractures and core breaks, gray-white, DIORITE Recovery - 60"/60" = 100% RQD - 57"/60" = 95%		35
C-2	48'-53'	3 2.5 3 3 5	60"	Hard, highly fractured and core breaks, gray-white, DIORITE Recovery - 58"/60" = 97% RQD - 25"/60" = 42%		30
				Bottom of Exploration @ 53'	53'	25 20 15 10

Moving Massachusetts Forward massDOT Highway

Probe Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E Mail: Lamsoneng@msn.com

Probe No. PS-1

Page 1/1

City/Town: Wilmington	Bridge No.: W-38-011	Project File No.: 608051	Contract No.:
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 1:00 PM 1/9/24	Total Hours: 2
Coordinates: N 3,021,112.1 E 747,590.2	Ground Elev.(Feet): 81.9'	Date & Time Completed: 3:00 PM 1/9/24	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	
Inspector's Name: James Gu	Type of Drill Rig: GT8 GtechDrill	Drill Rods/Solid Augers: 1.5" Drill Rods	Type: Size: Hammer:

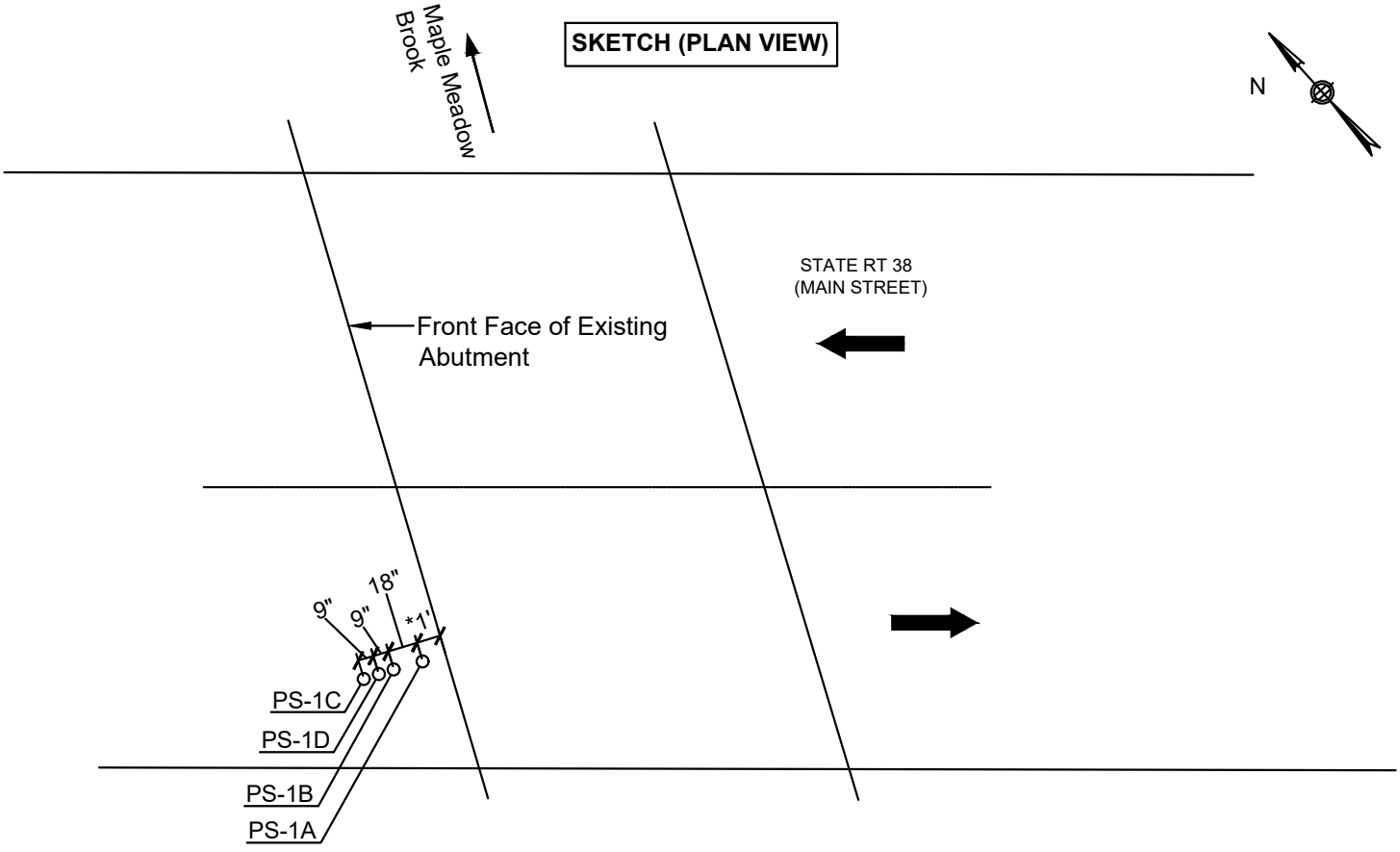
INFORMATION LOG

Probe Number	Depth	Distance from Face of the Structure*	Refusal or Required Depth
PS-1A	2'- 7.5"	12"	Refusal
PS-1B	4'- 3.5"	30"	Refusal**
PS-1C	20'	48"	Required Depth
PS-1D	10'	39"	Refusal**

Probe Number	Depth	Distance from Face of the Structure*	Refusal or Required Depth

Remarks: Coordinates and ground elevation are for probe PS-1A.
*Due to unknown skewed angle "Distance from Face of the Structure" is approximated.
**PS-1B & PS-1D slide outward and stop at refusal, depth data is not representative.
Wilmington Police Detail: Robert DeGregorio #223, John Fortes #228

SKETCH (PLAN VIEW)



Summary: -
-

massDOT Highway
Probe Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E Mail: Lamsoneng@msn.com

Probe No. PS-2

Page 1/1

City/Town: Wilmington	Bridge No.: W-38-011	Project File No.: 608051	Contract No.:
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 8:30 PM 1/9/24	Total Hours: 4.5
Coordinates: N 3,021,100.2 E 747,603.3	Ground Elev.(Feet): 82.0'	Date & Time Completed: 1:00 PM 1/9/24	
Drilling Company: New England Boring Contractors	Driller's Name: Ken Smith	Helper's Name: Rick Larhette	
Inspector's Name: James Gu	Type of Drill Rig: GT8 GtechDrill	Drill Rods/Solid Augers: 1.5" Drill Rods	Type: Size: Hammer:

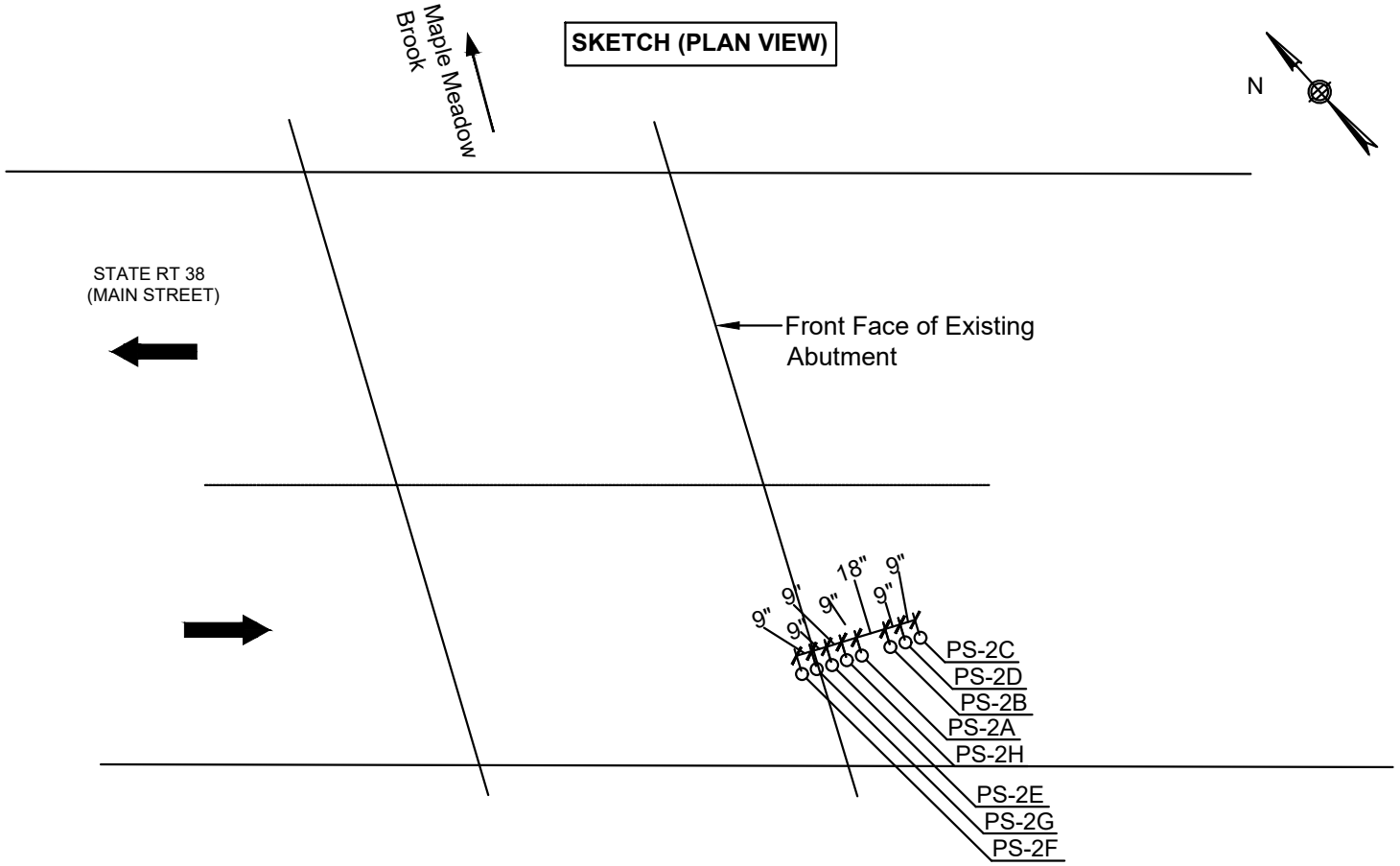
INFORMATION LOG

Probe Number	Depth	Distance from Face of the Structure*	Refusal or Required Depth
PS-2A	7'- 6"	2'- 2"	Refusal
PS-2B	6'- 6"	3'- 8"	Refusal
PS-2C	20'	5'- 2"	Required Depth
PS-2D	6'- 6"	4'- 5"	Refusal

Probe Number	Depth	Distance from Face of the Structure*	Refusal or Required Depth
PS-2E	1'- 6"	8"	Refusal
PS-2F	1'- 6"	-10"	Refusal
PS-2G	1'- 6"	-1"	Refusal
PS-2H	2'- 7"	1'- 5"	Refusal

Remarks: Coordinates and ground elevation are for probe PS-2A.
*Due to unknown skewed angle "Distance from Face of the Structure" is approximated.
Wilmington Police Detail: Robert DeGregorio #223, John Fortes #228

SKETCH (PLAN VIEW)



Summary: -
-

Vacuumed Hole Log	LAMSON ENGINEERING CORPORATION 437 Cherry Street, Suite #109, Newton, Massachusetts 02465 Phone: (617) 558-0101 E Mail: Klam@lamsonengineering.com	Test Pit No. VH-1

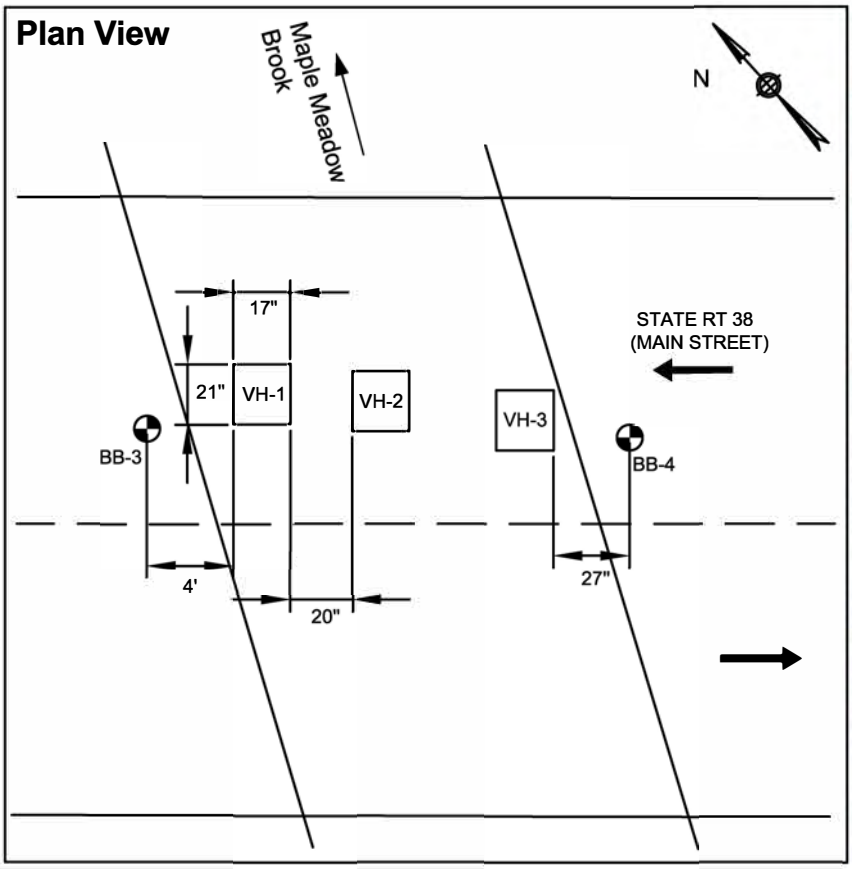
City/Town: Wilmington, MA	Bridge No. : W-38-011	Project File No. : 608051	
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 9:45 AM 12/19/23	Total Hours: 0.75
Coordinates: N N/A E N/A	Ground Elev.(Ft): N/A	Date & Time Completed: 10:30 AM 12/19/23	
Excavating Company: New England Boring Contractors	Operator's Name: Sam Cooley	Helper's Name: Adam Ford	
Inspector's Name: James Gu	Equipment Used: Vacuum Truck		

INFORMATION LOG

Depth Range	Field Description	Strata Changes
0" to 6"	Pavement structure 6" total	0' - 6"
6" to 1' - 10"	Dry, Fine to Coarse Sand, some Fine to Coarse Gravel, trace Inorganic Silt	1' - 10"
		Hit concrete, bottom of Vacuumed Hole

Remark: Plice Detail's Name: John Fortes #228 & Jonathan Morales #224, 8:30 AM to 3:00 PM 12/19/23.
Hole locations are determined by Green International Engineer: Alex Tsoukales.

SKETCHES & PICTURES





Comments: The Vacuumed Hole is used instead of a test pit. The hole was backfilled with gravel and sand, then finished with Asphalt on top with hand compactor used.

Vacuumed Hole Log	LAMSON ENGINEERING CORPORATION 437 Cherry Street, Suite #109, Newton, Massachusetts 02465 Phone: (617) 558-0101 E Mail: Klam@lamsonengineering.com	Test Pit No. VH-2

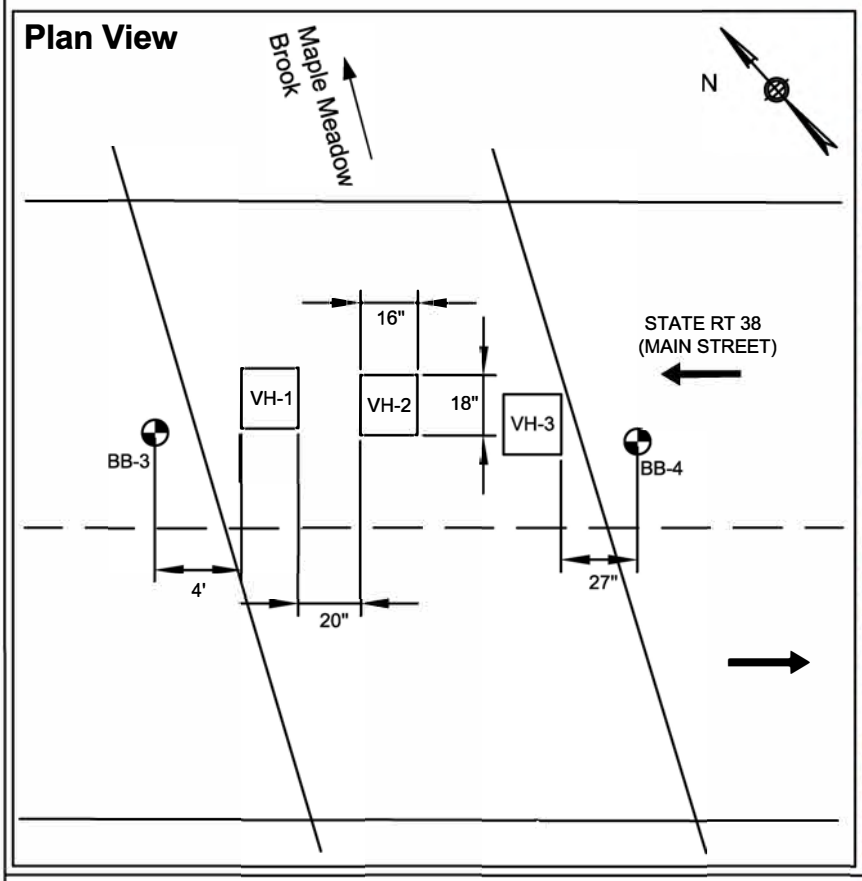
City/Town: Wilmington, MA	Bridge No. : W-38-011	Project File No. : 608051	
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 10:30 AM 12/19/23	Total Hours: 0.75
Coordinates: N N/A E N/A	Ground Elev.(Ft): N/A	Date & Time Completed: 11:15 AM 12/19/23	
Excavating Company: New England Boring Contractors	Operator's Name: Sam Cooley	Helper's Name: Adam Ford	
Inspector's Name: James Gu	Equipment Used: Vacuum Truck		

INFORMATION LOG

Depth Range	Field Description	Strata Changes
0" to 6"	Pavement structure 6" total	0' - 6"
6" to 2' - 1"	Dry, Fine to Coarse Sand, some Fine to Coarse Gravel, trace Inorganic Silt	2' - 1"
		Hit concrete, bottom of Vacuumed Hole

Remark: Plice Detail's Name: John Fortes #228 & Jonathan Morales #224, 8:30 AM to 3:00 PM 12/19/23.
Hole locations are determined by Green International Engineer: Alex Tsoukales.

SKETCHES & PICTURES





Comments: The Vacuumed Hole is used instead of a test pit. The hole was backfilled with gravel and sand, then finished with Asphalt on top with hand compactor used.

Vacuumed Hole Log	LAMSON ENGINEERING CORPORATION 437 Cherry Street, Suite #109, Newton, Massachusetts 02465 Phone: (617) 558-0101 E Mail: Klam@lamsonengineering.com	Test Pit No. VH-3

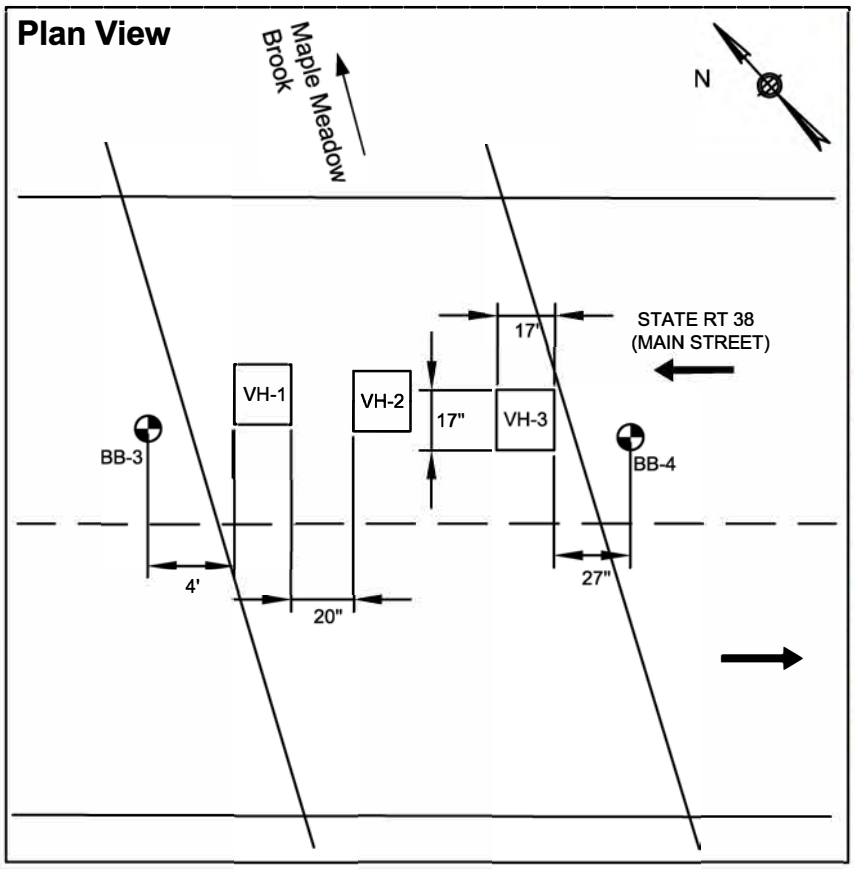
City/Town: Wilmington, MA	Bridge No. : W-38-011	Project File No. : 608051	
Location: ST Route 38 (Main Street) over Maple Meadow Brook		Date & Time Started: 11:15 AM 12/19/23	Total Hours: 0.75
Coordinates: N N/A E N/A	Ground Elev.(Ft): N/A	Date & Time Completed: 12:00 PM 12/19/23	
Excavating Company: New England Boring Contractors	Operator's Name: Sam Cooley	Helper's Name: Adam Ford	
Inspector's Name: James Gu	Equipment Used: Vacuum Truck		

INFORMATION LOG

Depth Range	Field Description	Strata Changes
0" to 6"	Pavement structure 6" total	0' - 6"
6" to 2' - 0"	Dry, Fine to Coarse Sand, some Fine to Coarse Gravel, trace Inorganic Silt	2' - 0
		Hit concrete, bottom of Vacuumed Hole

Remark: Plice Detail's Name: John Fortes #228 & Jonathan Morales #224, 8:30 AM to 3:00 PM 12/19/23.
Hole locations are determined by Green International Engineer: Alex Tsoukales.

SKETCHES & PICTURES





Comments: The Vacuumed Hole is used instead of a test pit. The hole was backfilled with gravel and sand, then finished with Asphalt on top with hand compactor used.

APPENDIX 2

Calculations

Calculations Index

Description	Page
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Lpile Analysis - Abutments	16
Lpile Analysis - Wingwalls	75
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LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Summary of Micropile Resistance	Checked by:	JG	Date:	11/2025

Summary of Micropile Resistance

Based on BB-1,

Steel Casing: 10.75 in. O.D. x 0.595 in., Fy = 52 ksi, Wall Thickness = 0.595 in.

Steel Reinforcing Bar: #14, Threaded, Grade 60

Compressive strength of micropile grout at 28 days: f'c = 5 ksi

Rock Socket Diameter = 9.3 in.

Design Factored Axial Load per Pile	= 195.3 kips	(from Green)
Estimated Bonded Length into Rock (Grout into Rock)	= 7.0 ft.	
Plunge Length (Casing into Rock)	= 1.0 ft.	
Nominal Geotechnical Pile Resistance per Pile	= 491 kips	
Side Resistance Factor, φ_{stat}	= 0.55	
Factored Geotechnical Pile Resistance per Pile	= 270 kips	> 195.3 k OK
Nominal Uplift Resistance per Pile	= 245 kips	
Resistance Factor, φ_{up}	= 0.55	
Factored Uplift Resistance per Pile	= 135 kips	
Nominal Structural Pile Resistance per Pile	= 1097 k	(Portion of Cased Length)
Nominal Structural Pile Resistance per Pile	= 352 k	(Portion of Uncased Length)
Compression Resistance Factor, φ_C	= 0.75	
Factored Structural Pile Resistance per Pile	= 823 k	(Portion of Cased Length)
Factored Structural Pile Resistance per Pile	= 264 k	(Portion of Uncased Length)

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Summary of Micropile Resistance	Checked by:	JG	Date:	11/2025

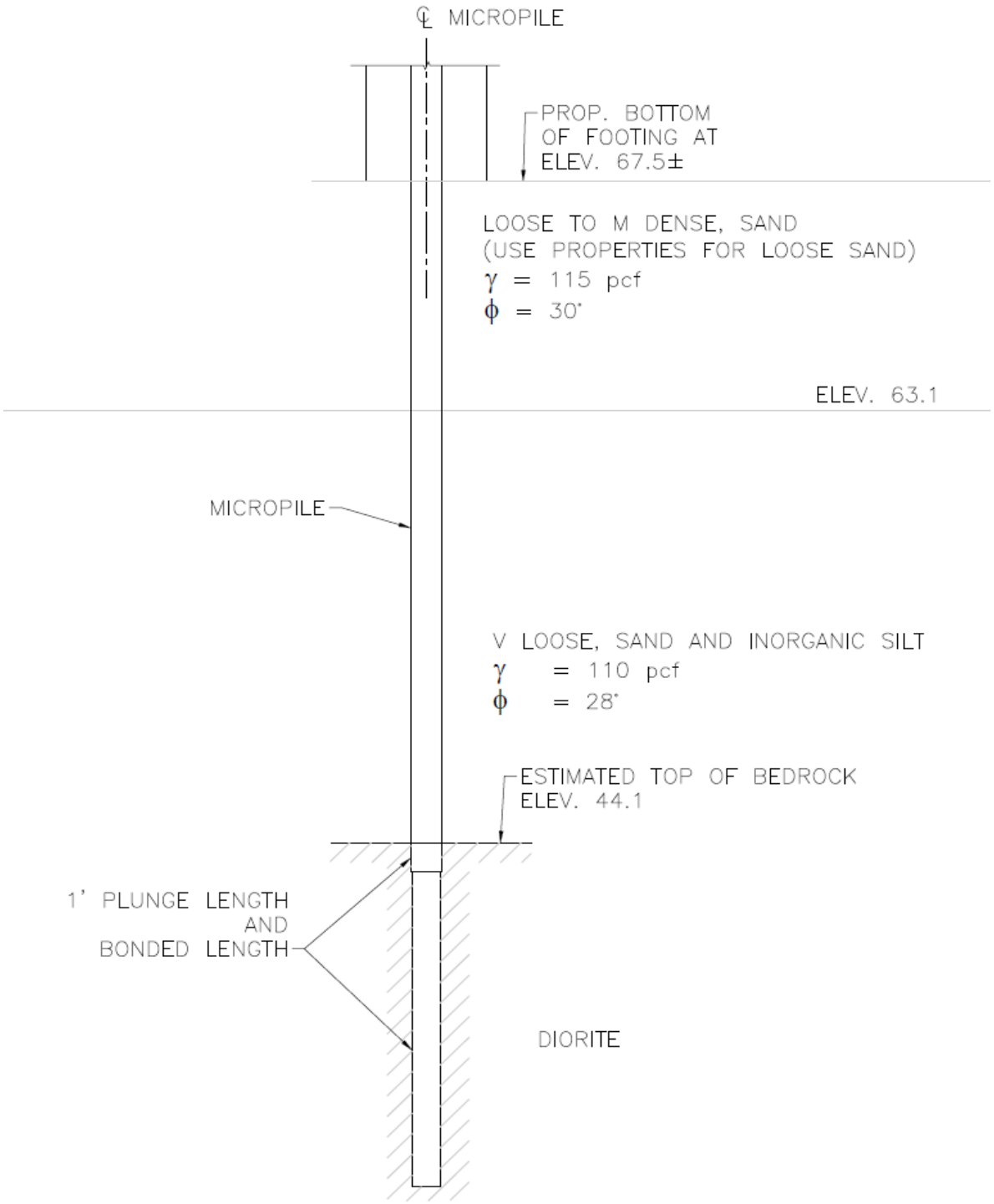
Summary of Micropile Resistance

Nominal Tension Resistance	= 995 k	(Portion of Cased Length)
Nominal Tension Resistance	= 135 k	(Portion of Uncased Length)
Tension Resistance Factor, φ_T	= 0.80	
Factored Tension Resistance	= 796 k	(Portion of Cased Length)
Factored Tension Resistance	= 108 k	(Portion of Uncased Length)

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Subject:	10.75 dia.Micropile	**Prepared by:**	JJL	**Date:**	11/2025
Detail:	Micropile Section	**Checked by:**	JG	**Date:**	11/2025

Micropile Section

(Based on controlling boring BB-1)



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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Lateral Earth Pressure Coefficient	Checked by:	JG	Date:	11/2025

Lateral Earth Pressure Coefficient

Effective angle of internal friction ϕ'_f	=	32	degree
Friction angle between fill and wall, δ	=	21	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	90	degree

Active pressure coefficient, K_a

$$= \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta)\left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2}$$

$$= 0.275$$

At-rest pressure coefficient, K_o

$$= 1 - \sin\phi'_f = 1 - \sin(32)$$

$$= 0.470$$

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Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

R_R = Factored Resistance of a micropile

= φR_n = $\varphi_{qp} R_p + \varphi_{qs} R_s$

in which:

R_p = $q_p A_p$ (tip resistance is neglected)

R_s = $q_s A_s$

where:

R_p = nominal tip resistance
(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

R_s = nominal grout to ground bond resistance

φ_{qp} = resistance factor for tip resistance (AASHTO 10.5.5.2.5-1)
(tip resistance is neglected)

φ_{qs} = resistance factor for grout-to-ground resistance (AASHTO 10.5.5.2.5-1)
= 0.55

d_p = diameter of micropile tip
= 9.300 in.

A_p = area of micropile tip = $\pi D^2/4$
= 67.93 $in.^2$ = 0.47 ft^2

R_s = $\pi d_b \alpha_b L_b$

in which:

d_b = diameter of micropile drill hole through bonded length
= 9.300 in. = 0.78 ft

α_b = nominal micropile grout-to-ground bond strength

= 28.8 ksf Based on slightly fractured, hard, diorite from Boring BB-1
(AASHTO Table C10.9.3.5.2 - 1)

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Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

L_b = micropile bonded length

= 7 ft into Rock

$\varphi_{qs} R_s$ = 0.55 x 3.141 x 0.78 x [28.8 x 7]

= 270.0 kips

R_n = 269.96 / 0.55 = 491 kips

R_R = 270 kips

Uplift Resistance

Uplift Resistance = 50 % of the compression resistance

= 0.5 x 270 = 135 kips

φ_{up} = resistance factor

= 0.55 (AASHTO 10.5.5.2.5-1)

Nominal Resistance = 135 / 0.55 = 245 kips

Structural Resistance

Axial Compression Resistance

R_C = Factored Structural Resistance of a micropile

= $\varphi_c R_n$

in which:

φ_C = compression resistance factor

= 0.75 (AASHTO 10.5.5.2.5-2)

R_n = Nominal axial compression resistance

- For the cased length

F_y = 52 ksi

f_y = 60 ksi

R_n = 0.85 [0.85 f'_c A_g + f_y (A_b + A'_c)]

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Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

where:

f'_c = specified compressive strength of micropile grout at 28 days

= 5.0 ksi

f_y = specified minimum yield strength of reinforcement bar or steel casing, or stress in steel reinforcement bar or casing at a strain of 0.003, whichever is less

Min. (F_y , f_y) = 52.0 ksi

d_b = 1.69 in. #14 threaded bar

A_b = cross-section area of steel reinforcing bar

= 2.25 $in.^2$

A_c = cross-section area of steel casing

= 18.98 $in.^2$

A'_c = cross-section area of steel casing with 1/16" section loss on outside of the casing

= 16.88 $in.^2$ Section loss = 0.063 in.

A_g = cross-section area of grout within micropile

= $A_{ID} - A_b$ = 71.78 - 2.25

= 69.53 $in.^2$

R_n = 0.85 x [0.85 x 5 x 69.53 + 52 x (2.25 + 16.88)]

= 1096.9 kips

R_{CC} = 0.75 x 1096.9 = 823 kips

- For the uncased length

R_n = 0.85 [0.85 f'_c A'_g + f_y A_b]

f_y = specified minimum yield strength of reinforcement bar or stress in steel reinforcement bar at a strain of 0.003, whichever is less

= 60.0 ksi

= 60 ksi

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Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

A'_g = cross-section area of grout for the uncased length

= $A_p - A_b$ = 67.93 - 2.25

= 65.68 $in.^2$

R_n = 0.85 x [0.85 x 5 x 65.68 + 60 x 2.25]

= 352.1 kips

R_{CU} = 0.75 x 352.1 = 264 kips

Axial Tension Resistance

R_T = factored Structural Resistance of a micropile

= $\varphi_T R_n$

in which:

φ_T = tension resistance factor

= 0.80 (AASHTO 10.5.5.2.5-2)

R_n = nominal axial tension resistance

- For the cased length

R_n = $f_y (A_b + A'_c)]$

= 52 x (2.25 + 16.88) = 995.0 kips

R_{TC} = 0.8 x 995 = 796 kips

- For the uncased length

R_n = $f_y A_b$

= 60 x 2.25 = 135.1 kips

R_{TU} = 0.8 x 135.1 = 108 kips

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	**Job No:**		**Preliminary Sheet No:**	
Subject:	10.75 dia.Micropile	**Prepared by:**	JJL	**Date:**	11/2025
Detail:	Micropile Vertical Resistance	**Checked by:**	JG	**Date:**	11/2025

Soil/Rock Description	Typical Range of Grout-to-Ground Bond Nominal Resistance for Micropile Types[1] (ksf)				
	Type A	Type B	Type C	Type D	Type E
Silt & Clay (some sand) (soft medium plastic)	0.7–1.4	0.7–2.0	0.7–2.5	0.7–3.0	0.7–2.0
Silt & Clay (some sand) (stiff, dense to very dense)	0.7–2.5	1.4–4.0	2.0–4.0	2.0–4.0	1.4–4.0
Sand (some silt) (fine, loose-medium dense)	1.4–3.0	1.4–4.0	2.0–4.0	2.0–5.0	1.4–5.0
Sand (some silt, gravel) (fine-coarse, medium-very dense)	2.0–4.5	2.5–7.5	3.0–7.5	3.0–8.0	2.5–7.5
Gravel (some sand) (medium-very dense)	2.0–5.5	2.5–7.5	3.0–7.5	3.0–8.0	2.5–7.5
Glacial Till (silt, sand, gravel) (medium-very dense, cemented)	2.0–4.0	2.0–6.5	2.5–6.5	2.5–7.0	2.0–6.5
Soft Shales (fresh-moderate fracturing, little to no weathering)	4.3–11.5	N/A	N/A	N/A	N/A
Slates and Hard Shales (fresh-moderate fracturing, little to no weathering)	10.8–28.8	N/A	N/A	N/A	N/A
Limestone (fresh-moderate fracturing, little to no weathering)	21.6–43.2	N/A	N/A	N/A	N/A
Sandstone (fresh-moderate fracturing, little to no weathering)	10.8–36.0	N/A	N/A	N/A	N/A
Granite and Basalt (fresh-moderate fracturing, little to no weathering)	28.8–87.7	N/A	N/A	N/A	N/A

Based on Boring BB-1, the rock core is slightly fractured, hard, diorite. Geologically, diorite is between a grabbro and a granite. Use the lower bond value for granite and basalt bond resistance of 28.8 ksf for conservative. The micropile resistance will be verified by load tests.

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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

A_{sc}: compression area of steel tube A_{bc}: compression area of reinforcement if present
A_{cc}: compression area of concrete infill A_{st}: tension area of steel tube, A_{bt}: tension area of reinforcement

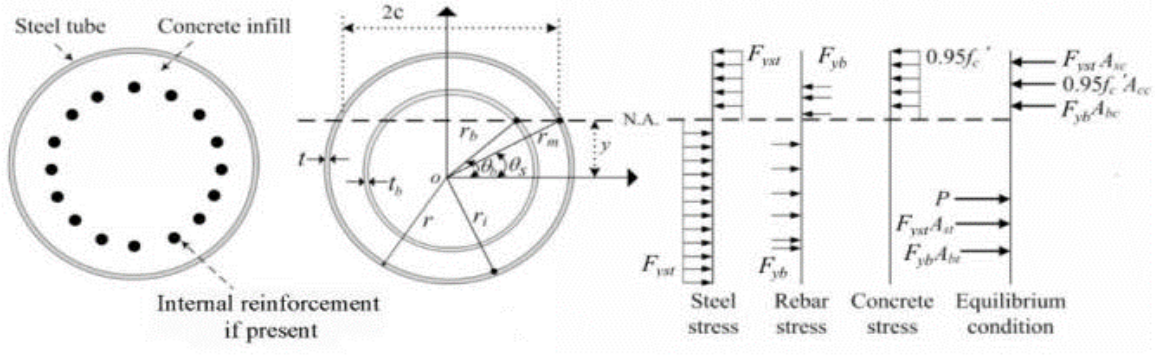


Figure C6.12.2.3.3-1—PSDM Model

$$P_n = F_{yst} t r_m \left[\left(\pi - 2\theta_s \right) - \left(\pi + 2\theta_s \right) \right] + t_b r_b \left[F_{yb} \left(\pi - 2\theta_b \right) - \left(F_{yb} - 0.95 f'_c \right) \left(\pi + 2\theta_b \right) \right] + \frac{0.95 f'_c}{2} \left[\left(\pi - 2\theta_s \right) r_i^2 - 2yc \right] \quad \text{(C6.12.2.3.3-1)}$$

$$M_n = 0.95 f'_c c \left[\left(r_i^2 - y^2 \right) - \frac{c^2}{3} \right] + 4 F_{yst} t c \frac{r_m^2}{r_i} + 4 F_{yb} t_b c_b r_b \quad \text{(C6.12.2.3.3-2)}$$

in which:

$$r_m = r - \frac{t}{2} \quad \text{(C6.12.2.3.3-3)}$$

$$\theta_s = \sin^{-1}\left(\frac{y}{r_m} \right) \quad \text{(C6.12.2.3.3-4)}$$

$$\theta_b = \sin^{-1}\left(\frac{y}{r_b} \right) \quad \text{(C6.12.2.3.3-5)}$$

$$c = r_i \cos\theta_s \quad \text{(C6.12.2.3.3-6)}$$

$$c_b = r_b \cos\theta_b \quad \text{(C6.12.2.3.3-7)}$$

$$t_b = \frac{n A_b}{2\pi r_b} \quad \text{(C6.12.2.3.3-8)}$$

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Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

Steel Pipe with 1/16" loss

Yield Strength, F_{yst} = 52.00 ksi

Strength of Concrete, f'_c = 5.00 ksi

Resistance factor for CFST in compression, ϕ_c = 0.90 (AASHTO 6.5.4.2)

Yield Strength, F_{yb} = 60.00 ksi

(AASHTO 6.9.6.2 Limitations) D/t = 20.0 < 0.15 E / F_{yst} = 83.7 **OK**

Concrete shall be greater than 3 ksi or 0.075 F_{yst} = 3.9 ksi < 5.00 ksi **OK**

A_s =	2.25	in^2	Cover =	3.93	in.
r =	5.313	in.	D =	10.63	in.
r_m =	5.046	in.	t =	0.53	in.
r_i =	4.780	in.			
r_b =	0.423	in.			

Number of reinforcing bars, n = 1.0

t_b = n A_s / (2 π r_b) = 0.376 in.

Abutments

Strength I

			Factored Moment Capacity =	236.0	k-ft
Factored Moment =	103.6 k-ft	from Lpile	Factored Lateral Resistance =	37.7	k from Lpile
Factored Axial Load =	195.3 k	from Green	Factored Lateral Load =	19.7	k from Green

Service I

Factored Moment =	73.1 k-ft	from Lpile	Service Lateral Resistance =	27.6	k from Lpile
Factored Axial Load =	145.1 k	from Green	Unfactored Lateral Load =	14.7	k from Green

Extreme I

			Factored Moment Capacity =	263.0	k-ft
Factored Moment =	72.7 k-ft	from Lpile	Factored Lateral Resistance =	42.0	k from Lpile
Factored Axial Load =	127.5 k	from Green	Factored Lateral Load =	14.6	k from Green

Wingwalls

Strength I

			Factored Moment Capacity =	236.0	k-ft
Factored Moment =	203.4 k-ft	from Lpile	Factored Lateral Resistance =	38.2	k from Lpile
Factored Axial Load =	143.2 k	from Green	Factored Lateral Load =	34.1	k from Green

Service I

Factored Moment =	129.1 k-ft	from Lpile	Service Lateral Resistance =	27.6	k from Lpile
Factored Axial Load =	95.6 k	from Green	Unfactored Lateral Load =	24.2	k from Green

Extreme II

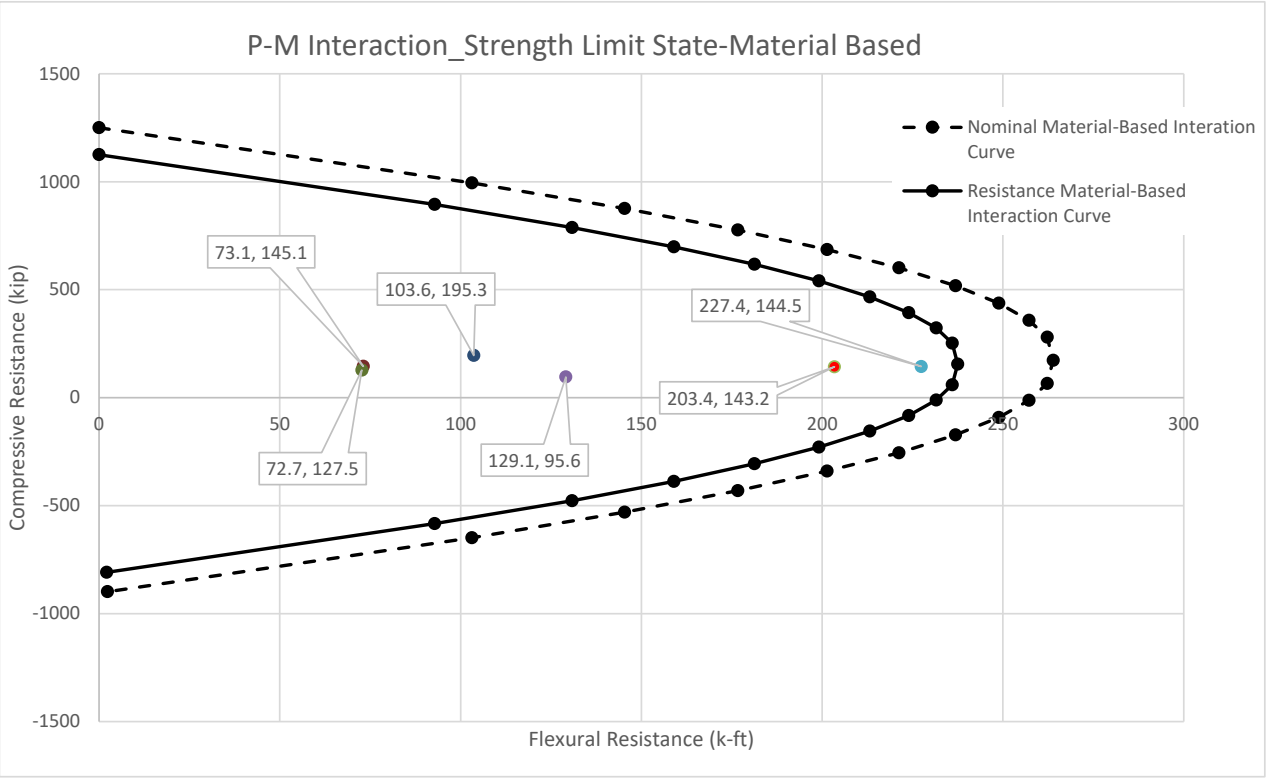
			Factored Moment Capacity =	263.0	k-ft
Factored Moment =	227.4 k-ft	from Lpile	Factored Lateral Resistance =	42.0	k from Lpile
Factored Axial Load =	144.5 k	from Green	Factored Lateral Load =	37.1	k from Green

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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2\,\theta_s$	$\pi + 2\,\theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c\, M_n$ (kips-ft)	$\phi_c\ P_n$ (kips)
-5.05	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	1250.10	0.00	1125.09
-4.54	-1.12	-1.57	2.08	0.00	5.38	0.90	103.09	994.01	92.78	894.61
-4.04	-0.93	-1.57	2.87	0.00	5.00	1.29	145.35	875.59	130.81	788.03
-3.53	-0.78	-1.57	3.41	0.00	4.69	1.59	176.62	776.48	158.95	698.83
-3.03	-0.64	-1.57	3.82	0.00	4.43	1.85	201.36	686.17	181.23	617.55
-2.52	-0.52	-1.57	4.14	0.00	4.19	2.09	221.20	600.76	199.08	540.68
-2.02	-0.41	-1.57	4.38	0.00	3.96	2.32	236.88	518.34	213.19	466.50
-1.51	-0.30	-1.57	4.56	0.00	3.75	2.53	248.81	437.82	223.93	394.04
-1.01	-0.20	-1.57	4.68	0.00	3.54	2.74	257.20	358.51	231.48	322.66
-0.50	-0.10	-1.57	4.76	0.00	3.34	2.94	262.20	279.92	235.98	251.93
0.00	0.00	0.00	4.78	0.42	3.14	3.14	263.86	172.85	237.47	155.57
0.50	0.10	1.57	4.76	0.00	2.94	3.34	262.20	65.78	235.98	59.21
1.01	0.20	1.57	4.68	0.00	2.74	3.54	257.20	-12.81	231.48	-11.53
1.51	0.30	1.57	4.56	0.00	2.53	3.75	248.81	-92.12	223.93	-82.90
2.02	0.41	1.57	4.38	0.00	2.32	3.96	236.88	-172.63	213.19	-155.37
2.52	0.52	1.57	4.14	0.00	2.09	4.19	221.20	-255.05	199.08	-229.54
3.03	0.64	1.57	3.82	0.00	1.85	4.43	201.36	-340.46	181.23	-306.42
3.53	0.78	1.57	3.41	0.00	1.59	4.69	176.62	-430.78	158.95	-387.70
4.04	0.93	1.57	2.87	0.00	1.29	5.00	145.35	-529.88	130.81	-476.89
4.54	1.12	1.57	2.08	0.00	0.90	5.38	103.09	-648.30	92.78	-583.47
5.05	1.56	1.57	0.05	0.00	0.02	6.26	2.30	-898.86	2.07	-808.98

Steel Pipe with 1/16" loss



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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

A_{sc}: compression area of steel tube A_{bc}: compression area of reinforcement if present
A_{cc}: compression area of concrete infill A_{st}: tension area of steel tube, A_{bt}: tension area of reinforcement

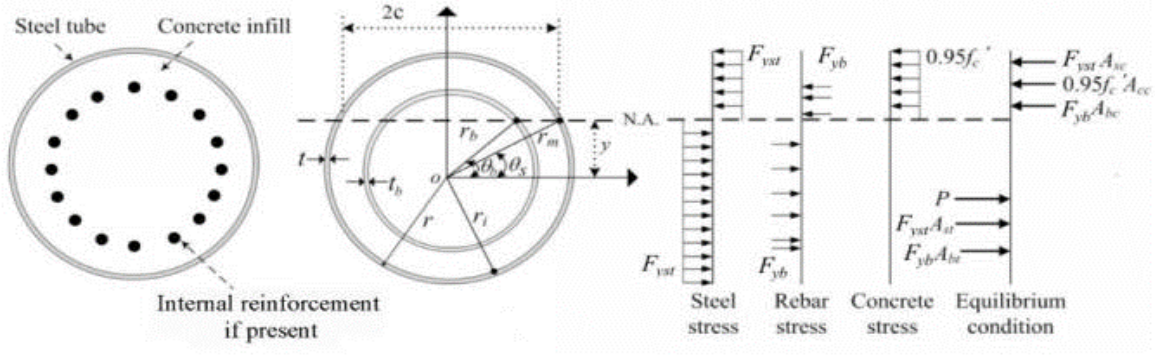


Figure C6.12.2.3.3-1—PSDM Model

$$P_n = F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] + t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95 f'_c)(\pi + 2\theta_b) \right] + \frac{0.95 f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right] \quad \text{(C6.12.2.3.3-1)}$$

$$M_n = 0.95 f'_c c \left[\left(r_i^2 - y^2 \right) - \frac{c^2}{3} \right] + 4 F_{yst} t c \frac{r_m^2}{r_i} + 4 F_{yb} t_b c_b r_b \quad \text{(C6.12.2.3.3-2)}$$

in which:

$$r_m = r - \frac{t}{2} \quad \text{(C6.12.2.3.3-3)}$$

$$\theta_s = \sin^{-1}\left(\frac{y}{r_m} \right) \quad \text{(C6.12.2.3.3-4)}$$

$$\theta_b = \sin^{-1}\left(\frac{y}{r_b} \right) \quad \text{(C6.12.2.3.3-5)}$$

$$c = r_i \cos\theta_s \quad \text{(C6.12.2.3.3-6)}$$

$$c_b = r_b \cos\theta_b \quad \text{(C6.12.2.3.3-7)}$$

$$t_b = \frac{n A_b}{2\pi r_b} \quad \text{(C6.12.2.3.3-8)}$$

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

Steel Pipe at Threaded Casing Joint (Consider wall thickness reduced to 50%)

Yield Strength, F_{yst} = 52.00 ksi

Strength of Concrete, f'_c = 5.00 ksi

Resistance factor for CFST in compression, ϕ_c = 0.90 (AASHTO 6.5.4.2)

Yield Strength, F_{yb} = 60.00 ksi

(AASHTO 6.9.6.2 Limitations) D/t = 35.7 < 0.15 E / F_{yst} = 83.7 **OK**

Concrete shall be greater than 3 ksi or 0.075 F_{yst} = 3.9 ksi < 5.00 ksi **OK**

A_s = 2.25 in^2 Cover = 3.934 in.

r = 5.078 in. D = 10.155 in.

r_m = 4.929 in. t = 0.298 in.

r_i = 4.780 in.

r_b = 0.000 in. Internal reinforcement is not considered.

Number of reinforcing bars, n = 1.0

t_b = n A_s / (2 π r_b) = 0 in.

Abutments

Strength I

Factored Moment = 45.0 k-ft from Lpile (at depth of 3')

Factored Axial Load = 195.3 k from Green Factored Lateral Load = 19.7 k from Green

Service I

Factored Moment = 30.3 k-ft from Lpile (at depth of 3')

Factored Axial Load = 145.1 k from Green Factored Lateral Load = 14.7 k from Green

Extreme I

Factored Moment = 30.0 k-ft from Lpile (at depth of 3')

Factored Axial Load = 127.5 k from Green Factored Lateral Load = 14.6 k from Green

Wingwalls

Strength I

Factored Moment = 101.1 k-ft from Lpile (at depth of 3')

Factored Axial Load = 143.2 k from Green Factored Lateral Load = 34.1 k from Green

Service I

Factored Moment = 57.7 k-ft from Lpile (at depth of 3')

Factored Axial Load = 95.6 k from Green Factored Lateral Load = 24.2 k from Green

Extreme II

Factored Moment = 115.7 k-ft from Lpile (at depth of 3')

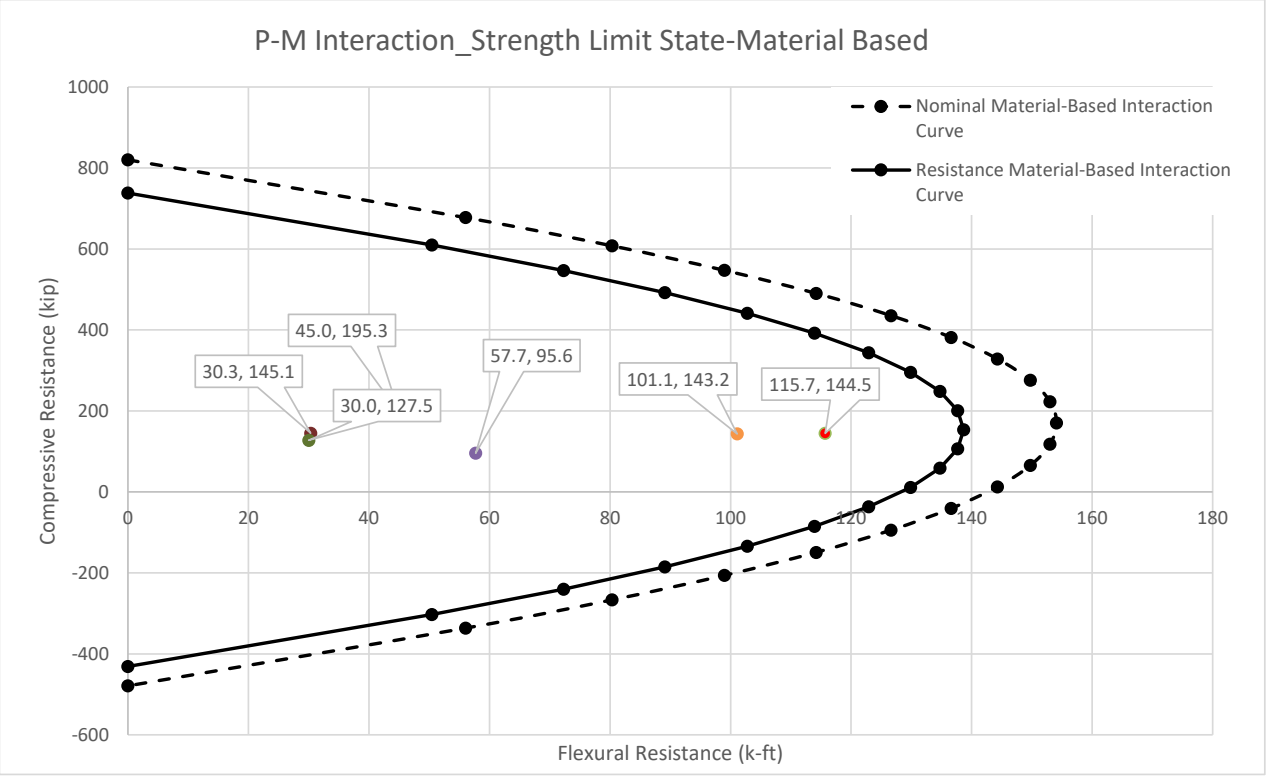
Factored Axial Load = 144.5 k from Green Factored Lateral Load = 37.1 k from Green

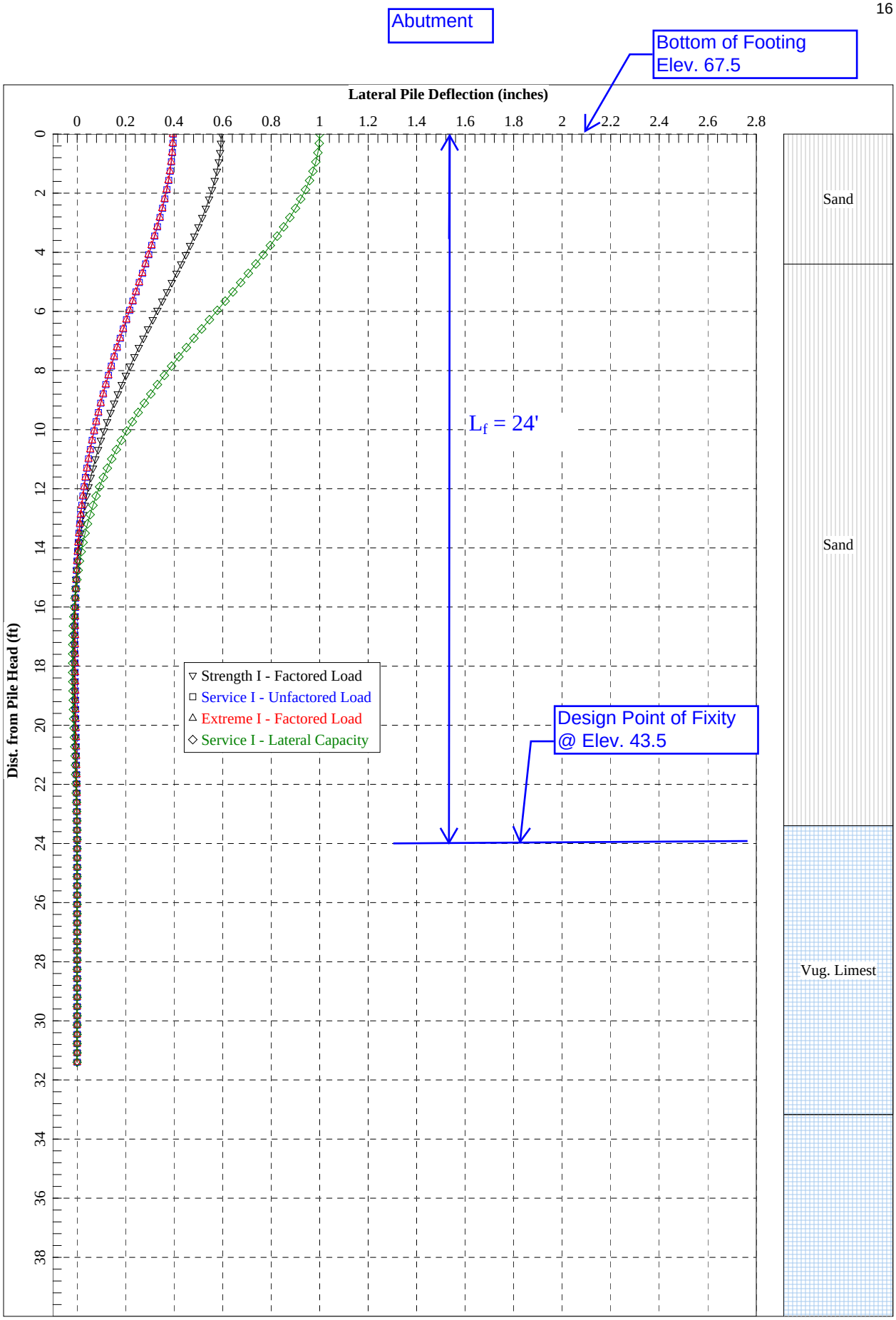
LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

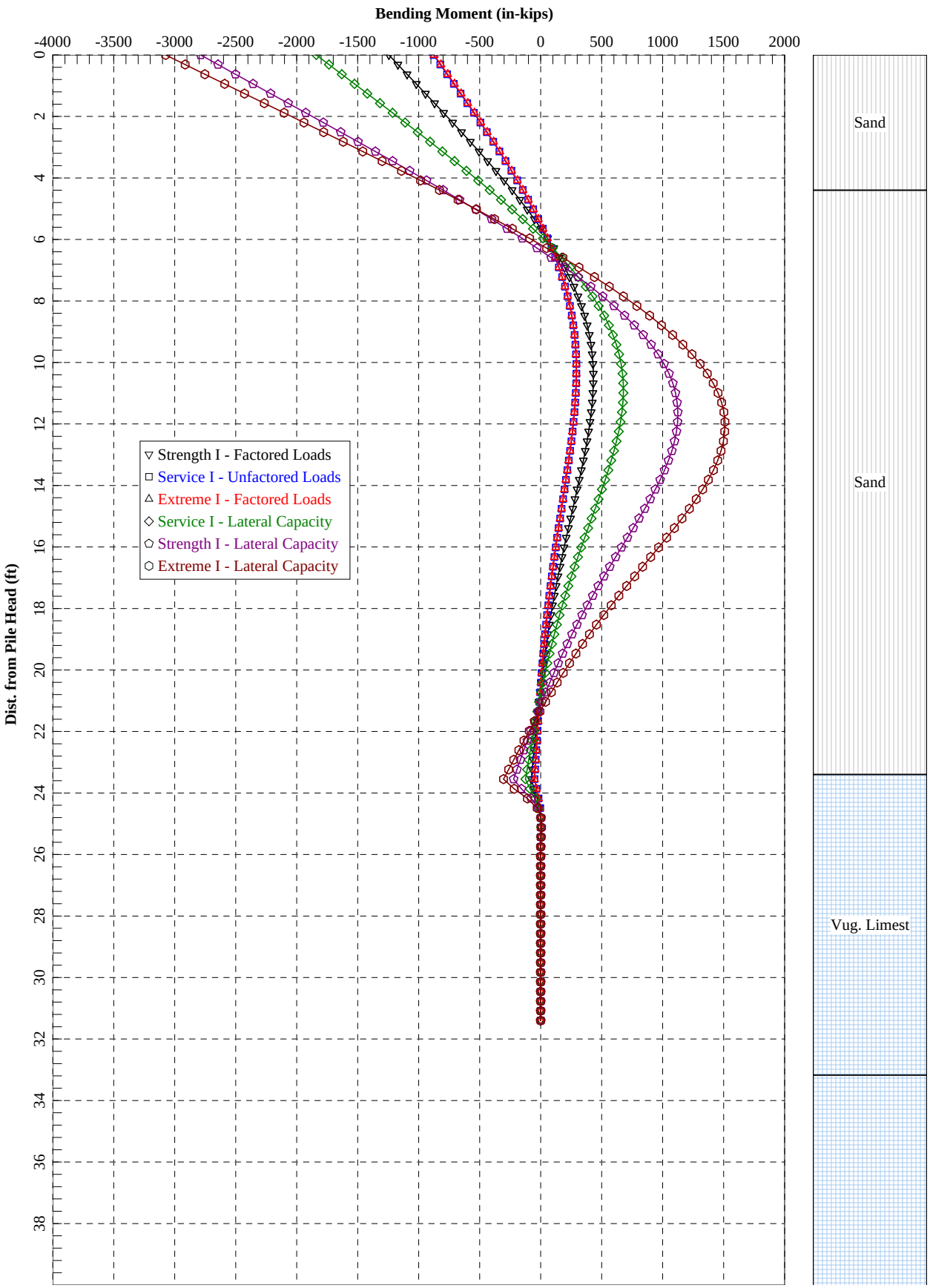
y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2\,\theta_s$	$\pi + 2\,\theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c\, M_n$ (kips-ft)	$\phi_c\ P_n$ (kips)
-4.93	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	820.04	0.00	738.03
-4.44	-1.12	-1.57	2.08	0.00	5.38	0.90	56.03	677.43	50.42	609.69
-3.94	-0.93	-1.57	2.87	0.00	5.00	1.29	80.34	607.65	72.30	546.88
-3.45	-0.78	-1.57	3.41	0.00	4.69	1.59	99.00	547.06	89.10	492.36
-2.96	-0.64	-1.57	3.82	0.00	4.43	1.85	114.18	490.30	102.77	441.27
-2.46	-0.52	-1.57	4.14	0.00	4.19	2.09	126.61	435.45	113.95	391.91
-1.97	-0.41	-1.57	4.38	0.00	3.96	2.32	136.60	381.68	122.94	343.51
-1.48	-0.30	-1.57	4.56	0.00	3.75	2.53	144.28	328.50	129.85	295.65
-0.99	-0.20	-1.57	4.68	0.00	3.54	2.74	149.74	275.67	134.77	248.11
-0.49	-0.10	-1.57	4.76	0.00	3.34	2.94	153.00	223.03	137.70	200.73
0.00	0.00	1.57	4.78	0.00	3.14	3.14	154.09	170.48	138.68	153.43
0.49	0.10	1.57	4.76	0.00	2.94	3.34	153.00	117.92	137.70	106.13
0.99	0.20	1.57	4.68	0.00	2.74	3.54	149.74	65.28	134.77	58.76
1.48	0.30	1.57	4.56	0.00	2.53	3.75	144.28	12.46	129.85	11.21
1.97	0.41	1.57	4.38	0.00	2.32	3.96	136.60	-40.72	122.94	-36.65
2.46	0.52	1.57	4.14	0.00	2.09	4.19	126.61	-94.50	113.95	-85.05
2.96	0.64	1.57	3.82	0.00	1.85	4.43	114.18	-149.34	102.77	-134.40
3.45	0.78	1.57	3.41	0.00	1.59	4.69	99.00	-206.11	89.10	-185.50
3.94	0.93	1.57	2.87	0.00	1.29	5.00	80.34	-266.69	72.30	-240.02
4.44	1.12	1.57	2.08	0.00	0.90	5.38	56.03	-336.47	50.42	-302.82
4.93	1.57	1.57	0.00	0.00	0.00	6.28	0.00	-479.08	0.00	-431.17

Steel Pipe at Threaded Casing Joint (Consider wall thickness reduced to 50%)

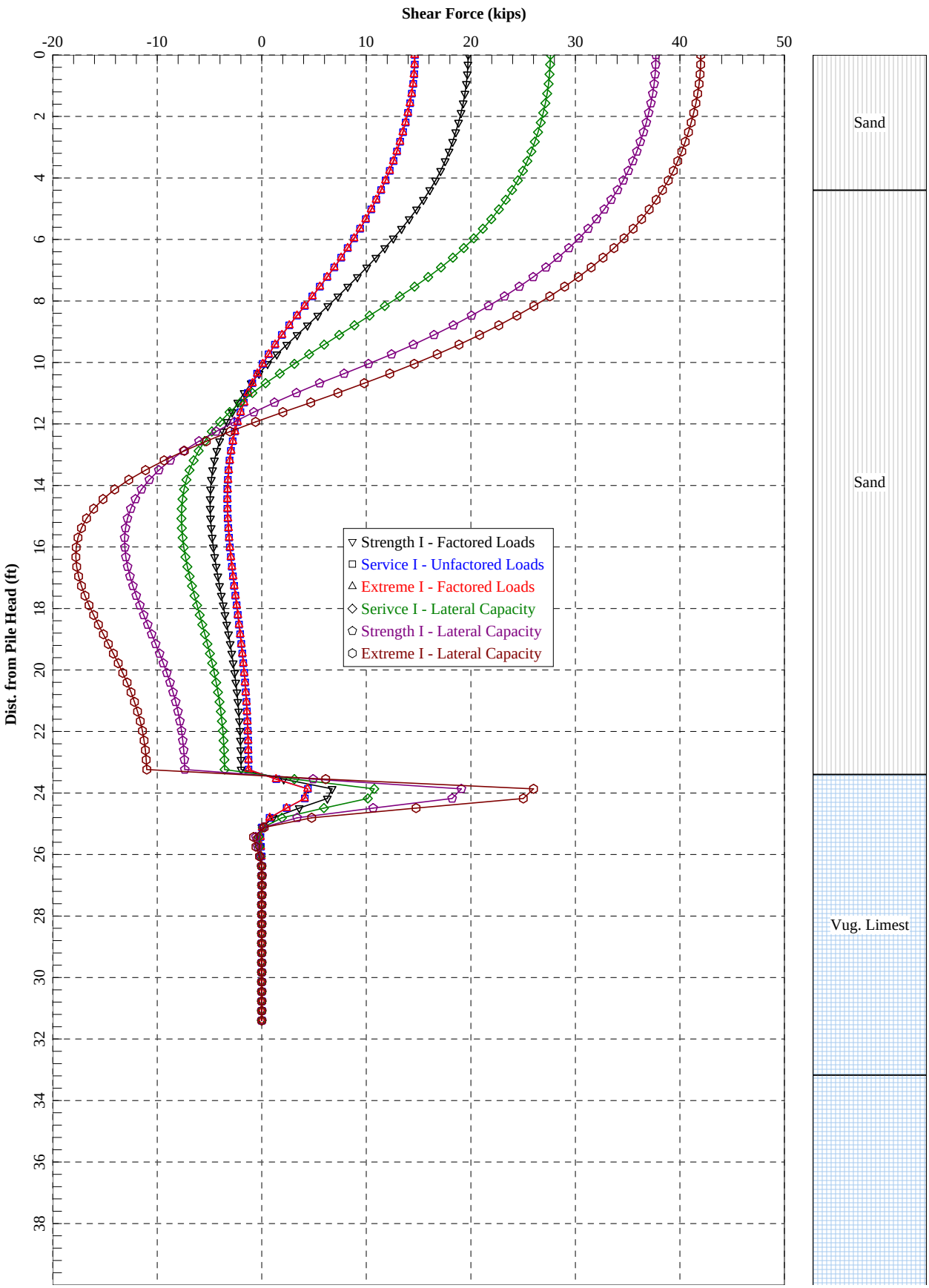



Abutment
Bottom of Footing
Elev. 67.5
Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Sand
Sand
Vug. Limest
L_f = 24'
Strength I - Factored Load
Service I - Unfactored Load
Extreme I - Factored Load
Service I - Lateral Capacity
Design Point of Fixity
@ Elev. 43.5

Abutment


Bending Moment (in-kips)
-4000
-3500
-3000
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
2000
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Strength I - Factored Loads
Service I - Unfactored Loads
Extreme I - Factored Loads
Service I - Lateral Capacity
Strength I - Lateral Capacity
Extreme I - Lateral Capacity
Sand
Sand
Vug. Limest

Abutment


Shear Force (kips)
-20
-10
0
10
20
30
40
50
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Strength I - Factored Loads
Service I - Unfactored Loads
Extreme I - Factored Loads
Serivce I - Lateral Capacity
Strength I - Lateral Capacity
Extreme I - Lateral Capacity
Sand
Sand
Vug. Limest

==========

LPile for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\Green- Willmington Culvert\Micropile\Lpile\abutment\

Name of input data file:
Micropile-2.lp12d

Name of output report file:
Micropile-2.lp12o

Name of plot output file:
Micropile-2.lp12p

Name of runtime message file:
Micropile-2.lp12r

Date and Time of Analysis

Date: November 24, 2025 Time: 7:48:24

Problem Title

Bridge W-38-011, Willmington

Job Number:

Client: MassDOT

Engineer: Lamson Engineering Corporation

Description: 10.75 Micropile

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 1000
 - Deflection tolerance for convergence = 1.0000E-02 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 31.400 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.6250
2	24.400	10.6250
3	24.400	9.3000
4	31.400	9.3000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                =    24.400000 ft
   Casing outside diameter                          =    10.625000 in

Pile Section No. 2:

   Section 2 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                =     7.000000 ft
   Shaft Diameter                                   =     9.300000 in




--------------------------------------------------------------------------------
                      Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


--------------------------------------------------------------------------------
                      Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =       0.0000 ft
   Distance from top of pile to bottom of layer     =     4.400000 ft
   Effective unit weight at top of layer            =    52.600000 pcf
   Effective unit weight at bottom of layer         =    52.600000 pcf
   Friction angle at top of layer                   =    30.000000 deg.
   Friction angle at bottom of layer                =    30.000000 deg.
   Subgrade k at top of layer                       =    30.000000 pci
   Subgrade k at bottom of layer                    =    30.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =     4.400000 ft
   Distance from top of pile to bottom of layer     =    23.400000 ft
   Effective unit weight at top of layer            =    47.600000 pcf
   Effective unit weight at bottom of layer         =    47.600000 pcf
   Friction angle at top of layer                   =    28.000000 deg.
   Friction angle at bottom of layer                =    28.000000 deg.
   Subgrade k at top of layer                       =    20.000000 pci
   Subgrade k at bottom of layer                    =    20.000000 pci


Layer 3 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer        =    23.400000 ft
   Distance from top of pile to bottom of layer     =    60.000000 ft
   Effective unit weight at top of layer            =   168.000000 pcf
   Effective unit weight at bottom of layer         =   168.000000 pcf
   Uniaxial compressive strength at top of layer    =       12630. psi
   Uniaxial compressive strength at bottom of layer =       12630. psi
```

(Depth of the lowest soil layer extends 28.600 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 168.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci
1	Sand	0.00	52.6000	30.0000	--	30.0000
	(Reese, et al.)	4.4000	52.6000	30.0000	--	30.0000
2	Sand	4.4000	47.6000	28.0000	--	20.0000
	(Reese, et al.)	23.4000	47.6000	28.0000	--	20.0000
3	Strong Rock	23.4000	168.0000	--	12630.	--
	(Vuggy Limestone)	60.0000	168.0000	--	12630.	--

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.8500	1.0000
2	120.000	0.8500	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 6

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	2	V =	19740. lbs	S =	0.0000 in/in	195300.	No	Yes
2	2	V =	14650. lbs	S =	0.0000 in/in	145100.	No	Yes
3	2	V =	14630. lbs	S =	0.0000 in/in	127500.	No	Yes
4	5	y =	1.000000 in	S =	0.0000 in/in	108700.	N.A.	Yes
5	2	V =	37700. lbs	S =	0.0000 in/in	146200.	No	Yes

6	2	V =	42000. lbs	S =	0.0000 in/in	125900.	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	24.400000 ft
Outer Diameter of Casing	=	10.625000 in
Concrete Cover Thickness Inside Casing	=	3.803000 in
Casing Wall Thickness	=	0.532500 in
Moment of Inertia of Steel Casing	=	215.567404 in^4
Yield Stress of Casing	=	52000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	2.250000 sq. in.
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	88.664090 sq. in.
Area of Concrete	=	69.530366 sq. in.
Cross-sectional Area of Steel Casing	=	16.883724 sq. in.
Area of All Steel (Casing and Bars)	=	19.133724 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.58 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1308.458 kips
Tensile Load for Cracking of Concrete	=	-96.019 kips
Nominal Axial Tensile Capacity	=	-1012.954 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

```
Compressive Strength of Concrete                        =        5000. psi
Modulus of Elasticity of Concrete                       =     4030509. psi
Modulus of Rupture of Concrete                          =   -530.33009 psi
Compression Strain at Peak Stress                       =     0.002109
Tensile Strain at Fracture of Concrete                  =   -0.0001150
Maximum Coarse Aggregate Size                           =       0.0000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 6

   Number     Axial Thrust Force
                    kips
   ------     ------------------
      1              108.700
      2              125.900
      3              127.500
      4              145.100
      5              146.200
      6              195.300


Definitions of Run Messages and Notes:
--------------------------------------

  C = concrete in section has cracked in tension.
  Y = stress in reinforcing steel has reached yield stress.
  T = ACI 318 criteria for tension-controlled section met, tensile strain in
      reinforcement exceeds 0.005 while simultaneously compressive strain in
      concrete more than 0.003. See ACI 318-14, Section 21.2.3.
  Z = depth of tensile zone in concrete section is less than 10 percent of
      section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =    108.700 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens      Max Conc      Max Steel
Max Casing  Run
   Curvature      Moment       Stiffness      N Axis        Strain        Strain        Stress        Stress
Stress    Msg
    rad/in.       in-kip        kip-in2         in           in/in         in/in          ksi           ksi
  ksi
------------- ------------- ------------- ------------- ------------- ------------- ------------- -------------
------------- ---
   0.00000125    10.1160880      8092870.   104.7115519     0.0001309     0.0001176     0.6010927     3.6321024
3.7938680
   0.00000250    20.2307212      8092288.    55.0130173     0.0001375     0.0001110     0.6302948     3.6610610
3.9845922
   0.00000375    30.3453429      8092091.    38.4472828     0.0001442     0.0001043     0.6594069     3.6900678
4.1753647
   0.00000500    40.4599474      8091989.    30.1647482     0.0001508    0.00009770     0.6884291     3.7191229
4.3661854
   0.00000625    50.5745290      8091925.    25.1954936     0.0001575    0.00009107     0.7173613     3.7482262
4.5570543
   0.00000750    60.6890819      8091878.    21.8828791     0.0001641    0.00008443     0.7462033     3.7773778
4.7479715
   0.00000875    70.8036005      8091840.    19.5169160     0.0001708    0.00007780     0.7749551     3.8065776
4.9389370
   0.00001000    80.9180788      8091808.    17.7426100     0.0001774    0.00007118     0.8036167     3.8358257
5.1299507
   0.00001125    91.0325112      8091779.    16.3627421     0.0001841    0.00006455     0.8321879     3.8651220
5.3210126
   0.00001250   101.1468920      8091751.    15.2589809     0.0001907    0.00005792     0.8606687     3.8944665
5.5121228
   0.00001375   111.2612153      8091725.    14.3560245     0.0001974    0.00005130     0.8890589     3.9238593
```

```
5.7032812
   0.00001500   121.3754756      8091698.    13.6036718     0.0002041    0.00004468     0.9173587     3.9533004
5.8944879
   0.00001625   131.4896669      8091672.    12.9671680     0.0002107    0.00003806     0.9455678     3.9827897
6.0857428
   0.00001750   141.6037835      8091645.    12.4216884     0.0002174    0.00003144     0.9736861     4.0123272
6.2770460
   0.00001875   151.7178198      8091617.    11.9490282     0.0002240    0.00002483     1.0017137     4.0419130
6.4683974
   0.00002000   161.8317699      8091588.    11.5355336     0.0002307    0.00001821     1.0296504     4.0715471
6.6597971
   0.00002125   171.9456281      8091559.    11.1707638     0.0002374    0.00001160     1.0574962     4.1012294
6.8512450
   0.00002250   182.0593887      8091528.    10.8465979     0.0002440    0.00000499     1.0852510     4.1309599
7.0427412
   0.00002375   192.1730459      8091497.    10.5566248     0.0002507   -0.00000162     1.1129147     4.1607387
7.2342856
   0.00002500   202.2865940      8091464.    10.2957156     0.0002574   -0.00000823     1.1404872     4.1905658
7.4258783
   0.00002625   212.4000272      8091430.    10.0597182     0.0002641   -0.00001484     1.1679685     4.2204411
7.6175192
   0.00002750   222.5132811      8091392.     9.8452352     0.0002707   -0.00002144     1.1953585     4.2503642
7.8092079
   0.00002875   232.6260554      8091341.     9.6494576     0.0002774   -0.00002805     1.2226566     4.2803330
8.0009424
   0.00003000   242.7379369      8091265.     9.4700437     0.0002841   -0.00003465     1.2498626     4.3103444
8.1927194
   0.00003125   252.8485075      8091152.     9.3050263     0.0002908   -0.00004125     1.2769757     4.3403950
8.3845356
   0.00003250   262.9573861      8090996.     9.1527409     0.0002975   -0.00004785     1.3039956     4.3704818
8.5763881
   0.00003375   273.0642218      8090792.     9.0117698     0.0003041   -0.00005445     1.3309217     4.4006018
8.7682736
   0.00003500   283.1687129      8090535.     8.8808980     0.0003108   -0.00006104     1.3577536     4.4307522
8.9601897
   0.00003625   293.2705907      8090223.     8.7590786     0.0003175   -0.00006764     1.3844909     4.4609307
9.1521338
   0.00003750   303.3696180      8089856.     8.6454042     0.0003242   -0.00007423     1.4111333     4.4911350
9.3441037
   0.00003875   313.4655906      8089435.     8.5390847     0.0003309   -0.00008083     1.4376805     4.5213630
9.5360973
   0.00004000   323.5583297      8088958.     8.4394291     0.0003376   -0.00008742     1.4641321     4.5516129
9.7281129
   0.00004125   333.6476786      8088429.     8.3458302     0.0003443   -0.00009402     1.4904879     4.5818831
9.9201487
   0.00004250   343.7335025      8087847.     8.2577524     0.0003510     -0.000101     1.5167477     4.6121721
10.1122034
   0.00004375   353.8156834      8087216.     8.1747214     0.0003576     -0.000107     1.5429113     4.6424786
10.3042755
   0.00004500   363.8941152      8086536.     8.0963156     0.0003643     -0.000114     1.5689784     4.6728014
10.4963639
   0.00004625   365.3737821      7899974.     7.9660945     0.0003684     -0.000123     1.5847948     4.6279423
10.6132704 C
   0.00004750   374.5196846      7884625.     7.8909393     0.0003748     -0.000130     1.6095226     4.6494955
10.7965893 C
   0.00004875   383.6375819      7869489.     7.8194189     0.0003812     -0.000137     1.6341189     4.6707388
10.9795982 C
   0.00005125   401.7892688      7839791.     7.6861868     0.0003939     -0.000151     1.6829128     4.7122476
11.3446382 C
   0.00005375   419.8487937      7811140.     7.5646507     0.0004066     -0.000164     1.7312067     4.7526690
11.7085908 C
   0.00005625   437.8312700      7783667.     7.4533491     0.0004193     -0.000178     1.7790246     4.7921626
12.0716157 C
   0.00005875   455.7460501      7757380.     7.3510309     0.0004319     -0.000192     1.8263817     4.8308229
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   0.00006125   473.6021083      7732279.     7.2566530     0.0004445     -0.000206     1.8732934     4.8687512
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   0.00006375   491.4079584      7708360.     7.1693401     0.0004570     -0.000220     1.9197757     4.9060560
13.1561029 C
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0.00007125	544.5469094	7642764.	6.9423904	0.0004946	-0.000262	2.0566743	5.0143042
14.2349448 C							
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0.00007875	597.3835816	7585823.	6.7569845	0.0005321	-0.000305	2.1899896	5.1187049
15.3099393 C							
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0.0001213	893.4881777	7368975.	6.1293293	0.0007432	-0.000545	2.8832431	5.6741882
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0.0001238	910.7939237	7359951.	6.1056432	0.0007556	-0.000559	2.9208974	5.7061782
21.7209751 C							
0.0001263	928.0805324	7351133.	6.0828007	0.0007680	-0.000573	2.9581776	5.7378224
22.0761505 C							
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0.0001313	962.6339856	7334354.	6.0397981	0.0007927	-0.000602	3.0317540	5.8013808
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29.5426176 C							
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30.9671457 C							
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32.3927957 C							
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0.0002188	1562.	7141480.	5.6092947	0.0012270	-0.001097	4.1024808	6.9379676
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51.0420266 C							
0.0003388	2370.	6995788.	5.3963161	0.0018280	-0.001771	4.8995547	8.6516906
52.0000000 CY							
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52.0000000 CY							
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0.0004788	2835.	5921412.	5.2977954	0.0025363	-0.002550	4.9999723	-11.267767
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52.0000000 CY							

Axial Thrust Force = 125.900 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0933896	8074712.	120.6449642	0.0001508	0.0001375	0.6892291	4.2096885	4.3714542	
0.00000250	20.1850904	8074036.	62.9797270	0.0001574	0.0001309	0.7181367	4.2386474	4.5621787	
0.00000375	30.2767797	8073808.	43.7584265	0.0001641	0.0001243	0.7469543	4.2676547	4.7529516	
0.00000500	40.3684518	8073690.	34.1481102	0.0001707	0.0001176	0.7756819	4.2967104	4.9437729	
0.00000625	50.4601008	8073616.	28.3821876	0.0001774	0.0001110	0.8043195	4.3258145	5.1346426	
0.00000750	60.5517211	8073563.	24.5384618	0.0001840	0.0001044	0.8328668	4.3549670	5.3255608	
0.00000875	70.6433069	8073521.	21.7931341	0.0001907	0.00009772	0.8613239	4.3841680	5.5165273	
0.00001000	80.7348523	8073485.	19.7343054	0.0001973	0.00009109	0.8896907	4.4134173	5.7075423	
0.00001125	90.8263516	8073453.	18.1331425	0.0002040	0.00008447	0.9179671	4.4427151	5.8986058	
0.00001250	100.9177991	8073424.	16.8523458	0.0002107	0.00007784	0.9461530	4.4720613	6.0897176	
0.00001375	111.0091890	8073396.	15.8045427	0.0002173	0.00007122	0.9742484	4.5014560	6.2808778	
0.00001500	121.1005156	8073368.	14.9314847	0.0002240	0.00006460	1.0022531	4.5308990	6.4720865	
0.00001625	131.1917729	8073340.	14.1928461	0.0002306	0.00005798	1.0301672	4.5603905	6.6633436	
0.00001750	141.2829554	8073312.	13.5598227	0.0002373	0.00005136	1.0579905	4.5899304	6.8546491	
0.00001875	151.3740571	8073283.	13.0112915	0.0002440	0.00004474	1.0857229	4.6195187	7.0460031	
0.00002000	161.4650724	8073254.	12.5314102	0.0002506	0.00003813	1.1133645	4.6491554	7.2374054	
0.00002125	171.5559955	8073223.	12.1080640	0.0002573	0.00003152	1.1409150	4.6788406	7.4288562	
0.00002250	181.6468206	8073192.	11.7318306	0.0002640	0.00002490	1.1683745	4.7085742	7.6203555	
0.00002375	191.7375420	8073160.	11.3952710	0.0002706	0.00001829	1.1957429	4.7383562	7.8119031	
0.00002500	201.8281538	8073126.	11.0924341	0.0002773	0.00001169	1.2230200	4.7681867		

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25.2613806 C							
0.0001463	1072.	7330695.	6.0932508	0.0008911	-0.000663	3.3114595	6.6911060
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25.9739901 C							
0.0001588	1158.	7294949.	6.0048256	0.0009533	-0.000733	3.4765807	6.8559045
27.4001389 C							
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52.0000000 CY							
0.0007288	3036.	4166338.	5.2899401	0.0038550	-0.003888	4.9982433	-17.317731
52.0000000 CY							

Axial Thrust Force = 127.500 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0912739	8073019.	122.1300689	0.0001527	0.0001394	0.6973986	4.2635236	4.4252892	
0.00000250	20.1808373	8072335.	63.7222797	0.0001593	0.0001327	0.7262787	4.2924825	4.6160137	
0.00000375	30.2703891	8072104.	44.2534620	0.0001660	0.0001261	0.7550689	4.3214898	4.8067867	
0.00000500	40.3599237	8071985.	34.5193872	0.0001726	0.0001195	0.7837691	4.3505455	4.9976080	
0.00000625	50.4494353	8071910.	28.6792096	0.0001792	0.0001128	0.8123791	4.3796497	5.1884778	
0.00000750	60.5389181	8071856.	24.7859805	0.0001859	0.0001062	0.8408990	4.4088023	5.3793961	
0.00000875	70.6283664	8071813.	22.0052935	0.0001925	0.00009958	0.8693286	4.4380034	5.5703628	
0.00001000	80.7177743	8071777.	19.9199452	0.0001992	0.00009295	0.8976679	4.4672529	5.7613779	
0.00001125	90.8071362	8071745.	18.2981562	0.0002059	0.00008632	0.9259168	4.4965508	5.9524414	
0.00001250	100.8964461	8071716.	17.0008585	0.0002125	0.00007970	0.9540753	4.5258972	6.1435534	
0.00001375	110.9856985	8071687.	15.9395546	0.0002192	0.00007308	0.9821432	4.5552920	6.3347139	
0.00001500	121.0748874	8071659.	15.0552461	0.0002258	0.00006645	1.0101204	4.5847352	6.5259227	
0.00001625	131.1640071	8071631.	14.3070878	0.0002325	0.00005983	1.0380070	4.6142269	6.7171800	
0.00001750	141.2530520	8071603.	13.6659047	0.0002392	0.00005322	1.0658028	4.6437670	6.9084858	
0.00001875	151.3420161	8071574.	13.1103018	0.0002458	0.00004660	1.0935077	4.6733556	7.0998399	
0.00002000	161.4308937	8071545.	12.6242328	0.0002525	0.00003998	1.1211217	4.7029926	7.2912426	
0.00002125	171.5196791	8071514.	12.1954269	0.0002592	0.00003337	1.1486448	4.7326780	7.4826936	
0.00002250	181.6083664	8071483.	11.8143404	0.0002658	0.00002676	1.1760767	4.7624119	7.6741931	
0.00002375	191.6969500	8071451.	11.4734386	0.0002725	0.00002015	1.2034176	4.7921942	7.8657411	
0.00002500	201.7854240	8071417.	11.1666938	0.0002792	0.00001354	1.2306672	4.8220250	8.0573375	
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0.0002488	1772.	7122261.	5.6445034	0.0014041	-0.001239	4.4203407	8.1434471
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0.0002588	1839.	7107985.	5.6197221	0.0014541	-0.001295	4.4975070	8.2848690
41.7703534 C							
0.0002688	1907.	7094355.	5.5969861	0.0015042	-0.001351	4.5692390	8.4278589
43.2074683 C							
0.0002788	1974.	7081297.	5.5760645	0.0015543	-0.001407	4.6355147	8.5723284
44.6460628 C							
0.0002888	2041.	7068714.	5.5566784	0.0016045	-0.001463	4.6962865	8.7175214
46.0853807 C							
0.0002988	2108.	7056594.	5.5387747	0.0016547	-0.001520	4.7515780	8.8643140
47.5262984 C							
0.0003088	2175.	7044892.	5.5222106	0.0017050	-0.001575	4.8013711	9.0127163
48.9688257 C							
0.0003188	2242.	7033565.	5.5068610	0.0017553	-0.001631	4.8456474	9.1627382
50.4129726 C							
0.0003288	2309.	7022577.	5.4926161	0.0018057	-0.001687	4.8843883	9.3143899
51.8587493 C							
0.0003388	2374.	7007901.	5.4805843	0.0018565	-0.001743	4.9178237	9.4795195
52.0000000 CY							
0.0003488	2436.	6985672.	5.4718983	0.0019083	-0.001797	4.9460232	9.6715101

52.0000000 CY
0.0003588 2494. 6952392. 5.4660677 0.0019610 -0.001851 4.9686384 9.8881692
52.0000000 CY
0.0003688 2545. 6901161. 5.4617940 0.0020140 -0.001904 4.9852694 10.1180956
52.0000000 CY
0.0003788 2589. 6835873. 5.4577249 0.0020671 -0.001957 4.9956893 10.3477902
52.0000000 CY
0.0003888 2628. 6759221. 5.4525553 0.0021197 -0.002011 4.9998901 10.5627172
52.0000000 CY
0.0003988 2661. 6674397. 5.4463662 0.0021717 -0.002065 4.9999994 10.7628594
52.0000000 CY
0.0004088 2692. 6584763. 5.4396915 0.0022235 -0.002119 4.9984237 10.9536546
52.0000000 CY
0.0004188 2719. 6492280. 5.4327590 0.0022750 -0.002174 4.9986880 11.1374466
52.0000000 CY
0.0004288 2743. 6398522. 5.4258109 0.0023263 -0.002229 4.9987646 11.3170247
52.0000000 CY
0.0004388 2766. 6304359. 5.4189050 0.0023775 -0.002284 4.9986710 11.4931091
52.0000000 CY
0.0004488 2787. 6209969. 5.4122331 0.0024287 -0.002339 4.9983960 11.6682341
52.0000000 CY
0.0004588 2806. 6116052. 5.4056624 0.0024798 -0.002394 4.9978848 11.8408368
52.0000000 CY
0.0004688 2823. 6023195. 5.3992078 0.0025309 -0.002450 4.9999979 12.0112050
52.0000000 CY
0.0004788 2840. 5931705. 5.3928797 0.0025818 -0.002505 4.9998805 12.1795865
52.0000000 CY
0.0004888 2855. 5841292. 5.3870764 0.0026329 -0.002560 4.9994927 12.3517355
52.0000000 CY
0.0004988 2869. 5752699. 5.3814282 0.0026840 -0.002615 4.9986745 12.5227620
52.0000000 CY
0.0005088 2882. 5665462. 5.3756735 0.0027349 -0.002671 4.9980796 12.6889413
52.0000000 CY
0.0005188 2895. 5579785. 5.3704236 0.0027859 -0.002726 4.9998389 12.8593769
52.0000000 CY
0.0005288 2906. 5496292. 5.3652973 0.0028369 -0.002781 4.9989583 13.0286634
52.0000000 CY
0.0005388 2917. 5414057. 5.3603461 0.0028879 -0.002836 4.9972494 13.1977122
52.0000000 CY
0.0005488 2927. 5333864. 5.3554999 0.0029388 -0.002892 4.9997298 13.3655601
52.0000000 CY
0.0006088 2976. 4889044. 5.3307687 0.0032451 -0.003223 4.9980947 14.3903451
52.0000000 CY
0.0006688 3011. 4502564. 5.3120668 0.0035524 -0.003553 4.9998073 -15.462795
52.0000000 CY
0.0007288 3036. 4166674. 5.2978406 0.0038608 -0.003882 4.9956898 -17.150763
52.0000000 CY

Axial Thrust Force = 145.100 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0679550	8054364.	138.4993534	0.0001731	0.0001598	0.7869318	4.8569102	5.0186758	
0.00000250	20.1339587	8053583.	71.9069257	0.0001798	0.0001532	0.8155094	4.8858693	5.2094006	
0.00000375	30.1999508	8053320.	49.7098968	0.0001864	0.0001466	0.8439970	4.9148771	5.4001739	
0.00000500	40.2659256	8053185.	38.6117176	0.0001931	0.0001399	0.8723945	4.9439334	5.5909959	
0.00000625	50.3318773	8053100.	31.9530784	0.0001997	0.0001333	0.9007019	4.9730384	5.7818666	

0.00000750	60.3978002	8053040.	27.5142090	0.0002064	0.0001267	0.9289190	5.0021921
5.9727858							
0.00000875	70.4636883	8052993.	24.3437797	0.0002130	0.0001200	0.9570459	5.0313943
6.1637537							
0.00001000	80.5295360	8052954.	21.9661253	0.0002197	0.0001134	0.9850823	5.0606451
6.3547701							
0.00001125	90.5953374	8052919.	20.1169876	0.0002263	0.0001068	1.0130283	5.0899446
6.5458352							
0.00001250	100.6610867	8052887.	18.6378115	0.0002330	0.0001002	1.0408838	5.1192927
6.7369489							
0.00001375	110.7267782	8052857.	17.4276985	0.0002396	0.00009354	1.0686487	5.1486894
6.9281112							
0.00001500	120.7924061	8052827.	16.4193827	0.0002463	0.00008692	1.0963229	5.1781347
7.1193222							
0.00001625	130.8579645	8052798.	15.5662957	0.0002530	0.00008030	1.1239064	5.2076286
7.3105817							
0.00001750	140.9234477	8052768.	14.8351740	0.0002596	0.00007368	1.1513990	5.2371711
7.5018899							
0.00001875	150.9888499	8052739.	14.2016246	0.0002663	0.00006706	1.1788008	5.2667623
7.6932467							
0.00002000	161.0541653	8052708.	13.6473527	0.0002729	0.00006045	1.2061115	5.2964021
7.8846521							
0.00002125	171.1193880	8052677.	13.1583681	0.0002796	0.00005383	1.2333313	5.3260905
8.0761061							
0.00002250	181.1845125	8052645.	12.7237897	0.0002863	0.00004722	1.2604599	5.3558275
8.2676088							
0.00002375	191.2495327	8052612.	12.3350270	0.0002930	0.00004061	1.2874973	5.3856132
8.4591601							
0.00002500	201.3144429	8052578.	11.9852076	0.0002996	0.00003401	1.3144434	5.4154475
8.6507600							
0.00002625	211.3792374	8052542.	11.6687683	0.0003063	0.00002740	1.3412982	5.4453304
8.8424085							
0.00002750	221.4439103	8052506.	11.3811571	0.0003130	0.00002079	1.3680615	5.4752619
9.0341056							
0.00002875	231.5084559	8052468.	11.1186139	0.0003197	0.00001419	1.3947334	5.5052421
9.2258514							
0.00003000	241.5728684	8052429.	10.8780052	0.0003263	0.00000759	1.4213137	5.5352708
9.4176458							
0.00003125	251.6371419	8052389.	10.6566988	0.0003330	9.90588E-07	1.4478024	5.5653482
9.6094889							
0.00003250	261.7012706	8052347.	10.4524676	0.0003397	-0.00000561	1.4741993	5.5954743
9.8013805							
0.00003375	271.7652489	8052304.	10.2634144	0.0003464	-0.00001220	1.5005044	5.6256489
9.9933208							
0.00003500	281.8290708	8052259.	10.0879128	0.0003531	-0.00001880	1.5267177	5.6558722
10.1853097							
0.00003625	291.8927042	8052213.	9.9245609	0.0003598	-0.00002539	1.5528390	5.6861440
10.3773471							
0.00003750	301.9559601	8052159.	9.7721424	0.0003665	-0.00003198	1.5788681	5.7164628
10.5694316							
0.00003875	312.0185496	8052092.	9.6295974	0.0003731	-0.00003857	1.6048046	5.7468266
10.7615610							
0.00004000	322.0801619	8052004.	9.4959982	0.0003798	-0.00004516	1.6306481	5.7772331
10.9537331							
0.00004125	332.1404836	8051891.	9.3705295	0.0003865	-0.00005175	1.6563983	5.8076796
11.1459452							
0.00004250	342.1992231	8051746.	9.2524718	0.0003932	-0.00005833	1.6820547	5.8381639
11.3381951							
0.00004375	352.2561099	8051568.	9.1411883	0.0003999	-0.00006492	1.7076170	5.8686836
11.5304805							
0.00004500	362.3108948	8051353.	9.0361128	0.0004066	-0.00007150	1.7330848	5.8992367
11.7227992							
0.00004625	372.3633508	8051099.	8.9367403	0.0004133	-0.00007808	1.7584579	5.9298210
11.9151491							
0.00004750	382.4132714	8050806.	8.8426193	0.0004200	-0.00008466	1.7837359	5.9604348
12.1075285							
0.00004875	392.4604689	8050471.	8.7533446	0.0004267	-0.00009124	1.8089186	5.9910762
12.2999356							
0.00005125	412.5460365	8049679.	8.5879112	0.0004401	-0.000104	1.8589970	6.0524355

12.6848261
0.00005375 426.6979853 7938567. 8.4058981 0.0004518 -0.000119 1.9022693 6.0639633
13.0198852 C
0.00005625 445.2350703 7915290. 8.2622402 0.0004648 -0.000133 1.9498630 6.1116661
13.3911193 C
0.00005875 463.6536151 7891976. 8.1301247 0.0004776 -0.000147 1.9969407 6.1582041
13.7611884 C
0.00006125 481.9534059 7868627. 8.0081017 0.0004905 -0.000160 2.0434975 6.2035119
14.1300275 C
0.00006375 500.1582465 7845620. 7.8951108 0.0005033 -0.000174 2.0895666 6.2478246
14.4978715 C
0.00006625 518.2789702 7823079. 7.7901791 0.0005161 -0.000188 2.1351624 6.2912373
14.8648154 C
0.00006875 536.3248993 7801089. 7.6924709 0.0005289 -0.000202 2.1802984 6.3338367
15.2309460 C
0.00007125 554.3017917 7779674. 7.6012477 0.0005416 -0.000215 2.2249825 6.3756681
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16.3248005 C
0.00007875 607.8730508 7719023. 7.3605168 0.0005796 -0.000257 2.3564011 6.4970219
16.6882562 C
0.00008125 625.6367130 7700144. 7.2897018 0.0005923 -0.000271 2.3993746 6.5364187
17.0511843 C
0.00008375 643.3487458 7681776. 7.2228452 0.0006049 -0.000285 2.4419194 6.5751612
17.4134581 C
0.00008625 661.0351709 7664176. 7.1597746 0.0006175 -0.000299 2.4840873 6.6136795
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0.00008875 678.6745829 7647038. 7.1000190 0.0006301 -0.000313 2.5258342 6.6515843
18.1369437 C
0.00009125 696.2890064 7630564. 7.0434468 0.0006427 -0.000327 2.5672045 6.6892488
18.4981395 C
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18.8589157 C
0.00009625 731.4248662 7599219. 6.9387320 0.0006679 -0.000355 2.6487775 6.7634976
19.2194507 C
0.00009875 748.9491714 7584295. 6.8901714 0.0006804 -0.000369 2.6889851 6.8001076
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0.0001013 766.4590722 7569966. 6.8439879 0.0006930 -0.000383 2.7288392 6.8366558
19.9396714 C
0.0001038 783.9315698 7555967. 6.7998487 0.0007055 -0.000397 2.7682871 6.8726583
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20.6588377 C
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21.7362064 C
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22.0947491 C
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22.8120524 C
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23.1702851 C
0.0001263 940.4105038 7448796. 6.4794742 0.0008180 -0.000523 3.1071084 7.1901432
23.5284713 C
0.0001288 957.7225200 7438622. 6.4506483 0.0008305 -0.000537 3.1429818 7.2248937
23.8867531 C
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24.2450037 C
0.0001338 992.2975685 7419047. 6.3960984 0.0008555 -0.000566 3.2136495 7.2938867
24.6028086 C
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24.9607082 C

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0.0001413	1044.	7391716.	6.3214880	0.0008929	-0.000608	3.3170703	7.3972666
25.6767823 C							
0.0001438	1061.	7383000.	6.2982436	0.0009054	-0.000622	3.3508178	7.4312915
26.0343384 C							
0.0001463	1079.	7374536.	6.2758161	0.0009178	-0.000636	3.3842322	7.4654108
26.3919890 C							
0.0001488	1096.	7366311.	6.2541644	0.0009303	-0.000650	3.4173134	7.4996246
26.7497340 C							
0.0001588	1164.	7335336.	6.1743109	0.0009802	-0.000707	3.5461896	7.6361759
28.1804102 C							
0.0001688	1233.	7307164.	6.1039723	0.0010300	-0.000763	3.6696145	7.7729750
29.6113344 C							
0.0001788	1302.	7281244.	6.0414318	0.0010799	-0.000819	3.7875348	7.9093970
31.0418813 C							
0.0001888	1370.	7257418.	5.9856899	0.0011298	-0.000876	3.9000564	8.0467647
32.4733741 C							
0.0001988	1438.	7235289.	5.9356119	0.0011797	-0.000932	4.0071224	8.1844476
33.9051819 C							
0.0002088	1506.	7214730.	5.8905467	0.0012297	-0.000988	4.1087972	8.3234309
35.3382902 C							
0.0002188	1574.	7195416.	5.8496336	0.0012796	-0.001045	4.2049943	8.4626160
36.7716004 C							
0.0002288	1642.	7177306.	5.8125301	0.0013296	-0.001101	4.2957935	8.6033437
38.2064531 C							
0.0002388	1710.	7160210.	5.7786882	0.0013797	-0.001157	4.3811497	8.7451338
39.6423682 C							
0.0002488	1777.	7143976.	5.7476640	0.0014297	-0.001213	4.4610308	8.8876218
41.0789811 C							
0.0002588	1845.	7128564.	5.7192469	0.0014799	-0.001269	4.5354723	9.0316783
42.5171627 C							
0.0002688	1912.	7113880.	5.6931470	0.0015300	-0.001325	4.6044566	9.1773129
43.9569223 C							
0.0002788	1979.	7099803.	5.6690253	0.0015802	-0.001381	4.6679348	9.3237999
45.3975343 C							
0.0002888	2046.	7086286.	5.6467166	0.0016305	-0.001437	4.7259101	9.4714793
46.8393387 C							
0.0002988	2113.	7073293.	5.6260871	0.0016808	-0.001493	4.7783830	9.6207668
48.2827512 C							
0.0003088	2180.	7060769.	5.6069746	0.0017312	-0.001549	4.8253352	9.7716722
49.7277816 C							
0.0003188	2247.	7048671.	5.5892374	0.0017816	-0.001605	4.8667482	9.9242057
51.1744401 C							
0.0003288	2313.	7035516.	5.5731475	0.0018322	-0.001661	4.9026896	10.0821563
52.0000000 CY							
0.0003388	2377.	7016687.	5.5599696	0.0018834	-0.001716	4.9333581	10.2593815
52.0000000 CY							
0.0003488	2437.	6987822.	5.5511057	0.0019359	-0.001770	4.9587748	10.4725933
52.0000000 CY							
0.0003588	2493.	6949017.	5.5461504	0.0019897	-0.001822	4.9784996	10.7213293
52.0000000 CY							
0.0003688	2543.	6897545.	5.5432477	0.0020441	-0.001874	4.9919856	10.9891397
52.0000000 CY							
0.0003788	2588.	6834221.	5.5407228	0.0020985	-0.001926	4.9989551	11.2594178
52.0000000 CY							
0.0003888	2628.	6760594.	5.5374532	0.0021527	-0.001978	4.9996281	11.5198307
52.0000000 CY							
0.0003988	2663.	6677364.	5.5324083	0.0022060	-0.002031	4.9999132	11.7578256
52.0000000 CY							
0.0004088	2693.	6588642.	5.5264616	0.0022589	-0.002084	4.9999956	11.9822039
52.0000000 CY							
0.0004188	2721.	6497001.	5.5201384	0.0023116	-0.002138	4.9989231	12.1985585
52.0000000 CY							
0.0004288	2746.	6403820.	5.5136235	0.0023640	-0.002192	4.9981052	12.4088627
52.0000000 CY							
0.0004388	2768.	6309760.	5.5071941	0.0024163	-0.002245	4.9980687	12.6164755
52.0000000 CY							
0.0004488	2789.	6215692.	5.5008412	0.0024685	-0.002299	4.9991175	12.8213569

52.0000000 CY
0.0004588 2809. 6122225. 5.4945652 0.0025206 -0.002354 4.9999924 13.0235775
52.0000000 CY
0.0004688 2826. 6029418. 5.4881816 0.0025726 -0.002408 4.9998991 13.2206928
52.0000000 CY
0.0004788 2843. 5937668. 5.4820576 0.0026245 -0.002462 4.9996158 13.4177087
52.0000000 CY
0.0004888 2858. 5847244. 5.4762263 0.0026765 -0.002516 4.9990149 13.6153219
52.0000000 CY
0.0004988 2872. 5758616. 5.4704948 0.0027284 -0.002571 4.9979302 13.8109995
52.0000000 CY
0.0005088 2885. 5671359. 5.4649803 0.0027803 -0.002625 4.9999793 14.0065514
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0.0005188 2898. 5585581. 5.4595323 0.0028321 -0.002680 4.9995106 14.1999043
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0.0005288 2909. 5501862. 5.4542846 0.0028840 -0.002734 4.9982399 14.3931723
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0.0005388 2920. 5419686. 5.4494367 0.0029359 -0.002788 4.9999896 14.5896421
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0.0005488 2930. 5339335. 5.4443864 0.0029876 -0.002843 4.9992956 14.7800772
52.0000000 CY
0.0006088 2979. 4893605. 5.4193539 0.0032990 -0.003169 4.9999531 15.9542057
52.0000000 CY
0.0006688 3014. 4506355. 5.3996802 0.0036110 -0.003494 4.9992658 17.1451462
52.0000000 CY
0.0007288 3039. 4169774. 5.3846143 0.0039240 -0.003819 4.9999775 18.3650052
52.0000000 CY

Axial Thrust Force = 146.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0664947	8053196.	139.5244592	0.0001744	0.0001611	0.7925073	4.8940702	5.0558359	
0.00000250	20.1310230	8052409.	72.4194788	0.0001810	0.0001545	0.8210660	4.9230294	5.2465607	
0.00000375	30.1955397	8052144.	50.0515991	0.0001877	0.0001478	0.8495347	4.9520372	5.4373341	
0.00000500	40.2600391	8052008.	38.8679947	0.0001943	0.0001412	0.8779132	4.9810936	5.6281561	
0.00000625	50.3245154	8051922.	32.1581003	0.0002010	0.0001346	0.9062017	5.0101987	5.8190268	
0.00000750	60.3889628	8051862.	27.6850609	0.0002076	0.0001280	0.9343998	5.0393523	6.0099461	
0.00000875	70.4533756	8051814.	24.4902244	0.0002143	0.0001213	0.9625077	5.0685546	6.2009140	
0.00001000	80.5177478	8051775.	22.0942648	0.0002209	0.0001147	0.9905252	5.0978056	6.3919306	
0.00001125	90.5820737	8051740.	20.2308896	0.0002276	0.0001081	1.0184523	5.1271051	6.5829957	
0.00001250	100.6463476	8051708.	18.7403237	0.0002343	0.0001014	1.0462888	5.1564533	6.7741096	
0.00001375	110.7105637	8051677.	17.5208916	0.0002409	0.00009482	1.0740347	5.1858501	6.9652720	
0.00001500	120.7747160	8051648.	16.5048101	0.0002476	0.00008820	1.1016899	5.2152956	7.1564831	
0.00001625	130.8387990	8051618.	15.6451520	0.0002542	0.00008158	1.1292544	5.2447896	7.3477428	
0.00001750	140.9028066	8051589.	14.9083980	0.0002609	0.00007496	1.1567281	5.2743323	7.5390511	
0.00001875	150.9667333	8051559.	14.2699673	0.0002676	0.00006834	1.1841108	5.3039237	7.7304080	

0.00002000	161.0305731	8051529.	13.7114243	0.0002742	0.00006173	1.2114026	5.3335636
7.9218136							
0.00002125	171.0943203	8051497.	13.2186711	0.0002809	0.00005512	1.2386033	5.3632522
8.1132679							
0.00002250	181.1579691	8051465.	12.7807428	0.0002876	0.00004850	1.2657129	5.3929894
8.3047707							
0.00002375	191.2215137	8051432.	12.3889829	0.0002942	0.00004189	1.2927313	5.4227753
8.4963222							
0.00002500	201.2849483	8051398.	12.0364660	0.0003009	0.00003529	1.3196584	5.4526098
8.6879223							
0.00002625	211.3482671	8051363.	11.7175861	0.0003076	0.00002868	1.3464942	5.4824929
8.8795711							
0.00002750	221.4114644	8051326.	11.4277562	0.0003143	0.00002208	1.3732386	5.5124247
9.0712685							
0.00002875	231.4745342	8051288.	11.1631873	0.0003209	0.00001547	1.3998914	5.5424051
9.2630145							
0.00003000	241.5374709	8051249.	10.9207217	0.0003276	0.00000887	1.4264527	5.5724342
9.4548092							
0.00003125	251.6002686	8051209.	10.6977070	0.0003343	0.00000227	1.4529223	5.6025119
9.6466525							
0.00003250	261.6629215	8051167.	10.4918988	0.0003410	-0.00000433	1.4793002	5.6326382
9.8385444							
0.00003375	271.7254239	8051124.	10.3013855	0.0003477	-0.00001092	1.5055864	5.6628132
10.0304850							
0.00003500	281.7877699	8051079.	10.1245281	0.0003544	-0.00001752	1.5317806	5.6930368
10.2224743							
0.00003625	291.8499412	8051033.	9.9599140	0.0003610	-0.00002411	1.5578829	5.7233089
10.4145121							
0.00003750	301.9117925	8050981.	9.8063179	0.0003677	-0.00003070	1.5838930	5.7536286
10.6065974							
0.00003875	311.9730439	8050917.	9.6626717	0.0003744	-0.00003729	1.6098106	5.7839938
10.7987282							
0.00004000	322.0333893	8050835.	9.5280406	0.0003811	-0.00004388	1.6356353	5.8144022
10.9909022							
0.00004125	332.0925217	8050728.	9.4016030	0.0003878	-0.00005047	1.6613667	5.8448513
11.1831169							
0.00004250	342.1501436	8050592.	9.2826341	0.0003945	-0.00005705	1.6870044	5.8753388
11.3753700							
0.00004375	352.2059793	8050422.	9.1704918	0.0004012	-0.00006363	1.7125481	5.9058623
11.5676592							
0.00004500	362.2597762	8050217.	9.0646055	0.0004079	-0.00007022	1.7379974	5.9364197
11.7599822							
0.00004625	372.3113029	8049974.	8.9644667	0.0004146	-0.00007680	1.7633520	5.9670090
11.9523371							
0.00004750	382.3603484	8049692.	8.8696200	0.0004213	-0.00008338	1.7886116	5.9976282
12.1447219							
0.00004875	392.4067223	8049369.	8.7796571	0.0004280	-0.00008996	1.8137759	6.0282755
12.3371349							
0.00005125	412.4907942	8048601.	8.6129492	0.0004414	-0.000103	1.8638178	6.0896483
12.7220389							
0.00005375	426.8429221	7941264.	8.4309507	0.0004532	-0.000118	1.9072931	6.1030141
13.0589360 C							
0.00005625	445.3938565	7918113.	8.2862932	0.0004661	-0.000132	1.9548718	6.1509027
13.4303559 C							
0.00005875	463.8262776	7894915.	8.1532671	0.0004790	-0.000145	2.0019350	6.1976330
13.8006173 C							
0.00006125	482.1495651	7871830.	8.0304793	0.0004919	-0.000159	2.0484931	6.2432602
14.1697758 C							
0.00006375	500.3732811	7848993.	7.9167601	0.0005047	-0.000173	2.0945574	6.2878486
14.5378955 C							
0.00006625	518.5070405	7826521.	7.8111208	0.0005175	-0.000186	2.1401400	6.3314715
14.9050496 C							
0.00006875	536.5603927	7804515.	7.7127208	0.0005302	-0.000200	2.1852536	6.3742099
15.2713193 C							
0.00007125	554.5427135	7783056.	7.6208411	0.0005430	-0.000214	2.2299119	6.4161530
15.6367937 C							
0.00007375	572.4631050	7762212.	7.5348640	0.0005557	-0.000228	2.2741287	6.4573975
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0.00007625	590.3303039	7742037.	7.4542557	0.0005684	-0.000242	2.3179185	6.4980473

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0.00008625 661.3335971 7667636. 7.1764217 0.0006190 -0.000297 2.4889145 6.6553181
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21.7790922 C
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22.1379200 C
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22.8552567 C
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25.3625853 C
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25.7206932 C
0.0001438 1062. 7385501. 6.3088476 0.0009069 -0.000620 3.3549663 7.4754971
26.0785440 C
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29.6561917 C
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31.0869360 C
0.0001888 1370. 7259309. 5.9939861 0.0011314 -0.000874 3.9035363 8.0921762
32.5187856 C
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    0.0002188        1574.      7196995.     5.8568756     0.0012812     -0.001043     4.2079868     8.5085574
36.8175418 C
    0.0002288        1642.      7178791.     5.8194688     0.0013312     -0.001099     4.2986152     8.6493732
38.2524826 C
    0.0002388        1710.      7161630.     5.7853888     0.0013813     -0.001155     4.3838155     8.7915267
39.6887610 C
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    0.0002588        1845.      7129827.     5.7254540     0.0014815     -0.001268     4.5377907     9.0782544
42.5637388 C
    0.0002688        1912.      7115074.     5.6991350     0.0015316     -0.001324     4.6065999     9.2239816
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    0.0002788        1979.      7100948.     5.6748444     0.0015819     -0.001380     4.6699140     9.3708406
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    0.0002888        2046.      7087371.     5.6523457     0.0016321     -0.001436     4.7277116     9.5186159
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    0.0002988        2113.      7074320.     5.6315389     0.0016824     -0.001492     4.7800059     9.6679998
48.3299842 C
    0.0003088        2180.      7061744.     5.6122607     0.0017328     -0.001548     4.8267786     9.8190025
49.7751119 C
    0.0003188        2247.      7049595.     5.5943683     0.0017832     -0.001604     4.8680112     9.9716339
51.2218683 C
    0.0003288        2313.      7036294.     5.5781951     0.0018338     -0.001659     4.9037842    10.1302790
52.0000000 CY
    0.0003388        2377.      7016978.     5.5650179     0.0018851     -0.001714     4.9342909    10.3089734
52.0000000 CY
    0.0003488        2437.      6987790.     5.5561151     0.0019377     -0.001768     4.9595236    10.5232575
52.0000000 CY
    0.0003588        2493.      6948746.     5.5511766     0.0019915     -0.001820     4.9790566    10.7736208
52.0000000 CY
    0.0003688        2543.      6897195.     5.5483078     0.0020459     -0.001872     4.9923360    11.0432511
52.0000000 CY
    0.0003788        2588.      6833720.     5.5458969     0.0021005     -0.001924     4.9990851    11.3162479
52.0000000 CY
    0.0003888        2628.      6760214.     5.5426864     0.0021547     -0.001976     4.9997067    11.5788284
52.0000000 CY
    0.0003988        2663.      6677431.     5.5378361     0.0022082     -0.002029     4.9999507    11.8205918
52.0000000 CY
    0.0004088        2693.      6588766.     5.5319315     0.0022612     -0.002082     4.9998855    12.0470426
52.0000000 CY
    0.0004188        2721.      6497162.     5.5256436     0.0023139     -0.002135     4.9982229    12.2654131
52.0000000 CY
    0.0004288        2746.      6404005.     5.5191618     0.0023663     -0.002189     4.9983180    12.4777242
52.0000000 CY
    0.0004388        2769.      6310068.     5.5127017     0.0024187     -0.002243     4.9982151    12.6865522
52.0000000 CY
    0.0004488        2789.      6216003.     5.5063817     0.0024710     -0.002297     4.9980148    12.8934593
52.0000000 CY
    0.0004588        2809.      6122408.     5.5000649     0.0025232     -0.002351     5.0000000    13.0967431
52.0000000 CY
    0.0004688        2826.      6029607.     5.4937168     0.0025752     -0.002405     4.9999468    13.2959364
52.0000000 CY
    0.0004788        2843.      5937950.     5.4875676     0.0026272     -0.002460     4.9997177    13.4942087
52.0000000 CY
    0.0004888        2858.      5847522.     5.4817749     0.0026792     -0.002514     4.9991872    13.6939660
52.0000000 CY
    0.0004988        2872.      5758889.     5.4760979     0.0027312     -0.002568     4.9981910    13.8920414
52.0000000 CY
    0.0005088        2885.      5671614.     5.4705336     0.0027831     -0.002622     4.9999976    14.0884846
52.0000000 CY
    0.0005188        2898.      5585831.     5.4651321     0.0028350     -0.002677     4.9996374    14.2841463
52.0000000 CY
    0.0005288        2909.      5502181.     5.4598686     0.0028869     -0.002731     4.9984928    14.4787971
52.0000000 CY
    0.0005388        2920.      5419910.     5.4549990     0.0029389     -0.002785     5.0000000    14.6765438
52.0000000 CY
    0.0005488        2930.      5339571.     5.4499860     0.0029907     -0.002840     4.9994580    14.8691878
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52.0000000 CY
0.0007288 3039. 4169875. 5.3900415 0.0039280 -0.003815 4.9999997 18.4797015
52.0000000 CY

Axial Thrust Force = 195.300 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0009631	8000770.	185.5277023	0.0002319	0.0002186	1.0389200	6.5616878	6.7234534	
0.00000250	19.9992806	7999712.	95.4211109	0.0002386	0.0002120	1.0666285	6.5906477	6.9141790	
0.00000375	29.9975866	7999356.	65.3860323	0.0002452	0.0002054	1.0942468	6.6196568	7.1049537	
0.00000500	39.9958750	7999175.	50.3688319	0.0002518	0.0001987	1.1217748	6.6487150	7.2957775	
0.00000625	49.9941400	7999062.	41.3587828	0.0002585	0.0001921	1.1492126	6.6778224	7.4866505	
0.00000750	59.9923759	7998983.	35.3523093	0.0002651	0.0001855	1.1765600	6.7069789	7.6775726	
0.00000875	69.9905767	7998923.	31.0621648	0.0002718	0.0001788	1.2038169	6.7361845	7.8685439	
0.00001000	79.9887365	7998874.	27.8447259	0.0002784	0.0001722	1.2309833	6.7654393	8.0595643	
0.00001125	89.9868497	7998831.	25.3424240	0.0002851	0.0001656	1.2580591	6.7947432	8.2506338	
0.00001250	99.9849102	7998793.	23.3407181	0.0002918	0.0001589	1.2850442	6.8240963	8.4417525	
0.00001375	109.9829122	7998757.	21.7030819	0.0002984	0.0001523	1.3119386	6.8534985	8.6329204	
0.00001500	119.9808499	7998723.	20.3384981	0.0003051	0.0001457	1.3387422	6.8829498	8.8241373	
0.00001625	129.9787174	7998690.	19.1839545	0.0003117	0.0001391	1.3654548	6.9124503	9.0154035	
0.00001750	139.9765089	7998658.	18.1944426	0.0003184	0.0001325	1.3920765	6.9420000	9.2067187	
0.00001875	149.9742184	7998625.	17.3369560	0.0003251	0.0001258	1.4186071	6.9715988	9.3980831	
0.00002000	159.9718403	7998592.	16.5867399	0.0003317	0.0001192	1.4450465	7.0012467	9.5894967	
0.00002125	169.9693685	7998559.	15.9248643	0.0003384	0.0001126	1.4713948	7.0309438	9.7809594	
0.00002250	179.9667974	7998524.	15.3366058	0.0003451	0.0001060	1.4976518	7.0606900	9.9724712	
0.00002375	189.9641208	7998489.	14.8103405	0.0003517	0.00009940	1.5238174	7.0904854	10.1640322	
0.00002500	199.9613332	7998453.	14.3367696	0.0003584	0.00009279	1.5498916	7.1203299	10.3556424	
0.00002625	209.9584285	7998416.	13.9083653	0.0003651	0.00008619	1.5758743	7.1502236	10.5473017	
0.00002750	219.9554009	7998378.	13.5189684	0.0003718	0.00007958	1.6017655	7.1801664	10.7390102	
0.00002875	229.9522446	7998339.	13.1634911	0.0003785	0.00007298	1.6275649	7.2101584	10.9307678	
0.00003000	239.9489537	7998298.	12.8376934	0.0003851	0.00006638	1.6532726	7.2401995	11.1225745	
0.00003125	249.9455224	7998257.	12.5380137	0.0003918	0.00005978	1.6788885	7.2702898	11.3144304	

0.00003250	259.9419448	7998214.	12.2614385	0.0003985	0.00005318	1.7044126	7.3004293
11.5063355							
0.00003375	269.9382150	7998169.	12.0054005	0.0004052	0.00004659	1.7298447	7.3306179
11.6982897							
0.00003500	279.9343273	7998124.	11.7676994	0.0004119	0.00003999	1.7551847	7.3608556
11.8902931							
0.00003625	289.9302756	7998077.	11.5464383	0.0004186	0.00003340	1.7804326	7.3911426
12.0823457							
0.00003750	299.9260543	7998028.	11.3399731	0.0004252	0.00002681	1.8055884	7.4214786
12.2744474							
0.00003875	309.9216574	7997978.	11.1468720	0.0004319	0.00002022	1.8306518	7.4518639
12.4665983							
0.00004000	319.9170790	7997927.	10.9658821	0.0004386	0.00001364	1.8556230	7.4822983
12.6587983							
0.00004125	329.9123133	7997874.	10.7959023	0.0004453	0.00000705	1.8805017	7.5127819
12.8510475							
0.00004250	339.9073545	7997820.	10.6359613	0.0004520	4.65856E-07	1.9052879	7.5433146
13.0433459							
0.00004375	349.9021967	7997764.	10.4851985	0.0004587	-0.00000612	1.9299816	7.5738965
13.2356934							
0.00004500	359.8968340	7997707.	10.3428491	0.0004654	-0.00001270	1.9545827	7.6045276
13.4280901							
0.00004625	369.8912606	7997649.	10.2082309	0.0004721	-0.00001928	1.9790910	7.6352078
13.6205360							
0.00004750	379.8854705	7997589.	10.0807336	0.0004788	-0.00002585	2.0035065	7.6659373
13.8130310							
0.00004875	389.8794353	7997527.	9.9598093	0.0004855	-0.00003243	2.0278291	7.6967157
14.0055751							
0.00005125	409.8660348	7997386.	9.7357530	0.0004990	-0.00004557	2.0761949	7.7584153
14.3908060							
0.00005375	429.8494179	7997198.	9.5326543	0.0005124	-0.00005871	2.1241862	7.8202946
14.7762164							
0.00005625	449.8277694	7996938.	9.3477102	0.0005258	-0.00007185	2.1718007	7.8823392
15.1617923							
0.00005875	469.7993780	7996585.	9.1785949	0.0005392	-0.00008498	2.2190362	7.9445351
15.5475195							
0.00006125	489.7627074	7996126.	9.0233627	0.0005527	-0.00009810	2.2658906	8.0068692
15.9333849							
0.00006375	509.7164309	7995552.	8.8803739	0.0005661	-0.000111	2.3123621	8.0693297
16.3193765							
0.00006625	525.2059195	7927637.	8.7290586	0.0005783	-0.000126	2.3540681	8.0950595
16.6686377 C							
0.00006875	543.9195622	7911557.	8.6019024	0.0005914	-0.000139	2.3985421	8.1470158
17.0441251 C							
0.00007125	562.5149611	7894947.	8.4831637	0.0006044	-0.000153	2.4425170	8.1979269
17.4185676 C							
0.00007375	581.0005026	7877973.	8.3720081	0.0006174	-0.000166	2.4860012	8.2478396
17.7920115 C							
0.00007625	599.3849664	7860786.	8.2677155	0.0006304	-0.000180	2.5290043	8.2968103
18.1645134 C							
0.00007875	617.6773670	7843522.	8.1696610	0.0006434	-0.000193	2.5715366	8.3449048
18.5361392 C							
0.00008125	635.8868130	7826299.	8.0773005	0.0006563	-0.000207	2.6136091	8.3921981
18.9069638 C							
0.00008375	654.0223799	7809222.	7.9901585	0.0006692	-0.000221	2.6552336	8.4387734
19.2770702 C							
0.00008625	672.0929953	7792383.	7.9078175	0.0006820	-0.000234	2.6964224	8.4847218
19.6465499 C							
0.00008875	690.0873549	7775632.	7.8298033	0.0006949	-0.000248	2.7371577	8.5298665
20.0152259 C							
0.00009125	708.0218231	7759143.	7.7558307	0.0007077	-0.000262	2.7774624	8.5743946
20.3832852 C							
0.00009375	725.9123245	7743065.	7.6856532	0.0007205	-0.000276	2.8173609	8.6185144
20.7509363 C							
0.00009625	743.7444435	7727215.	7.6188962	0.0007333	-0.000289	2.8568307	8.6620059
21.1179590 C							
0.00009875	761.5269944	7711666.	7.5553343	0.0007461	-0.000303	2.8958842	8.7049677
21.4844521 C							
0.0001013	779.2806059	7696599.	7.4948361	0.0007589	-0.000317	2.9345554	8.7477090

21.8507246 C							
0.0001038	796.9706942	7681645.	7.4369942	0.0007716	-0.000331	2.9727867	8.7896698
22.2162167 C							
0.0001063	814.6470932	7667267.	7.3818743	0.0007843	-0.000345	3.0106609	8.8316310
22.5817092 C							
0.0001088	832.2622689	7652986.	7.3290391	0.0007970	-0.000358	3.0480975	8.8728051
22.9464145 C							
0.0001113	849.8707101	7639287.	7.2786128	0.0008097	-0.000372	3.0851897	8.9140898
23.3112304 C							
0.0001138	867.4198600	7625669.	7.2301605	0.0008224	-0.000386	3.1218459	8.9545743
23.6752462 C							
0.0001163	884.9616949	7612574.	7.1838216	0.0008351	-0.000400	3.1581577	8.9951582
24.0393613 C							
0.0001188	902.4607220	7599669.	7.1392745	0.0008478	-0.000414	3.1940611	9.0351934
24.4029278 C							
0.0001213	919.9399304	7587133.	7.0965274	0.0008605	-0.000428	3.2295985	9.0750984
24.7663640 C							
0.0001238	937.4010509	7574958.	7.0554768	0.0008731	-0.000442	3.2647721	9.1148934
25.1296902 C							
0.0001263	954.8215768	7562943.	7.0159032	0.0008858	-0.000456	3.2995409	9.1541440
25.4924721 C							
0.0001288	972.2352249	7551342.	6.9778946	0.0008984	-0.000470	3.3339677	9.1934994
25.8553588 C							
0.0001313	989.6215512	7539974.	6.9412519	0.0009110	-0.000483	3.3680134	9.2325428
26.2179334 C							
0.0001338	1007.	7528825.	6.9058974	0.0009237	-0.000497	3.4016782	9.2712695
26.5801913 C							
0.0001363	1024.	7518035.	6.8718664	0.0009363	-0.000511	3.4350017	9.3100994
26.9425525 C							
0.0001388	1042.	7507468.	6.8390008	0.0009489	-0.000525	3.4679519	9.3486838
27.3046682 C							
0.0001413	1059.	7497077.	6.8072119	0.0009615	-0.000539	3.5005197	9.3869134
27.6664290 C							
0.0001438	1076.	7486998.	6.7765532	0.0009741	-0.000553	3.5327467	9.4252449
28.0282917 C							
0.0001463	1094.	7477217.	6.7469667	0.0009867	-0.000567	3.5646325	9.4636784
28.3902565 C							
0.0001488	1111.	7467494.	6.7182197	0.0009993	-0.000581	3.5961102	9.5014431
28.7515525 C							
0.0001588	1180.	7431013.	6.6123235	0.0010497	-0.000637	3.7185451	9.6526762
30.1969106 C							
0.0001688	1248.	7397577.	6.5187710	0.0011000	-0.000693	3.8353150	9.8028962
31.6412555 C							
0.0001788	1317.	7366769.	6.4355471	0.0011504	-0.000749	3.9464535	9.9523967
33.0848811 C							
0.0001888	1385.	7338192.	6.3609943	0.0012006	-0.000805	4.0519627	10.1010906
34.5277000 C							
0.0001988	1453.	7311710.	6.2939908	0.0012509	-0.000861	4.1519248	10.2500566
35.9707910 C							
0.0002088	1521.	7287009.	6.2334338	0.0013012	-0.000917	4.2463295	10.3991858
37.4140452 C							
0.0002188	1589.	7263840.	6.1784142	0.0013515	-0.000973	4.3351656	10.5483198
38.8573042 C							
0.0002288	1657.	7242109.	6.1283351	0.0014019	-0.001029	4.4184808	10.6983165
40.3014258 C							
0.0002388	1724.	7221591.	6.0825090	0.0014522	-0.001085	4.4962408	10.8487069
41.7459412 C							
0.0002488	1792.	7202178.	6.0404766	0.0015026	-0.001140	4.5684604	10.9998933
43.1912526 C							
0.0002588	1859.	7183818.	6.0018997	0.0015530	-0.001196	4.6351639	11.1526346
44.6381189 C							
0.0002688	1926.	7166252.	5.9661862	0.0016034	-0.001252	4.6962679	11.3053090
46.0849184 C							
0.0002788	1993.	7149531.	5.9332358	0.0016539	-0.001308	4.7518347	11.4596095
47.5333439 C							
0.0002888	2060.	7133566.	5.9027625	0.0017044	-0.001364	4.8018458	11.6155417
48.9834011 C							
0.0002988	2127.	7118199.	5.8743810	0.0017550	-0.001419	4.8462482	11.7719220
50.4339064 C							

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    0.0003088         2193.      7103429.     5.8479885     0.0018056     -0.001475     4.8850589    11.9296492
51.8857586 C
    0.0003188         2258.      7084466.     5.8248459     0.0018567     -0.001530     4.9185420    12.1021111
52.0000000 CY
    0.0003288         2320.      7057269.     5.8060444     0.0019087     -0.001584     4.9467475    12.3025341
52.0000000 CY
    0.0003388         2378.      7019295.     5.7923207     0.0019621     -0.001637     4.9694812    12.5419401
52.0000000 CY
    0.0003488         2431.      6970774.     5.7835301     0.0020170     -0.001688     4.9862888    12.8232673
52.0000000 CY
    0.0003588         2481.      6916349.     5.7781866     0.0020729     -0.001739     4.9965931    13.1353677
52.0000000 CY
    0.0003688         2529.      6857794.     5.7756578     0.0021298     -0.001788     4.9994372    13.4744722
52.0000000 CY
    0.0003788         2574.      6794998.     5.7750112     0.0021873     -0.001837     4.9994442    13.8327839
52.0000000 CY
    0.0003888         2615.      6726555.     5.7746173     0.0022449     -0.001886     4.9999169    14.1935658
52.0000000 CY
    0.0003988         2652.      6651893.     5.7736156     0.0023022     -0.001934     4.9988194    14.5470899
52.0000000 CY
    0.0004088         2686.      6571169.     5.7714721     0.0023591     -0.001984     4.9988402    14.8864990
52.0000000 CY
    0.0004188         2715.      6484728.     5.7677980     0.0024153     -0.002034     4.9991596    15.2060771
52.0000000 CY
    0.0004288         2742.      6394734.     5.7630807     0.0024709     -0.002085     4.9992856    15.5105532
52.0000000 CY
    0.0004388         2765.      6303066.     5.7578108     0.0025262     -0.002135     4.9992668    15.8052625
52.0000000 CY
    0.0004488         2787.      6210818.     5.7522164     0.0025813     -0.002187     4.9991031    16.0926890
52.0000000 CY
    0.0004588         2807.      6118379.     5.7466467     0.0026363     -0.002238     4.9987626    16.3772062
52.0000000 CY
    0.0004688         2825.      6026572.     5.7410321     0.0026911     -0.002289     4.9981683    16.6578784
52.0000000 CY
    0.0004788         2842.      5935868.     5.7353869     0.0027458     -0.002341     4.9995292    16.9348637
52.0000000 CY
    0.0004888         2857.      5846400.     5.7298701     0.0028005     -0.002392     4.9998987    17.2103951
52.0000000 CY
    0.0004988         2872.      5757743.     5.7243625     0.0028550     -0.002444     4.9994421    17.4828767
52.0000000 CY
    0.0005088         2885.      5670842.     5.7188366     0.0029095     -0.002496     4.9984355    17.7518818
52.0000000 CY
    0.0005188         2898.      5585574.     5.7136541     0.0029640     -0.002548     4.9996777    18.0228511
52.0000000 CY
    0.0005288         2909.      5501880.     5.7085460     0.0030184     -0.002600     4.9996563    18.2919531
52.0000000 CY
    0.0005388         2920.      5419811.     5.7033957     0.0030727     -0.002652     4.9983810    18.5574273
52.0000000 CY
    0.0005488         2930.      5339596.     5.6986877     0.0031272     -0.002703     4.9999951    18.8269585
52.0000000 CY
    0.0006088         2979.      4893647.     5.6721757     0.0034529     -0.003015     4.9975596    20.4174468
52.0000000 CY
    0.0006688         3013.      4505751.     5.6506887     0.0037789     -0.003327     4.9999122    22.0131419
52.0000000 CY
    0.0007288         3038.      4168203.     5.6330868     0.0041051     -0.003638     4.9965134    23.6161606
52.0000000 CY


-------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
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Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.      Max. Tens.
  No.              kips                 in-kip               Strain           Strain
 ----         ----------------     ------------------     ------------    ------------
   1              108.700              2940.754          0.00300000     -0.00307040
```

2	125.900	2937.193	0.00300000	-0.00296730
3	127.500	2936.794	0.00300000	-0.00295779
4	145.100	2931.911	0.00300000	-0.00285584
5	146.200	2931.555	0.00300000	-0.00284953
6	195.300	2905.199	0.00300000	-0.00258207

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	108.700000	2941.	70.655000	1911.	7071017.
2	0.65	125.900000	2937.	81.835000	1909.	7091973.
3	0.65	127.500000	2937.	82.875000	1909.	7093908.
4	0.65	145.100000	2932.	94.315000	1906.	7115213.
5	0.65	146.200000	2932.	95.030000	1906.	7116535.
6	0.65	195.300000	2905.	126.945000	1888.	7176079.
1	0.75	108.700000	2941.	81.525000	2206.	7021842.
2	0.75	125.900000	2937.	94.425000	2203.	7038674.
3	0.75	127.500000	2937.	95.625000	2203.	7040234.
4	0.75	145.100000	2932.	108.825000	2199.	7057340.
5	0.75	146.200000	2932.	109.650000	2199.	7058403.
6	0.75	195.300000	2905.	146.475000	2179.	7106596.
1	0.90	108.700000	2941.	97.830000	2647.	6693725.
2	0.90	125.900000	2937.	113.310000	2643.	6718883.
3	0.90	127.500000	2937.	114.750000	2643.	6720368.
4	0.90	145.100000	2932.	130.590000	2639.	6735109.
5	0.90	146.200000	2932.	131.580000	2638.	6735406.
6	0.90	195.300000	2905.	175.770000	2615.	6727000.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	9.300000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.803000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	67.929087 sq. in.
Total Area of Reinforcing Steel	=	2.250000 sq. in.
Area Ratio of Steel Reinforcement	=	3.31 percent
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As = 414.136 kips

Tensile Load for Cracking of Concrete = -37.939 kips
Nominal Axial Tensile Capacity = -135.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete = 5000. psi
Modulus of Elasticity of Concrete = 4030509. psi
Modulus of Rupture of Concrete = -530.33009 psi
Compression Strain at Peak Stress = 0.002109
Tensile Strain at Fracture of Concrete = -0.0001150
Maximum Coarse Aggregate Size = 0.0000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 6

Number	Axial Thrust Force kips
1	108.700
2	125.900
3	127.500
4	145.100
5	146.200
6	195.300

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 108.700 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.8760759	1500861.	250.2918652	0.0003129	0.0003012	1.3732561	8.9365445	
0.00000250	3.7484669	1499387.	127.4732480	0.0003187	0.0002954	1.3964809	8.9687392	
0.00000375	5.6208340	1498889.	86.5347462	0.0003245	0.0002896	1.4196468	9.0010468	
0.00000500	7.4931651	1498633.	66.0662732	0.0003303	0.0002838	1.4427534	9.0334671	
0.00000625	9.3654483	1498472.	53.7858118	0.0003362	0.0002780	1.4658008	9.0660003	
0.00000750	11.2376714	1498356.	45.5993562	0.0003420	0.0002722	1.4887887	9.0986462	
0.00000875	13.1098225	1498265.	39.7523324	0.0003478	0.0002665	1.5117171	9.1314050	

0.00001000	14.9818895	1498189.	35.3674536	0.0003537	0.0002607	1.5345856	9.1642766	
0.00001125	16.8538604	1498121.	31.9573381	0.0003595	0.0002549	1.5573943	9.1972609	
0.00001250	18.7257231	1498058.	29.2295569	0.0003654	0.0002491	1.5801429	9.2303582	
0.00001375	20.5974657	1497998.	26.9980189	0.0003712	0.0002433	1.6028314	9.2635682	
0.00001500	22.4690761	1497938.	25.1386633	0.0003771	0.0002376	1.6254594	9.2968911	
0.00001625	24.3405422	1497880.	23.5656019	0.0003829	0.0002318	1.6480270	9.3303268	
0.00001750	26.2118520	1497820.	22.2174858	0.0003888	0.0002261	1.6705339	9.3638753	
0.00001875	28.0829934	1497760.	21.0493261	0.0003947	0.0002203	1.6929800	9.3975368	
0.00002000	29.9539545	1497698.	20.0273810	0.0004005	0.0002145	1.7153651	9.4313110	
0.00002125	31.8247232	1497634.	19.1258479	0.0004064	0.0002088	1.7376891	9.4651982	
0.00002250	33.6952874	1497568.	18.3246581	0.0004123	0.0002031	1.7599519	9.4991982	
0.00002375	35.5656351	1497500.	17.6079680	0.0004182	0.0001973	1.7821532	9.5333111	
0.00002500	37.4357542	1497430.	16.9631026	0.0004241	0.0001916	1.8042930	9.5675370	
0.00002625	39.3056327	1497357.	16.3798013	0.0004300	0.0001858	1.8263711	9.6018757	
0.00002750	41.1752586	1497282.	15.8496690	0.0004359	0.0001801	1.8483872	9.6363274	
0.00002875	43.0446198	1497204.	15.3657707	0.0004418	0.0001744	1.8703414	9.6708920	
0.00003000	44.9137041	1497123.	14.9223270	0.0004477	0.0001687	1.8922334	9.7055696	
0.00003125	46.7824997	1497040.	14.5144834	0.0004536	0.0001630	1.9140631	9.7403601	
0.00003250	48.6509943	1496954.	14.1381324	0.0004595	0.0001572	1.9358302	9.7752636	
0.00003375	50.5191760	1496864.	13.7897746	0.0004654	0.0001515	1.9575348	9.8102801	
0.00003500	52.3870326	1496772.	13.4664108	0.0004713	0.0001458	1.9791766	9.8454096	
0.00003625	54.2545522	1496677.	13.1654556	0.0004772	0.0001401	2.0007554	9.8806522	
0.00003750	56.1217225	1496579.	12.8846679	0.0004832	0.0001344	2.0222712	9.9160077	
0.00003875	57.9885317	1496478.	12.6220962	0.0004891	0.0001287	2.0437237	9.9514764	
0.00004000	59.8549675	1496374.	12.3760328	0.0004950	0.0001230	2.0651128	9.9870581	
0.00004125	61.7210179	1496267.	12.1449768	0.0005010	0.0001174	2.0864384	10.0227529	
0.00004250	63.5866708	1496157.	11.9276041	0.0005069	0.0001117	2.1077003	10.0585609	
0.00004375	65.4519141	1496044.	11.7227418	0.0005129	0.0001060	2.1288984	10.0944820	
0.00004500	67.3167357	1495927.	11.5293476	0.0005188	0.0001003	2.1500324	10.1305162	
0.00004625	69.1811236	1495808.	11.3464914	0.0005248	0.00009465	2.1711023	10.1666636	
0.00004750	71.0450656	1495686.	11.1733415	0.0005307	0.00008898	2.1921079	10.2029242	
0.00004875	72.9085496	1495560.	11.0091511	0.0005367	0.00008332	2.2130491	10.2392981	
0.00005125	76.6340952	1495299.	10.7050267	0.0005486	0.00007201	2.2547374	10.3123855	
0.00005375	80.3576636	1495026.	10.4294838	0.0005606	0.00006071	2.2961660	10.3859261	
0.00005625	84.0791577	1494741.	10.1787115	0.0005726	0.00004943	2.3373338	10.4599201	
0.00005875	87.7984805	1494442.	9.9495477	0.0005845	0.00003816	2.3782394	10.5343677	
0.00006125	91.5155349	1494131.	9.7393466	0.0005965	0.00002691	2.4188818	10.6092690	
0.00006375	95.2302236	1493807.	9.5458775	0.0006085	0.00001567	2.4592595	10.6846244	
0.00006625	98.9424493	1493471.	9.3672463	0.0006206	0.00000446	2.4993715	10.7604340	
0.00006875	102.6521003	1493121.	9.2018342	0.0006326	-0.00000675	2.5392164	10.8366978	
0.00007125	106.3587424	1492754.	9.0482467	0.0006447	-0.00001794	2.5787922	10.9134094	
0.00007375	110.0614555	1492359.	8.9052735	0.0006568	-0.00002911	2.6180959	10.9905521	
0.00007625	113.7592102	1491924.	8.7718616	0.0006689	-0.00004027	2.6571240	11.0681062	
0.00007875	117.4509479	1491441.	8.6470913	0.0006810	-0.00005142	2.6958730	11.1460506	
0.00008125	121.1356913	1490901.	8.5301562	0.0006931	-0.00006255	2.7343397	11.2243652	
0.00008375	124.8125344	1490299.	8.4203469	0.0007052	-0.00007367	2.7725209	11.3030309	
0.00008625	128.4806426	1489631.	8.3170363	0.0007173	-0.00008478	2.8104136	11.3820292	
0.00008875	132.1392593	1488893.	8.2196687	0.0007295	-0.00009588	2.8480151	11.4613432	
0.00009125	135.7877085	1488084.	8.1277497	0.0007417	-0.000107	2.8853229	11.5409573	
0.00009375	134.2465073	1431963.	7.9974854	0.0007498	-0.000122	2.9098928	11.5029918	C
0.00009625	136.8607777	1421930.	7.9074700	0.0007611	-0.000134	2.9441294	11.5584828	C
0.00009875	139.3922779	1411567.	7.8213499	0.0007724	-0.000146	2.9778861	11.6120767	C
0.0001013	141.8460870	1400949.	7.7388644	0.0007836	-0.000158	3.0111761	11.6638552	C
0.0001038	144.2275277	1390145.	7.6597836	0.0007947	-0.000170	3.0440143	11.7139175	C
0.0001063	146.5374164	1379176.	7.5838569	0.0008058	-0.000182	3.0764018	11.7622312	C
0.0001088	148.7687202	1367988.	7.5107727	0.0008168	-0.000195	3.1083133	11.8085003	C
0.0001113	150.9404033	1356768.	7.4405084	0.0008278	-0.000207	3.1398084	11.8532700	C
0.0001138	153.0582938	1345567.	7.3729253	0.0008387	-0.000219	3.1709061	11.8966957	C
0.0001163	155.1196722	1334363.	7.3078126	0.0008495	-0.000232	3.2015975	11.9386503	C
0.0001188	157.1115854	1323045.	7.2448630	0.0008603	-0.000244	3.2318355	11.9786131	C
0.0001213	159.0633197	1311862.	7.1842243	0.0008711	-0.000257	3.2617205	12.0175734	C
0.0001238	160.9669389	1300743.	7.1256715	0.0008818	-0.000269	3.2912256	12.0552241	C
0.0001263	162.8103439	1289587.	7.0689391	0.0008925	-0.000282	3.3203056	12.0910538	C
0.0001288	164.6272509	1278658.	7.0142568	0.0009031	-0.000294	3.3490823	12.1263122	C
0.0001313	166.3814125	1267668.	6.9611291	0.0009136	-0.000307	3.3774229	12.1595574	C
0.0001338	168.1078021	1256881.	6.9098112	0.0009242	-0.000320	3.4054547	12.1921164	C
0.0001363	169.7887292	1246156.	6.8600202	0.0009347	-0.000332	3.4331138	12.2232710	C
0.0001388	171.4345965	1235565.	6.8117659	0.0009451	-0.000345	3.4604365	12.2533853	C
0.0001413	173.0445934	1225094.	6.7649565	0.0009556	-0.000358	3.4874223	12.2824260	C

0.0001438	174.6198645	1214747.	6.7195155	0.0009659	-0.000371	3.5140729	12.3103831 C
0.0001463	176.1612707	1204522.	6.6753802	0.0009763	-0.000384	3.5403935	12.3372862 C
0.0001488	177.6756998	1194458.	6.6325446	0.0009866	-0.000397	3.5664098	12.3633994 C
0.0001588	183.4336114	1155487.	6.4726042	0.0010275	-0.000449	3.6673230	12.4582269 C
0.0001688	188.7647695	1118606.	6.3287274	0.0010680	-0.000501	3.7634030	12.5389002 C
0.0001788	193.7609908	1083978.	6.1988744	0.0011080	-0.000554	3.8550476	12.6088210 C
0.0001888	198.4450002	1051364.	6.0808405	0.0011478	-0.000608	3.9423658	12.6681216 C
0.0001988	202.8515902	1020637.	5.9730109	0.0011871	-0.000661	4.0255249	12.7177775 C
0.0002088	207.0272565	991747.	5.8742478	0.0012262	-0.000715	4.1047500	12.7597787 C
0.0002188	210.9956035	964551.	5.7834398	0.0012651	-0.000769	4.1801653	12.7949623 C
0.0002288	214.7792737	938926.	5.6996866	0.0013038	-0.000824	4.2518918	12.8242775 C
0.0002388	218.3998108	914764.	5.6222564	0.0013423	-0.000878	4.3200460	12.8487940 C
0.0002488	221.8485610	891854.	5.5502112	0.0013806	-0.000933	4.3845980	12.8672473 C
0.0002588	225.1575295	870174.	5.4831963	0.0014188	-0.000988	4.4457112	12.8816603 C
0.0002688	228.3547246	849692.	5.4209250	0.0014569	-0.001043	4.5035314	12.8941758 C
0.0002788	231.4326752	830252.	5.3627753	0.0014949	-0.001098	4.5580315	12.9038916 C
0.0002888	234.3966754	811763.	5.3083241	0.0015328	-0.001153	4.6092377	12.9108500 C
0.0002988	237.2860537	794263.	5.2576464	0.0015707	-0.001208	4.6573398	12.9189206 C
0.0003088	240.0534806	777501.	5.2097886	0.0016085	-0.001263	4.7021183	12.9228459 C
0.0003188	242.7653729	761617.	5.1652587	0.0016464	-0.001318	4.7438738	12.9297769 C
0.0003288	245.3661604	746361.	5.1230678	0.0016842	-0.001373	4.7823574	12.9331792 C
0.0003388	247.9102630	731838.	5.0836627	0.0017221	-0.001428	4.8178003	12.9394779 C
0.0003488	250.3692617	717905.	5.0464419	0.0017599	-0.001483	4.8500736	12.9450138 C
0.0003588	252.7541542	704541.	5.0113606	0.0017978	-0.001539	4.8792204	12.9512193 C
0.0003688	255.0870005	691761.	4.9785267	0.0018358	-0.001594	4.9053028	12.9611063 C
0.0003788	257.3247721	679405.	4.9471963	0.0018738	-0.001649	4.9281669	12.9684707 C
0.0003888	259.5056128	667539.	4.9177531	0.0019118	-0.001704	4.9479287	12.9789386 C
0.0003988	261.6332011	656133.	4.8901171	0.0019499	-0.001758	4.9645710	12.9932280 C
0.0004088	263.6795438	645088.	4.8637724	0.0019881	-0.001813	4.9780109	13.0067931 C
0.0004188	265.6610472	634414.	4.8388565	0.0020263	-0.001868	4.9882771	13.0224302 C
0.0004288	267.5879221	624112.	4.8154235	0.0020646	-0.001923	4.9953607	13.0420541 C
0.0004388	269.4592542	614152.	4.7933772	0.0021031	-0.001977	4.9992270	13.0657305 C
0.0004488	271.2479036	604452.	4.7722671	0.0021416	-0.002032	4.9989909	13.0888026 C
0.0004588	272.9683804	595026.	4.7523357	0.0021801	-0.002086	4.9985880	13.1153135 C
0.0004688	274.6238100	585864.	4.7335984	0.0022189	-0.002141	4.9995676	13.1464953 C
0.0004788	276.2107745	576942.	4.7159963	0.0022578	-0.002195	4.9999455	13.1825700 C
0.0004888	277.7316819	568249.	4.6994540	0.0022969	-0.002249	4.9996903	13.2234584 C
0.0004988	279.1723560	559744.	4.6836095	0.0023360	-0.002302	4.9991139	13.2648437 C
0.0005088	280.5491243	551448.	4.6686374	0.0023752	-0.002356	4.9980838	13.3099117 C
0.0005188	281.8635595	543351.	4.6545634	0.0024146	-0.002410	4.9999290	13.3598048 C
0.0005288	283.1176807	535447.	4.6413321	0.0024541	-0.002463	4.9993731	-13.680278 C
0.0005388	284.3182692	527737.	4.6288726	0.0024938	-0.002517	4.9981110	-14.133671 C
0.0005488	285.4624823	520205.	4.6171561	0.0025337	-0.002570	4.9999082	-14.582466 C
0.0006088	291.2201000	478390.	4.5589736	0.0027753	-0.002886	4.9980814	-17.204043 C
0.0006688	295.4303343	441765.	4.5184355	0.0030217	-0.003198	4.9970513	-19.685907 C
0.0007288	298.3783554	409439.	4.4901697	0.0032722	-0.003505	4.9994184	-22.049481 C
0.0007888	300.3174852	380751.	4.4711943	0.0035267	-0.003809	4.9998199	-24.298917 C
0.0008488	301.4196194	355134.	4.4592760	0.0037848	-0.004109	4.9994957	-26.440679 C
0.0009088	291.2946471	320544.	4.4784393	0.0040698	-0.004382	4.9992857	-27.804803 C

Axial Thrust Force = 125.900 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.8225601	1458048.	292.3118858	0.0003654	0.0003538	1.5822741	10.4597702	
0.00000250	3.6407965	1456319.	148.4833138	0.0003712	0.0003480	1.6048191	10.4919690	
0.00000375	5.4590083	1455736.	100.5415185	0.0003770	0.0003422	1.6273051	10.5242833	
0.00000500	7.2771833	1455437.	76.5714175	0.0003829	0.0003364	1.6497319	10.5567129	
0.00000625	9.0953092	1455249.	62.1899941	0.0003887	0.0003306	1.6720992	10.5892582	
0.00000750	10.9133737	1455116.	52.6029096	0.0003945	0.0003248	1.6944070	10.6219190	
0.00000875	12.7313644	1455013.	45.7554474	0.0004004	0.0003190	1.7166550	10.6546953	
0.00001000	14.5492689	1454927.	40.6202490	0.0004062	0.0003132	1.7388432	10.6875871	
0.00001125	16.3670751	1454851.	36.6265599	0.0004120	0.0003074	1.7609714	10.7205945	
0.00001250	18.1847705	1454782.	33.4319273	0.0004179	0.0003016	1.7830394	10.7537174	
0.00001375	20.0023429	1454716.	30.8184268	0.0004238	0.0002959	1.8050470	10.7869558	
0.00001500	21.8197799	1454652.	28.6407752	0.0004296	0.0002901	1.8269942	10.8203097	

0.00001625	23.6370691	1454589.	26.7983922	0.0004355	0.0002843	1.8488808	10.8537792
0.00001750	25.4541983	1454526.	25.2194345	0.0004413	0.0002786	1.8707065	10.8873642
0.00001875	27.2711552	1454462.	23.8512170	0.0004472	0.0002728	1.8924713	10.9210648
0.00002000	29.0879273	1454396.	22.6542259	0.0004531	0.0002671	1.9141749	10.9548810
0.00002125	30.9045024	1454330.	21.5982449	0.0004590	0.0002613	1.9358173	10.9888128
0.00002250	32.7208681	1454261.	20.6597722	0.0004648	0.0002556	1.9573983	11.0228601
0.00002375	34.5370122	1454190.	19.8202540	0.0004707	0.0002499	1.9789178	11.0570231
0.00002500	36.3529221	1454117.	19.0648471	0.0004766	0.0002441	2.0003754	11.0913017
0.00002625	38.1685857	1454041.	18.3815356	0.0004825	0.0002384	2.0217713	11.1256959
0.00002750	39.9839906	1453963.	17.7604883	0.0004884	0.0002327	2.0431050	11.1602057
0.00002875	41.7991244	1453883.	17.1935838	0.0004943	0.0002269	2.0643766	11.1948312
0.00003000	43.6139748	1453799.	16.6740544	0.0005002	0.0002212	2.0855858	11.2295724
0.00003125	45.4285294	1453713.	16.1962149	0.0005061	0.0002155	2.1067325	11.2644292
0.00003250	47.2427759	1453624.	15.7552551	0.0005120	0.0002098	2.1278166	11.2994018
0.00003375	49.0567019	1453532.	15.3470772	0.0005180	0.0002041	2.1488378	11.3344900
0.00003500	50.8702951	1453437.	14.9681689	0.0005239	0.0001984	2.1697961	11.3696940
0.00003625	52.6835430	1453339.	14.6155023	0.0005298	0.0001927	2.1906912	11.4050137
0.00003750	54.4964335	1453238.	14.2864532	0.0005357	0.0001870	2.2115231	11.4404492
0.00003875	56.3089540	1453134.	13.9787362	0.0005417	0.0001813	2.2322915	11.4760005
0.00004000	58.1210921	1453027.	13.6903513	0.0005476	0.0001756	2.2529963	11.5116676
0.00004125	59.9328356	1452917.	13.4195411	0.0005536	0.0001699	2.2736374	11.5474505
0.00004250	61.7441721	1452804.	13.1647549	0.0005595	0.0001643	2.2942146	11.5833493
0.00004375	63.5550891	1452688.	12.9246192	0.0005655	0.0001586	2.3147277	11.6193639
0.00004500	65.3655743	1452568.	12.6979132	0.0005714	0.0001529	2.3351765	11.6554944
0.00004625	67.1756153	1452446.	12.4835480	0.0005774	0.0001472	2.3555611	11.6917408
0.00004750	68.9851997	1452320.	12.2805494	0.0005833	0.0001416	2.3758810	11.7281032
0.00004875	70.7943151	1452191.	12.0880430	0.0005893	0.0001359	2.3961363	11.7645815
0.00005125	74.4110892	1451924.	11.7314359	0.0006012	0.0001246	2.4364522	11.8378861
0.00005375	78.0258384	1451644.	11.4082993	0.0006132	0.0001133	2.4765074	11.9116548
0.00005625	81.6384634	1451350.	11.1141706	0.0006252	0.0001020	2.5163008	11.9858879
0.00005875	85.2488647	1451045.	10.8453469	0.0006372	0.00009079	2.5558310	12.0605855
0.00006125	88.8569428	1450726.	10.5987296	0.0006492	0.00007955	2.5950968	12.1357480
0.00006375	92.4625981	1450394.	10.3717064	0.0006612	0.00006832	2.6340970	12.2113754
0.00006625	96.0657310	1450049.	10.1620592	0.0006732	0.00005711	2.6728302	12.2874682
0.00006875	99.6662417	1449691.	9.9678925	0.0006853	0.00004592	2.7112953	12.3640266
0.00007125	103.2640302	1449320.	9.7875771	0.0006974	0.00003474	2.7494909	12.4410508
0.00007375	106.8589967	1448936.	9.6197044	0.0007095	0.00002358	2.7874158	12.5185411
0.00007625	110.4510411	1448538.	9.4630506	0.0007216	0.00001243	2.8250687	12.5964978
0.00007875	114.0400631	1448128.	9.3165475	0.0007337	0.00000130	2.8624484	12.6749213
0.00008125	117.6259212	1447704.	9.1792579	0.0007458	-0.00000981	2.8995535	12.7538110
0.00008375	121.2081332	1447261.	9.0503534	0.0007580	-0.00002091	2.9363820	12.8331593
0.00008625	124.7858934	1446793.	8.9290992	0.0007701	-0.00003199	2.9729308	12.9129515
0.00008875	128.3583317	1446291.	8.8148422	0.0007823	-0.00004306	3.0091973	12.9931710
0.00009125	131.9245760	1445749.	8.7070008	0.0007945	-0.00005411	3.0451783	13.0738005
0.00009375	135.4837825	1445160.	8.6050554	0.0008067	-0.00006515	3.0808709	13.1548227
0.00009625	139.0351555	1444521.	8.5085405	0.0008189	-0.00007618	3.1162724	13.2362209
0.00009875	142.5779565	1443827.	8.4170382	0.0008312	-0.00008719	3.1513801	13.3179791
0.0001013	146.1115067	1443077.	8.3301720	0.0008434	-0.00009820	3.1861916	13.4000823
0.0001038	149.6351861	1442267.	8.2476022	0.0008557	-0.000109	3.2207045	13.4825167
0.0001063	148.6842255	1399381.	8.1353866	0.0008644	-0.000124	3.2448912	13.4616321 C
0.0001088	151.3145439	1391398.	8.0544413	0.0008759	-0.000135	3.2768258	13.5230951 C
0.0001113	153.8681744	1383085.	7.9766126	0.0008874	-0.000147	3.3083073	13.5828761 C
0.0001138	156.3522492	1374525.	7.9017409	0.0008988	-0.000159	3.3393544	13.6411263 C
0.0001163	158.7720330	1365781.	7.8296682	0.0009102	-0.000171	3.3699813	13.6979562 C
0.0001188	161.1329829	1356909.	7.7602554	0.0009215	-0.000183	3.4002037	13.7534953 C
0.0001213	163.4157362	1347759.	7.6931512	0.0009328	-0.000195	3.4299650	13.8070876 C
0.0001238	165.6404758	1338509.	7.6283751	0.0009440	-0.000207	3.4593220	13.8593048 C
0.0001263	167.8191474	1329261.	7.5658877	0.0009552	-0.000219	3.4883109	13.9105087 C
0.0001288	169.9333458	1319871.	7.5053830	0.0009663	-0.000231	3.5168769	13.9600548 C
0.0001313	171.9920132	1310415.	7.4468098	0.0009774	-0.000243	3.5450449	14.0081795 C
0.0001338	174.0180304	1301069.	7.3902602	0.0009884	-0.000255	3.5728867	14.0556601 C
0.0001363	175.9703500	1291526.	7.3352443	0.0009994	-0.000268	3.6002744	14.1010014 C
0.0001388	177.8934818	1282115.	7.2820647	0.0010104	-0.000280	3.6273461	14.1457509 C
0.0001413	179.7656312	1272677.	7.2304259	0.0010213	-0.000292	3.6540352	14.1891069 C
0.0001438	181.5956231	1263274.	7.1803131	0.0010322	-0.000305	3.6803674	14.2313339 C
0.0001463	183.3896156	1253946.	7.1317022	0.0010430	-0.000317	3.7063647	14.2726606 C
0.0001488	185.1362919	1244614.	7.0844021	0.0010538	-0.000330	3.7319889	14.3125989 C
0.0001588	191.7811997	1208071.	6.9081079	0.0010967	-0.000380	3.8311974	14.4631742 C
0.0001688	197.9124591	1172815.	6.7497558	0.0011390	-0.000430	3.9252704	14.5993048 C

0.0001788	203.5772255	1138894.	6.6064337	0.0011809	-0.000481	4.0143860	14.7215040 C
0.0001888	208.8767365	1106632.	6.4764063	0.0012224	-0.000533	4.0989268	14.8333492 C
0.0001988	213.8268126	1075858.	6.3576172	0.0012636	-0.000585	4.1789725	14.9345525 C
0.0002088	218.4689201	1046558.	6.2486499	0.0013044	-0.000637	4.2546996	15.0263146 C
0.0002188	222.8498443	1018742.	6.1484422	0.0013450	-0.000689	4.3263056	15.1104464 C
0.0002288	226.9940477	992324.	6.0559603	0.0013853	-0.000742	4.3939048	15.1877079 C
0.0002388	230.9252076	967226.	5.9703593	0.0014254	-0.000795	4.4576079	15.2589718 C
0.0002488	234.6660530	943381.	5.8909467	0.0014654	-0.000848	4.5175206	15.3252281 C
0.0002588	238.2294894	920694.	5.8170632	0.0015052	-0.000901	4.5737097	15.3869144 C
0.0002688	241.6075636	899005.	5.7479344	0.0015448	-0.000955	4.6261623	15.4428052 C
0.0002788	244.8476341	878377.	5.6834535	0.0015843	-0.001008	4.6750674	15.4961735 C
0.0002888	247.9684915	858765.	5.6233092	0.0016237	-0.001062	4.7205037	15.5484572 C
0.0002988	250.9225502	839908.	5.5665345	0.0016630	-0.001115	4.7623168	15.5950498 C
0.0003088	253.7783070	821954.	5.5134560	0.0017023	-0.001169	4.8007492	15.6418081 C
0.0003188	256.5114091	804742.	5.4634675	0.0017415	-0.001223	4.8357287	15.6863445 C
0.0003288	259.1404931	788260.	5.4164435	0.0017807	-0.001277	4.8673150	15.7301498 C
0.0003388	261.6685067	772453.	5.3721505	0.0018198	-0.001331	4.8955216	15.7735101 C
0.0003488	264.1066319	757295.	5.3304503	0.0018590	-0.001384	4.9203725	15.8174035 C
0.0003588	266.4419947	742695.	5.2909829	0.0018981	-0.001438	4.9418367	15.8603397 C
0.0003688	268.7167879	728723.	5.2540329	0.0019374	-0.001492	4.9599957	15.9073058 C
0.0003788	270.8694587	715167.	5.2186909	0.0019766	-0.001546	4.9747227	15.9505026 C
0.0003888	272.9618913	702153.	5.1855409	0.0020159	-0.001599	4.9861203	15.9979130 C
0.0003988	274.9808632	689607.	5.1542719	0.0020553	-0.001653	4.9941411	16.0478479 C
0.0004088	276.8984308	677427.	5.1244105	0.0020946	-0.001707	4.9987519	16.0963324 C
0.0004188	278.7529409	665679.	5.0963408	0.0021341	-0.001760	4.9987580	16.1492469 C
0.0004288	280.5369931	654314.	5.0699674	0.0021737	-0.001814	4.9986345	16.2069856 C
0.0004388	282.2081411	643209.	5.0446730	0.0022134	-0.001867	4.9989241	16.2631527 C
0.0004488	283.8031876	632431.	5.0208675	0.0022531	-0.001920	4.9999961	16.3240254 C
0.0004588	285.3239704	621960.	4.9984896	0.0022931	-0.001973	4.9999308	16.3900826 C
0.0004688	286.7733288	611783.	4.9774406	0.0023332	-0.002026	4.9997297	16.4612258 C
0.0004788	288.1256406	601829.	4.9572192	0.0023733	-0.002079	4.9992945	16.5316495 C
0.0004888	289.4102433	592144.	4.9381277	0.0024135	-0.002132	4.9985180	16.6063600 C
0.0004988	290.6313071	582719.	4.9201382	0.0024539	-0.002184	4.9999907	16.6859353 C
0.0005088	291.7859825	573535.	4.9032006	0.0024945	-0.002237	4.9996910	16.7705969 C
0.0005188	292.8834573	564595.	4.8872209	0.0025352	-0.002289	4.9988499	16.8598446 C
0.0005288	293.9124469	555863.	4.8718805	0.0025760	-0.002341	5.0000000	16.9496291 C
0.0005388	294.8723213	547327.	4.8573264	0.0026169	-0.002393	4.9996309	17.0428004 C
0.0005488	295.7844918	539015.	4.8435657	0.0026579	-0.002445	4.9983855	17.1401561 C
0.0006088	300.2420583	493211.	4.7751979	0.0029069	-0.002754	4.9994098	17.8073027 C
0.0006688	303.2121676	453401.	4.7252474	0.0031600	-0.003059	4.9984362	18.5937086 C
0.0007288	305.0410004	418581.	4.6891928	0.0034172	-0.003360	4.9998025	19.4999602 C
0.0007888	305.9331007	387871.	4.6628559	0.0036778	-0.003658	4.9999245	20.5030236 C
0.0008488	300.1607621	353650.	4.6591629	0.0039545	-0.003939	4.9999008	21.9717844 C

Axial Thrust Force = 127.500 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.8175167	1454013.	296.2720478	0.0003703	0.0003587	1.6016530	10.6033261	
0.00000250	3.6306493	1452260.	150.4634001	0.0003762	0.0003529	1.6241340	10.6355253	
0.00000375	5.4437573	1451669.	101.8615820	0.0003820	0.0003471	1.6465560	10.6678402	
0.00000500	7.2568284	1451366.	77.5614714	0.0003878	0.0003413	1.6689186	10.7002707	
0.00000625	9.0698502	1451176.	62.9820437	0.0003936	0.0003355	1.6912218	10.7328172	
0.00000750	10.8828105	1451041.	53.2629576	0.0003995	0.0003297	1.7134655	10.7654794	
0.00000875	12.6956968	1450937.	46.3212094	0.0004053	0.0003239	1.7356495	10.7982574	
0.00001000	14.5084969	1450850.	41.1152975	0.0004112	0.0003182	1.7577735	10.8311512	
0.00001125	16.3211983	1450773.	37.0666099	0.0004170	0.0003124	1.7798376	10.8641608	
0.00001250	18.1337887	1450703.	33.8279791	0.0004228	0.0003066	1.8018414	10.8972861	
0.00001375	19.9462557	1450637.	31.1784808	0.0004287	0.0003008	1.8237849	10.9305273	
0.00001500	21.7585871	1450572.	28.9708316	0.0004346	0.0002951	1.8456679	10.9638842	
0.00001625	23.5707704	1450509.	27.1030666	0.0004404	0.0002893	1.8674903	10.9973570	
0.00001750	25.3827934	1450445.	25.5023534	0.0004463	0.0002835	1.8892518	11.0309456	
0.00001875	27.1946435	1450381.	24.1152816	0.0004522	0.0002778	1.9109524	11.0646500	
0.00002000	29.0063085	1450315.	22.9017934	0.0004580	0.0002720	1.9325918	11.0984702	
0.00002125	30.8177761	1450248.	21.8312566	0.0004639	0.0002663	1.9541700	11.1324063	
0.00002250	32.6290338	1450179.	20.8798459	0.0004698	0.0002605	1.9756867	11.1664582	

0.00002375	34.4400693	1450108.	20.0287519	0.0004757	0.0002548	1.9971418	11.2006260
0.00002500	36.2508702	1450035.	19.2629271	0.0004816	0.0002491	2.0185353	11.2349097
0.00002625	38.0614242	1449959.	18.5701902	0.0004875	0.0002433	2.0398668	11.2693093
0.00002750	39.8717189	1449881.	17.9405748	0.0004934	0.0002376	2.0611362	11.3038247
0.00002875	41.6817418	1449800.	17.3658476	0.0004993	0.0002319	2.0823434	11.3384561
0.00003000	43.4914808	1449716.	16.8391475	0.0005052	0.0002262	2.1034883	11.3732034
0.00003125	45.3009232	1449630.	16.3547114	0.0005111	0.0002205	2.1245706	11.4080667
0.00003250	47.1100569	1449540.	15.9076626	0.0005170	0.0002147	2.1455903	11.4430459
0.00003375	48.9188694	1449448.	15.4938471	0.0005229	0.0002090	2.1665471	11.4781411
0.00003500	50.7273482	1449353.	15.1097041	0.0005288	0.0002033	2.1874410	11.5133523
0.00003625	52.5354811	1449255.	14.7521641	0.0005348	0.0001976	2.2082717	11.5486795
0.00003750	54.3432556	1449153.	14.4185667	0.0005407	0.0001919	2.2290391	11.5841227
0.00003875	56.1506594	1449049.	14.1065951	0.0005466	0.0001863	2.2497430	11.6196820
0.00004000	57.9576799	1448942.	13.8142217	0.0005526	0.0001806	2.2703833	11.6553573
0.00004125	59.7643049	1448832.	13.5396650	0.0005585	0.0001749	2.2909599	11.6911487
0.00004250	61.5705219	1448718.	13.2813529	0.0005645	0.0001692	2.3114725	11.7270563
0.00004375	63.3763186	1448602.	13.0378930	0.0005704	0.0001635	2.3319210	11.7630800
0.00004500	65.1816824	1448482.	12.8080476	0.0005764	0.0001579	2.3523053	11.7992198
0.00004625	66.9866010	1448359.	12.5907130	0.0005823	0.0001522	2.3726252	11.8354758
0.00004750	68.7910620	1448233.	12.3849013	0.0005883	0.0001465	2.3928806	11.8718480
0.00004875	70.5950529	1448104.	12.1897264	0.0005942	0.0001409	2.4130712	11.9083364
0.00005125	74.2015747	1447836.	11.8281732	0.0006062	0.0001296	2.4532577	11.9816620
0.00005375	77.8060670	1447555.	11.5005514	0.0006182	0.0001183	2.4931834	12.0554528
0.00005625	81.4084303	1447261.	11.2023368	0.0006301	0.0001070	2.5328472	12.1297090
0.00005875	85.0085648	1446954.	10.9297755	0.0006421	0.00009575	2.5722478	12.2044308
0.00006125	88.6063708	1446635.	10.6797264	0.0006541	0.00008451	2.6113838	12.2796185
0.00006375	92.2017485	1446302.	10.4495411	0.0006662	0.00007328	2.6502541	12.3552723
0.00006625	95.7945980	1445956.	10.2369710	0.0006782	0.00006207	2.6888574	12.4313925
0.00006875	99.3848193	1445597.	10.0400945	0.0006903	0.00005088	2.7271923	12.5079793
0.00007125	102.9723123	1445225.	9.8572600	0.0007023	0.00003970	2.7652577	12.5850330
0.00007375	106.5569768	1444840.	9.6870395	0.0007144	0.00002854	2.8030523	12.6625540
0.00007625	110.1387124	1444442.	9.5281923	0.0007265	0.00001740	2.8405748	12.7405424
0.00007875	113.7174188	1444031.	9.3796356	0.0007386	0.00000627	2.8778239	12.8189986
0.00008125	117.2929941	1443606.	9.2404195	0.0007508	-0.00000484	2.9147984	12.8979230
0.00008375	120.8651404	1443166.	9.1097060	0.0007629	-0.00001594	2.9514966	12.9773117
0.00008625	124.4331803	1442704.	8.9867510	0.0007751	-0.00002702	2.9879159	13.0571529
0.00008875	127.9962806	1442212.	8.8708928	0.0007873	-0.00003808	3.0240534	13.1374311
0.00009125	131.5535604	1441683.	8.7615416	0.0007995	-0.00004913	3.0599062	13.2181291
0.00009375	135.1041733	1441111.	8.6581706	0.0008117	-0.00006017	3.0954715	13.2992296
0.00009625	138.6473152	1440492.	8.5603078	0.0008239	-0.00007120	3.1307462	13.3807162
0.00009875	142.1822323	1439820.	8.4675292	0.0008362	-0.00008221	3.1657279	13.4625726
0.0001013	145.7082259	1439094.	8.3794531	0.0008484	-0.00009321	3.2004140	13.5447838
0.0001038	149.2246522	1438310.	8.2957347	0.0008607	-0.000104	3.2348020	13.6273353
0.0001063	148.6961751	1399493.	8.1857387	0.0008697	-0.000118	3.2598888	13.6167797 C
0.0001088	151.3668023	1391879.	8.1040843	0.0008813	-0.000130	3.2918213	13.6796567 C
0.0001113	153.9642016	1383948.	8.0256208	0.0008929	-0.000142	3.3233118	13.7409889 C
0.0001138	156.4932563	1375765.	7.9501662	0.0009043	-0.000154	3.3543731	13.8008691 C
0.0001163	158.9374875	1367204.	7.8773644	0.0009157	-0.000165	3.3849584	13.8587521 C
0.0001188	161.3180229	1358468.	7.8072119	0.0009271	-0.000177	3.4151249	13.9152020 C
0.0001213	163.6418922	1349624.	7.7395956	0.0009384	-0.000189	3.4448926	13.9703978 C
0.0001238	165.9124467	1340707.	7.6743838	0.0009497	-0.000201	3.4742720	14.0244184 C
0.0001263	168.1025356	1331505.	7.6111788	0.0009609	-0.000213	3.5031826	14.0763307 C
0.0001288	170.2488793	1322321.	7.5501703	0.0009721	-0.000225	3.5317312	14.1272793 C
0.0001313	172.3511789	1313152.	7.4912280	0.0009832	-0.000237	3.5599186	14.1772431 C
0.0001338	174.3800885	1303776.	7.4339617	0.0009943	-0.000250	3.5876556	14.2251674 C
0.0001363	176.3787542	1294523.	7.3786497	0.0010053	-0.000262	3.6150725	14.2725070 C
0.0001388	178.3195150	1285186.	7.3249373	0.0010163	-0.000274	3.6420857	14.3182624 C
0.0001413	180.2179284	1275879.	7.2728629	0.0010273	-0.000286	3.6687415	14.3629355 C
0.0001438	182.0786659	1266634.	7.2223810	0.0010382	-0.000299	3.6950574	14.4067021 C
0.0001463	183.8865999	1257344.	7.1732618	0.0010491	-0.000311	3.7209833	14.4489288 C
0.0001488	185.6693383	1248197.	7.1256813	0.0010599	-0.000323	3.7466088	14.4906645 C
0.0001588	192.3932402	1211926.	6.9478303	0.0011030	-0.000373	3.8456098	14.6460486 C
0.0001688	198.5874879	1176815.	6.7880175	0.0011455	-0.000424	3.9394180	14.7865503 C
0.0001788	204.3471856	1143201.	6.6437518	0.0011876	-0.000475	4.0283796	14.9149535 C
0.0001888	209.6820487	1110898.	6.5123989	0.0012292	-0.000526	4.1125502	15.0303643 C
0.0001988	214.6899132	1080201.	6.3926612	0.0012705	-0.000578	4.1923009	15.1365357 C
0.0002088	219.3967811	1051003.	6.2829526	0.0013116	-0.000630	4.2677512	15.2339752 C
0.0002188	223.8236775	1023194.	6.1819470	0.0013523	-0.000682	4.3390020	15.3229921 C
0.0002288	228.0041990	996740.	6.0886852	0.0013928	-0.000735	4.4062003	15.4047961 C

0.0002388	231.9643619	971578.	6.0023325	0.0014331	-0.000787	4.4694642	15.4803456 C
0.0002488	235.7168820	947606.	5.9220822	0.0014731	-0.000840	4.5288613	15.5498312 C
0.0002588	239.2893574	924790.	5.8474092	0.0015130	-0.000893	4.5845119	15.6146230 C
0.0002688	242.7031287	903081.	5.7778406	0.0015528	-0.000947	4.6365106	15.6758864 C
0.0002788	245.9782384	882433.	5.7129886	0.0015925	-0.001000	4.6849431	15.7349279 C
0.0002888	249.0830966	862625.	5.6519981	0.0016320	-0.001053	4.7297137	15.7886910 C
0.0002988	252.0653379	843733.	5.5948988	0.0016715	-0.001107	4.7709967	15.8407909 C
0.0003088	254.9383244	825711.	5.5414432	0.0017109	-0.001160	4.8088447	15.8923983 C
0.0003188	257.6652090	808361.	5.4908624	0.0017502	-0.001214	4.8431481	15.9395756 C
0.0003288	260.3168341	791838.	5.4436207	0.0017896	-0.001268	4.8741267	15.9892501 C
0.0003388	262.8283936	775877.	5.3987105	0.0018288	-0.001322	4.9015976	16.0344287 C
0.0003488	265.2743452	760643.	5.3567187	0.0018682	-0.001375	4.9257601	16.0830754 C
0.0003588	267.6037473	745934.	5.3168318	0.0019074	-0.001429	4.9464826	16.1292659 C
0.0003688	269.8562881	731814.	5.2793147	0.0019467	-0.001483	4.9638521	16.1776635 C
0.0003788	272.0292181	718229.	5.2439438	0.0019861	-0.001536	4.9778445	16.2278740 C
0.0003888	274.0981245	705076.	5.2102730	0.0020255	-0.001590	4.9884184	16.2767373 C
0.0003988	276.1053414	692427.	5.1786644	0.0020650	-0.001643	4.9956135	16.3299168 C
0.0004088	278.0280632	680191.	5.1487006	0.0021045	-0.001697	4.9993849	16.3842610 C
0.0004188	279.8561564	668313.	5.1201924	0.0021441	-0.001750	4.9993923	16.4388919 C
0.0004288	281.6122358	656822.	5.0934090	0.0021838	-0.001804	4.9993085	16.4984495 C
0.0004388	283.2929878	645682.	5.0682402	0.0022237	-0.001857	4.9991162	16.5630184 C
0.0004488	284.8598612	634785.	5.0440610	0.0022635	-0.001910	4.9987613	16.6258601 C
0.0004588	286.3548373	624207.	5.0213186	0.0023035	-0.001963	4.9988344	16.6937947 C
0.0004688	287.7768815	613924.	4.9999286	0.0023437	-0.002016	4.9999723	16.7669220 C
0.0004788	289.1282857	603923.	4.9798012	0.0023841	-0.002068	4.9997721	16.8451721 C
0.0004888	290.3905582	594149.	4.9605030	0.0024244	-0.002121	4.9992763	16.9235014 C
0.0004988	291.5845390	584631.	4.9422142	0.0024649	-0.002173	4.9983554	17.0052369 C
0.0005088	292.7163624	575364.	4.9249738	0.0025056	-0.002226	4.9999660	17.0918327 C
0.0005188	293.7855725	566334.	4.9087268	0.0025464	-0.002278	4.9995123	17.1833743 C
0.0005288	294.8011485	557544.	4.8933834	0.0025874	-0.002330	4.9983883	17.2793484 C
0.0005388	295.7568489	548969.	4.8788114	0.0026285	-0.002382	4.9999518	17.3784760 C
0.0005488	296.6413355	540576.	4.8648140	0.0026696	-0.002434	4.9992261	17.4782946 C
0.0006088	300.9827964	494428.	4.7954613	0.0029192	-0.002742	4.9998742	18.1650274 C
0.0006688	303.8370372	454336.	4.7445552	0.0031729	-0.003046	4.9993315	18.9681604 C
0.0007288	305.5687196	419305.	4.7077396	0.0034308	-0.003347	4.9998837	19.8919248 C
0.0007888	306.3703739	388425.	4.6809203	0.0036921	-0.003643	4.9973144	20.9162236 C
0.0008488	300.5094941	354061.	4.6765860	0.0039693	-0.003924	4.9976076	22.4006308 C

Axial Thrust Force = 145.100 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.7612679	1409014.	340.4408651	0.0004256	0.0004139	1.8140580	12.2044457	
0.00000250	3.5174764	1406991.	172.5478702	0.0004314	0.0004081	1.8358245	12.2366493	
0.00000375	5.2736597	1406309.	116.5846307	0.0004372	0.0004023	1.8575318	12.2689717	
0.00000500	7.0298052	1405961.	88.6038300	0.0004430	0.0003965	1.8791797	12.3014129	
0.00000625	8.7859002	1405744.	71.8160048	0.0004489	0.0003907	1.9007681	12.3339728	
0.00000750	10.5419320	1405591.	60.6246675	0.0004547	0.0003849	1.9222968	12.3666514	
0.00000875	12.2978879	1405473.	52.6313231	0.0004605	0.0003791	1.9437657	12.3994489	
0.00001000	14.0537553	1405376.	46.6367245	0.0004664	0.0003734	1.9651745	12.4323651	
0.00001125	15.8095215	1405291.	41.9746230	0.0004722	0.0003676	1.9865232	12.4654001	
0.00001250	17.5651740	1405214.	38.2452694	0.0004781	0.0003618	2.0078115	12.4985536	
0.00001375	19.3206998	1405142.	35.1942781	0.0004839	0.0003560	2.0290394	12.5318262	
0.00001500	21.0760864	1405072.	32.6520584	0.0004898	0.0003503	2.0502066	12.5652177	
0.00001625	22.8313211	1405004.	30.5012016	0.0004956	0.0003445	2.0713130	12.5987279	
0.00001750	24.5863913	1404937.	28.6578442	0.0005015	0.0003388	2.0923584	12.6323569	
0.00001875	26.3412842	1404868.	27.0604862	0.0005074	0.0003330	2.1133428	12.6661048	
0.00002000	28.0959872	1404799.	25.6630030	0.0005133	0.0003273	2.1342658	12.6999715	
0.00002125	29.8504875	1404729.	24.4301223	0.0005191	0.0003215	2.1551274	12.7339571	
0.00002250	31.6047727	1404657.	23.3344106	0.0005250	0.0003158	2.1759274	12.7680615	
0.00002375	33.3588298	1404582.	22.3542096	0.0005309	0.0003100	2.1966656	12.8022848	
0.00002500	35.1126461	1404506.	21.4721926	0.0005368	0.0003043	2.2173419	12.8366272	
0.00002625	36.8662092	1404427.	20.6743334	0.0005427	0.0002986	2.2379561	12.8710883	
0.00002750	38.6195063	1404346.	19.9491560	0.0005486	0.0002929	2.2585081	12.9056683	
0.00002875	40.3725247	1404262.	19.2871802	0.0005545	0.0002871	2.2789976	12.9403672	
0.00003000	42.1252516	1404175.	18.6805057	0.0005604	0.0002814	2.2994246	12.9751850	

0.00003125	43.8776744	1404086.	18.1224964	0.0005663	0.0002757	2.3197889	13.0101218
0.00003250	45.6297803	1403993.	17.6075372	0.0005722	0.0002700	2.3400903	13.0451776
0.00003375	47.3815567	1403898.	17.1308447	0.0005782	0.0002643	2.3603286	13.0803524
0.00003500	49.1329909	1403800.	16.6883188	0.0005841	0.0002586	2.3805038	13.1156462
0.00003625	50.8840701	1403698.	16.2764253	0.0005900	0.0002529	2.4006156	13.1510591
0.00003750	52.6347816	1403594.	15.8921008	0.0005960	0.0002472	2.4206638	13.1865909
0.00003875	54.3851127	1403487.	15.5326773	0.0006019	0.0002415	2.4406484	13.2222419
0.00004000	56.1350506	1403376.	15.1958205	0.0006078	0.0002358	2.4605692	13.2580119
0.00004125	57.8845828	1403263.	14.8794789	0.0006138	0.0002302	2.4804259	13.2939011
0.00004250	59.6336963	1403146.	14.5818422	0.0006197	0.0002245	2.5002185	13.3299094
0.00004375	61.3823785	1403026.	14.3013072	0.0006257	0.0002188	2.5199467	13.3660368
0.00004500	63.1306167	1402903.	14.0364489	0.0006316	0.0002131	2.5396105	13.4022834
0.00004625	64.8783980	1402776.	13.7859961	0.0006376	0.0002075	2.5592096	13.4386493
0.00004750	66.6257098	1402647.	13.5488116	0.0006436	0.0002018	2.5787439	13.4751344
0.00004875	68.3725393	1402514.	13.3238747	0.0006495	0.0001962	2.5982132	13.5117387
0.00005125	71.8647004	1402238.	12.9071594	0.0006615	0.0001849	2.6369563	13.5853052
0.00005375	75.3547790	1401949.	12.5295146	0.0006735	0.0001736	2.6754376	13.6593491
0.00005625	78.8426731	1401648.	12.1857309	0.0006854	0.0001623	2.7136558	13.7338706
0.00005875	82.3282804	1401332.	11.8714859	0.0006974	0.0001511	2.7516097	13.8088699
0.00006125	85.8114984	1401004.	11.5831627	0.0007095	0.0001398	2.7892978	13.8843473
0.00006375	89.2922248	1400662.	11.3177119	0.0007215	0.0001286	2.8267189	13.9603031
0.00006625	92.7703568	1400307.	11.0725441	0.0007336	0.0001174	2.8638718	14.0367375
0.00006875	96.2457920	1399939.	10.8454470	0.0007456	0.0001062	2.9007551	14.1136508
0.00007125	99.7184275	1399557.	10.6345185	0.0007577	0.00009508	2.9373676	14.1910433
0.00007375	103.1881604	1399161.	10.4381144	0.0007698	0.00008394	2.9737078	14.2689154
0.00007625	106.6548878	1398753.	10.2548062	0.0007819	0.00007280	3.0097746	14.3472673
0.00007875	110.1185065	1398330.	10.0833469	0.0007941	0.00006169	3.0455666	14.4260994
0.00008125	113.5789134	1397894.	9.9226430	0.0008062	0.00005059	3.0810825	14.5054121
0.00008375	117.0360049	1397445.	9.7717312	0.0008184	0.00003951	3.1163210	14.5852056
0.00008625	120.4896778	1396982.	9.6297604	0.0008306	0.00002844	3.1512808	14.6654804
0.00008875	123.9398283	1396505.	9.4959751	0.0008428	0.00001739	3.1859606	14.7462368
0.00009125	127.3863527	1396015.	9.3697027	0.0008550	0.00000636	3.2203591	14.8274753
0.00009375	130.8291469	1395511.	9.2503422	0.0008672	-0.00000466	3.2544748	14.9091962
0.00009625	134.2679569	1394992.	9.1373541	0.0008795	-0.00001565	3.2883063	14.9913968
0.00009875	137.7022188	1394453.	9.0302511	0.0008917	-0.00002664	3.3218513	15.0740674
0.0001013	141.1312347	1393889.	8.9285928	0.0009040	-0.00003760	3.3551071	15.1571953
0.0001038	144.5542684	1393294.	8.8319810	0.0009163	-0.00004856	3.3880713	15.2407661
0.0001063	147.9705869	1392664.	8.7400546	0.0009286	-0.00005949	3.4207412	15.3247655
0.0001088	151.3794810	1391995.	8.6524861	0.0009410	-0.00007042	3.4531143	15.4091790
0.0001113	154.7802755	1391283.	8.5689772	0.0009533	-0.00008133	3.4851881	15.4939923
0.0001138	158.1723327	1390526.	8.4892561	0.0009657	-0.00009222	3.5169603	15.5791920
0.0001163	161.5550518	1389721.	8.4130746	0.0009780	-0.000103	3.5484287	15.6647649
0.0001188	161.6194402	1361006.	8.3174290	0.0009877	-0.000117	3.5727471	15.6722621 C
0.0001213	164.2853705	1354931.	8.2431616	0.0009995	-0.000128	3.6021650	15.7410618 C
0.0001238	166.8794941	1348521.	8.1714836	0.0010112	-0.000140	3.6311502	15.8083852 C
0.0001263	169.4132048	1341887.	8.1023180	0.0010229	-0.000151	3.6597307	15.8745141 C
0.0001288	171.8916855	1335081.	8.0355519	0.0010346	-0.000163	3.6879199	15.9395728 C
0.0001313	174.2957796	1327968.	7.9708868	0.0010462	-0.000174	3.7156701	16.0029475 C
0.0001338	176.6399290	1320672.	7.9083022	0.0010577	-0.000186	3.7430165	16.0650155 C
0.0001363	178.9407812	1313327.	7.8478089	0.0010693	-0.000198	3.7700028	16.1262724 C
0.0001388	181.1721968	1305746.	7.7890798	0.0010807	-0.000210	3.7965621	16.1858557 C
0.0001413	183.3533401	1298077.	7.7321577	0.0010922	-0.000221	3.8227432	16.2443259 C
0.0001438	185.4977907	1290419.	7.6770545	0.0011036	-0.000233	3.8485836	16.3021244 C
0.0001463	187.5678738	1282515.	7.6233654	0.0011149	-0.000245	3.8739827	16.3579309 C
0.0001488	189.6151501	1274724.	7.5714218	0.0011262	-0.000257	3.8990788	16.4134793 C
0.0001588	197.3135103	1242920.	7.3773516	0.0011712	-0.000305	3.9957397	16.6234569 C
0.0001688	204.3899021	1211199.	7.2032091	0.0012155	-0.000354	4.0869096	16.8183955 C
0.0001788	210.8967154	1179842.	7.0457248	0.0012594	-0.000403	4.1727676	16.9986819 C
0.0001888	216.9327631	1149313.	6.9027404	0.0013029	-0.000452	4.2536312	17.1669962 C
0.0001988	222.5440221	1119718.	6.7722192	0.0013460	-0.000502	4.3296723	17.3242106 C
0.0002088	227.7975077	1091246.	6.6527242	0.0013888	-0.000553	4.4011228	17.4724794 C
0.0002188	232.6930531	1063740.	6.5425835	0.0014312	-0.000603	4.4680163	17.6107804 C
0.0002288	237.2916897	1037341.	6.4409225	0.0014734	-0.000654	4.5305672	17.7414504 C
0.0002388	241.6243883	1012039.	6.3468226	0.0015153	-0.000705	4.5888973	17.8655090 C
0.0002488	245.7154848	987801.	6.2594849	0.0015570	-0.000756	4.6431058	17.9837699 C
0.0002588	249.5885246	964593.	6.1782494	0.0015986	-0.000808	4.6932863	18.0971649 C
0.0002688	253.2435567	942302.	6.1023613	0.0016400	-0.000859	4.7394638	18.2051192 C
0.0002788	256.7011928	920901.	6.0313468	0.0016812	-0.000911	4.7817182	18.3084562 C
0.0002888	259.9954259	900417.	5.9649494	0.0017224	-0.000963	4.8201581	18.4092665 C

0.0002988	263.1463009	880824.	5.9028645	0.0017635	-0.001015	4.8548459	18.5089287	C
0.0003088	266.1045803	861877.	5.8441744	0.0018044	-0.001067	4.8856820	18.6029780	C
0.0003188	268.9427230	843742.	5.7891778	0.0018453	-0.001119	4.9128427	18.6971285	C
0.0003288	271.6440039	826294.	5.7373782	0.0018862	-0.001171	4.9362989	18.7898609	C
0.0003388	274.2070563	809467.	5.6884368	0.0019270	-0.001223	4.9560555	18.8806271	C
0.0003488	276.6616317	793295.	5.6423907	0.0019678	-0.001276	4.9721661	18.9722904	C
0.0003588	278.9844088	777657.	5.5987401	0.0020085	-0.001328	4.9845977	19.0621689	C
0.0003688	281.2022712	762582.	5.5575549	0.0020493	-0.001380	4.9933840	19.1530944	C
0.0003788	283.3163012	748030.	5.5186342	0.0020902	-0.001432	4.9985150	19.2450047	C
0.0003888	285.3063372	733907.	5.4816057	0.0021310	-0.001484	4.9988364	19.3356742	C
0.0003988	287.2151934	720289.	5.4468911	0.0021719	-0.001536	4.9990099	19.4316232	C
0.0004088	288.9835607	706993.	5.4137280	0.0022129	-0.001589	4.9990479	19.5258302	C
0.0004188	290.6546152	694101.	5.3824650	0.0022539	-0.001640	4.9989710	19.6238762	C
0.0004288	292.2424935	681615.	5.3531068	0.0022951	-0.001692	4.9987701	19.7274741	C
0.0004388	293.7062435	669416.	5.3250032	0.0023363	-0.001744	4.9986654	19.8299948	C
0.0004488	295.0812302	657563.	5.2984478	0.0023777	-0.001796	4.9999929	19.9363832	C
0.0004588	296.3794080	646059.	5.2734604	0.0024192	-0.001847	4.9998944	20.0482258	C
0.0004688	297.5975109	634875.	5.2498151	0.0024609	-0.001899	4.9996106	20.1638159	C
0.0004788	298.7148213	623947.	5.2270930	0.0025025	-0.001950	4.9990270	20.2785083	C
0.0004888	299.7694398	613339.	5.2056459	0.0025443	-0.002001	4.9984328	20.3980920	C
0.0004988	300.7575855	603023.	5.1854157	0.0025862	-0.002052	4.9998938	20.5228384	C
0.0005088	301.6856501	592994.	5.1663083	0.0026284	-0.002103	4.9993161	20.6524097	C
0.0005188	302.5374233	583205.	5.1479042	0.0026705	-0.002154	4.9980650	20.7814867	C
0.0005288	303.3241772	573663.	5.1303948	0.0027127	-0.002205	4.9998667	20.9136096	C
0.0005388	304.0588223	564378.	5.1138256	0.0027551	-0.002255	4.9989718	21.0502673	C
0.0005488	304.7502415	555354.	5.0981087	0.0027976	-0.002306	4.9999999	21.1908762	C
0.0006088	307.8610540	505727.	5.0183600	0.0030549	-0.002606	4.9977508	22.1000106	C
0.0006688	309.6022210	462957.	4.9587396	0.0033162	-0.002903	4.9999655	23.1219809	C
0.0007288	310.2686607	425755.	4.9135743	0.0035808	-0.003197	4.9968352	24.2419713	C
0.0007888	307.9535168	390432.	4.8852676	0.0038533	-0.003482	4.9968626	25.5904121	C

Axial Thrust Force = 146.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.7577040	1406163.	343.2394737	0.0004290	0.0004174	1.8272854	12.3058953	
0.00000250	3.5103057	1404122.	173.9471786	0.0004349	0.0004116	1.8490067	12.3380992	
0.00000375	5.2628822	1403435.	117.5175074	0.0004407	0.0004058	1.8706687	12.3704221	
0.00000500	7.0154208	1403084.	89.3034922	0.0004465	0.0004000	1.8922713	12.4028639	
0.00000625	8.7679087	1402865.	72.3757394	0.0004523	0.0003942	1.9138144	12.4354247	
0.00000750	10.5203334	1402711.	61.0911179	0.0004582	0.0003884	1.9352978	12.4681044	
0.00000875	12.2726821	1402592.	53.0311428	0.0004640	0.0003826	1.9567214	12.5009031	
0.00001000	14.0249422	1402494.	46.9865717	0.0004699	0.0003769	1.9780849	12.5338208	
0.00001125	15.7771009	1402409.	42.2856033	0.0004757	0.0003711	1.9993883	12.5668575	
0.00001250	17.5291456	1402332.	38.5251569	0.0004816	0.0003653	2.0206312	12.6000128	
0.00001375	19.2810635	1402259.	35.4487264	0.0004874	0.0003595	2.0418137	12.6332875	
0.00001500	21.0328420	1402189.	32.8853078	0.0004933	0.0003538	2.0629356	12.6666811	
0.00001625	22.7844683	1402121.	30.7165139	0.0004991	0.0003480	2.0839966	12.7001938	
0.00001750	24.5359298	1402053.	28.8577822	0.0005050	0.0003423	2.1049967	12.7338255	
0.00001875	26.2872137	1401985.	27.2471003	0.0005109	0.0003365	2.1259356	12.7675762	
0.00002000	28.0383074	1401915.	25.8379589	0.0005168	0.0003308	2.1468133	12.8014459	
0.00002125	29.7891982	1401845.	24.5947920	0.0005226	0.0003250	2.1676294	12.8354347	
0.00002250	31.5398734	1401772.	23.4899372	0.0005285	0.0003193	2.1883840	12.8695426	
0.00002375	33.2903202	1401698.	22.5015557	0.0005344	0.0003135	2.2090768	12.9037695	
0.00002500	35.0405257	1401621.	21.6121767	0.0005403	0.0003078	2.2297077	12.9381157	
0.00002625	36.7904777	1401542.	20.8076569	0.0005462	0.0003021	2.2502764	12.9725808	
0.00002750	38.5401632	1401460.	20.0764246	0.0005521	0.0002964	2.2707829	13.0071650	
0.00002875	40.2895695	1401376.	19.4089206	0.0005580	0.0002906	2.2912270	13.0418683	
0.00003000	42.0386839	1401289.	18.7971789	0.0005639	0.0002849	2.3116085	13.0766907	
0.00003125	43.7874937	1401200.	18.2345080	0.0005698	0.0002792	2.3319273	13.1116323	
0.00003250	45.5359861	1401107.	17.7152459	0.0005757	0.0002735	2.3521832	13.1466931	
0.00003375	47.2841484	1401012.	17.2345695	0.0005817	0.0002678	2.3723760	13.1818731	
0.00003500	49.0319679	1400913.	16.7883445	0.0005876	0.0002621	2.3925056	13.2171723	
0.00003625	50.7794318	1400812.	16.3730071	0.0005935	0.0002564	2.4125718	13.2525907	
0.00003750	52.5265274	1400707.	15.9854685	0.0005995	0.0002507	2.4325745	13.2881283	
0.00003875	54.2732421	1400600.	15.6230385	0.0006054	0.0002450	2.4525135	13.3237852	

0.00004000	56.0195629	1400489.	15.2833632	0.0006113	0.0002393	2.4723886	13.3595614	
0.00004125	57.7654772	1400375.	14.9643741	0.0006173	0.0002337	2.4921997	13.3954570	
0.00004250	59.5109723	1400258.	14.6642458	0.0006232	0.0002280	2.5119467	13.4314718	
0.00004375	61.2560353	1400138.	14.3813618	0.0006292	0.0002223	2.5316293	13.4676060	
0.00004500	63.0006535	1400015.	14.1142850	0.0006351	0.0002166	2.5512474	13.5038596	
0.00004625	64.7448142	1399888.	13.8617339	0.0006411	0.0002110	2.5708008	13.5402326	
0.00004750	66.4885045	1399758.	13.6225616	0.0006471	0.0002053	2.5902894	13.5767250	
0.00004875	68.2317118	1399625.	13.3957391	0.0006530	0.0001997	2.6097130	13.6133369	
0.00005125	71.7166258	1399349.	12.9755287	0.0006650	0.0001884	2.6483646	13.6869191	
0.00005375	75.1994541	1399060.	12.5947145	0.0006770	0.0001771	2.6867544	13.7609795	
0.00005625	78.6800941	1398757.	12.2480437	0.0006890	0.0001658	2.7248810	13.8355182	
0.00005875	82.1584436	1398442.	11.9311576	0.0007010	0.0001546	2.7627431	13.9105356	
0.00006125	85.6343998	1398113.	11.6404095	0.0007130	0.0001434	2.8003395	13.9860319	
0.00006375	89.1078602	1397770.	11.3727243	0.0007250	0.0001321	2.8376688	14.0620073	
0.00006625	92.5787221	1397415.	11.1254913	0.0007371	0.0001209	2.8747297	14.1384622	
0.00006875	96.0468826	1397046.	10.8964795	0.0007491	0.0001098	2.9115210	14.2153968	
0.00007125	99.5122387	1396663.	10.6837710	0.0007612	0.00009859	2.9480413	14.2928114	
0.00007375	102.9746875	1396267.	10.4857080	0.0007733	0.00008745	2.9842894	14.3707063	
0.00007625	106.4341257	1395857.	10.3008501	0.0007854	0.00007631	3.0202639	14.4490819	
0.00007875	109.8904501	1395434.	10.1279399	0.0007976	0.00006520	3.0559635	14.5279385	
0.00008125	113.3435573	1394998.	9.9658745	0.0008097	0.00005410	3.0913870	14.6072764	
0.00008375	116.7933436	1394547.	9.8136830	0.0008219	0.00004302	3.1265329	14.6870961	
0.00008625	120.2397056	1394084.	9.6705070	0.0008341	0.00003196	3.1614000	14.7673978	
0.00008875	123.6825393	1393606.	9.5355847	0.0008463	0.00002091	3.1959870	14.8481819	
0.00009125	127.1217408	1393115.	9.4082378	0.0008585	0.00000988	3.2302926	14.9294489	
0.00009375	130.5572061	1392610.	9.2878605	0.0008707	-0.00000114	3.2643154	15.0111992	
0.00009625	133.9887649	1392091.	9.1739094	0.0008830	-0.00001214	3.2980540	15.0934317	
0.00009875	137.4159509	1391554.	9.0658938	0.0008953	-0.00002312	3.3315063	15.1761391	
0.0001013	140.8380955	1390994.	8.9633698	0.0009075	-0.00003408	3.3646698	15.2593093	
0.0001038	144.2544732	1390405.	8.8659360	0.0009198	-0.00004503	3.3975420	15.3429285	
0.0001063	147.6643541	1389782.	8.7732284	0.0009322	-0.00005597	3.4301203	15.4269823	
0.0001088	151.0670254	1389122.	8.6849165	0.0009445	-0.00006689	3.4624021	15.5114563	
0.0001113	154.4618029	1388421.	8.6006995	0.0009568	-0.00007780	3.4943849	15.5963364	
0.0001138	157.8480421	1387675.	8.5203033	0.0009692	-0.00008869	3.5260665	15.6816089	
0.0001163	161.2251480	1386883.	8.4434776	0.0009816	-0.00009957	3.5574446	15.7672610	
0.0001188	164.5925586	1386043.	8.3699933	0.0009939	-0.000110	3.5885169	15.8532804	
0.0001213	164.2098373	1354308.	8.2741975	0.0010032	-0.000124	3.6115837	15.8501902	C
0.0001238	166.8324970	1348141.	8.2021795	0.0010150	-0.000136	3.6405585	15.9185451	C
0.0001263	169.3957413	1341748.	8.1327032	0.0010268	-0.000147	3.6691318	15.9857618	C
0.0001288	171.8789293	1334982.	8.0654471	0.0010384	-0.000159	3.6972527	16.0511940	C
0.0001313	174.3026743	1328020.	8.0004283	0.0010501	-0.000171	3.7249712	16.1153899	C
0.0001338	176.6781862	1320958.	7.9376026	0.0010617	-0.000182	3.7523165	16.1786648	C
0.0001363	178.9870695	1313667.	7.8766978	0.0010732	-0.000194	3.7792425	16.2404196	C
0.0001388	181.2366887	1306210.	7.8176525	0.0010847	-0.000206	3.8057670	16.3008251	C
0.0001413	183.4507033	1298766.	7.7605496	0.0010962	-0.000217	3.8319524	16.3606259	C
0.0001438	185.5893899	1291057.	7.7049660	0.0011076	-0.000229	3.8576951	16.4184777	C
0.0001463	187.6930480	1283371.	7.6511289	0.0011190	-0.000241	3.8831011	16.4756827	C
0.0001488	189.7462993	1275605.	7.5988273	0.0011303	-0.000253	3.9081307	16.5317022	C
0.0001588	197.5156650	1244193.	7.4038226	0.0011754	-0.000301	4.0046502	16.7453242	C
0.0001688	204.6346275	1212650.	7.2286774	0.0012198	-0.000350	4.0955974	16.9430288	C
0.0001788	211.1968314	1181521.	7.0704374	0.0012638	-0.000399	4.1812653	17.1267819	C
0.0001888	217.2965605	1151240.	6.9268930	0.0013075	-0.000448	4.2619598	17.2992020	C
0.0001988	222.9304005	1121662.	6.7955692	0.0013506	-0.000498	4.3377056	17.4587962	C
0.0002088	228.2069221	1093207.	6.6753688	0.0013935	-0.000548	4.4088552	17.6095650	C
0.0002188	233.1520990	1065838.	6.5648357	0.0014361	-0.000598	4.4755184	17.7519413	C
0.0002288	237.7903670	1039521.	6.4627700	0.0014784	-0.000649	4.5378003	17.8863821	C
0.0002388	242.1468789	1014228.	6.3681945	0.0015204	-0.000700	4.5958057	18.0134830	C
0.0002488	246.2559490	989974.	6.2803895	0.0015622	-0.000751	4.6496631	18.1345710	C
0.0002588	250.1296814	966685.	6.1985833	0.0016039	-0.000802	4.6994343	18.2497455	C
0.0002688	253.7960179	944357.	6.1222665	0.0016454	-0.000854	4.7452220	18.3602556	C
0.0002788	257.2773686	922968.	6.0509845	0.0016867	-0.000906	4.7871079	18.4672024	C
0.0002888	260.5949744	902493.	5.9843626	0.0017280	-0.000957	4.8251639	18.5718280	C
0.0002988	263.7338752	882791.	5.9217585	0.0017691	-0.001009	4.8593705	18.6726217	C
0.0003088	266.7096065	863837.	5.8628610	0.0018102	-0.001061	4.8897813	18.7702927	C
0.0003188	269.5701063	845710.	5.8077461	0.0018512	-0.001113	4.9165087	18.8687695	C
0.0003288	272.2538145	828148.	5.7554642	0.0018921	-0.001165	4.9394414	18.9622886	C
0.0003388	274.8384533	811331.	5.7064617	0.0019331	-0.001217	4.9587280	19.0577001	C
0.0003488	277.2752429	795054.	5.6599843	0.0019739	-0.001269	4.9742945	19.1502279	C
0.0003588	279.6185745	779425.	5.6163238	0.0020149	-0.001322	4.9862131	19.2451053	C

0.0003688	281.8183738	764253.	5.5747508	0.0020557	-0.001374	4.9944325	19.3369828	C
0.0003788	283.9464284	749694.	5.5358112	0.0020967	-0.001426	4.9989991	19.4336730	C
0.0003888	285.9218733	735490.	5.4984928	0.0021375	-0.001478	4.9992629	19.5260545	C
0.0003988	287.8099564	721780.	5.4634558	0.0021786	-0.001530	4.9994016	19.6231734	C
0.0004088	289.5911027	708480.	5.4303701	0.0022197	-0.001582	4.9994410	19.7231010	C
0.0004188	291.2408356	695501.	5.3988164	0.0022608	-0.001634	4.9993840	19.8224440	C
0.0004288	292.8073086	682932.	5.3691834	0.0023020	-0.001685	4.9992293	19.9273658	C
0.0004388	294.2805963	670725.	5.3411902	0.0023434	-0.001737	4.9989410	20.0359543	C
0.0004488	295.6359845	658799.	5.3143770	0.0023848	-0.001789	4.9984533	20.1436829	C
0.0004588	296.9164562	647229.	5.2891370	0.0024264	-0.001840	4.9999930	20.2567834	C
0.0004688	298.1222755	635994.	5.2653724	0.0024681	-0.001891	4.9998560	20.3752979	C
0.0004788	299.2388502	625042.	5.2426899	0.0025099	-0.001942	4.9994582	20.4950505	C
0.0004888	300.2730256	614369.	5.2210328	0.0025518	-0.001994	4.9986697	20.6161821	C
0.0004988	301.2467250	604003.	5.2005775	0.0025938	-0.002045	4.9999948	20.7421347	C
0.0005088	302.1550477	593917.	5.1812771	0.0026360	-0.002095	4.9996732	20.8732562	C
0.0005188	303.0098623	584115.	5.1630191	0.0026783	-0.002146	4.9987273	21.0088851	C
0.0005288	303.7858486	574536.	5.1453423	0.0027206	-0.002197	4.9999900	21.1428241	C
0.0005388	304.5013973	565200.	5.1286014	0.0027630	-0.002247	4.9994418	21.2811177	C
0.0005488	305.1739458	556126.	5.1127199	0.0028056	-0.002298	4.9978922	21.4233946	C
0.0006088	308.2172255	506312.	5.0323899	0.0030635	-0.002598	4.9985277	22.3476884	C
0.0006688	309.8994302	463401.	4.9723370	0.0033253	-0.002894	4.9984223	23.3857024	C
0.0007288	310.4941016	426064.	4.9264958	0.0035902	-0.003187	4.9978589	24.5150488	C
0.0007888	308.1175812	390640.	4.8976138	0.0038630	-0.003472	4.9979127	25.8728159	C

Axial Thrust Force = 195.300 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.5921871	1273750.	473.2255123	0.0005915	0.0005799	2.4113364	17.0178892	
0.00000250	3.1772649	1270906.	238.9403994	0.0005974	0.0005741	2.4309549	17.0501077	
0.00000375	4.7623154	1269951.	160.8465461	0.0006032	0.0005683	2.4505138	17.0824550	
0.00000500	6.3473249	1269465.	121.8005077	0.0006090	0.0005625	2.4700129	17.1149311	
0.00000625	7.9322795	1269165.	98.3735953	0.0006148	0.0005567	2.4894521	17.1475360	
0.00000750	9.5171657	1268955.	82.7562459	0.0006207	0.0005509	2.5088312	17.1802698	
0.00000875	11.1019696	1268797.	71.6015040	0.0006265	0.0005451	2.5281500	17.2131323	
0.00001000	12.6866775	1268668.	63.2358917	0.0006324	0.0005394	2.5474084	17.2461236	
0.00001125	14.2712757	1268558.	56.7296992	0.0006382	0.0005336	2.5666062	17.2792438	
0.00001250	15.8557504	1268460.	51.5251006	0.0006441	0.0005278	2.5857431	17.3124928	
0.00001375	17.4400878	1268370.	47.2671158	0.0006499	0.0005220	2.6048191	17.3458706	
0.00001500	19.0242743	1268285.	43.7190913	0.0006558	0.0005163	2.6238340	17.3793773	
0.00001625	20.6082960	1268203.	40.7171902	0.0006617	0.0005105	2.6427875	17.4130128	
0.00001750	22.1921393	1268122.	38.1443860	0.0006675	0.0005048	2.6616795	17.4467772	
0.00001875	23.7757904	1268042.	35.9148594	0.0006734	0.0004990	2.6805099	17.4806705	
0.00002000	25.3592355	1267962.	33.9642458	0.0006793	0.0004933	2.6992785	17.5146926	
0.00002125	26.9424609	1267881.	32.2433254	0.0006852	0.0004875	2.7179851	17.5488437	
0.00002250	28.5254528	1267798.	30.7138159	0.0006911	0.0004818	2.7366294	17.5831237	
0.00002375	30.1081974	1267714.	29.3454946	0.0006970	0.0004761	2.7552115	17.6175326	
0.00002500	31.6906811	1267627.	28.1141833	0.0007029	0.0004704	2.7737310	17.6520704	
0.00002625	33.2728900	1267539.	27.0003092	0.0007088	0.0004646	2.7921878	17.6867372	
0.00002750	34.8548103	1267448.	25.9878581	0.0007147	0.0004589	2.8105817	17.7215331	
0.00002875	36.4364283	1267354.	25.0636010	0.0007206	0.0004532	2.8289126	17.7564579	
0.00003000	38.0177302	1267258.	24.2165135	0.0007265	0.0004475	2.8471803	17.7915118	
0.00003125	39.5987022	1267158.	23.4373355	0.0007324	0.0004418	2.8653846	17.8266947	
0.00003250	41.1793305	1267056.	22.7182312	0.0007383	0.0004361	2.8835253	17.8620067	
0.00003375	42.7596015	1266951.	22.0525258	0.0007443	0.0004304	2.9016023	17.8974477	
0.00003500	44.3395011	1266843.	21.4344979	0.0007502	0.0004247	2.9196154	17.9330179	
0.00003625	45.9190158	1266731.	20.8592155	0.0007561	0.0004190	2.9375644	17.9687172	
0.00003750	47.4981316	1266617.	20.3224041	0.0007621	0.0004133	2.9554491	18.0045457	
0.00003875	49.0768348	1266499.	19.8203406	0.0007680	0.0004077	2.9732694	18.0405033	
0.00004000	50.6551115	1266378.	19.3497674	0.0007740	0.0004020	2.9910251	18.0765902	
0.00004125	52.2329480	1266253.	18.9078219	0.0007799	0.0003963	3.0087160	18.1128063	
0.00004250	53.8103304	1266125.	18.4919780	0.0007859	0.0003907	3.0263419	18.1491517	
0.00004375	55.3872449	1265994.	18.0999986	0.0007919	0.0003850	3.0439027	18.1856264	
0.00004500	56.9636777	1265860.	17.7298949	0.0007978	0.0003793	3.0613982	18.2222304	
0.00004625	58.5396149	1265721.	17.3798933	0.0008038	0.0003737	3.0788282	18.2589638	
0.00004750	60.1150426	1265580.	17.0484067	0.0008098	0.0003680	3.0961926	18.2958266	

0.00004875	61.6899472	1265435.	16.7340110	0.0008158	0.0003624	3.1134911	18.3328188
0.00005125	64.8381311	1265134.	16.1514901	0.0008278	0.0003511	3.1478900	18.4071916
0.00005375	67.9840556	1264820.	15.6234895	0.0008398	0.0003399	3.1820235	18.4820825
0.00005625	71.1276098	1264491.	15.1427402	0.0008518	0.0003287	3.2158901	18.5574919
0.00005875	74.2686827	1264148.	14.7032101	0.0008638	0.0003174	3.2494885	18.6334200
0.00006125	77.4071628	1263790.	14.2998523	0.0008759	0.0003062	3.2828173	18.7098671
0.00006375	80.5429390	1263419.	13.9284113	0.0008879	0.0002951	3.3158750	18.7868336
0.00006625	83.6758997	1263032.	13.5852741	0.0009000	0.0002839	3.3486602	18.8643199
0.00006875	86.8059334	1262632.	13.2673532	0.0009121	0.0002728	3.3811716	18.9423263
0.00007125	89.9329283	1262217.	12.9719945	0.0009243	0.0002616	3.4134077	19.0208532
0.00007375	93.0567726	1261787.	12.6969037	0.0009364	0.0002505	3.4453670	19.0999010
0.00007625	96.1773542	1261342.	12.4400873	0.0009486	0.0002394	3.4770483	19.1794701
0.00007875	99.2945611	1260883.	12.1998052	0.0009607	0.0002284	3.5084500	19.2595610
0.00008125	102.4082808	1260410.	11.9745313	0.0009729	0.0002173	3.5395707	19.3401740
0.00008375	105.5184009	1259921.	11.7629218	0.0009851	0.0002063	3.5704091	19.4213097
0.00008625	108.6248088	1259418.	11.5637886	0.0009974	0.0001953	3.6009636	19.5029685
0.00008875	111.7273916	1258900.	11.3760777	0.0010096	0.0001843	3.6312328	19.5851508
0.00009125	114.8260364	1258368.	11.1988503	0.0010219	0.0001733	3.6612154	19.6678573
0.00009375	117.9206299	1257820.	11.0312681	0.0010342	0.0001623	3.6909098	19.7510884
0.00009625	121.0110588	1257258.	10.8725795	0.0010465	0.0001514	3.7203146	19.8348447
0.00009875	124.0972095	1256681.	10.7221094	0.0010588	0.0001404	3.7494284	19.9191267
0.0001013	127.1789683	1256089.	10.5792491	0.0010711	0.0001295	3.7782498	20.0039349
0.0001038	130.2562212	1255482.	10.4434488	0.0010835	0.0001186	3.8067772	20.0892700
0.0001063	133.3288541	1254860.	10.3142102	0.0010959	0.0001078	3.8350093	20.1751325
0.0001088	136.3967524	1254223.	10.1910811	0.0011083	0.00009691	3.8629445	20.2615231
0.0001113	139.4598016	1253571.	10.0736498	0.0011207	0.00008607	3.8905815	20.3484423
0.0001138	142.5178869	1252904.	9.9615407	0.0011331	0.00007525	3.9179187	20.4358909
0.0001163	145.5708931	1252223.	9.8544107	0.0011456	0.00006445	3.9449547	20.5238694
0.0001188	148.6187049	1251526.	9.7519456	0.0011580	0.00005367	3.9716880	20.6123786
0.0001213	151.6612068	1250814.	9.6538569	0.0011705	0.00004291	3.9981171	20.7014192
0.0001238	154.6982829	1250087.	9.5598797	0.0011830	0.00003216	4.0242406	20.7909918
0.0001263	157.7298171	1249345.	9.4697699	0.0011956	0.00002143	4.0500570	20.8810972
0.0001288	160.7556930	1248588.	9.3833023	0.0012081	0.00001073	4.0755648	20.9717361
0.0001313	163.7757941	1247816.	9.3002692	0.0012207	3.53261E-08	4.1007625	21.0629092
0.0001338	166.7899822	1247028.	9.2204778	0.0012332	-0.00001064	4.1256485	21.1546169
0.0001363	169.7979503	1246223.	9.1437490	0.0012458	-0.00002129	4.1502212	21.2468553
0.0001388	172.7992672	1245400.	9.0699153	0.0012585	-0.00003192	4.1744784	21.3396176
0.0001413	175.7934682	1244556.	8.9988211	0.0012711	-0.00004254	4.1984181	21.4328957
0.0001438	178.7800721	1243687.	8.9303214	0.0012837	-0.00005314	4.2220383	21.5266810
0.0001463	181.7585665	1242794.	8.8642810	0.0012964	-0.00006372	4.2453369	21.6209639
0.0001488	184.7284316	1241872.	8.8005733	0.0013091	-0.00007429	4.2683117	21.7157343
0.0001588	194.2974212	1223921.	8.5541832	0.0013580	-0.000118	4.3535169	22.0412970 C
0.0001688	203.8768887	1208159.	8.3386532	0.0014071	-0.000162	4.4338958	22.3749734 C
0.0001788	212.6963373	1189910.	8.1447677	0.0014559	-0.000206	4.5082843	22.6958456 C
0.0001888	220.8140396	1169876.	7.9691444	0.0015042	-0.000251	4.5768412	23.0042248 C
0.0001988	228.3041972	1148700.	7.8092214	0.0015521	-0.000296	4.6397546	23.3012349 C
0.0002088	235.2503535	1126948.	7.6630543	0.0015997	-0.000342	4.6972260	23.5887621 C
0.0002188	241.6564758	1104715.	7.5285943	0.0016469	-0.000387	4.7493217	23.8657813 C
0.0002288	247.6251619	1082514.	7.4047951	0.0016938	-0.000434	4.7962632	24.1355378 C
0.0002388	253.1584026	1060349.	7.2901985	0.0017405	-0.000480	4.8381048	24.3972080 C
0.0002488	258.2944480	1038370.	7.1838154	0.0017870	-0.000526	4.8749557	24.6516590 C
0.0002588	263.0813899	1016740.	7.0849055	0.0018332	-0.000573	4.9069289	24.9004857 C
0.0002688	267.5439569	995512.	6.9927156	0.0018793	-0.000620	4.9340960	25.1443172 C
0.0002788	271.7066750	974732.	6.9066158	0.0019252	-0.000667	4.9565215	25.3839085 C
0.0002888	275.5936443	954437.	6.8260788	0.0019710	-0.000714	4.9742607	25.6201482 C
0.0002988	279.2090063	934591.	6.7505174	0.0020167	-0.000762	4.9873468	25.8527808 C
0.0003088	282.5606699	915176.	6.6794388	0.0020623	-0.000809	4.9958174	26.0817264 C
0.0003188	285.6932920	896293.	6.6127015	0.0021078	-0.000857	4.9997144	26.3095744 C
0.0003288	288.6221692	877938.	6.5500768	0.0021533	-0.000904	4.9999977	26.5379258 C
0.0003388	291.2831359	859876.	6.4908628	0.0021988	-0.000952	4.9995322	26.7634597 C
0.0003488	293.7421632	842271.	6.4352039	0.0022443	-0.000999	4.9998739	26.9906052 C
0.0003588	296.0070420	825107.	6.3828219	0.0022898	-0.001047	4.9999925	27.2195593 C
0.0003688	298.0519741	808277.	6.3331797	0.0023354	-0.001094	4.9989364	27.4474317 C
0.0003788	299.9488376	791944.	6.2865569	0.0023810	-0.001141	4.9991631	27.6796758 C
0.0003888	301.6461214	775939.	6.2421640	0.0024266	-0.001189	4.9992555	27.9100174 C
0.0003988	303.2179354	760421.	6.2003811	0.0024724	-0.001236	4.9992463	28.1447943 C
0.0004088	304.6323739	745278.	6.1606396	0.0025182	-0.001283	4.9991242	28.3795327 C
0.0004188	305.9172439	730549.	6.1229547	0.0025640	-0.001330	4.9988685	28.6161975 C
0.0004288	307.1073020	716285.	6.0874128	0.0026100	-0.001377	4.9988285	28.8576512 C

0.0004388	308.1385518	702310.	6.0532242	0.0026559	-0.001425	4.9999828	29.0957085 C
0.0004488	309.0935741	688788.	6.0210003	0.0027019	-0.001471	4.9998346	29.3395046 C
0.0004588	309.9592762	675661.	5.9903820	0.0027481	-0.001518	4.9994501	29.5859612 C
0.0004688	310.7066881	662841.	5.9608923	0.0027942	-0.001565	4.9986971	29.8300213 C
0.0004788	311.3935746	650430.	5.9329962	0.0028404	-0.001612	4.9999890	30.0790933 C
0.0004888	312.0166725	638397.	5.9066135	0.0028869	-0.001659	4.9996558	30.3334346 C
0.0004988	312.5284926	626624.	5.8809438	0.0029331	-0.001705	4.9987085	30.5827884 C
0.0005088	312.9886102	615211.	5.8565561	0.0029795	-0.001752	4.9999752	30.8361662 C
0.0005188	313.3949054	604135.	5.8334299	0.0030261	-0.001798	4.9993751	31.0943785 C
0.0005288	313.7595193	593399.	5.8113975	0.0030728	-0.001845	4.9978036	31.3559478 C
0.0005388	314.0254838	582878.	5.7898989	0.0031193	-0.001891	4.9996852	31.6130794 C
0.0005488	314.2552849	572675.	5.7694184	0.0031660	-0.001937	4.9981857	31.8739450 C
0.0006088	314.7554801	517052.	5.6633877	0.0034476	-0.002214	4.9973703	33.4871835 C
0.0006688	314.0242713	469569.	5.5796888	0.0037314	-0.002488	4.9992614	35.1645324 C
0.0007288	294.8748824	404631.	5.5588817	0.0040510	-0.002726	4.9963210	37.8797493 C

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	108.700	295.060	0.00300000	-0.00317023
2	125.900	301.335	0.00300000	-0.00286662
3	127.500	301.891	0.00300000	-0.00283902
4	145.100	307.197	0.00300000	-0.00254228
5	146.200	307.468	0.00300000	-0.00252404
6	195.300	313.167	0.00300000	-0.00177227

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	108.700000	295.059526	70.655000	191.788692	1097647.
2	0.65	125.900000	301.334527	81.835000	195.867443	1184574.
3	0.65	127.500000	301.891472	82.875000	196.229457	1190181.
4	0.65	145.100000	307.197081	94.315000	199.678103	1232320.
5	0.65	146.200000	307.468186	95.030000	199.854321	1233831.
6	0.65	195.300000	313.167265	126.945000	203.558722	1208683.
1	0.75	108.700000	295.059526	81.525000	221.294644	895533.
2	0.75	125.900000	301.334527	94.425000	226.000895	998655.
3	0.75	127.500000	301.891472	95.625000	226.418604	1006773.
4	0.75	145.100000	307.197081	108.825000	230.397811	1076636.
5	0.75	146.200000	307.468186	109.650000	230.601140	1079956.
6	0.75	195.300000	313.167265	146.475000	234.875449	1128122.
1	0.90	108.700000	295.059526	97.830000	265.553573	634993.
2	0.90	125.900000	301.334527	113.310000	271.201074	713104.
3	0.90	127.500000	301.891472	114.750000	271.702325	720273.

4	0.90	145.100000	307.197081	130.590000	276.477373	794509.
5	0.90	146.200000	307.468186	131.580000	276.721368	798754.
6	0.90	195.300000	313.167265	175.770000	281.850538	919290.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4216.
2	4.4000	4.7007	Yes	No	4216.	219451.
3	23.4000	23.4000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
for Layer n. Layering correction equivalent depths are computed only
for soil types with both shallow-depth and deep-depth expressions for
peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 19740.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 195300.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5942	-1244431.	19740.	0.00	0.00	7.40E+09	0.00	0.00	0.00
0.3140	0.5930	-1169818.	19723.	-6.15E-04	0.00	7.40E+09	-8.980	57.0617	0.00
0.6280	0.5895	-1094893.	19670.	-0.00119	0.00	7.48E+09	-19.453	124.3357	0.00
0.9420	0.5840	-1019839.	19576.	-0.00172	0.00	7.52E+09	-30.288	195.4101	0.00
1.2560	0.5766	-944839.	19442.	-0.00221	0.00	7.57E+09	-40.655	265.6817	0.00
1.5700	0.5674	-870071.	19270.	-0.00266	0.00	7.63E+09	-50.612	336.1226	0.00
1.8840	0.5565	-795704.	19063.	-0.00307	0.00	7.68E+09	-59.511	402.9175	0.00
2.1980	0.5442	-721895.	18825.	-0.00344	0.00	7.75E+09	-66.852	462.8542	0.00
2.5120	0.5306	-648777.	18557.	-0.00377	0.00	7.82E+09	-75.087	533.2213	0.00
2.8260	0.5158	-576495.	18257.	-0.00407	0.00	7.88E+09	-84.491	617.2203	0.00
3.1400	0.5000	-505210.	17917.	-0.00432	0.00	8.00E+09	-95.566	720.2497	0.00
3.4540	0.4832	-435107.	17537.	-0.00455	0.00	8.00E+09	-106.099	827.3347	0.00
3.7680	0.4657	-366359.	17110.	-0.00473	0.00	8.00E+09	-120.676	976.3843	0.00
4.0820	0.4475	-299197.	16623.	-0.00489	0.00	8.00E+09	-137.843	1161.	0.00
4.3960	0.4288	-233889.	16070.	-0.00502	0.00	8.00E+09	-155.966	1370.	0.00
4.7100	0.4097	-170714.	15462.	-0.00511	0.00	8.00E+09	-166.402	1530.	0.00
5.0240	0.3903	-109842.	14808.	-0.00518	0.00	8.00E+09	-181.004	1747.	0.00
5.3380	0.3707	-51502.	14105.	-0.00522	0.00	8.00E+09	-191.971	1951.	0.00
5.6520	0.3510	4130.	13362.	-0.00523	0.00	8.00E+09	-202.299	2172.	0.00
5.9660	0.3313	56889.	12582.	-0.00521	0.00	8.00E+09	-211.913	2410.	0.00
6.2800	0.3117	106619.	11767.	-0.00517	0.00	8.00E+09	-220.756	2668.	0.00
6.5940	0.2923	153178.	10920.	-0.00511	0.00	8.00E+09	-228.783	2949.	0.00
6.9080	0.2732	196435.	10044.	-0.00503	0.00	8.00E+09	-235.963	3254.	0.00

7.2220	0.2544	236275.	9143.	-0.00493	0.00	8.00E+09	-242.280	3588.	0.00
7.5360	0.2361	272592.	8220.	-0.00481	0.00	8.00E+09	-247.730	3954.	0.00
7.8500	0.2182	305298.	7278.	-0.00467	0.00	8.00E+09	-252.325	4357.	0.00
8.1640	0.2009	334316.	6320.	-0.00452	0.00	8.00E+09	-256.089	4804.	0.00
8.4780	0.1841	359581.	5350.	-0.00436	0.00	8.00E+09	-259.060	5302.	0.00
8.7920	0.1680	381044.	4369.	-0.00418	0.00	8.00E+09	-261.178	5857.	0.00
9.1060	0.1526	398667.	3384.	-0.00400	0.00	8.00E+09	-262.067	6471.	0.00
9.4200	0.1379	412431.	2397.	-0.00381	0.00	8.00E+09	-261.654	7151.	0.00
9.7340	0.1239	422336.	1441.	-0.00361	0.00	8.00E+09	-245.996	7482.	0.00
10.0480	0.1106	428603.	549.7629	-0.00341	0.00	8.00E+09	-226.799	7724.	0.00
10.3620	0.09817	431501.	-268.481	-0.00321	0.00	8.00E+09	-207.514	7965.	0.00
10.6760	0.08646	431303.	-1014.	-0.00301	0.00	8.00E+09	-188.299	8206.	0.00
10.9900	0.07551	428283.	-1688.	-0.00280	0.00	8.00E+09	-169.300	8448.	0.00
11.3040	0.06533	422710.	-2291.	-0.00260	0.00	8.00E+09	-150.653	8689.	0.00
11.6180	0.05590	414851.	-2824.	-0.00241	0.00	8.00E+09	-132.480	8930.	0.00
11.9320	0.04720	404968.	-3290.	-0.00221	0.00	8.00E+09	-114.891	9172.	0.00
12.2460	0.03922	393313.	-3691.	-0.00202	0.00	8.00E+09	-97.984	9413.	0.00
12.5600	0.03194	380131.	-4030.	-0.00184	0.00	8.00E+09	-81.844	9655.	0.00
12.8740	0.02534	365654.	-4310.	-0.00167	0.00	8.00E+09	-66.543	9896.	0.00
13.1880	0.01938	350107.	-4533.	-0.00150	0.00	8.00E+09	-52.143	10137.	0.00
13.5020	0.01405	333697.	-4704.	-0.00134	0.00	8.00E+09	-38.692	10379.	0.00
13.8160	0.00931	316623.	-4827.	-0.00118	0.00	8.00E+09	-26.227	10620.	0.00
14.1300	0.00513	299066.	-4904.	-0.00104	0.00	8.00E+09	-14.774	10861.	0.00
14.4440	0.00148	281196.	-4940.	-9.02E-04	0.00	8.00E+09	-4.351	11103.	0.00
14.7580	-0.00167	263167.	-4939.	-7.74E-04	0.00	8.00E+09	5.0376	11344.	0.00
15.0720	-0.00436	245118.	-4904.	-6.54E-04	0.00	8.00E+09	13.3931	11585.	0.00
15.3860	-0.00660	227174.	-4840.	-5.43E-04	0.00	8.00E+09	20.7266	11827.	0.00
15.7000	-0.00845	209446.	-4750.	-4.40E-04	0.00	8.00E+09	27.0565	12068.	0.00
16.0140	-0.00992	192029.	-4638.	-3.46E-04	0.00	8.00E+09	32.4080	12310.	0.00
16.3280	-0.01105	175006.	-4507.	-2.59E-04	0.00	8.00E+09	36.8129	12551.	0.00
16.6420	-0.01187	158444.	-4362.	-1.81E-04	0.00	8.00E+09	40.3080	12792.	0.00
16.9560	-0.01241	142401.	-4205.	-1.10E-04	0.00	8.00E+09	42.9356	13034.	0.00
17.2700	-0.01270	126917.	-4040.	-4.63E-05	0.00	8.00E+09	44.7417	13275.	0.00
17.5840	-0.01276	112024.	-3869.	1.00E-05	0.00	8.00E+09	45.7766	13516.	0.00
17.8980	-0.01262	97743.	-3696.	5.94E-05	0.00	8.00E+09	46.0933	13758.	0.00
18.2120	-0.01231	84082.	-3523.	1.02E-04	0.00	8.00E+09	45.7478	13999.	0.00
18.5260	-0.01185	71042.	-3353.	1.39E-04	0.00	8.00E+09	44.7986	14240.	0.00
18.8400	-0.01127	58613.	-3187.	1.69E-04	0.00	8.00E+09	43.3058	14482.	0.00
19.1540	-0.01058	46778.	-3027.	1.94E-04	0.00	8.00E+09	41.3314	14723.	0.00
19.4680	-0.00980	35515.	-2876.	2.14E-04	0.00	8.00E+09	38.9388	14965.	0.00
19.7820	-0.00897	24791.	-2734.	2.28E-04	0.00	8.00E+09	36.1929	15206.	0.00
20.0960	-0.00809	14573.	-2604.	2.37E-04	0.00	8.00E+09	33.1594	15447.	0.00
20.4100	-0.00718	4821.	-2485.	2.42E-04	0.00	8.00E+09	29.9055	15689.	0.00
20.7240	-0.00627	-4509.	-2379.	2.42E-04	0.00	8.00E+09	26.4994	15930.	0.00
21.0380	-0.00536	-13460.	-2285.	2.37E-04	0.00	8.00E+09	23.0105	16171.	0.00
21.3520	-0.00448	-22080.	-2205.	2.29E-04	0.00	8.00E+09	19.5095	16413.	0.00
21.6660	-0.00364	-30416.	-2138.	2.17E-04	0.00	8.00E+09	16.0686	16654.	0.00
21.9800	-0.00285	-38513.	-2084.	2.00E-04	0.00	8.00E+09	12.7617	16895.	0.00
22.2940	-0.00213	-46415.	-2042.	1.80E-04	0.00	8.00E+09	9.6646	17137.	0.00
22.6080	-0.00149	-54164.	-2011.	1.57E-04	0.00	8.00E+09	6.8551	17378.	0.00
22.9220	-9.44E-04	-61797.	-1989.	1.29E-04	0.00	8.00E+09	4.4133	17619.	0.00
23.2360	-5.11E-04	-69346.	-1976.	9.85E-05	0.00	8.00E+09	2.4219	17861.	0.00
23.5500	-2.01E-04	-76837.	2097.	6.41E-05	0.00	8.00E+09	2159.	4.05E+07	0.00
23.8640	-2.78E-05	-53641.	6726.	3.34E-05	0.00	8.00E+09	297.9517	4.05E+07	0.00
24.1780	5.04E-05	-26197.	6268.	1.46E-05	0.00	8.00E+09	-541.402	4.05E+07	0.00
24.4920	8.21E-05	-6430.	3587.	-1.13E-06	0.00	1.27E+09	-881.604	4.05E+07	0.00
24.8060	4.19E-05	833.5501	1078.	-9.44E-06	0.00	1.27E+09	-449.734	4.05E+07	0.00
25.1200	1.10E-05	1710.	9.5047	-5.68E-06	0.00	1.27E+09	-117.610	4.05E+07	0.00
25.4340	-9.12E-07	913.5375	-193.622	-1.80E-06	0.00	1.27E+09	9.7936	4.05E+07	0.00
25.7480	-2.60E-06	253.8240	-122.643	-7.17E-08	0.00	1.27E+09	27.8806	4.05E+07	0.00
26.0620	-1.45E-06	-10.598	-40.737	2.88E-07	0.00	1.27E+09	15.5943	4.05E+07	0.00
26.3760	-4.26E-07	-53.592	-2.736	1.93E-07	0.00	1.27E+09	4.5762	4.05E+07	0.00
26.6900	2.70E-09	-31.498	5.8312	6.73E-08	0.00	1.27E+09	-0.02900	4.05E+07	0.00
27.0040	8.06E-08	-9.747	4.1469	6.25E-09	0.00	1.27E+09	-0.865	4.05E+07	0.00
27.3180	4.98E-08	-0.256	1.5099	-8.54E-09	0.00	1.27E+09	-0.535	4.05E+07	0.00
27.6320	1.62E-08	1.6440	0.1752	-6.49E-09	0.00	1.27E+09	-0.174	4.05E+07	0.00
27.9460	8.86E-10	1.0738	-0.170	-2.47E-09	0.00	1.27E+09	-0.00951	4.05E+07	0.00
28.2600	-2.44E-09	0.3661	-0.139	-3.42E-10	0.00	1.27E+09	0.02621	4.05E+07	0.00
28.5740	-1.69E-09	0.02987	-0.05506	2.44E-10	0.00	1.27E+09	0.01813	4.05E+07	0.00

28.8880	-6.02E-10	-0.04912	-0.00872	2.16E-10	0.00	1.27E+09	0.00647	4.05E+07	0.00
29.2020	-6.35E-11	-0.03619	0.00474	8.94E-11	0.00	1.27E+09	6.82E-04	4.05E+07	0.00
29.5160	7.18E-11	-0.01351	0.00458	1.59E-11	0.00	1.27E+09	-7.71E-04	4.05E+07	0.00
29.8300	5.66E-11	-0.00173	0.00198	-6.60E-12	0.00	1.27E+09	-6.08E-04	4.05E+07	0.00
30.1440	2.20E-11	0.00142	3.88E-04	-7.07E-12	0.00	1.27E+09	-2.37E-04	4.05E+07	0.00
30.4580	3.28E-12	0.00120	-1.24E-04	-3.20E-12	0.00	1.27E+09	-3.53E-05	4.05E+07	0.00
30.7720	-2.09E-12	4.84E-04	-1.48E-04	0.00	0.00	1.27E+09	2.24E-05	4.05E+07	0.00
31.0860	-2.07E-12	8.45E-05	-6.42E-05	0.00	0.00	1.27E+09	2.22E-05	4.05E+07	0.00
31.4000	-1.11E-12	0.00	0.00	0.00	0.00	1.27E+09	1.19E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.59417008 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -1244431. inch-lbs
Maximum shear force = 19740. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 14650.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 145100.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3962	-877893.	14650.	0.00	0.00	7.49E+09	0.00	0.00	0.00
0.3140	0.3953	-822571.	14633.	-4.28E-04	0.00	7.49E+09	-8.918	85.0028	0.00
0.6280	0.3929	-767149.	14580.	-8.26E-04	0.00	7.57E+09	-19.262	184.7049	0.00
0.9420	0.3891	-711792.	14488.	-0.00119	0.00	7.62E+09	-29.842	288.9822	0.00
1.2560	0.3840	-656666.	14356.	-0.00153	0.00	7.67E+09	-39.785	390.4349	0.00
1.5700	0.3776	-601929.	14189.	-0.00184	0.00	7.73E+09	-49.088	489.8707	0.00
1.8840	0.3701	-547728.	13989.	-0.00212	0.00	7.79E+09	-57.084	581.1782	0.00
2.1980	0.3616	-494193.	13762.	-0.00237	0.00	7.85E+09	-63.293	659.4957	0.00
2.5120	0.3523	-441427.	13511.	-0.00259	0.00	7.92E+09	-69.833	746.9981	0.00
2.8260	0.3421	-389537.	13235.	-0.00279	0.00	8.05E+09	-76.820	846.1472	0.00
3.1400	0.3312	-338638.	12931.	-0.00296	0.00	8.05E+09	-84.487	961.0783	0.00
3.4540	0.3198	-288853.	12601.	-0.00311	0.00	8.05E+09	-90.606	1068.	0.00
3.7680	0.3078	-240280.	12243.	-0.00323	0.00	8.05E+09	-99.726	1221.	0.00
4.0820	0.2955	-193061.	11847.	-0.00333	0.00	8.05E+09	-110.242	1406.	0.00
4.3960	0.2827	-147358.	11413.	-0.00341	0.00	8.05E+09	-120.343	1604.	0.00
4.7100	0.2698	-103326.	10952.	-0.00347	0.00	8.05E+09	-124.128	1734.	0.00
5.0240	0.2566	-61030.	10468.	-0.00351	0.00	8.05E+09	-132.946	1952.	0.00
5.3380	0.2433	-20605.	9951.	-0.00353	0.00	8.05E+09	-141.449	2190.	0.00
5.6520	0.2300	17816.	9403.	-0.00353	0.00	8.05E+09	-149.581	2450.	0.00
5.9660	0.2167	54109.	8824.	-0.00351	0.00	8.05E+09	-157.300	2735.	0.00
6.2800	0.2036	88155.	8218.	-0.00348	0.00	8.05E+09	-164.567	3046.	0.00

6.5940	0.1905	119841.	7585.	-0.00343	0.00	8.05E+09	-171.358	3389.	0.00
6.9080	0.1777	149065.	6928.	-0.00337	0.00	8.05E+09	-177.655	3766.	0.00
7.2220	0.1652	175727.	6247.	-0.00329	0.00	8.05E+09	-183.340	4182.	0.00
7.5360	0.1529	199742.	5547.	-0.00320	0.00	8.05E+09	-188.251	4638.	0.00
7.8500	0.1411	221033.	4830.	-0.00310	0.00	8.05E+09	-192.335	5138.	0.00
8.1640	0.1296	239536.	4100.	-0.00300	0.00	8.05E+09	-195.545	5687.	0.00
8.4780	0.1185	255202.	3358.	-0.00288	0.00	8.05E+09	-197.840	6292.	0.00
8.7920	0.1079	267994.	2621.	-0.00276	0.00	8.05E+09	-193.448	6758.	0.00
9.1060	0.09770	277971.	1915.	-0.00263	0.00	8.05E+09	-181.496	7000.	0.00
9.4200	0.08804	285300.	1254.	-0.00250	0.00	8.05E+09	-169.186	7241.	0.00
9.7340	0.07888	290153.	640.2965	-0.00236	0.00	8.05E+09	-156.636	7482.	0.00
10.0480	0.07023	292709.	73.9689	-0.00223	0.00	8.05E+09	-143.962	7724.	0.00
10.3620	0.06210	293145.	-444.571	-0.00209	0.00	8.05E+09	-131.271	7965.	0.00
10.6760	0.05449	291643.	-915.448	-0.00195	0.00	8.05E+09	-118.664	8206.	0.00
10.9900	0.04738	288382.	-1339.	-0.00182	0.00	8.05E+09	-106.234	8448.	0.00
11.3040	0.04079	283538.	-1717.	-0.00168	0.00	8.05E+09	-94.067	8689.	0.00
11.6180	0.03470	277287.	-2049.	-0.00155	0.00	8.05E+09	-82.240	8930.	0.00
11.9320	0.02910	269797.	-2337.	-0.00142	0.00	8.05E+09	-70.823	9172.	0.00
12.2460	0.02397	261232.	-2583.	-0.00130	0.00	8.05E+09	-59.876	9413.	0.00
12.5600	0.01930	251750.	-2789.	-0.00118	0.00	8.05E+09	-49.453	9655.	0.00
12.8740	0.01508	241502.	-2957.	-0.00106	0.00	8.05E+09	-39.597	9896.	0.00
13.1880	0.01128	230630.	-3089.	-9.54E-04	0.00	8.05E+09	-30.346	10137.	0.00
13.5020	0.00789	219268.	-3187.	-8.49E-04	0.00	8.05E+09	-21.728	10379.	0.00
13.8160	0.00488	207541.	-3254.	-7.49E-04	0.00	8.05E+09	-13.766	10620.	0.00
14.1300	0.00225	195566.	-3292.	-6.54E-04	0.00	8.05E+09	-6.474	10861.	0.00
14.4440	-4.78E-05	183449.	-3304.	-5.66E-04	0.00	8.05E+09	0.1410	11103.	0.00
14.7580	-0.00202	171287.	-3292.	-4.83E-04	0.00	8.05E+09	6.0756	11344.	0.00
15.0720	-0.00369	159167.	-3259.	-4.05E-04	0.00	8.05E+09	11.3340	11585.	0.00
15.3860	-0.00507	147168.	-3208.	-3.34E-04	0.00	8.05E+09	15.9253	11827.	0.00
15.7000	-0.00620	135357.	-3141.	-2.68E-04	0.00	8.05E+09	19.8634	12068.	0.00
16.0140	-0.00709	123793.	-3059.	-2.07E-04	0.00	8.05E+09	23.1663	12310.	0.00
16.3280	-0.00776	112527.	-2967.	-1.52E-04	0.00	8.05E+09	25.8562	12551.	0.00
16.6420	-0.00824	101599.	-2866.	-1.02E-04	0.00	8.05E+09	27.9586	12792.	0.00
16.9560	-0.00853	91042.	-2757.	-5.66E-05	0.00	8.05E+09	29.5019	13034.	0.00
17.2700	-0.00866	80880.	-2644.	-1.64E-05	0.00	8.05E+09	30.5173	13275.	0.00
17.5840	-0.00865	71132.	-2528.	1.91E-05	0.00	8.05E+09	31.0383	13516.	0.00
17.8980	-0.00852	61805.	-2411.	5.02E-05	0.00	8.05E+09	31.1002	13758.	0.00
18.2120	-0.00827	52905.	-2295.	7.71E-05	0.00	8.05E+09	30.7400	13999.	0.00
18.5260	-0.00794	44427.	-2180.	9.99E-05	0.00	8.05E+09	29.9960	14240.	0.00
18.8400	-0.00752	36364.	-2069.	1.19E-04	0.00	8.05E+09	28.9078	14482.	0.00
19.1540	-0.00704	28701.	-1963.	1.34E-04	0.00	8.05E+09	27.5159	14723.	0.00
19.4680	-0.00651	21423.	-1863.	1.46E-04	0.00	8.05E+09	25.8616	14965.	0.00
19.7820	-0.00594	14506.	-1769.	1.54E-04	0.00	8.05E+09	23.9870	15206.	0.00
20.0960	-0.00535	7925.	-1682.	1.59E-04	0.00	8.05E+09	21.9348	15447.	0.00
20.4100	-0.00474	1654.	-1604.	1.62E-04	0.00	8.05E+09	19.7484	15689.	0.00
20.7240	-0.00413	-4336.	-1534.	1.61E-04	0.00	8.05E+09	17.4718	15930.	0.00
21.0380	-0.00353	-10078.	-1472.	1.58E-04	0.00	8.05E+09	15.1499	16171.	0.00
21.3520	-0.00295	-15602.	-1419.	1.52E-04	0.00	8.05E+09	12.8281	16413.	0.00
21.6660	-0.00239	-20940.	-1375.	1.43E-04	0.00	8.05E+09	10.5530	16654.	0.00
21.9800	-0.00187	-26123.	-1340.	1.32E-04	0.00	8.05E+09	8.3720	16895.	0.00
22.2940	-0.00139	-31180.	-1312.	1.19E-04	0.00	8.05E+09	6.3337	17137.	0.00
22.6080	-9.73E-04	-36139.	-1292.	1.03E-04	0.00	8.05E+09	4.4882	17378.	0.00
22.9220	-6.17E-04	-41026.	-1278.	8.48E-05	0.00	8.05E+09	2.8869	17619.	0.00
23.2360	-3.34E-04	-45860.	-1269.	6.45E-05	0.00	8.05E+09	1.5828	17861.	0.00
23.5500	-1.31E-04	-50661.	1390.	4.19E-05	0.00	8.05E+09	1410.	4.05E+07	0.00
23.8640	-1.80E-05	-35434.	4410.	2.18E-05	0.00	8.05E+09	193.5550	4.05E+07	0.00
24.1780	3.28E-05	-17449.	4112.	9.40E-06	0.00	8.05E+09	-351.970	4.05E+07	0.00
24.4920	5.28E-05	-4458.	2380.	-6.49E-07	0.00	1.41E+09	-567.257	4.05E+07	0.00
24.8060	2.79E-05	486.7947	746.9940	-5.97E-06	0.00	1.41E+09	-299.499	4.05E+07	0.00
25.1200	7.86E-06	1178.	23.7290	-3.74E-06	0.00	1.41E+09	-84.400	4.05E+07	0.00
25.4340	-3.02E-07	669.7083	-129.176	-1.27E-06	0.00	1.41E+09	3.2400	4.05E+07	0.00
25.7480	-1.72E-06	206.1786	-88.342	-9.99E-08	0.00	1.41E+09	18.4340	4.05E+07	0.00
26.0620	-1.05E-06	4.0699	-32.277	1.81E-07	0.00	1.41E+09	11.3245	4.05E+07	0.00
26.3760	-3.52E-07	-37.262	-3.830	1.37E-07	0.00	1.41E+09	3.7747	4.05E+07	0.00
26.6900	-2.38E-08	-24.946	3.7630	5.36E-08	0.00	1.41E+09	0.2558	4.05E+07	0.00
27.0040	5.26E-08	-8.962	3.1810	8.30E-09	0.00	1.41E+09	-0.565	4.05E+07	0.00
27.3180	3.87E-08	-0.983	1.3341	-5.00E-09	0.00	1.41E+09	-0.416	4.05E+07	0.00
27.6320	1.49E-08	1.0971	0.2494	-4.85E-09	0.00	1.41E+09	-0.160	4.05E+07	0.00
27.9460	2.18E-09	0.9015	-0.09650	-2.18E-09	0.00	1.41E+09	-0.02342	4.05E+07	0.00

28.2600	-1.47E-09	0.3722	-0.111	-4.72E-10	0.00	1.41E+09	0.01581	4.05E+07	0.00
28.5740	-1.38E-09	0.06684	-0.05318	1.15E-10	0.00	1.41E+09	0.01478	4.05E+07	0.00
28.8880	-6.08E-10	-0.02869	-0.01303	1.66E-10	0.00	1.41E+09	0.00653	4.05E+07	0.00
29.2020	-1.28E-10	-0.03154	0.00184	8.53E-11	0.00	1.41E+09	0.00137	4.05E+07	0.00
29.5160	3.49E-11	-0.01489	0.00372	2.32E-11	0.00	1.41E+09	-3.75E-04	4.05E+07	0.00
29.8300	4.73E-11	-0.00355	0.00205	-1.46E-12	0.00	1.41E+09	-5.08E-04	4.05E+07	0.00
30.1440	2.40E-11	5.78E-04	6.11E-04	-5.43E-12	0.00	1.41E+09	-2.57E-04	4.05E+07	0.00
30.4580	6.40E-12	0.00106	-3.34E-06	-3.25E-12	0.00	1.41E+09	-6.87E-05	4.05E+07	0.00
30.7720	0.00	5.56E-04	-1.22E-04	-1.09E-12	0.00	1.41E+09	5.69E-06	4.05E+07	0.00
31.0860	-1.85E-12	1.37E-04	-7.38E-05	0.00	0.00	1.41E+09	1.99E-05	4.05E+07	0.00
31.4000	-1.80E-12	0.00	0.00	0.00	0.00	1.41E+09	1.93E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.39616480 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -877893. inch-lbs
Maximum shear force = 14650. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 14630.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 127500.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3948	-872375.	14630.	0.00	0.00	7.44E+09	0.00	0.00	0.00
0.3140	0.3939	-817143.	14613.	-4.28E-04	0.00	7.44E+09	-8.904	85.1672	0.00
0.6280	0.3915	-761838.	14560.	-8.26E-04	0.00	7.52E+09	-19.229	185.0547	0.00
0.9420	0.3877	-706624.	14468.	-0.00119	0.00	7.56E+09	-29.790	289.5266	0.00
1.2560	0.3825	-651663.	14337.	-0.00153	0.00	7.61E+09	-39.713	391.1704	0.00
1.5700	0.3762	-597110.	14170.	-0.00184	0.00	7.67E+09	-48.997	490.7921	0.00
1.8840	0.3687	-543113.	13970.	-0.00212	0.00	7.73E+09	-56.974	582.2717	0.00
2.1980	0.3602	-489797.	13744.	-0.00237	0.00	7.80E+09	-63.166	660.7452	0.00
2.5120	0.3508	-437264.	13494.	-0.00259	0.00	7.87E+09	-69.681	748.3641	0.00
2.8260	0.3407	-385620.	13218.	-0.00279	0.00	8.07E+09	-76.637	847.6066	0.00
3.1400	0.3298	-334977.	12915.	-0.00295	0.00	8.07E+09	-84.265	962.5982	0.00
3.4540	0.3184	-285456.	12586.	-0.00310	0.00	8.07E+09	-90.343	1069.	0.00
3.7680	0.3065	-237153.	12228.	-0.00322	0.00	8.07E+09	-99.422	1222.	0.00
4.0820	0.2941	-190209.	11834.	-0.00332	0.00	8.07E+09	-109.897	1408.	0.00
4.3960	0.2815	-144782.	11401.	-0.00340	0.00	8.07E+09	-119.958	1606.	0.00
4.7100	0.2685	-101026.	10942.	-0.00346	0.00	8.07E+09	-123.732	1736.	0.00
5.0240	0.2554	-59004.	10459.	-0.00349	0.00	8.07E+09	-132.524	1955.	0.00
5.3380	0.2422	-18851.	9944.	-0.00351	0.00	8.07E+09	-141.004	2194.	0.00
5.6520	0.2290	19305.	9397.	-0.00351	0.00	8.07E+09	-149.117	2454.	0.00

5.9660	0.2157	55340.	8821.	-0.00349	0.00	8.07E+09	-156.820	2739.	0.00
6.2800	0.2026	89135.	8216.	-0.00346	0.00	8.07E+09	-164.076	3051.	0.00
6.5940	0.1897	120581.	7585.	-0.00341	0.00	8.07E+09	-170.859	3395.	0.00
6.9080	0.1769	149574.	6929.	-0.00335	0.00	8.07E+09	-177.154	3773.	0.00
7.2220	0.1644	176019.	6251.	-0.00327	0.00	8.07E+09	-182.826	4190.	0.00
7.5360	0.1522	199828.	5553.	-0.00318	0.00	8.07E+09	-187.728	4646.	0.00
7.8500	0.1404	220927.	4838.	-0.00309	0.00	8.07E+09	-191.807	5147.	0.00
8.1640	0.1290	239253.	4109.	-0.00298	0.00	8.07E+09	-195.017	5697.	0.00
8.4780	0.1180	254757.	3370.	-0.00286	0.00	8.07E+09	-197.316	6303.	0.00
8.7920	0.1074	267402.	2635.	-0.00274	0.00	8.07E+09	-192.625	6758.	0.00
9.1060	0.09730	277252.	1932.	-0.00262	0.00	8.07E+09	-180.748	7000.	0.00
9.4200	0.08769	284474.	1274.	-0.00248	0.00	8.07E+09	-168.514	7241.	0.00
9.7340	0.07858	289240.	662.5419	-0.00235	0.00	8.07E+09	-156.042	7482.	0.00
10.0480	0.06998	291725.	98.3038	-0.00221	0.00	8.07E+09	-143.447	7724.	0.00
10.3620	0.06189	292109.	-418.443	-0.00208	0.00	8.07E+09	-130.835	7965.	0.00
10.6760	0.05432	290569.	-887.823	-0.00194	0.00	8.07E+09	-118.305	8206.	0.00
10.9900	0.04726	287284.	-1310.	-0.00181	0.00	8.07E+09	-105.952	8448.	0.00
11.3040	0.04070	282430.	-1687.	-0.00167	0.00	8.07E+09	-93.859	8689.	0.00
11.6180	0.03464	276181.	-2018.	-0.00154	0.00	8.07E+09	-82.103	8930.	0.00
11.9320	0.02907	268704.	-2306.	-0.00142	0.00	8.07E+09	-70.754	9172.	0.00
12.2460	0.02397	260162.	-2552.	-0.00129	0.00	8.07E+09	-59.872	9413.	0.00
12.5600	0.01932	250712.	-2758.	-0.00117	0.00	8.07E+09	-49.508	9655.	0.00
12.8740	0.01512	240503.	-2927.	-0.00106	0.00	8.07E+09	-39.708	9896.	0.00
13.1880	0.01134	229676.	-3059.	-9.50E-04	0.00	8.07E+09	-30.508	10137.	0.00
13.5020	0.00796	218364.	-3158.	-8.45E-04	0.00	8.07E+09	-21.936	10379.	0.00
13.8160	0.00497	206692.	-3225.	-7.46E-04	0.00	8.07E+09	-14.014	10620.	0.00
14.1300	0.00234	194774.	-3264.	-6.52E-04	0.00	8.07E+09	-6.757	10861.	0.00
14.4440	5.87E-05	182717.	-3278.	-5.64E-04	0.00	8.07E+09	-0.173	11103.	0.00
14.7580	-0.00191	170617.	-3267.	-4.81E-04	0.00	8.07E+09	5.7365	11344.	0.00
15.0720	-0.00357	158559.	-3236.	-4.05E-04	0.00	8.07E+09	10.9747	11585.	0.00
15.3860	-0.00495	146622.	-3186.	-3.33E-04	0.00	8.07E+09	15.5506	11827.	0.00
15.7000	-0.00608	134873.	-3120.	-2.68E-04	0.00	8.07E+09	19.4780	12068.	0.00
16.0140	-0.00697	123370.	-3040.	-2.07E-04	0.00	8.07E+09	22.7747	12310.	0.00
16.3280	-0.00764	112163.	-2949.	-1.52E-04	0.00	8.07E+09	25.4626	12551.	0.00
16.6420	-0.00812	101292.	-2849.	-1.03E-04	0.00	8.07E+09	27.5669	12792.	0.00
16.9560	-0.00842	90790.	-2742.	-5.77E-05	0.00	8.07E+09	29.1159	13034.	0.00
17.2700	-0.00856	80681.	-2631.	-1.77E-05	0.00	8.07E+09	30.1404	13275.	0.00
17.5840	-0.00855	70981.	-2516.	1.77E-05	0.00	8.07E+09	30.6734	13516.	0.00
17.8980	-0.00842	61702.	-2400.	4.86E-05	0.00	8.07E+09	30.7500	13758.	0.00
18.2120	-0.00818	52845.	-2285.	7.54E-05	0.00	8.07E+09	30.4070	13999.	0.00
18.5260	-0.00785	44408.	-2172.	9.81E-05	0.00	8.07E+09	29.6821	14240.	0.00
18.8400	-0.00745	36382.	-2062.	1.17E-04	0.00	8.07E+09	28.6148	14482.	0.00
19.1540	-0.00697	28754.	-1957.	1.32E-04	0.00	8.07E+09	27.2450	14723.	0.00
19.4680	-0.00645	21507.	-1857.	1.44E-04	0.00	8.07E+09	25.6139	14965.	0.00
19.7820	-0.00589	14619.	-1764.	1.52E-04	0.00	8.07E+09	23.7631	15206.	0.00
20.0960	-0.00530	8065.	-1679.	1.58E-04	0.00	8.07E+09	21.7349	15447.	0.00
20.4100	-0.00470	1817.	-1601.	1.60E-04	0.00	8.07E+09	19.5726	15689.	0.00
20.7240	-0.00410	-4153.	-1531.	1.59E-04	0.00	8.07E+09	17.3198	15930.	0.00
21.0380	-0.00350	-9876.	-1470.	1.56E-04	0.00	8.07E+09	15.0209	16171.	0.00
21.3520	-0.00292	-15384.	-1418.	1.50E-04	0.00	8.07E+09	12.7213	16413.	0.00
21.6660	-0.00237	-20707.	-1374.	1.42E-04	0.00	8.07E+09	10.4670	16654.	0.00
21.9800	-0.00185	-25878.	-1339.	1.31E-04	0.00	8.07E+09	8.3052	16895.	0.00
22.2940	-0.00138	-30924.	-1312.	1.18E-04	0.00	8.07E+09	6.2843	17137.	0.00
22.6080	-9.66E-04	-35875.	-1291.	1.02E-04	0.00	8.07E+09	4.4541	17378.	0.00
22.9220	-6.13E-04	-40754.	-1278.	8.42E-05	0.00	8.07E+09	2.8655	17619.	0.00
23.2360	-3.32E-04	-45583.	-1269.	6.40E-05	0.00	8.07E+09	1.5716	17861.	0.00
23.5500	-1.30E-04	-50380.	1373.	4.16E-05	0.00	8.07E+09	1401.	4.05E+07	0.00
23.8640	-1.80E-05	-35279.	4376.	2.16E-05	0.00	8.07E+09	193.2897	4.05E+07	0.00
24.1780	3.24E-05	-17426.	4084.	9.31E-06	0.00	8.07E+09	-347.925	4.05E+07	0.00
24.4920	5.22E-05	-4509.	2374.	-6.05E-07	0.00	1.45E+09	-560.105	4.05E+07	0.00
24.8060	2.78E-05	461.6442	755.1284	-5.86E-06	0.00	1.45E+09	-298.941	4.05E+07	0.00
25.1200	8.03E-06	1187.	29.5783	-3.72E-06	0.00	1.45E+09	-86.170	4.05E+07	0.00
25.4340	-1.99E-07	688.1222	-128.746	-1.29E-06	0.00	1.45E+09	2.1344	4.05E+07	0.00
25.7480	-1.71E-06	218.3531	-90.238	-1.17E-07	0.00	1.45E+09	18.3050	4.05E+07	0.00
26.0620	-1.08E-06	8.2037	-33.923	1.77E-07	0.00	1.45E+09	11.5862	4.05E+07	0.00
26.3760	-3.73E-07	-37.457	-4.544	1.39E-07	0.00	1.45E+09	4.0074	4.05E+07	0.00
26.6900	-3.31E-08	-26.175	3.6748	5.64E-08	0.00	1.45E+09	0.3551	4.05E+07	0.00
27.0040	5.15E-08	-9.818	3.3016	9.74E-09	0.00	1.45E+09	-0.553	4.05E+07	0.00
27.3180	4.03E-08	-1.304	1.4443	-4.67E-09	0.00	1.45E+09	-0.433	4.05E+07	0.00

27.6320	1.63E-08	1.0711	0.2995	-4.98E-09	0.00	1.45E+09	-0.175	4.05E+07	0.00
27.9460	2.79E-09	0.9582	-0.08693	-2.35E-09	0.00	1.45E+09	-0.02999	4.05E+07	0.00
28.2600	-1.37E-09	0.4183	-0.116	-5.63E-10	0.00	1.45E+09	0.01468	4.05E+07	0.00
28.5740	-1.45E-09	0.08634	-0.05887	9.14E-11	0.00	1.45E+09	0.01552	4.05E+07	0.00
28.8880	-6.79E-10	-0.02544	-0.01590	1.70E-10	0.00	1.45E+09	0.00729	4.05E+07	0.00
29.2020	-1.62E-10	-0.03362	0.00112	9.37E-11	0.00	1.45E+09	0.00174	4.05E+07	0.00
29.5160	2.70E-11	-0.01706	0.00386	2.81E-11	0.00	1.45E+09	-2.90E-04	4.05E+07	0.00
29.8300	4.95E-11	-0.00459	0.00231	0.00	0.00	1.45E+09	-5.32E-04	4.05E+07	0.00
30.1440	2.72E-11	3.35E-04	7.56E-04	-5.49E-12	0.00	1.45E+09	-2.92E-04	4.05E+07	0.00
30.4580	8.18E-12	0.00111	4.01E-05	-3.61E-12	0.00	1.45E+09	-8.78E-05	4.05E+07	0.00
30.7720	0.00	6.40E-04	-1.25E-04	-1.35E-12	0.00	1.45E+09	1.82E-07	4.05E+07	0.00
31.0860	-1.96E-12	1.71E-04	-8.49E-05	0.00	0.00	1.45E+09	2.11E-05	4.05E+07	0.00
31.4000	-2.24E-12	0.00	0.00	0.00	0.00	1.45E+09	2.40E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = 0.39475644 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -872375. inch-lbs
Maximum shear force = 14630. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 1.000000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 108700.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0000	-1839137.	27623.	0.00	0.00	7.08E+09	0.00	0.00	0.00
0.3140	0.9982	-1734926.	27587.	-9.50E-04	0.00	7.08E+09	-8.945	33.7657	0.00
0.6280	0.9928	-1630464.	27533.	-0.00184	0.00	7.13E+09	-19.377	73.5391	0.00
0.9420	0.9843	-1525925.	27440.	-0.00268	0.00	7.15E+09	-30.168	115.4899	0.00
1.2560	0.9727	-1421484.	27307.	-0.00345	0.00	7.18E+09	-40.493	156.8659	0.00
1.5700	0.9583	-1317312.	27136.	-0.00417	0.00	7.20E+09	-50.410	198.2172	0.00
1.8840	0.9413	-1213574.	26929.	-0.00483	0.00	7.24E+09	-59.272	237.2752	0.00
2.1980	0.9219	-1110419.	26692.	-0.00543	0.00	7.27E+09	-66.581	272.1434	0.00
2.5120	0.9003	-1007973.	26426.	-0.00598	0.00	7.31E+09	-74.781	312.9756	0.00
2.8260	0.8768	-906376.	26126.	-0.00647	0.00	7.36E+09	-84.143	361.6022	0.00
3.1400	0.8515	-805784.	25788.	-0.00691	0.00	7.42E+09	-95.169	421.1191	0.00
3.4540	0.8247	-706376.	25410.	-0.00729	0.00	7.49E+09	-105.654	482.7076	0.00
3.7680	0.7966	-608322.	24985.	-0.00762	0.00	7.57E+09	-120.164	568.3951	0.00
4.0820	0.7673	-511850.	24500.	-0.00790	0.00	7.68E+09	-137.252	673.9995	0.00
4.3960	0.7371	-417224.	23948.	-0.00812	0.00	7.82E+09	-155.288	793.8464	0.00
4.7100	0.7061	-324720.	23344.	-0.00830	0.00	8.09E+09	-165.669	884.0804	0.00
5.0240	0.6745	-234506.	22686.	-0.00843	0.00	8.09E+09	-183.734	1026.	0.00
5.3380	0.6426	-146857.	21957.	-0.00852	0.00	8.09E+09	-202.736	1189.	0.00
5.6520	0.6103	-62058.	21156.	-0.00857	0.00	8.09E+09	-222.676	1375.	0.00
5.9660	0.5780	19592.	20278.	-0.00858	0.00	8.09E+09	-243.554	1588.	0.00

6.2800	0.5457	97780.	19319.	-0.00855	0.00	8.09E+09	-265.369	1832.	0.00
6.5940	0.5136	172181.	18276.	-0.00849	0.00	8.09E+09	-288.121	2114.	0.00
6.9080	0.4818	242459.	17146.	-0.00839	0.00	8.09E+09	-311.810	2439.	0.00
7.2220	0.4504	308264.	15924.	-0.00826	0.00	8.09E+09	-336.436	2815.	0.00
7.5360	0.4195	369233.	14609.	-0.00810	0.00	7.89E+09	-362.000	3252.	0.00
7.8500	0.3893	424991.	13208.	-0.00791	0.00	7.80E+09	-381.539	3693.	0.00
8.1640	0.3599	475247.	11764.	-0.00769	0.00	7.73E+09	-384.612	4027.	0.00
8.4780	0.3313	519948.	10312.	-0.00745	0.00	7.67E+09	-386.104	4391.	0.00
8.7920	0.3037	559062.	8857.	-0.00718	0.00	7.63E+09	-386.088	4790.	0.00
9.1060	0.2772	592582.	7405.	-0.00690	0.00	7.59E+09	-384.653	5229.	0.00
9.4200	0.2518	620520.	5961.	-0.00660	0.00	7.56E+09	-381.910	5716.	0.00
9.7340	0.2275	642909.	4530.	-0.00628	0.00	7.54E+09	-377.984	6261.	0.00
10.0480	0.2044	659800.	3115.	-0.00596	0.00	7.53E+09	-373.013	6876.	0.00
10.3620	0.1826	671259.	1720.	-0.00562	0.00	7.52E+09	-367.148	7576.	0.00
10.6760	0.1621	677368.	363.5453	-0.00528	0.00	7.51E+09	-352.940	8206.	0.00
10.9900	0.1428	678327.	-904.495	-0.00494	0.00	7.51E+09	-320.118	8448.	0.00
11.3040	0.1248	674602.	-2050.	-0.00460	0.00	7.51E+09	-287.783	8689.	0.00
11.6180	0.1081	666652.	-3075.	-0.00427	0.00	7.52E+09	-256.165	8930.	0.00
11.9320	0.09263	654929.	-3982.	-0.00394	0.00	7.53E+09	-225.469	9172.	0.00
12.2460	0.07841	639870.	-4776.	-0.00361	0.00	7.55E+09	-195.877	9413.	0.00
12.5600	0.06539	621899.	-5460.	-0.00330	0.00	7.56E+09	-167.548	9655.	0.00
12.8740	0.05354	601423.	-6041.	-0.00300	0.00	7.58E+09	-140.619	9896.	0.00
13.1880	0.04282	578827.	-6523.	-0.00270	0.00	7.60E+09	-115.201	10137.	0.00
13.5020	0.03318	554479.	-6912.	-0.00242	0.00	7.63E+09	-91.386	10379.	0.00
13.8160	0.02457	528720.	-7215.	-0.00216	0.00	7.66E+09	-69.244	10620.	0.00
14.1300	0.01694	501873.	-7437.	-0.00190	0.00	7.69E+09	-48.822	10861.	0.00
14.4440	0.01023	474231.	-7586.	-0.00166	0.00	7.73E+09	-30.152	11103.	0.00
14.7580	0.00440	446067.	-7668.	-0.00144	0.00	7.77E+09	-13.245	11344.	0.00
15.0720	-6.19E-04	417626.	-7689.	-0.00123	0.00	7.81E+09	1.9045	11585.	0.00
15.3860	-0.00488	389129.	-7657.	-0.00104	0.00	7.86E+09	15.3150	11827.	0.00
15.7000	-0.00844	360774.	-7577.	-8.60E-04	0.00	8.09E+09	27.0201	12068.	0.00
16.0140	-0.01136	332733.	-7456.	-6.98E-04	0.00	8.09E+09	37.1117	12310.	0.00
16.3280	-0.01370	305156.	-7300.	-5.50E-04	0.00	8.09E+09	45.6324	12551.	0.00
16.6420	-0.01550	278169.	-7115.	-4.14E-04	0.00	8.09E+09	52.6346	12792.	0.00
16.9560	-0.01682	251875.	-6906.	-2.91E-04	0.00	8.09E+09	58.1795	13034.	0.00
17.2700	-0.01769	226360.	-6679.	-1.79E-04	0.00	8.09E+09	62.3358	13275.	0.00
17.5840	-0.01817	201687.	-6439.	-7.96E-05	0.00	8.09E+09	65.1793	13516.	0.00
17.8980	-0.01829	177900.	-6190.	8.82E-06	0.00	8.09E+09	66.7918	13758.	0.00
18.2120	-0.01810	155028.	-5938.	8.63E-05	0.00	8.09E+09	67.2602	13999.	0.00
18.5260	-0.01764	133081.	-5686.	1.53E-04	0.00	8.09E+09	66.6764	14240.	0.00
18.8400	-0.01695	112056.	-5437.	2.10E-04	0.00	8.09E+09	65.1360	14482.	0.00
19.1540	-0.01606	91934.	-5196.	2.58E-04	0.00	8.09E+09	62.7384	14723.	0.00
19.4680	-0.01500	72685.	-4966.	2.96E-04	0.00	8.09E+09	59.5859	14965.	0.00
19.7820	-0.01382	54268.	-4749.	3.26E-04	0.00	8.09E+09	55.7839	15206.	0.00
20.0960	-0.01255	36633.	-4547.	3.47E-04	0.00	8.09E+09	51.4404	15447.	0.00
20.4100	-0.01121	19721.	-4362.	3.60E-04	0.00	8.09E+09	46.6658	15689.	0.00
20.7240	-0.00983	3468.	-4195.	3.66E-04	0.00	8.09E+09	41.5733	15930.	0.00
21.0380	-0.00845	-12195.	-4049.	3.64E-04	0.00	8.09E+09	36.2786	16171.	0.00
21.3520	-0.00709	-27341.	-3922.	3.54E-04	0.00	8.09E+09	30.9002	16413.	0.00
21.6660	-0.00578	-42043.	-3816.	3.38E-04	0.00	8.09E+09	25.5598	16654.	0.00
21.9800	-0.00455	-56374.	-3729.	3.15E-04	0.00	8.09E+09	20.3821	16895.	0.00
22.2940	-0.00341	-70405.	-3662.	2.86E-04	0.00	8.09E+09	15.4958	17137.	0.00
22.6080	-0.00239	-84202.	-3612.	2.50E-04	0.00	8.09E+09	11.0334	17378.	0.00
22.9220	-0.00153	-97827.	-3577.	2.07E-04	0.00	8.09E+09	7.1318	17619.	0.00
23.2360	-8.30E-04	-111332.	-3557.	1.59E-04	0.00	8.09E+09	3.9327	17861.	0.00
23.5500	-3.30E-04	-124760.	3115.	1.04E-04	0.00	8.09E+09	3538.	4.05E+07	0.00
23.8640	-4.83E-05	-87939.	10757.	5.42E-05	0.00	8.09E+09	518.2232	4.05E+07	0.00
24.1780	7.87E-05	-43743.	10142.	2.35E-05	0.00	8.09E+09	-844.630	4.05E+07	0.00
24.4920	1.29E-04	-11531.	5944.	-1.18E-06	0.00	1.50E+09	-1384.	4.05E+07	0.00
24.8060	6.98E-05	1050.	1925.	-1.44E-05	0.00	1.50E+09	-749.437	4.05E+07	0.00
25.1200	2.07E-05	2989.	95.1086	-9.29E-06	0.00	1.50E+09	-221.946	4.05E+07	0.00
25.4340	-1.65E-07	1774.	-319.706	-3.30E-06	0.00	1.50E+09	1.7687	4.05E+07	0.00
25.7480	-4.22E-06	582.4446	-231.002	-3.45E-07	0.00	1.50E+09	45.3139	4.05E+07	0.00
26.0620	-2.77E-06	33.5506	-89.659	4.28E-07	0.00	1.50E+09	29.7087	4.05E+07	0.00
26.3760	-9.96E-07	-93.580	-13.537	3.53E-07	0.00	1.50E+09	10.6962	4.05E+07	0.00
26.6900	-1.11E-07	-68.752	8.8514	1.49E-07	0.00	1.50E+09	1.1872	4.05E+07	0.00
27.0040	1.25E-07	-26.997	8.5640	2.86E-08	0.00	1.50E+09	-1.340	4.05E+07	0.00
27.3180	1.05E-07	-4.236	3.9209	-1.06E-08	0.00	1.50E+09	-1.125	4.05E+07	0.00
27.6320	4.47E-08	2.5590	0.8978	-1.27E-08	0.00	1.50E+09	-0.480	4.05E+07	0.00

27.9460	8.81E-09	2.5401	-0.184	-6.33E-09	0.00	1.50E+09	-0.09455	4.05E+07	0.00
28.2600	-3.04E-09	1.1761	-0.301	-1.67E-09	0.00	1.50E+09	0.03269	4.05E+07	0.00
28.5740	-3.77E-09	0.2750	-0.163	1.52E-10	0.00	1.50E+09	0.04049	4.05E+07	0.00
28.8880	-1.90E-09	-0.05145	-0.04824	4.33E-10	0.00	1.50E+09	0.02036	4.05E+07	0.00
29.2020	-5.08E-10	-0.08883	3.93E-04	2.57E-10	0.00	1.50E+09	0.00545	4.05E+07	0.00
29.5160	4.02E-11	-0.04869	0.00985	8.44E-11	0.00	1.50E+09	-4.31E-04	4.05E+07	0.00
29.8300	1.28E-10	-0.01463	0.00646	4.87E-12	0.00	1.50E+09	-0.00137	4.05E+07	0.00
30.1440	7.69E-11	-2.67E-05	0.00232	-1.35E-11	0.00	1.50E+09	-8.25E-04	4.05E+07	0.00
30.4580	2.57E-11	0.00286	2.45E-04	-9.97E-12	0.00	1.50E+09	-2.76E-04	4.05E+07	0.00
30.7720	1.70E-12	0.00182	-3.11E-04	-4.09E-12	0.00	1.50E+09	-1.83E-05	4.05E+07	0.00
31.0860	-5.08E-12	5.25E-04	-2.42E-04	-1.14E-12	0.00	1.50E+09	5.45E-05	4.05E+07	0.00
31.4000	-6.90E-12	0.00	0.00	0.00	0.00	1.50E+09	7.40E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

Pile-head deflection = 1.00000000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -1839137. inch-lbs
Maximum shear force = 27623. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 37700.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 146200.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.8004	-2787667.	37700.	0.00	0.00	6.33E+09	0.00	0.00	0.00
0.3140	1.7973	-2645156.	37683.	-0.00162	0.00	6.33E+09	-8.985	18.8374	0.00
0.6280	1.7882	-2501907.	37629.	-0.00308	0.00	6.94E+09	-19.464	41.0134	0.00
0.9420	1.7740	-2358186.	37536.	-0.00439	0.00	7.02E+09	-30.303	64.3626	0.00
1.2560	1.7551	-2214198.	37402.	-0.00562	0.00	7.06E+09	-40.674	87.3226	0.00
1.5700	1.7317	-2070136.	37230.	-0.00676	0.00	7.08E+09	-50.634	110.1748	0.00
1.8840	1.7042	-1926187.	37022.	-0.00782	0.00	7.11E+09	-59.536	131.6377	0.00
2.1980	1.6728	-1782521.	36784.	-0.00880	0.00	7.14E+09	-66.879	150.6481	0.00
2.5120	1.6379	-1639286.	36517.	-0.00970	0.00	7.18E+09	-75.117	172.8111	0.00
2.8260	1.5997	-1496644.	36216.	-0.01052	0.00	7.22E+09	-84.523	199.0900	0.00
3.1400	1.5586	-1354772.	35877.	-0.01126	0.00	7.27E+09	-95.601	231.1248	0.00
3.4540	1.5148	-1213870.	35497.	-0.01193	0.00	7.32E+09	-106.137	264.0089	0.00
3.7680	1.4687	-1074131.	35069.	-0.01251	0.00	7.38E+09	-120.718	309.7062	0.00
4.0820	1.4205	-935804.	34582.	-0.01302	0.00	7.46E+09	-137.891	365.7623	0.00
4.3960	1.3706	-799173.	34028.	-0.01346	0.00	7.55E+09	-156.020	428.9356	0.00
4.7100	1.3191	-664539.	33421.	-0.01382	0.00	7.67E+09	-166.459	475.4895	0.00
5.0240	1.2664	-532087.	32759.	-0.01411	0.00	7.81E+09	-184.621	549.3125	0.00
5.3380	1.2127	-402116.	32028.	-0.01434	0.00	8.05E+09	-203.728	632.9858	0.00

5.6520	1.1584	-274933.	31222.	-0.01449	0.00	8.05E+09	-223.781	727.9279	0.00
5.9660	1.1035	-150857.	30339.	-0.01459	0.00	8.05E+09	-244.781	835.8190	0.00
6.2800	1.0484	-30217.	29376.	-0.01464	0.00	8.05E+09	-266.728	958.6439	0.00
6.5940	0.9932	86644.	28328.	-0.01462	0.00	8.05E+09	-289.623	1099.	0.00
6.9080	0.9382	199370.	27191.	-0.01456	0.00	8.05E+09	-313.466	1259.	0.00
7.2220	0.8835	307595.	25963.	-0.01444	0.00	8.05E+09	-338.258	1443.	0.00
7.5360	0.8294	410937.	24640.	-0.01427	0.00	8.04E+09	-364.001	1654.	0.00
7.8500	0.7760	509006.	23219.	-0.01405	0.00	7.84E+09	-390.693	1897.	0.00
8.1640	0.7235	601392.	21694.	-0.01378	0.00	7.73E+09	-418.338	2179.	0.00
8.4780	0.6721	687678.	20064.	-0.01347	0.00	7.64E+09	-446.935	2506.	0.00
8.7920	0.6220	767431.	18324.	-0.01310	0.00	7.57E+09	-476.487	2886.	0.00
9.1060	0.5734	840209.	16472.	-0.01270	0.00	7.52E+09	-506.994	3332.	0.00
9.4200	0.5263	905557.	14502.	-0.01226	0.00	7.47E+09	-538.459	3855.	0.00
9.7340	0.4809	963008.	12412.	-0.01179	0.00	7.44E+09	-570.883	4473.	0.00
10.0480	0.4374	1012085.	10198.	-0.01129	0.00	7.41E+09	-604.269	5205.	0.00
10.3620	0.3959	1052300.	7869.	-0.01077	0.00	7.39E+09	-631.922	6015.	0.00
10.6760	0.3563	1083247.	5537.	-0.01022	0.00	7.38E+09	-605.892	6407.	0.00
10.9900	0.3188	1105286.	3315.	-0.00966	0.00	7.37E+09	-573.484	6777.	0.00
11.3040	0.2835	1118873.	1215.	-0.00909	0.00	7.36E+09	-541.260	7194.	0.00
11.6180	0.2503	1124458.	-764.845	-0.00852	0.00	7.36E+09	-509.491	7669.	0.00
11.9320	0.2193	1122493.	-2626.	-0.00794	0.00	7.36E+09	-478.429	8220.	0.00
12.2460	0.1905	1113419.	-4372.	-0.00737	0.00	7.36E+09	-448.307	8869.	0.00
12.5600	0.1638	1097665.	-6006.	-0.00680	0.00	7.37E+09	-418.951	9639.	0.00
12.8740	0.1392	1075655.	-7484.	-0.00625	0.00	7.38E+09	-365.544	9896.	0.00
13.1880	0.1167	1048152.	-8764.	-0.00571	0.00	7.39E+09	-313.891	10137.	0.00
13.5020	0.09617	1015898.	-9854.	-0.00518	0.00	7.41E+09	-264.898	10379.	0.00
13.8160	0.07762	979598.	-10766.	-0.00468	0.00	7.43E+09	-218.764	10620.	0.00
14.1300	0.06094	939919.	-11509.	-0.00419	0.00	7.45E+09	-175.647	10861.	0.00
14.4440	0.04604	897485.	-12095.	-0.00373	0.00	7.48E+09	-135.667	11103.	0.00
14.7580	0.03285	852875.	-12537.	-0.00329	0.00	7.51E+09	-98.907	11344.	0.00
15.0720	0.02127	806625.	-12847.	-0.00287	0.00	7.55E+09	-65.413	11585.	0.00
15.3860	0.01121	759225.	-13036.	-0.00248	0.00	7.58E+09	-35.201	11827.	0.00
15.7000	0.00258	711117.	-13118.	-0.00212	0.00	7.62E+09	-8.252	12068.	0.00
16.0140	-0.00474	662699.	-13105.	-0.00178	0.00	7.67E+09	15.4778	12310.	0.00
16.3280	-0.01083	614321.	-13007.	-0.00147	0.00	7.72E+09	36.0585	12551.	0.00
16.6420	-0.01578	566289.	-12839.	-0.00118	0.00	7.77E+09	53.5836	12792.	0.00
16.9560	-0.01971	518867.	-12609.	-9.16E-04	0.00	7.83E+09	68.1663	13034.	0.00
17.2700	-0.02269	472276.	-12330.	-6.79E-04	0.00	7.89E+09	79.9371	13275.	0.00
17.5840	-0.02482	426695.	-12012.	-4.65E-04	0.00	7.98E+09	89.0409	13516.	0.00
17.8980	-0.02620	382267.	-11664.	-2.75E-04	0.00	8.05E+09	95.6446	13758.	0.00
18.2120	-0.02689	339099.	-11295.	-1.06E-04	0.00	8.05E+09	99.9193	13999.	0.00
18.5260	-0.02700	297261.	-10915.	4.28E-05	0.00	8.05E+09	102.0235	14240.	0.00
18.8400	-0.02657	256796.	-10530.	1.72E-04	0.00	8.05E+09	102.1258	14482.	0.00
19.1540	-0.02570	217715.	-10149.	2.83E-04	0.00	8.05E+09	100.4044	14723.	0.00
19.4680	-0.02444	180002.	-9777.	3.77E-04	0.00	8.05E+09	97.0461	14965.	0.00
19.7820	-0.02286	143622.	-9420.	4.52E-04	0.00	8.05E+09	92.2454	15206.	0.00
20.0960	-0.02103	108514.	-9084.	5.11E-04	0.00	8.05E+09	86.2044	15447.	0.00
20.4100	-0.01901	74601.	-8772.	5.54E-04	0.00	8.05E+09	79.1321	15689.	0.00
20.7240	-0.01685	41794.	-8489.	5.81E-04	0.00	8.05E+09	71.2447	15930.	0.00
21.0380	-0.01462	9986.	-8237.	5.93E-04	0.00	8.05E+09	62.7650	16171.	0.00
21.3520	-0.01238	-20932.	-8017.	5.91E-04	0.00	8.05E+09	53.9234	16413.	0.00
21.6660	-0.01017	-51080.	-7831.	5.74E-04	0.00	8.05E+09	44.9572	16654.	0.00
21.9800	-0.00805	-80576.	-7678.	5.43E-04	0.00	8.05E+09	36.1121	16895.	0.00
22.2940	-0.00608	-109538.	-7558.	4.99E-04	0.00	8.05E+09	27.6418	17137.	0.00
22.6080	-0.00430	-138080.	-7468.	4.41E-04	0.00	8.05E+09	19.8091	17378.	0.00
22.9220	-0.00276	-166305.	-7407.	3.70E-04	0.00	8.05E+09	12.8867	17619.	0.00
23.2360	-0.00151	-194305.	-7369.	2.85E-04	0.00	8.05E+09	7.1571	17861.	0.00
23.5500	-6.07E-04	-222152.	4913.	1.88E-04	0.00	8.05E+09	6512.	4.05E+07	0.00
23.8640	-9.50E-05	-157490.	19102.	9.89E-05	0.00	8.05E+09	1020.	4.05E+07	0.00
24.1780	1.39E-04	-78312.	18213.	4.37E-05	0.00	8.05E+09	-1491.	4.05E+07	0.00
24.4920	2.35E-04	-20286.	10656.	-1.84E-06	0.00	1.40E+09	-2520.	4.05E+07	0.00
24.8060	1.25E-04	1997.	3380.	-2.64E-05	0.00	1.41E+09	-1343.	4.05E+07	0.00
25.1200	3.56E-05	5212.	129.3244	-1.67E-05	0.00	1.40E+09	-382.491	4.05E+07	0.00
25.4340	-1.09E-06	2990.	-569.208	-5.73E-06	0.00	1.40E+09	11.7202	4.05E+07	0.00
25.7480	-7.59E-06	929.1038	-393.631	-4.80E-07	0.00	1.41E+09	81.4738	4.05E+07	0.00
26.0620	-4.71E-06	23.8571	-144.959	7.97E-07	0.00	1.41E+09	50.5174	4.05E+07	0.00
26.3760	-1.58E-06	-164.188	-17.804	6.09E-07	0.00	1.41E+09	16.9750	4.05E+07	0.00
26.6900	-1.15E-07	-110.984	16.4939	2.41E-07	0.00	1.41E+09	1.2297	4.05E+07	0.00
27.0040	2.32E-07	-40.156	14.1281	3.80E-08	0.00	1.41E+09	-2.485	4.05E+07	0.00

27.3180	1.72E-07	-4.556	5.9639	-2.19E-08	0.00	1.41E+09	-1.848	4.05E+07	0.00
27.6320	6.68E-08	4.8124	1.1321	-2.15E-08	0.00	1.41E+09	-0.717	4.05E+07	0.00
27.9460	9.97E-09	3.9987	-0.420	-9.71E-09	0.00	1.41E+09	-0.107	4.05E+07	0.00
28.2600	-6.45E-09	1.6601	-0.491	-2.13E-09	0.00	1.41E+09	0.06926	4.05E+07	0.00
28.5740	-6.11E-09	0.3024	-0.237	4.97E-10	0.00	1.41E+09	0.06556	4.05E+07	0.00
28.8880	-2.71E-09	-0.125	-0.05853	7.34E-10	0.00	1.41E+09	0.02908	4.05E+07	0.00
29.2020	-5.74E-10	-0.140	0.00787	3.80E-10	0.00	1.41E+09	0.00616	4.05E+07	0.00
29.5160	1.52E-10	-0.06619	0.01642	1.04E-10	0.00	1.41E+09	-0.00163	4.05E+07	0.00
29.8300	2.09E-10	-0.01591	0.00911	-6.02E-12	0.00	1.41E+09	-0.00225	4.05E+07	0.00
30.1440	1.06E-10	0.00249	0.00273	-2.40E-11	0.00	1.41E+09	-0.00114	4.05E+07	0.00
30.4580	2.86E-11	0.00466	-5.33E-06	-1.44E-11	0.00	1.41E+09	-3.07E-04	4.05E+07	0.00
30.7720	-2.24E-12	0.00246	-5.38E-04	-4.88E-12	0.00	1.41E+09	2.41E-05	4.05E+07	0.00
31.0860	-8.19E-12	6.09E-04	-3.27E-04	0.00	0.00	1.41E+09	8.79E-05	4.05E+07	0.00
31.4000	-7.98E-12	0.00	0.00	0.00	0.00	1.41E+09	8.57E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

Pile-head deflection = 1.80037457 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -2787667. inch-lbs
Maximum shear force = 37700. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 10
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 6

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 42000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 125900.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.7411	-3073804.	42000.	0.00	0.00	2.23E+09	0.00	0.00	0.00
0.3140	2.7313	-2914315.	41983.	-0.00506	0.00	2.23E+09	-8.976	12.3830	0.00
0.6280	2.7029	-2752615.	41930.	-0.00835	0.00	6.33E+09	-19.443	27.1045	0.00
0.9420	2.6684	-2590413.	41836.	-0.00988	0.00	6.82E+09	-30.269	42.7420	0.00
1.2560	2.6285	-2427963.	41702.	-0.01125	0.00	6.99E+09	-40.626	58.2382	0.00
1.5700	2.5836	-2265468.	41531.	-0.01252	0.00	7.03E+09	-50.571	73.7541	0.00
1.8840	2.5341	-2103115.	41323.	-0.01368	0.00	7.06E+09	-59.457	88.4067	0.00
2.1980	2.4805	-1941073.	41085.	-0.01476	0.00	7.09E+09	-66.786	101.4528	0.00
2.5120	2.4229	-1779489.	40818.	-0.01575	0.00	7.12E+09	-75.007	116.6475	0.00
2.8260	2.3618	-1618524.	40518.	-0.01665	0.00	7.15E+09	-84.393	134.6409	0.00
3.1400	2.2975	-1458353.	40179.	-0.01745	0.00	7.20E+09	-95.447	156.5409	0.00
3.4540	2.2303	-1299174.	39800.	-0.01817	0.00	7.24E+09	-105.958	179.0163	0.00
3.7680	2.1605	-1141179.	39373.	-0.01881	0.00	7.30E+09	-120.505	210.1664	0.00
4.0820	2.0885	-984616.	38887.	-0.01935	0.00	7.37E+09	-137.637	248.3164	0.00
4.3960	2.0147	-829768.	38334.	-0.01981	0.00	7.46E+09	-155.719	291.2400	0.00
4.7100	1.9392	-676932.	37728.	-0.02019	0.00	7.58E+09	-166.123	322.7878	0.00

5.0240	1.8625	-526295.	37068.	-0.02049	0.00	7.74E+09	-184.232	372.7193	0.00
5.3380	1.7848	-378152.	36337.	-0.02070	0.00	8.07E+09	-203.281	429.1559	0.00
5.6520	1.7065	-232812.	35534.	-0.02085	0.00	8.07E+09	-223.269	492.9944	0.00
5.9660	1.6277	-90590.	34653.	-0.02092	0.00	8.07E+09	-244.196	565.2929	0.00
6.2800	1.5488	48185.	33692.	-0.02093	0.00	8.07E+09	-266.063	647.2948	0.00
6.5940	1.4700	183172.	32646.	-0.02088	0.00	8.07E+09	-288.868	740.4665	0.00
6.9080	1.3914	314018.	31513.	-0.02076	0.00	8.07E+09	-312.613	846.5452	0.00
7.2220	1.3135	440355.	30289.	-0.02058	0.00	7.86E+09	-337.296	967.5979	0.00
7.5360	1.2363	561803.	28970.	-0.02034	0.00	7.70E+09	-362.919	1106.	0.00
7.8500	1.1602	677968.	27552.	-0.02003	0.00	7.58E+09	-389.481	1265.	0.00
8.1640	1.0853	788443.	26033.	-0.01967	0.00	7.49E+09	-416.982	1448.	0.00
8.4780	1.0120	892811.	24408.	-0.01924	0.00	7.42E+09	-445.422	1658.	0.00
8.7920	0.9403	990639.	22674.	-0.01876	0.00	7.37E+09	-474.802	1903.	0.00
9.1060	0.8706	1081486.	20828.	-0.01823	0.00	7.33E+09	-505.122	2186.	0.00
9.4200	0.8029	1164897.	18866.	-0.01765	0.00	7.29E+09	-536.381	2517.	0.00
9.7340	0.7375	1240407.	16784.	-0.01703	0.00	7.27E+09	-568.581	2905.	0.00
10.0480	0.6746	1307540.	14579.	-0.01637	0.00	7.24E+09	-601.720	3361.	0.00
10.3620	0.6142	1365807.	12248.	-0.01567	0.00	7.22E+09	-635.799	3901.	0.00
10.6760	0.5565	1414709.	9805.	-0.01495	0.00	7.21E+09	-660.744	4474.	0.00
10.9900	0.5015	1453879.	7280.	-0.01420	0.00	7.20E+09	-679.380	5104.	0.00
11.3040	0.4495	1483042.	4685.	-0.01343	0.00	7.19E+09	-698.018	5851.	0.00
11.6180	0.4004	1501926.	2020.	-0.01265	0.00	7.19E+09	-716.658	6745.	0.00
11.9320	0.3542	1510262.	-593.352	-0.01186	0.00	7.18E+09	-670.447	7132.	0.00
12.2460	0.3110	1508703.	-3032.	-0.01106	0.00	7.18E+09	-624.105	7561.	0.00
12.5600	0.2708	1497907.	-5299.	-0.01028	0.00	7.19E+09	-579.116	8057.	0.00
12.8740	0.2336	1478517.	-7400.	-0.00950	0.00	7.19E+09	-535.769	8643.	0.00
13.1880	0.1993	1451153.	-9340.	-0.00873	0.00	7.20E+09	-494.323	9347.	0.00
13.5020	0.1678	1416410.	-11128.	-0.00798	0.00	7.21E+09	-454.828	10213.	0.00
13.8160	0.1391	1374858.	-12724.	-0.00725	0.00	7.22E+09	-392.170	10620.	0.00
14.1300	0.1132	1327398.	-14078.	-0.00655	0.00	7.24E+09	-326.241	10861.	0.00
14.4440	0.08982	1274978.	-15191.	-0.00587	0.00	7.25E+09	-264.661	11103.	0.00
14.7580	0.06896	1218487.	-16081.	-0.00522	0.00	7.27E+09	-207.602	11344.	0.00
15.0720	0.05047	1158748.	-16764.	-0.00461	0.00	7.30E+09	-155.183	11585.	0.00
15.3860	0.03424	1096522.	-17259.	-0.00403	0.00	7.32E+09	-107.473	11827.	0.00
15.7000	0.02014	1032503.	-17583.	-0.00348	0.00	7.35E+09	-64.495	12068.	0.00
16.0140	0.00803	967317.	-17754.	-0.00297	0.00	7.38E+09	-26.226	12310.	0.00
16.3280	-0.00222	901524.	-17789.	-0.00249	0.00	7.42E+09	7.3984	12551.	0.00
16.6420	-0.01074	835619.	-17707.	-0.00205	0.00	7.46E+09	36.4779	12792.	0.00
16.9560	-0.01768	770032.	-17523.	-0.00165	0.00	7.51E+09	61.1478	13034.	0.00
17.2700	-0.02315	705129.	-17254.	-0.00128	0.00	7.56E+09	81.5740	13275.	0.00
17.5840	-0.02731	641218.	-16916.	-9.43E-04	0.00	7.62E+09	97.9496	13516.	0.00
17.8980	-0.03026	578547.	-16523.	-6.43E-04	0.00	7.68E+09	110.4922	13758.	0.00
18.2120	-0.03215	517310.	-16090.	-3.75E-04	0.00	7.75E+09	119.4404	13999.	0.00
18.5260	-0.03309	457650.	-15629.	-1.39E-04	0.00	7.83E+09	125.0505	14240.	0.00
18.8400	-0.03320	399661.	-15153.	6.48E-05	0.00	8.00E+09	127.5933	14482.	0.00
19.1540	-0.03260	343394.	-14673.	2.39E-04	0.00	8.07E+09	127.3804	14723.	0.00
19.4680	-0.03140	288859.	-14198.	3.87E-04	0.00	8.07E+09	124.6918	14965.	0.00
19.7820	-0.02969	236031.	-13737.	5.09E-04	0.00	8.07E+09	119.7990	15206.	0.00
20.0960	-0.02756	184851.	-13299.	6.07E-04	0.00	8.07E+09	112.9853	15447.	0.00
20.4100	-0.02511	135235.	-12889.	6.82E-04	0.00	8.07E+09	104.5457	15689.	0.00
20.7240	-0.02242	87073.	-12513.	7.34E-04	0.00	8.07E+09	94.7866	15930.	0.00
21.0380	-0.01958	40238.	-12177.	7.64E-04	0.00	8.07E+09	84.0259	16171.	0.00
21.3520	-0.01667	-5413.	-11881.	7.72E-04	0.00	8.07E+09	72.5929	16413.	0.00
21.6660	-0.01376	-50033.	-11630.	7.59E-04	0.00	8.07E+09	60.8287	16654.	0.00
21.9800	-0.01095	-93778.	-11423.	7.25E-04	0.00	8.07E+09	49.0872	16895.	0.00
22.2940	-0.00830	-136805.	-11259.	6.71E-04	0.00	8.07E+09	37.7351	17137.	0.00
22.6080	-0.00589	-179266.	-11137.	5.98E-04	0.00	8.07E+09	27.1530	17378.	0.00
22.9220	-0.00379	-221302.	-11053.	5.04E-04	0.00	8.07E+09	17.7364	17619.	0.00
23.2360	-0.00209	-263037.	-11001.	3.91E-04	0.00	8.07E+09	9.8963	17861.	0.00
23.5500	-8.45E-04	-304573.	6112.	2.59E-04	0.00	8.07E+09	9073.	4.05E+07	0.00
23.8640	-1.38E-04	-217224.	26001.	1.37E-04	0.00	8.07E+09	1484.	4.05E+07	0.00
24.1780	1.87E-04	-108762.	25019.	6.09E-05	0.00	8.07E+09	-2005.	4.05E+07	0.00
24.4920	3.20E-04	-28736.	14763.	-1.75E-06	0.00	1.45E+09	-3439.	4.05E+07	0.00
24.8060	1.74E-04	2495.	4774.	-3.58E-05	0.00	1.46E+09	-1863.	4.05E+07	0.00
25.1200	5.09E-05	7277.	234.7283	-2.31E-05	0.00	1.46E+09	-546.911	4.05E+07	0.00
25.4340	-6.25E-07	4286.	-783.014	-8.14E-06	0.00	1.46E+09	6.7088	4.05E+07	0.00
25.7480	-1.04E-05	1384.	-559.917	-8.07E-07	0.00	1.46E+09	111.7076	4.05E+07	0.00
26.0620	-6.71E-06	66.8611	-213.780	1.07E-06	0.00	1.46E+09	72.0169	4.05E+07	0.00
26.3760	-2.36E-06	-227.968	-30.366	8.59E-07	0.00	1.46E+09	25.3368	4.05E+07	0.00

26.6900	-2.32E-07	-162.791	22.0556	3.55E-07	0.00	1.46E+09	2.4878	4.05E+07	0.00
27.0040	3.11E-07	-62.093	20.4437	6.39E-08	0.00	1.46E+09	-3.343	4.05E+07	0.00
27.3180	2.50E-07	-8.788	9.0889	-2.77E-08	0.00	1.46E+09	-2.684	4.05E+07	0.00
27.6320	1.03E-07	6.4269	1.9512	-3.07E-08	0.00	1.46E+09	-1.105	4.05E+07	0.00
27.9460	1.85E-08	5.9454	-0.504	-1.47E-08	0.00	1.46E+09	-0.198	4.05E+07	0.00
28.2600	-8.09E-09	2.6407	-0.714	-3.64E-09	0.00	1.46E+09	0.08685	4.05E+07	0.00
28.5740	-8.94E-09	0.5658	-0.370	5.06E-10	0.00	1.46E+09	0.09597	4.05E+07	0.00
28.8880	-4.28E-09	-0.147	-0.103	1.05E-09	0.00	1.46E+09	0.04594	4.05E+07	0.00
29.2020	-1.05E-09	-0.208	0.00535	5.88E-10	0.00	1.46E+09	0.01131	4.05E+07	0.00
29.5160	1.49E-10	-0.107	0.02365	1.80E-10	0.00	1.46E+09	-0.00160	4.05E+07	0.00
29.8300	3.05E-10	-0.02974	0.01447	2.94E-12	0.00	1.46E+09	-0.00327	4.05E+07	0.00
30.1440	1.71E-10	0.00158	0.00485	-3.34E-11	0.00	1.46E+09	-0.00184	4.05E+07	0.00
30.4580	5.27E-11	0.00682	3.21E-04	-2.26E-11	0.00	1.46E+09	-5.66E-04	4.05E+07	0.00
30.7720	0.00	0.00402	-7.61E-04	-8.60E-12	0.00	1.46E+09	-8.36E-06	4.05E+07	0.00
31.0860	-1.21E-11	0.00109	-5.33E-04	-2.00E-12	0.00	1.46E+09	1.30E-04	4.05E+07	0.00
31.4000	-1.43E-11	0.00	0.00	0.00	0.00	1.46E+09	1.53E-04	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

* WARNING: Some values of computed curvature exceeded the maximum curvature calculated or entered by the user
  Depth = 0.00 ft Computed Curv. = 0.00136 rad/in Maximum Curv. = 7.29E-04 rad/in
  Depth = 0.3140 ft Computed Curv. = 0.00129 rad/in Maximum Curv. = 7.29E-04 rad/in

Output Summary for Load Case No. 6:

Pile-head deflection = 2.74110542 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -3073804. inch-lbs
Maximum shear force = 42000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 37
Number of zero deflection points = 7

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	19740.	S, rad	0.00	195300.	0.5942	0.00	19740.	-1244431.
2	V, lb	14650.	S, rad	0.00	145100.	0.3962	0.00	14650.	-877893.
3	V, lb	14630.	S, rad	0.00	127500.	0.3948	0.00	14630.	-872375.
4	y, in	1.0000	S, rad	0.00	108700.	1.0000	0.00	27623.	-1839137.
5	V, lb	37700.	S, rad	0.00	146200.	1.8004	0.00	37700.	-2787667.
6	V, lb	42000.	S, rad	0.00	125900.	2.7411	0.00	42000.	-3073804.

Maximum pile-head deflection = 2.7411054173 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

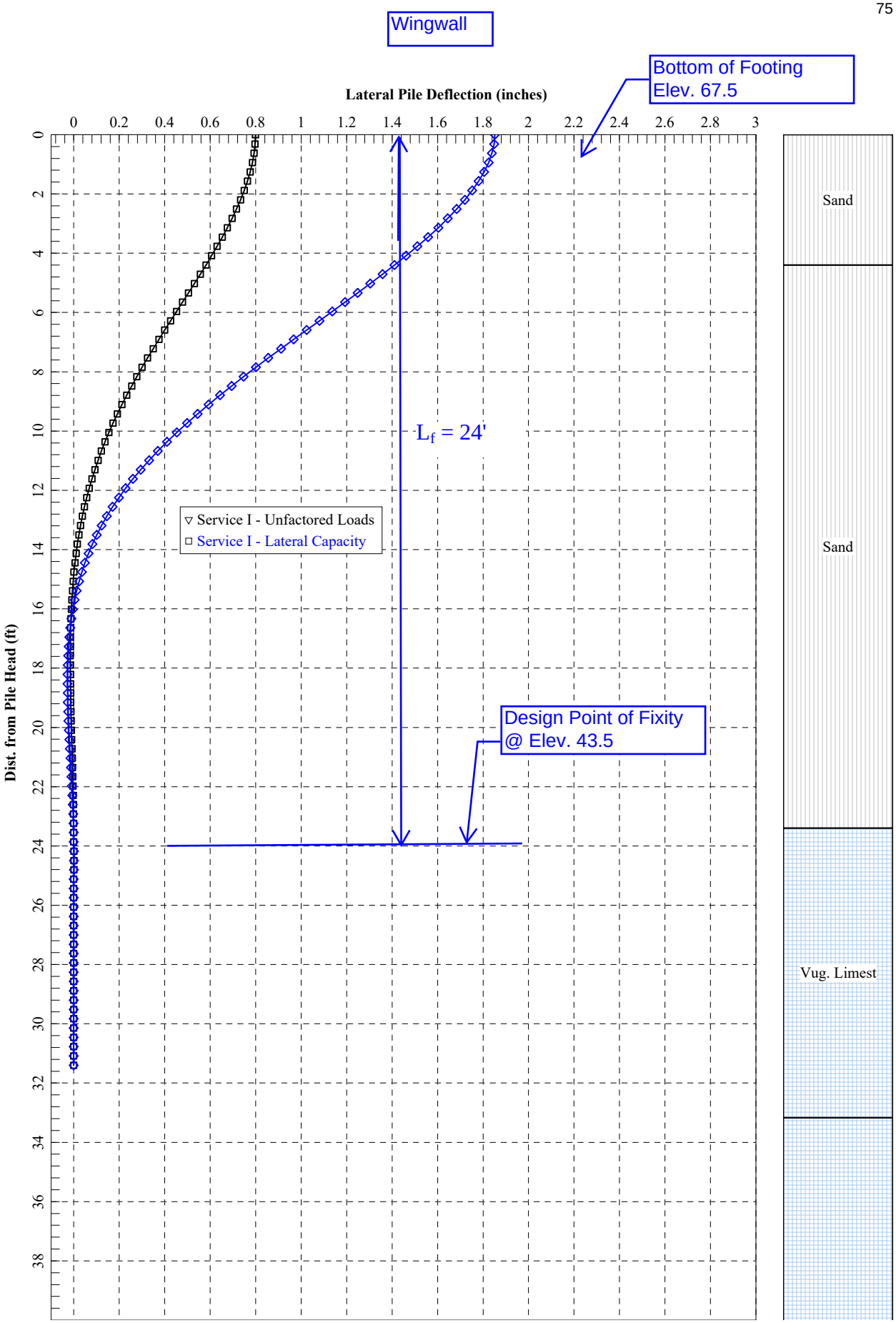
Summary of Warning Messages

The following warning was reported 3614 times

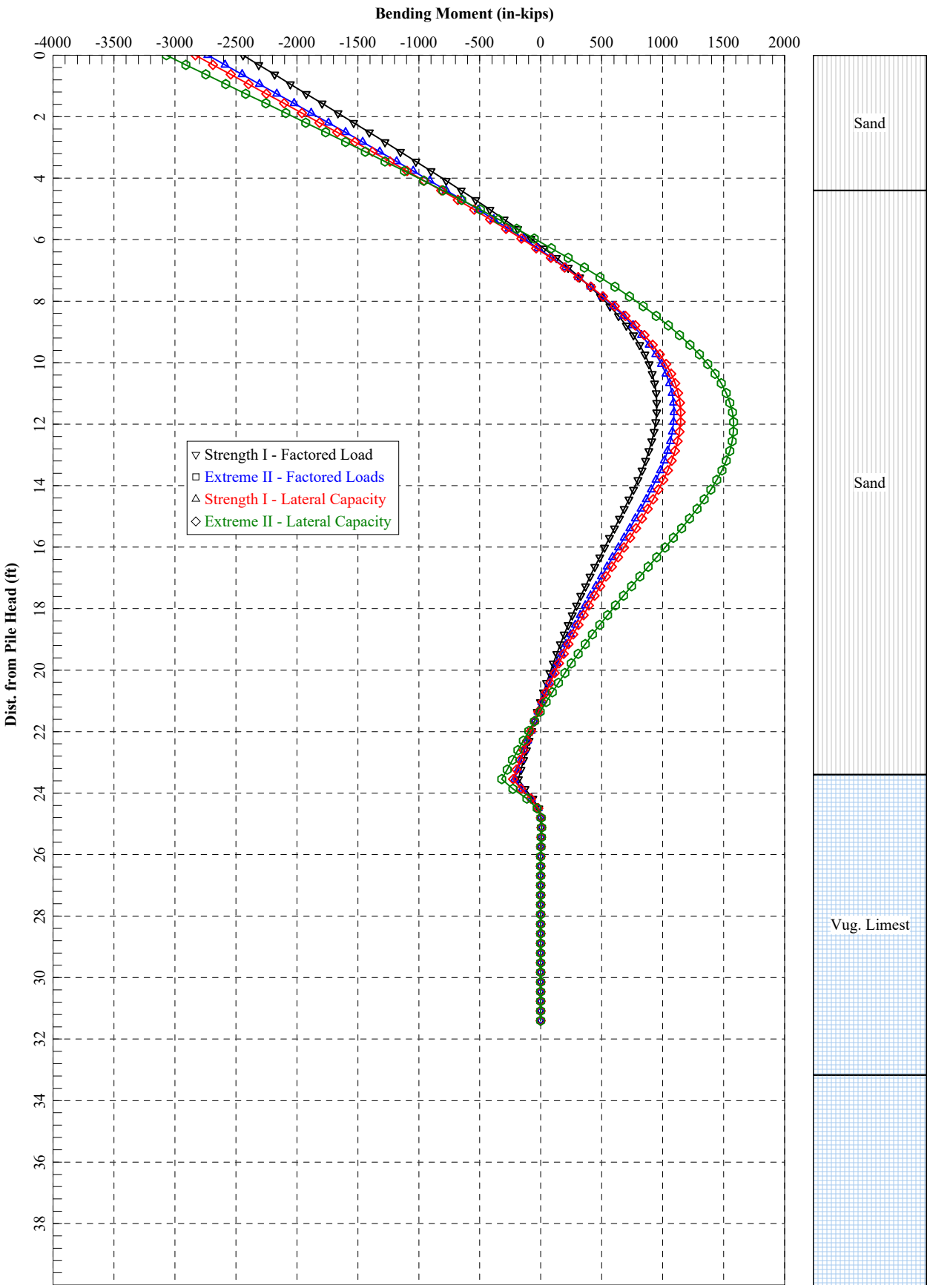
**** Warning ****

This warning is for an input value for uniaxial compressive strength that
has been specified for a soil defined using the vuggy limestone criteria.
The input value is outside of the range of 1,000 to 2,500 psi
(6,895 to 17,237 kPa) which were used in actual field tests
on which this theory is based. Higher or lower values may be applicable
but the user is warned about the theoretical and testing limitations.

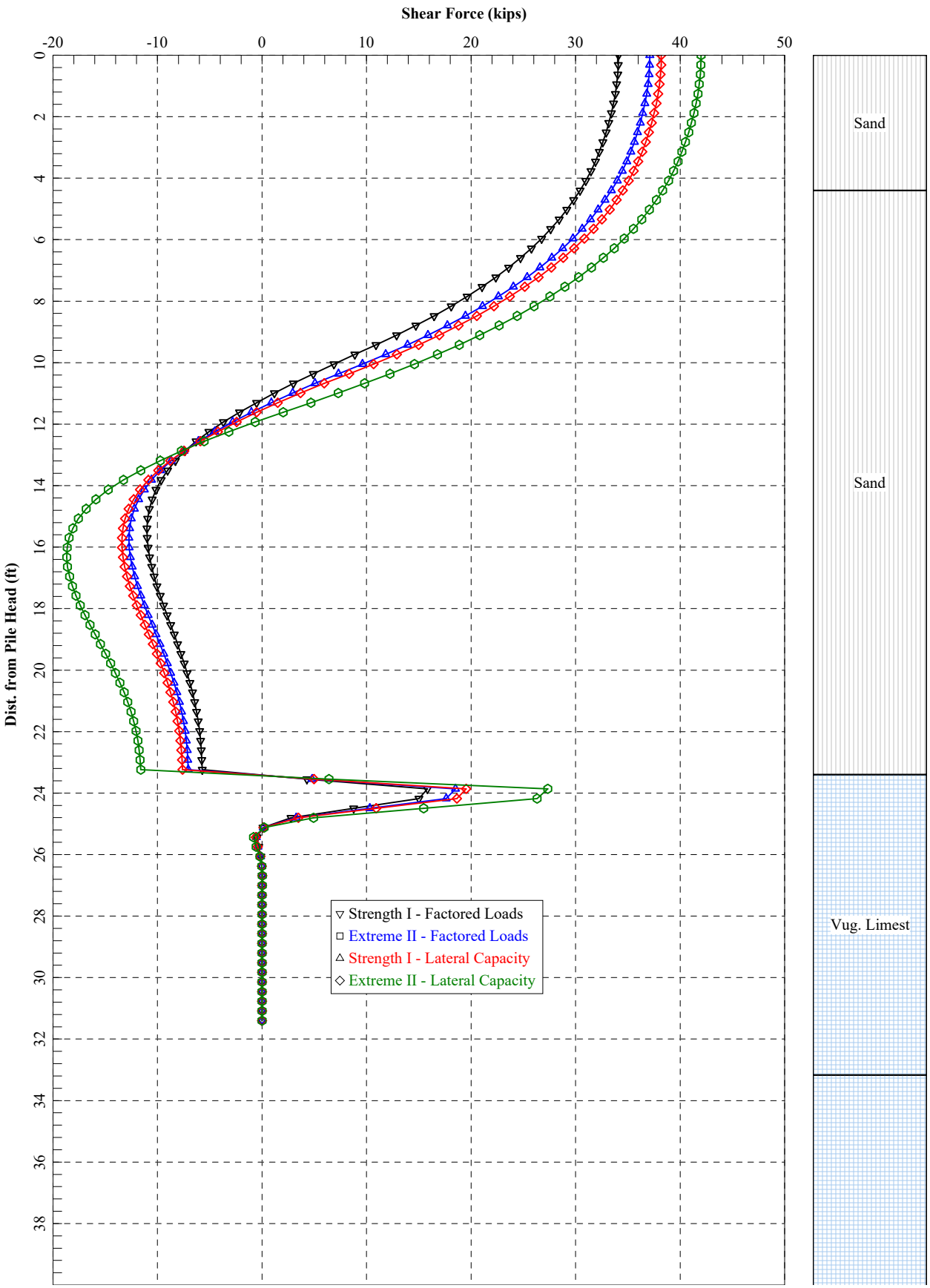
The analysis ended normally.


Wingwall
Bottom of Footing
Elev. 67.5
Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
L_f = 24'
Service I - Unfactored Loads
Service I - Lateral Capacity
Design Point of Fixity
@ Elev. 43.5
Sand
Sand
Vug. Limest

Wingwall


Bending Moment (in-kips)
-4000
-3500
-3000
-2500
-2000
-1500
-1000
-500
0
500
1000
1500
2000
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Strength I - Factored Load
Extreme II - Factored Loads
Strength I - Lateral Capacity
Extreme II - Lateral Capacity
Sand
Sand
Vug. Limest

Wingwall


Shear Force (kips)
-20
-10
0
10
20
30
40
50
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Strength I - Factored Loads
Extreme II - Factored Loads
Strength I - Lateral Capacity
Extreme II - Lateral Capacity
Sand
Sand
Vug. Limest

Wingwall

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LPile for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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LAMSON ENGINEERING CORPORATION
437 CHERRY STREET, #109 NEWTON, MA 02465

Serial Number of Security Device: 447579478

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Files Used for Analysis

Path to file locations:
\Green- Willmington Culvert\Micropile\Lpile\wingwall\

Name of input data file:
Micropile.lp12d

Name of output report file:
Micropile.lp12o

Name of plot output file:
Micropile.lp12p

Name of runtime message file:
Micropile.lp12r

Date and Time of Analysis

Date: September 12, 2025 Time: 10:06:15

Problem Title

Bridge W-38-011, Willmington

Job Number:

Client: MassDOT

Engineer: Lamson Engineering Corporation

Description: 10.75 Micropile

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 1000
 - Deflection tolerance for convergence = 1.0000E-02 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 31.400 ft
Depth of ground surface below top of pile = 0.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.6250
2	24.400	10.6250
3	24.400	9.3000
4	31.400	9.3000

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Input Structural Properties for Pile Sections:
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Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                =    24.400000 ft
   Casing outside diameter                          =    10.625000 in

Pile Section No. 2:

   Section 2 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                =     7.000000 ft
   Shaft Diameter                                   =     9.300000 in




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                      Ground Slope and Pile Batter Angles
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Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


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                      Soil and Rock Layering Information
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The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =       0.0000 ft
   Distance from top of pile to bottom of layer       =     4.400000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =    30.000000 pci
   Subgrade k at bottom of layer                      =    30.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =     4.400000 ft
   Distance from top of pile to bottom of layer       =    23.400000 ft
   Effective unit weight at top of layer              =    47.600000 pcf
   Effective unit weight at bottom of layer           =    47.600000 pcf
   Friction angle at top of layer                     =    28.000000 deg.
   Friction angle at bottom of layer                  =    28.000000 deg.
   Subgrade k at top of layer                         =    20.000000 pci
   Subgrade k at bottom of layer                      =    20.000000 pci


Layer 3 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer          =    23.400000 ft
   Distance from top of pile to bottom of layer       =    60.000000 ft
   Effective unit weight at top of layer              =   168.000000 pcf
   Effective unit weight at bottom of layer           =   168.000000 pcf
   Uniaxial compressive strength at top of layer      =       12630. psi
   Uniaxial compressive strength at bottom of layer   =       12630. psi
```

(Depth of the lowest soil layer extends 28.600 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 168.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci
1	Sand	0.00	52.6000	30.0000	--	30.0000
	(Reese, et al.)	4.4000	52.6000	30.0000	--	30.0000
2	Sand	4.4000	47.6000	28.0000	--	20.0000
	(Reese, et al.)	23.4000	47.6000	28.0000	--	20.0000
3	Strong Rock	23.4000	168.0000	--	12630.	--
	(Vuggy Limestone)	60.0000	168.0000	--	12630.	--

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.8500	1.0000
2	120.000	0.8500	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 6

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	2	V = 34100. lbs	S = 0.0000 in/in	143200.	No	Yes
2	2	V = 24200. lbs	S = 0.0000 in/in	95600.	No	Yes
3	2	V = 37100. lbs	S = 0.0000 in/in	144500.	No	Yes
4	2	V = 38200. lbs	S = 0.0000 in/in	143200.	No	Yes
5	5	y = 1.000000 in	S = 0.0000 in/in	95600.	N.A.	Yes

6	2	V =	42000. lbs	S =	0.0000 in/in	144500.	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	24.400000 ft
Outer Diameter of Casing	=	10.625000 in
Concrete Cover Thickness Inside Casing	=	3.803000 in
Casing Wall Thickness	=	0.532500 in
Moment of Inertia of Steel Casing	=	215.567404 in^4
Yield Stress of Casing	=	52000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	2.250000 sq. in.
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	88.664090 sq. in.
Area of Concrete	=	69.530366 sq. in.
Cross-sectional Area of Steel Casing	=	16.883724 sq. in.
Area of All Steel (Casing and Bars)	=	19.133724 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.58 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1308.458 kips
Tensile Load for Cracking of Concrete	=	-96.019 kips
Nominal Axial Tensile Capacity	=	-1012.954 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

```
Compressive Strength of Concrete                        =        5000. psi
Modulus of Elasticity of Concrete                       =     4030509. psi
Modulus of Rupture of Concrete                          =   -530.33009 psi
Compression Strain at Peak Stress                       =     0.002109
Tensile Strain at Fracture of Concrete                  =   -0.0001150
Maximum Coarse Aggregate Size                           =       0.0000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

   Number     Axial Thrust Force
                     kips
   ------     ------------------
      1               95.600
      2              143.200
      3              144.500


Definitions of Run Messages and Notes:
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  C = concrete in section has cracked in tension.
  Y = stress in reinforcing steel has reached yield stress.
  T = ACI 318 criteria for tension-controlled section met, tensile strain in
      reinforcement exceeds 0.005 while simultaneously compressive strain in
      concrete more than 0.003. See ACI 318-14, Section 21.2.3.
  Z = depth of tensile zone in concrete section is less than 10 percent of
      section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =     95.600 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens      Max Conc      Max Steel
Max Casing  Run
   Curvature      Moment       Stiffness      N Axis        Strain        Strain        Stress        Stress
Stress    Msg
    rad/in.       in-kip        kip-in2         in           in/in         in/in          ksi           ksi
 ksi
------------- ------------- ------------- ------------- ------------- ------------- ------------- -------------
------------- ---
   0.00000125    10.1333215      8106657.    92.6145852     0.0001158     0.0001025     0.5335822     3.1935873
3.3553529
   0.00000250    20.2653653      8106146.    48.9645313     0.0001224    0.00009585     0.5630078     3.2225457
3.5460770
   0.00000375    30.3973978      8105973.    34.4149557     0.0001291    0.00008921     0.5923436     3.2515522
3.7368491
   0.00000500    40.5294131      8105883.    27.1404998     0.0001357    0.00008258     0.6215894     3.2806069
3.9276694
   0.00000625    50.6614055      8105825.    22.7760916     0.0001424    0.00007594     0.6507452     3.3097096
4.1185377
   0.00000750    60.7933693      8105783.    19.8667074     0.0001490    0.00006931     0.6798110     3.3388604
4.3094542
   0.00000875    70.9252989      8105748.    17.7887655     0.0001557    0.00006268     0.7087866     3.3680594
4.5004188
   0.00001000    81.0571883      8105719.    16.2304749     0.0001623    0.00005605     0.7376719     3.3973065
4.6914315
   0.00001125    91.1890320      8105692.    15.0186186     0.0001690    0.00004943     0.7664669     3.4266017
4.8824923
   0.00001250   101.3208241      8105666.    14.0492663     0.0001756    0.00004280     0.7951716     3.4559450
5.0736013
   0.00001375   111.4525590      8105641.    13.2562805     0.0001823    0.00003618     0.8237858     3.4853364
5.2647583
   0.00001500   121.5842310      8105615.    12.5955697     0.0001889    0.00002956     0.8523095     3.5147760
5.4559635
```

```
   0.00001625   131.7158342      8105590.    12.0366087     0.0001956     0.00002294     0.8807425     3.5442636
5.6472168
   0.00001750   141.8473629      8105564.    11.5575942     0.0002023     0.00001632     0.9090849     3.5737994
5.8385182
   0.00001875   151.9788115      8105537.    11.1425367     0.0002089     0.00000970     0.9373366     3.6033833
6.0298677
   0.00002000   162.1101746      8105509.    10.7794444     0.0002156     0.00000309     0.9654973     3.6330147
6.2212647
   0.00002125   172.2414456      8105480.    10.4591469     0.0002223    -0.00000352     0.9935673     3.6626949
6.4127105
   0.00002250   182.3726189      8105450.    10.1745117     0.0002289    -0.00001014     1.0215463     3.6924237
6.6042049
   0.00002375   192.5036770      8105418.     9.9199079     0.0002356    -0.00001675     1.0494342     3.7221999
6.7957468
   0.00002500   202.6343976      8105376.     9.6908286     0.0002423    -0.00002335     1.0772307     3.7520227
6.9873352
   0.00002625   212.7643312      8105308.     9.4836230     0.0002489    -0.00002996     1.1049354     3.7818886
7.1789667
   0.00002750   222.8930017      8105200.     9.2953037     0.0002556    -0.00003657     1.1325475     3.8117938
7.3706376
   0.00002875   233.0199695      8105042.     9.1234030     0.0002623    -0.00004317     1.1600665     3.8417350
7.5623443
   0.00003000   243.1448473      8104828.     8.9658647     0.0002690    -0.00004977     1.1874919     3.8717086
7.7540836
   0.00003125   253.2672934      8104553.     8.8209620     0.0002757    -0.00005638     1.2148233     3.9017117
7.9458523
   0.00003250   263.3870183      8104216.     8.6872340     0.0002823    -0.00006298     1.2420601     3.9317416
8.1376478
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8.3294677
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8.5213099
   0.00003625   293.7275546      8102829.     8.3415171     0.0003024    -0.00008278     1.3231997     4.0219691
8.7131723
   0.00003750   303.8342374      8102246.     8.2416797     0.0003091    -0.00008937     1.3500550     4.0520845
8.9050533
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9.0969514
   0.00004000   324.0365129      8100913.     8.0607674     0.0003224     -0.000103      1.4034772     4.1123653
9.2888653
   0.00004125   334.1318896      8100167.     7.9785533     0.0003291     -0.000109      1.4300437     4.1425281
9.4807937
   0.00004250   335.2129598      7887364.     7.8365720     0.0003331     -0.000119      1.4455431     4.0930673
9.5930986 C
   0.00004375   344.3225226      7870229.     7.7580338     0.0003394     -0.000125      1.4706590     4.1138063
9.7756032 C
   0.00004500   353.4080766      7853513.     7.6836483     0.0003458     -0.000132      1.4956483     4.1342706
9.9578331 C
   0.00004625   362.4657434      7837097.     7.6130335     0.0003521     -0.000139      1.5205030     4.1543993
10.1397274 C
   0.00004750   371.4960043      7820969.     7.5458853     0.0003584     -0.000146      1.5452225     4.1741836
10.3212774 C
   0.00004875   380.5123508      7805382.     7.4820721     0.0003648     -0.000153      1.5698331     4.1938148
10.5026742 C
   0.00005125   398.4743360      7775109.     7.3631661     0.0003774     -0.000167      1.6186668     4.2321581
10.8645487 C
   0.00005375   416.3691079      7746402.     7.2547685     0.0003899     -0.000181      1.6670354     4.2696400
11.2255619 C
   0.00005625   434.2056441      7719211.     7.1555410     0.0004025     -0.000195      1.7149549     4.3063631
11.5858162 C
   0.00005875   451.9924371      7693488.     7.0643770     0.0004150     -0.000209      1.7624421     4.3424364
11.9454208 C
   0.00006125   469.7260592      7668997.     6.9802314     0.0004275     -0.000223      1.8094852     4.3777573
12.3042729 C
   0.00006375   487.4211150      7645821.     6.9024043     0.0004400     -0.000237      1.8561166     4.4125584
12.6626053 C
   0.00006625   505.0855012      7623932.     6.8302515     0.0004525     -0.000251      1.9023554     4.4469764
13.0205545 C
   0.00006875   522.7166317      7603151.     6.7631207     0.0004650     -0.000266      1.9481943     4.4809447
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13.3780541 C
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14.0919825 C
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14.4482641 C
0.00007875 592.9782272 7529882. 6.5357173 0.0005147 -0.000322 2.1277074 4.6133861
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19.0659525 C
0.0001113 819.4306889 7365669. 6.0726083 0.0006756 -0.000506 2.6712501 5.0232147
19.4203553 C
0.0001138 836.7663533 7356188. 6.0477757 0.0006879 -0.000521 2.7106398 5.0541797
19.7748516 C
0.0001163 854.0955054 7347058. 6.0240379 0.0007003 -0.000535 2.7497034 5.0852348
20.1294379 C
0.0001188 871.4171860 7338250. 6.0013150 0.0007127 -0.000549 2.7884369 5.1163454
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20.8383873 C
0.0001238 906.0188423 7321364. 5.9584649 0.0007374 -0.000577 2.8648335 5.1779902
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0.0001288 940.5944459 7305588. 5.9190395 0.0007621 -0.000606 2.9399254 5.2399976
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0.0001313 957.8724493 7298076. 5.9004888 0.0007744 -0.000620 2.9769814 5.2711368
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22.9654131 C
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23.3199513 C
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23.6745800 C
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24.0292994 C
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24.7389468 C
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26.1580459 C
0.0001688 1216. 7206261. 5.6886004 0.0009600 -0.000833 3.4926457 5.7402485
27.5786079 C

```
    0.0001788        1285.      7186697.     5.6474413     0.0010095     -0.000890     3.6175136     5.8670529
28.9995372 C
    0.0001888        1353.      7168633.     5.6108917     0.0010591     -0.000946     3.7370953     5.9952163
30.4218257 C
    0.0001988        1421.      7151851.     5.5782780     0.0011087     -0.001003     3.8513852     6.1248666
31.8456010 C
    0.0002088        1490.      7136092.     5.5488670     0.0011583     -0.001060     3.9602907     6.2549896
33.2698489 C
    0.0002188        1558.      7121282.     5.5223817     0.0012080     -0.001116     4.0638791     6.3866133
34.6955976 C
    0.0002288        1626.      7107296.     5.4984403     0.0012578     -0.001173     4.1621343     6.5197516
36.1228610 C
    0.0002388        1694.      7094027.     5.4767245     0.0013076     -0.001229     4.2550395     6.6544136
37.5516480 C
    0.0002488        1761.      7081357.     5.4568800     0.0013574     -0.001286     4.3425403     6.7899790
38.9813384 C
    0.0002588        1829.      7069235.     5.4387492     0.0014073     -0.001342     4.4246513     6.9268942
40.4123786 C
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52.0000000 CY

Axial Thrust Force = 143.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.0704766	8056381.	136.7292792	0.0001709	0.0001576	0.7772956	4.7927450	4.9545106	
0.00000250	20.1390278	8055611.	71.0218882	0.0001776	0.0001510	0.8059059	4.8217041	5.1452353	
0.00000375	30.2075675	8055351.	49.1198713	0.0001842	0.0001444	0.8344262	4.8507118	5.3360087	
0.00000500	40.2760900	8055218.	38.1691981	0.0001908	0.0001377	0.8628565	4.8797681	5.5268306	
0.00000625	50.3445893	8055134.	31.5990622	0.0001975	0.0001311	0.8911966	4.9088730	5.7177011	
0.00000750	60.4130598	8055075.	27.2191951	0.0002041	0.0001245	0.9194465	4.9380265	5.9086203	
0.00000875	70.4814956	8055028.	24.0909101	0.0002108	0.0001178	0.9476061	4.9672286	6.0995880	
0.00001000	80.5498909	8054989.	21.7448639	0.0002174	0.0001112	0.9756753	4.9964793	6.2906043	
0.00001125	90.6182400	8054955.	19.9203103	0.0002241	0.0001046	1.0036540	5.0257786	6.4816692	
0.00001250	100.6865370	8054923.	18.4608015	0.0002308	0.00009795	1.0315423	5.0551265	6.6727828	
0.00001375	110.7547762	8054893.	17.2667797	0.0002374	0.00009132	1.0593399	5.0845230	6.8639449	
0.00001500	120.8229518	8054863.	16.2718734	0.0002441	0.00008470	1.0870469	5.1139681	7.0551556	
0.00001625	130.8910580	8054834.	15.4301326	0.0002507	0.00007808	1.1146632	5.1434618	7.2464149	
0.00001750	140.9590891	8054805.	14.7087363	0.0002574	0.00007147	1.1421886	5.1730040	7.4377228	
0.00001875	151.0270391	8054775.	14.0836156	0.0002641	0.00006485	1.1696231	5.2025949	7.6290793	
0.00002000	161.0949023	8054745.	13.5367187	0.0002707	0.00005823	1.1969667	5.2322344	7.8204844	
0.00002125	171.1626730	8054714.	13.0542415	0.0002774	0.00005162	1.2242192	5.2619225	8.0119381	
0.00002250	181.2303454	8054682.	12.6254474	0.0002841	0.00004501	1.2513806	5.2916592	8.2034404	
0.00002375	191.2979136	8054649.	12.2418601	0.0002907	0.00003840	1.2784508	5.3214445	8.3949914	
0.00002500	201.3653719	8054615.	11.8966985	0.0002974	0.00003179	1.3054297	5.3512784	8.5865909	
0.00002625	211.4327145	8054580.	11.5844734	0.0003041	0.00002519	1.3323174	5.3811609	8.7782390	

0.00002750	221.4999356	8054543.	11.3006932	0.0003108	0.00001858	1.3591135	5.4110920
8.9699357							
0.00002875	231.5670293	8054505.	11.0416479	0.0003174	0.00001198	1.3858182	5.4410717
9.1616811							
0.00003000	241.6339900	8054466.	10.8042456	0.0003241	0.00000538	1.4124314	5.4711000
9.3534750							
0.00003125	251.7008118	8054426.	10.5858891	0.0003308	-0.00000122	1.4389529	5.5011770
9.5453176							
0.00003250	261.7674889	8054384.	10.3843809	0.0003375	-0.00000782	1.4653827	5.5313025
9.7372087							
0.00003375	271.8340156	8054341.	10.1978488	0.0003442	-0.00001442	1.4917207	5.5614766
9.9291485							
0.00003500	281.9003855	8054297.	10.0246883	0.0003509	-0.00002101	1.5179668	5.5916994
10.1211369							
0.00003625	291.9665161	8054249.	9.8635157	0.0003576	-0.00002760	1.5441209	5.6219702
10.3131733							
0.00003750	302.0321672	8054191.	9.7131305	0.0003642	-0.00003420	1.5701827	5.6522873
10.5052561							
0.00003875	312.0970259	8054117.	9.5724867	0.0003709	-0.00004078	1.5961518	5.6826485
10.6973828							
0.00004000	322.1607744	8054019.	9.4406689	0.0003776	-0.00004737	1.6220278	5.7130511
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0.00004125	332.2231080	8053894.	9.3168728	0.0003843	-0.00005396	1.6478103	5.7434928
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0.00004250	342.2837390	8053735.	9.2003886	0.0003910	-0.00006055	1.6734989	5.7739712
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12.0433025							
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    0.0005088        2885.      5670913.     5.4553951     0.0027754     -0.002630     4.9999055    13.8651342
52.0000000 CY
    0.0005188        2897.      5585144.     5.4498672     0.0028271     -0.002685     4.9992471    14.0545063
52.0000000 CY
    0.0005288        2909.      5501307.     5.4446468     0.0028789     -0.002739     4.9977574    14.2453893
52.0000000 CY
    0.0005388        2920.      5419295.     5.4398369     0.0029307     -0.002794     4.9999241    14.4396571
52.0000000 CY
    0.0005488        2930.      5338832.     5.4348072     0.0029824     -0.002848     4.9989687    14.6276375
52.0000000 CY
    0.0006088        2979.      4893234.     5.4098699     0.0032933     -0.003175     4.9998318    15.7867765
52.0000000 CY
    0.0006688        3013.      4506083.     5.3901840     0.0036047     -0.003501     4.9988556    16.9609796
52.0000000 CY
    0.0007288        3039.      4169534.     5.3753448     0.0039173     -0.003826     4.9998582    18.1691060
52.0000000 CY


Axial Thrust Force =    144.500 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens      Max Conc      Max Steel
```

Max Casing Curvature rad/in.	Moment in-kip	Stiffness kip-in2	N Axis in	Strain in/in	Strain in/in	Stress ksi	Stress ksi	Run Msg
0.00000125	10.0687514	8055001.	137.9403055	0.0001724	0.0001591	0.7838895	4.8366447	4.9984103
0.00000250	20.1355597	8054224.	71.6274016	0.0001791	0.0001525	0.8124775	4.8656038	5.1891351
0.00000375	30.2023564	8053962.	49.5235473	0.0001857	0.0001459	0.8409754	4.8946116	5.3799084
0.00000500	40.2691359	8053827.	38.4719554	0.0001924	0.0001392	0.8693833	4.9236679	5.5707304
0.00000625	50.3358922	8053743.	31.8412684	0.0001990	0.0001326	0.8977010	4.9527729	5.7616010
0.00000750	60.4026196	8053683.	27.4210339	0.0002057	0.0001260	0.9259285	4.9819265	5.9525202
0.00000875	70.4693124	8053636.	24.2639151	0.0002123	0.0001193	0.9540657	5.0111286	6.1434880
0.00001000	80.5359647	8053596.	21.8962437	0.0002190	0.0001127	0.9821125	5.0403794	6.3345044
0.00001125	90.6025708	8053562.	20.0548704	0.0002256	0.0001061	1.0100688	5.0696789	6.5255695
0.00001250	100.6691247	8053530.	18.5819059	0.0002323	0.00009946	1.0379347	5.0990269	6.7166831
0.00001375	110.7356209	8053500.	17.3768750	0.0002389	0.00009284	1.0657099	5.1284235	6.9078454
0.00001500	120.8020534	8053470.	16.3727944	0.0002456	0.00008622	1.0933945	5.1578687	7.0990562
0.00001625	130.8684165	8053441.	15.5232909	0.0002523	0.00007960	1.1209883	5.1873626	7.2903157
0.00001750	140.9347044	8053412.	14.7952408	0.0002589	0.00007298	1.1484913	5.2169051	7.4816238
0.00001875	151.0009113	8053382.	14.1643534	0.0002656	0.00006636	1.1759034	5.2464961	7.6729805
0.00002000	161.0670314	8053352.	13.6124108	0.0002722	0.00005975	1.2032245	5.2761358	7.8643858
0.00002125	171.1330589	8053320.	13.1254815	0.0002789	0.00005314	1.2304546	5.3058241	8.0558398
0.00002250	181.1989880	8053288.	12.6927300	0.0002856	0.00004652	1.2575935	5.3355611	8.2473423
0.00002375	191.2648130	8053255.	12.3056018	0.0002923	0.00003991	1.2846413	5.3653466	8.4388935
0.00002500	201.3305280	8053221.	11.9572535	0.0002989	0.00003331	1.3115978	5.3951808	8.6304933
0.00002625	211.3961272	8053186.	11.6421451	0.0003056	0.00002670	1.3384629	5.4250635	8.8221417
0.00002750	221.4616049	8053149.	11.3557439	0.0003123	0.00002010	1.3652367	5.4549949	9.0138387
0.00002875	231.5269553	8053111.	11.0943055	0.0003190	0.00001349	1.3919189	5.4849749	9.2055843
0.00003000	241.5921726	8053072.	10.8547095	0.0003256	0.00000689	1.4185096	5.5150036	9.3973786
0.00003125	251.6572509	8053032.	10.6343348	0.0003323	2.91712E-07	1.4450086	5.5450808	9.5892215
0.00003250	261.7221845	8052990.	10.4309636	0.0003390	-0.00000631	1.4714159	5.5752067	9.7811130
0.00003375	271.7869677	8052947.	10.2427066	0.0003457	-0.00001290	1.4977314	5.6053812	9.9730531
0.00003500	281.8515945	8052903.	10.0679445	0.0003524	-0.00001950	1.5239551	5.6356043	10.1650418
0.00003625	291.9160208	8052856.	9.9052809	0.0003591	-0.00002609	1.5500868	5.6658758	10.3570789
0.00003750	301.9800369	8052801.	9.7535046	0.0003658	-0.00003268	1.5761262	5.6961942	10.5491629
0.00003875	312.0433506	8052732.	9.6115601	0.0003724	-0.00003927	1.6020730	5.7265572	10.7412915

0.00004000	322.1056433	8052641.	9.4785236	0.0003791	-0.00004586	1.6279268	5.7569624
10.9334624							
0.00004125	332.1666054	8052524.	9.3535831	0.0003858	-0.00005245	1.6536871	5.7874075
11.1256731							
0.00004250	342.2259476	8052375.	9.2360224	0.0003925	-0.00005903	1.6793537	5.8178900
11.3179212							
0.00004375	352.2834006	8052192.	9.1252072	0.0003992	-0.00006562	1.7049261	5.8484076
11.5102045							
0.00004500	362.3387171	8051971.	9.0205737	0.0004059	-0.00007220	1.7304041	5.8789582
11.7025207							
0.00004625	372.3916725	8051712.	8.9216192	0.0004126	-0.00007878	1.7557873	5.9095398
11.8948679							
0.00004750	382.4420629	8051412.	8.8278939	0.0004193	-0.00008536	1.7810753	5.9401505
12.0872443							
0.00004875	392.4897034	8051071.	8.7389944	0.0004260	-0.00009194	1.8062680	5.9707886
12.2796480							
0.00005125	412.5760778	8050265.	8.5742560	0.0004394	-0.000105	1.8563663	6.0321405
12.6645312							
0.00005375	426.6188868	7937096.	8.3922354	0.0004511	-0.000120	1.8995278	6.0426666
12.9985885 C							
0.00005625	445.1484142	7913750.	8.2491226	0.0004640	-0.000134	1.9471297	6.0902681
13.3697212 C							
0.00005875	463.5521312	7890249.	8.1174524	0.0004769	-0.000147	1.9942042	6.1366136
13.7395980 C							
0.00006125	481.8430546	7866825.	7.9958746	0.0004897	-0.000161	2.0407662	6.1817935
14.1083091 C							
0.00006375	500.0404491	7843772.	7.8833010	0.0005026	-0.000175	2.0868422	6.2259912
14.4760381 C							
0.00006625	518.1538042	7821189.	7.7787534	0.0005153	-0.000189	2.1324449	6.2692857
14.8428638 C							
0.00006875	536.1924634	7799163.	7.6813996	0.0005281	-0.000202	2.1775874	6.3117634
15.2088728 C							
0.00007125	554.1655226	7777762.	7.5905281	0.0005408	-0.000216	2.2222838	6.3535187
15.5741594 C							
0.00007375	572.0703873	7756887.	7.5054456	0.0005535	-0.000230	2.2665273	6.3944789
15.9386508 C							
0.00007625	589.9176675	7736625.	7.4256372	0.0005662	-0.000244	2.3103347	6.4347648
16.3024679 C							
0.00007875	607.7204937	7717086.	7.3506803	0.0005789	-0.000258	2.3537296	6.4745577
16.6657920 C							
0.00008125	625.4850497	7698278.	7.2801651	0.0005915	-0.000272	2.3967241	6.5139478
17.0287134 C							
0.00008375	643.1903703	7679885.	7.2135375	0.0006041	-0.000286	2.4392749	6.5525552
17.3908521 C							
0.00008625	660.8702818	7662264.	7.1506815	0.0006167	-0.000300	2.4814486	6.5909352
17.7527634 C							
0.00008875	678.5105522	7645189.	7.0911791	0.0006293	-0.000314	2.5232167	6.6288328
18.1141921 C							
0.00009125	696.1186626	7628698.	7.0347957	0.0006419	-0.000328	2.5645927	6.6663556
18.4752462 C							
0.00009375	713.6994267	7612794.	6.9813143	0.0006545	-0.000342	2.6055879	6.7035929
18.8360148 C							
0.00009625	731.2492730	7597395.	6.9304755	0.0006671	-0.000356	2.6461927	6.7404517
19.1964048 C							
0.00009875	748.7744074	7582526.	6.8821212	0.0006796	-0.000370	2.6864217	6.7770537
19.5565381 C							
0.0001013	766.2784560	7568182.	6.8360859	0.0006922	-0.000384	2.7262816	6.8134535
19.9164691 C							
0.0001038	783.7517703	7554234.	6.7921343	0.0007047	-0.000398	2.7657509	6.8494476
20.2759945 C							
0.0001063	801.2183849	7540879.	6.7502831	0.0007172	-0.000412	2.8048852	6.8855405
20.6356186 C							
0.0001088	818.6465005	7527784.	6.7101620	0.0007297	-0.000426	2.8436081	6.9210214
20.9946308 C							
0.0001113	836.0650050	7515191.	6.6718543	0.0007422	-0.000440	2.8819898	6.9565350
21.3536756 C							
0.0001138	853.4721481	7503052.	6.6352263	0.0007548	-0.000454	2.9200256	6.9920352
21.7127071 C							
0.0001163	870.8461603	7491150.	6.6000156	0.0007673	-0.000468	2.9576609	7.0270020

22.0712051 C							
0.0001188	888.2134477	7479692.	6.5663153	0.0007797	-0.000482	2.9949626	7.0620650
22.4297994 C							
0.0001213	905.5737017	7468649.	6.5340300	0.0007923	-0.000496	3.0319296	7.0972169
22.7884825 C							
0.0001238	922.8999848	7457778.	6.5028815	0.0008047	-0.000510	3.0684915	7.1317670
23.1465639 C							
0.0001263	940.2195348	7447283.	6.4729926	0.0008172	-0.000524	3.1047202	7.1664125
23.5047407 C							
0.0001288	957.5323420	7437144.	6.4442901	0.0008297	-0.000538	3.1406154	7.2011536
23.8630130 C							
0.0001313	974.8282821	7427263.	6.4166326	0.0008422	-0.000552	3.1761493	7.2357106
24.2211012 C							
0.0001338	992.1034384	7417596.	6.3899335	0.0008547	-0.000566	3.2113117	7.2699743
24.5788962 C							
0.0001363	1009.	7408234.	6.3642381	0.0008671	-0.000581	3.2461410	7.3043329
24.9367860 C							
0.0001388	1027.	7399160.	6.3394923	0.0008796	-0.000595	3.2806370	7.3387864
25.2947707 C							
0.0001413	1044.	7390321.	6.3156050	0.0008921	-0.000609	3.3147835	7.3731685
25.6526841 C							
0.0001438	1061.	7381635.	6.2924604	0.0009045	-0.000623	3.3485531	7.4071832
26.0102300 C							
0.0001463	1078.	7373200.	6.2701294	0.0009170	-0.000637	3.3819896	7.4412922
26.3678703 C							
0.0001488	1096.	7365003.	6.2485709	0.0009295	-0.000651	3.4150929	7.4754958
26.7256051 C							
0.0001588	1164.	7334099.	6.1690260	0.0009793	-0.000707	3.5440437	7.6118455
28.1560799 C							
0.0001688	1233.	7305994.	6.0989603	0.0010292	-0.000764	3.6675450	7.7484477
29.5868071 C							
0.0001788	1301.	7280157.	6.0366917	0.0010791	-0.000820	3.7855556	7.8848255
31.0173099 C							
0.0001888	1370.	7256385.	5.9811653	0.0011289	-0.000877	3.8981562	8.0219986
32.4486080 C							
0.0001988	1438.	7234324.	5.9313071	0.0011788	-0.000933	4.0053137	8.1596355
33.8803698 C							
0.0002088	1506.	7213812.	5.8864158	0.0012288	-0.000989	4.1070701	8.2984235
35.3132829 C							
0.0002188	1574.	7194553.	5.8456840	0.0012787	-0.001045	4.2033599	8.4375610
36.7465453 C							
0.0002288	1642.	7176496.	5.8087459	0.0013288	-0.001102	4.2942523	8.5782406
38.1813500 C							
0.0002388	1709.	7159435.	5.7750339	0.0013788	-0.001158	4.3796934	8.7198325
39.6170669 C							
0.0002488	1777.	7143245.	5.7441498	0.0014289	-0.001214	4.4596690	8.8622707
41.0536301 C							
0.0002588	1844.	7127874.	5.7158618	0.0014790	-0.001270	4.5342055	9.0062771
42.4917615 C							
0.0002688	1912.	7113228.	5.6898814	0.0015292	-0.001326	4.6032852	9.1518612
43.9314706 C							
0.0002788	1979.	7099177.	5.6658517	0.0015794	-0.001382	4.6668529	9.2981453
45.3718796 C							
0.0002888	2046.	7085694.	5.6436467	0.0016296	-0.001438	4.7249250	9.4457725
46.8136318 C							
0.0002988	2113.	7072731.	5.6231139	0.0016799	-0.001494	4.7774953	9.5950073
48.2569917 C							
0.0003088	2180.	7060237.	5.6040917	0.0017303	-0.001550	4.8245454	9.7458598
49.7019691 C							
0.0003188	2247.	7048166.	5.5864392	0.0017807	-0.001606	4.8660568	9.8983398
51.1485742 C							
0.0003288	2313.	7035091.	5.5703945	0.0018313	-0.001662	4.9020899	10.0559095
52.0000000 CY							
0.0003388	2377.	7016444.	5.5572431	0.0018825	-0.001717	4.9328515	10.2325954
52.0000000 CY							
0.0003488	2437.	6987838.	5.5483737	0.0019350	-0.001770	4.9583635	10.4449631
52.0000000 CY							
0.0003588	2493.	6949163.	5.5434093	0.0019887	-0.001823	4.9781928	10.6928120
52.0000000 CY							

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    0.0003688         2544.      6897735.     5.5404882     0.0020431     -0.001875     4.9917913    10.9596303
52.0000000 CY
    0.0003788         2589.      6834494.     5.5379013     0.0020975     -0.001927     4.9988805    11.2284264
52.0000000 CY
    0.0003888         2628.      6760801.     5.5345993     0.0021516     -0.001979     4.9995814    11.4876578
52.0000000 CY
    0.0003988         2663.      6677327.     5.5294484     0.0022049     -0.002032     4.9998884    11.7235987
52.0000000 CY
    0.0004088         2693.      6588574.     5.5234789     0.0022577     -0.002085     4.9999885    11.9468476
52.0000000 CY
    0.0004188         2721.      6496912.     5.5171364     0.0023103     -0.002139     4.9994806    12.1621035
52.0000000 CY
    0.0004288         2746.      6403718.     5.5106036     0.0023627     -0.002193     4.9985783    12.3713140
52.0000000 CY
    0.0004388         2768.      6309591.     5.5041910     0.0024150     -0.002247     4.9986531    12.5782646
52.0000000 CY
    0.0004488         2789.      6215521.     5.4978202     0.0024671     -0.002301     4.9997188    12.7820359
52.0000000 CY
    0.0004588         2808.      6122055.     5.4915286     0.0025192     -0.002355     4.9999821    12.9831785
52.0000000 CY
    0.0004688         2826.      6029313.     5.4851636     0.0025712     -0.002409     4.9998667    13.1796663
52.0000000 CY
    0.0004788         2843.      5937514.     5.4790532     0.0026231     -0.002464     4.9995537    13.3759974
52.0000000 CY
    0.0004888         2858.      5847092.     5.4732010     0.0026750     -0.002518     4.9989141    13.5724448
52.0000000 CY
    0.0004988         2872.      5758463.     5.4674164     0.0027269     -0.002572     4.9977794    13.7664741
52.0000000 CY
    0.0005088         2885.      5671219.     5.4619524     0.0027788     -0.002627     4.9999618    13.9618791
52.0000000 CY
    0.0005188         2897.      5585444.     5.4564791     0.0028305     -0.002681     4.9994335    14.1539740
52.0000000 CY
    0.0005288         2909.      5501687.     5.4512400     0.0028823     -0.002736     4.9980938    14.3464884
52.0000000 CY
    0.0005388         2920.      5419563.     5.4464042     0.0029343     -0.002790     4.9999754    14.5422621
52.0000000 CY
    0.0005488         2930.      5339177.     5.4413603     0.0029859     -0.002845     4.9991991    14.7319215
52.0000000 CY
    0.0006088         2979.      4893489.     5.4163578     0.0032972     -0.003171     4.9999229    15.9013125
52.0000000 CY
    0.0006688         3014.      4506271.     5.3966781     0.0036090     -0.003496     4.9991460    17.0869259
52.0000000 CY
    0.0007288         3039.      4169712.     5.3816657     0.0039219     -0.003821     4.9999507    18.3026891
52.0000000 CY


-------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
-------------------------------------------------------------------------------

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.      Max. Tens.
  No.              kips                in-kip               Strain          Strain
 ----         ----------------     ------------------     ------------    ------------
   1               95.600              2942.758           0.00300000     -0.00315110
   2              143.200              2932.470           0.00300000     -0.00286666
   3              144.500              2932.088           0.00300000     -0.00285925

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.
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The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	95.600000	2943.	62.140000	1913.	7054942.
2	0.65	143.200000	2932.	93.080000	1906.	7112933.
3	0.65	144.500000	2932.	93.925000	1906.	7114494.
1	0.75	95.600000	2943.	71.700000	2207.	7008962.
2	0.75	143.200000	2932.	107.400000	2199.	7055510.
3	0.75	144.500000	2932.	108.375000	2199.	7056762.
1	0.90	95.600000	2943.	86.040000	2648.	6669584.
2	0.90	143.200000	2932.	128.880000	2639.	6734163.
3	0.90	144.500000	2932.	130.050000	2639.	6734979.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	9.300000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.803000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	67.929087 sq. in.
Total Area of Reinforcing Steel	=	2.250000 sq. in.
Area Ratio of Steel Reinforcement	=	3.31 percent
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	414.136 kips
Tensile Load for Cracking of Concrete	=	-37.939 kips
Nominal Axial Tensile Capacity	=	-135.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

Compressive Strength of Concrete	=	5000. psi
Modulus of Elasticity of Concrete	=	4030509. psi
Modulus of Rupture of Concrete	=	-530.33009 psi
Compression Strain at Peak Stress	=	0.002109
Tensile Strain at Fracture of Concrete	=	-0.0001150
Maximum Coarse Aggregate Size	=	0.0000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

Number	Axial Thrust Force kips
1	95.600
2	143.200
3	144.500

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 95.600 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.9160111	1532809.	218.9367075	0.0002737	0.0002620	1.2132465	7.7999200	
0.00000250	3.8288120	1531525.	111.7956295	0.0002795	0.0002562	1.2369785	7.8321119	
0.00000375	5.7415895	1531091.	76.0829562	0.0002853	0.0002504	1.2606516	7.8644146	
0.00000500	7.6543316	1530866.	58.2273842	0.0002911	0.0002446	1.2842656	7.8968282	
0.00000625	9.5670266	1530724.	47.5146526	0.0002970	0.0002388	1.3078204	7.9293527	
0.00000750	11.4796626	1530622.	40.3733413	0.0003028	0.0002331	1.3313159	7.9619880	
0.00000875	13.3922278	1530540.	35.2728416	0.0003086	0.0002273	1.3547518	7.9947342	
0.00001000	15.3047103	1530471.	31.4478492	0.0003145	0.0002215	1.3781280	8.0275913	
0.00001125	17.2170984	1530409.	28.4731949	0.0003203	0.0002157	1.4014445	8.0605592	
0.00001250	19.1293802	1530350.	26.0937774	0.0003262	0.0002099	1.4247009	8.0936381	
0.00001375	21.0415439	1530294.	24.1472593	0.0003320	0.0002041	1.4478973	8.1268278	
0.00001500	22.9535776	1530239.	22.5254158	0.0003379	0.0001984	1.4710334	8.1601284	
0.00001625	24.8654696	1530183.	21.1533221	0.0003437	0.0001926	1.4941091	8.1935399	
0.00001750	26.7772079	1530126.	19.9774603	0.0003496	0.0001869	1.5171243	8.2270624	
0.00001875	28.6887808	1530068.	18.9585840	0.0003555	0.0001811	1.5400787	8.2606957	
0.00002000	30.6001764	1530009.	18.0672585	0.0003613	0.0001753	1.5629723	8.2944400	
0.00002125	32.5113829	1529947.	17.2809749	0.0003672	0.0001696	1.5858048	8.3282952	
0.00002250	34.4223885	1529884.	16.5822261	0.0003731	0.0001639	1.6085763	8.3622613	
0.00002375	36.3331812	1529818.	15.9571909	0.0003790	0.0001581	1.6312864	8.3963384	
0.00002500	38.2437493	1529750.	15.3948123	0.0003849	0.0001524	1.6539350	8.4305265	
0.00002625	40.1540810	1529679.	14.8861393	0.0003908	0.0001466	1.6765221	8.4648255	
0.00002750	42.0641643	1529606.	14.4238485	0.0003967	0.0001409	1.6990474	8.4992355	
0.00002875	43.9739875	1529530.	14.0018900	0.0004026	0.0001352	1.7215108	8.5337565	
0.00003000	45.8835386	1529451.	13.6152224	0.0004085	0.0001295	1.7439122	8.5683885	
0.00003125	47.7928059	1529370.	13.2596106	0.0004144	0.0001237	1.7662514	8.6031316	
0.00003250	49.7017775	1529285.	12.9314714	0.0004203	0.0001180	1.7885282	8.6379857	
0.00003375	51.6104414	1529198.	12.6277523	0.0004262	0.0001123	1.8107426	8.6729508	
0.00003500	53.5187860	1529108.	12.3458368	0.0004321	0.0001066	1.8328943	8.7080270	
0.00003625	55.4267992	1529015.	12.0834694	0.0004380	0.0001009	1.8549832	8.7432142	
0.00003750	57.3344693	1528919.	11.8386954	0.0004440	0.00009520	1.8770091	8.7785126	
0.00003875	59.2417843	1528820.	11.6098121	0.0004499	0.00008951	1.8989720	8.8139221	
0.00004000	61.1487325	1528718.	11.3953298	0.0004558	0.00008381	1.9208716	8.8494427	
0.00004125	63.0553019	1528613.	11.1939393	0.0004617	0.00007812	1.9427078	8.8850744	
0.00004250	64.9614806	1528505.	11.0044855	0.0004677	0.00007244	1.9644805	8.9208173	

0.00004375	66.8672568	1528394.	10.8259453	0.0004736	0.00006676	1.9861895	8.9566714	
0.00004500	68.7726186	1528280.	10.6574093	0.0004796	0.00006108	2.0078347	8.9926367	
0.00004625	70.6775540	1528163.	10.4980661	0.0004855	0.00005541	2.0294159	9.0287132	
0.00004750	72.5820513	1528043.	10.3471903	0.0004915	0.00004974	2.0509329	9.0649010	
0.00004875	74.4860985	1527920.	10.2041303	0.0004975	0.00004408	2.0723856	9.1012000	
0.00005125	78.2927951	1527664.	9.9391707	0.0005094	0.00003276	2.1150976	9.1741319	
0.00005375	82.0975485	1527396.	9.6991441	0.0005213	0.00002145	2.1575507	9.2475092	
0.00005625	85.9002634	1527116.	9.4807264	0.0005333	0.00001017	2.1997435	9.3213320	
0.00005875	89.7008445	1526823.	9.2811590	0.0005453	-0.00000111	2.2416750	9.3956004	
0.00006125	93.4990622	1526515.	9.0981324	0.0005573	-0.00001236	2.2833437	9.4703122	
0.00006375	97.2940664	1526181.	8.9296926	0.0005693	-0.00002361	2.3247464	9.5454525	
0.00006625	101.0846661	1525806.	8.7741767	0.0005813	-0.00003484	2.3658794	9.6209990	
0.00006875	104.8696389	1525377.	8.6301626	0.0005933	-0.00004605	2.4067388	9.6969276	
0.00007125	108.6478528	1524882.	8.4964285	0.0006054	-0.00005725	2.4473207	9.7732150	
0.00007375	112.4182441	1524315.	8.3719184	0.0006174	-0.00006845	2.4876215	9.8498388	
0.00007625	116.1798775	1523671.	8.2557157	0.0006295	-0.00007963	2.5276380	9.9267784	
0.00007875	119.9319207	1522945.	8.1470209	0.0006416	-0.00009080	2.5673671	10.0040148	
0.00008125	123.6736298	1522137.	8.0451336	0.0006537	-0.000102	2.6068060	10.0815307	
0.00008375	127.4043458	1521246.	7.9494378	0.0006658	-0.000113	2.6459521	10.1593103	
0.00008625	124.4752063	1443191.	7.7990524	0.0006727	-0.000129	2.6679812	10.0864219	C
0.00008875	126.9826743	1430791.	7.7044389	0.0006838	-0.000142	2.7034169	10.1352706	C
0.00009125	129.4036561	1418122.	7.6142085	0.0006948	-0.000154	2.7383481	10.1819990	C
0.00009375	131.7435317	1405264.	7.5280410	0.0007058	-0.000166	2.7727892	10.2266899	C
0.00009625	134.0078719	1392290.	7.4456555	0.0007166	-0.000178	2.8067563	10.2694429	C
0.00009875	136.2023824	1379265.	7.3668051	0.0007275	-0.000191	2.8402666	10.3103740	C
0.0001013	138.3328554	1366250.	7.2912733	0.0007382	-0.000203	2.8733387	10.3496158	C
0.0001038	140.3933116	1353189.	7.2187320	0.0007489	-0.000216	2.9059489	10.3869034	C
0.0001063	142.3881020	1340123.	7.1489931	0.0007596	-0.000229	2.9381094	10.4223072	C
0.0001088	144.3325513	1327196.	7.0820184	0.0007702	-0.000241	2.9698756	10.4563166	C
0.0001113	146.2325332	1314450.	7.0176799	0.0007807	-0.000254	3.0012706	10.4891195	C
0.0001138	148.0633943	1301656.	6.9555063	0.0007912	-0.000267	3.0321965	10.5197350	C
0.0001163	149.8535461	1289063.	6.8956588	0.0008016	-0.000280	3.0627617	10.5491746	C
0.0001188	151.6099518	1276715.	6.8380674	0.0008120	-0.000292	3.0929962	10.5777090	C
0.0001213	153.3004698	1264334.	6.7822086	0.0008223	-0.000305	3.1227666	10.6039849	C
0.0001238	154.9680579	1252267.	6.7284540	0.0008326	-0.000318	3.1522480	10.6297096	C
0.0001263	156.5857259	1240283.	6.6763653	0.0008429	-0.000331	3.1813293	10.6537428	C
0.0001288	158.1716050	1228517.	6.6260365	0.0008531	-0.000344	3.2100839	10.6767938	C
0.0001313	159.7217862	1216928.	6.5773205	0.0008633	-0.000357	3.2384968	10.6986857	C
0.0001338	161.2358833	1205502.	6.5301071	0.0008734	-0.000370	3.2665633	10.7193400	C
0.0001363	162.7210024	1194283.	6.4843936	0.0008835	-0.000384	3.2943167	10.7390771	C
0.0001388	164.1731063	1183230.	6.4400390	0.0008936	-0.000397	3.3217361	10.7576515	C
0.0001413	165.5956130	1172358.	6.3970091	0.0009036	-0.000410	3.3488390	10.7752226	C
0.0001438	166.9952847	1161706.	6.3553018	0.0009136	-0.000423	3.3756536	10.7920680	C
0.0001463	168.3576409	1151163.	6.3146790	0.0009235	-0.000437	3.4021148	10.8074640	C
0.0001488	169.7141401	1140935.	6.2754455	0.0009335	-0.000450	3.4283682	10.8229639	C
0.0001588	174.8370929	1101336.	6.1282868	0.0009729	-0.000504	3.5301534	10.8730762	C
0.0001688	179.6534430	1064613.	5.9964019	0.0010119	-0.000557	3.6276229	10.9125826	C
0.0001788	184.1569311	1030249.	5.8769273	0.0010505	-0.000612	3.7207433	10.9399278	C
0.0001888	188.4224450	998265.	5.7685304	0.0010888	-0.000667	3.8099019	10.9586146	C
0.0001988	192.4739881	968423.	5.6696709	0.0011268	-0.000722	3.8952332	10.9694017	C
0.0002088	196.3346589	940525.	5.5791207	0.0011646	-0.000777	3.9768702	10.9731530	C
0.0002188	200.0266180	914407.	5.4958953	0.0012022	-0.000832	4.0549437	10.9708519	C
0.0002288	203.5729217	889936.	5.4192270	0.0012396	-0.000888	4.1295936	10.9637782	C
0.0002388	206.9948657	866994.	5.3484900	0.0012770	-0.000943	4.2009503	10.9533041	C
0.0002488	210.2765690	845333.	5.2827002	0.0013141	-0.000999	4.2689218	10.9374899	C
0.0002588	213.4653775	824987.	5.2218086	0.0013511	-0.001055	4.3337887	10.9202723	C
0.0002688	216.5701802	805843.	5.1653741	0.0013882	-0.001111	4.3956096	10.9024757	C
0.0002788	219.5604286	787661.	5.1124829	0.0014251	-0.001167	4.4542000	10.8805900	C
0.0002888	222.4931886	770539.	5.0634763	0.0014621	-0.001223	4.5098988	10.8605565	C
0.0002988	225.3222822	754217.	5.0173485	0.0014989	-0.001279	4.5624320	10.8370396	C
0.0003088	228.1045679	738800.	4.9745507	0.0015359	-0.001335	4.6121274	10.8165852	C
0.0003188	230.7862143	724035.	4.9340388	0.0015727	-0.001392	4.6586702	10.7924327	C
0.0003288	233.4221525	710029.	4.8963337	0.0016097	-0.001448	4.7023698	10.7715507	C
0.0003388	235.9824788	696627.	4.8607706	0.0016466	-0.001504	4.7430465	10.7498409	C
0.0003488	238.4782963	683809.	4.8273194	0.0016835	-0.001560	4.7807608	10.7288624	C
0.0003588	240.9274304	671575.	4.7960560	0.0017206	-0.001616	4.8155889	10.7112438	C
0.0003688	243.2985050	659793.	4.7663456	0.0017576	-0.001672	4.8473627	10.6920995	C
0.0003788	245.6138963	648486.	4.7383911	0.0017947	-0.001728	4.8761874	10.6750102	C
0.0003888	247.8815936	637638.	4.7121836	0.0018319	-0.001784	4.9020781	10.6614012	C

0.0003988	250.0892027	627183.	4.6874091	0.0018691	-0.001839	4.9249627	10.6491634 C
0.0004088	252.2284708	617073.	4.6638376	0.0019063	-0.001895	4.9448042	10.6368162 C
0.0004188	254.3189078	607329.	4.6416906	0.0019437	-0.001951	4.9616570	-10.829910 C
0.0004288	256.3597563	597924.	4.6208730	0.0019812	-0.002006	4.9754906	-11.347375 C
0.0004388	258.3474722	588826.	4.6012503	0.0020188	-0.002062	4.9862685	-11.861710 C
0.0004488	260.2634279	579974.	4.5824344	0.0020564	-0.002117	4.9939408	-12.376928 C
0.0004588	262.1284349	571397.	4.5647298	0.0020941	-0.002172	4.9985286	-12.888275 C
0.0004688	263.9414382	563075.	4.5480711	0.0021319	-0.002227	4.9994693	-13.395673 C
0.0004788	265.6955781	554978.	4.5324200	0.0021699	-0.002282	4.9999621	-13.898744 C
0.0004888	267.3877832	547085.	4.5177286	0.0022080	-0.002337	4.9997633	-14.397289 C
0.0004988	269.0108180	539370.	4.5037882	0.0022463	-0.002392	4.9992977	-14.893493 C
0.0005088	270.5661137	531825.	4.4905441	0.0022846	-0.002447	4.9984390	-15.387509 C
0.0005188	272.0622699	524457.	4.4781149	0.0023230	-0.002501	4.9999900	-15.876948 C
0.0005288	273.4957710	517250.	4.4664711	0.0023616	-0.002556	4.9996468	-16.361553 C
0.0005388	274.8741532	510207.	4.4555434	0.0024004	-0.002610	4.9986877	-16.841724 C
0.0005488	276.1996432	503325.	4.4452858	0.0024394	-0.002664	4.9999981	-17.317568 C
0.0006088	283.0230974	464925.	4.3955400	0.0026758	-0.002986	4.9991452	-20.089263 C
0.0006688	288.2197786	430983.	4.3618290	0.0029170	-0.003302	4.9988804	-22.723102 C
0.0007288	292.1041301	400829.	4.3400343	0.0031628	-0.003615	4.9984956	-25.222403 C
0.0007888	294.8922944	373873.	4.3269318	0.0034129	-0.003923	4.9968311	-27.598737 C
0.0008488	296.7787087	349666.	4.3200414	0.0036666	-0.004227	4.9958957	-29.867765 C
0.0009088	292.1258832	321459.	4.3320069	0.0039367	-0.004515	4.9952320	-31.663847 C

Axial Thrust Force = 143.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.7674100	1413928.	335.6176951	0.0004195	0.0004079	1.7911970	12.0296058	
0.00000250	3.5298345	1411934.	170.1362784	0.0004253	0.0004021	1.8130416	12.0618089	
0.00000375	5.2922340	1411262.	114.9768951	0.0004312	0.0003963	1.8348269	12.0941305	
0.00000500	7.0545956	1410919.	87.3980203	0.0004370	0.0003905	1.8565529	12.1265705	
0.00000625	8.8169070	1410705.	70.8513488	0.0004428	0.0003847	1.8782193	12.1591289	
0.00000750	10.5791553	1410554.	59.8207790	0.0004487	0.0003789	1.8998261	12.1918057	
0.00000875	12.3413279	1410437.	51.9422673	0.0004545	0.0003731	1.9213731	12.2246010	
0.00001000	14.1034123	1410341.	46.0337920	0.0004603	0.0003673	1.9428600	12.2575147	
0.00001125	15.8653959	1410257.	41.4386742	0.0004662	0.0003616	1.9642868	12.2905466	
0.00001250	17.6272658	1410181.	37.7629068	0.0004720	0.0003558	1.9856533	12.3236972	
0.00001375	19.3890096	1410110.	34.7557578	0.0004779	0.0003500	2.0069593	12.3569663	
0.00001500	21.1506145	1410041.	32.2500726	0.0004838	0.0003443	2.0282047	12.3903539	
0.00001625	22.9120680	1409973.	30.1301289	0.0004896	0.0003385	2.0493892	12.4238599	
0.00001750	24.6733574	1409906.	28.3132677	0.0004955	0.0003327	2.0705129	12.4574844	
0.00001875	26.4344700	1409838.	26.7388727	0.0005014	0.0003270	2.0915754	12.4912275	
0.00002000	28.1953933	1409770.	25.3614813	0.0005072	0.0003212	2.1125767	12.5250890	
0.00002125	29.9561145	1409700.	24.1463283	0.0005131	0.0003155	2.1335165	12.5590690	
0.00002250	31.7166211	1409628.	23.0663739	0.0005190	0.0003097	2.1543948	12.5931676	
0.00002375	33.4769003	1409554.	22.1002710	0.0005249	0.0003040	2.1752113	12.6273847	
0.00002500	35.2369394	1409478.	21.2309420	0.0005308	0.0002983	2.1959659	12.6617205	
0.00002625	36.9967260	1409399.	20.4445619	0.0005367	0.0002925	2.2166585	12.6961747	
0.00002750	38.7562474	1409318.	19.7298196	0.0005426	0.0002868	2.2372888	12.7307475	
0.00002875	40.5154907	1409234.	19.0773711	0.0005485	0.0002811	2.2578567	12.7654388	
0.00003000	42.2744435	1409148.	18.4794296	0.0005544	0.0002754	2.2783621	12.8002488	
0.00003125	44.0330930	1409059.	17.9294543	0.0005603	0.0002697	2.2988048	12.8351774	
0.00003250	45.7914265	1408967.	17.4219107	0.0005662	0.0002640	2.3191846	12.8702247	
0.00003375	47.5494315	1408872.	16.9520841	0.0005721	0.0002583	2.3395015	12.9053906	
0.00003500	49.3070951	1408774.	16.5159335	0.0005781	0.0002526	2.3597551	12.9406751	
0.00003625	51.0644048	1408673.	16.1099752	0.0005840	0.0002469	2.3799454	12.9760784	
0.00003750	52.8213479	1408569.	15.7311899	0.0005899	0.0002412	2.4000722	13.0116004	
0.00003875	54.5779116	1408462.	15.3769480	0.0005959	0.0002355	2.4201354	13.0472411	
0.00004000	56.3340833	1408352.	15.0449486	0.0006018	0.0002298	2.4401347	13.0830005	
0.00004125	58.0898503	1408239.	14.7331697	0.0006077	0.0002241	2.4600700	13.1188788	
0.00004250	59.8451999	1408122.	14.4398271	0.0006137	0.0002184	2.4799412	13.1548758	
0.00004375	61.6001194	1408003.	14.1633406	0.0006196	0.0002128	2.4997482	13.1909917	
0.00004500	63.3545961	1407880.	13.9023055	0.0006256	0.0002071	2.5194906	13.2272264	
0.00004625	65.1086173	1407754.	13.6554691	0.0006316	0.0002014	2.5391684	13.2635799	
0.00004750	66.8621703	1407625.	13.4217103	0.0006375	0.0001958	2.5587815	13.3000524	
0.00004875	68.6152423	1407492.	13.2000233	0.0006435	0.0001901	2.5783296	13.3366438	

0.00005125	72.1198927	1407217.	12.7893314	0.0006555	0.0001788	2.6172304	13.4101834
0.00005375	75.6224666	1406930.	12.4171488	0.0006674	0.0001675	2.6558695	13.4841990
0.00005625	79.1228621	1406629.	12.0783410	0.0006794	0.0001563	2.6942456	13.5586908
0.00005875	82.6209773	1406315.	11.7686476	0.0006914	0.0001450	2.7323574	13.6336592
0.00006125	86.1167101	1405987.	11.4845037	0.0007034	0.0001338	2.7702037	13.7091042
0.00006375	89.6099582	1405646.	11.2229035	0.0007155	0.0001226	2.8077832	13.7850262
0.00006625	93.1006195	1405292.	10.9812952	0.0007275	0.0001114	2.8450945	13.8614255
0.00006875	96.5885915	1404925.	10.7574979	0.0007396	0.0001002	2.8821364	13.9383024
0.00007125	100.0737718	1404544.	10.5496370	0.0007517	0.00008904	2.9189075	14.0156570
0.00007375	103.5560578	1404150.	10.3560919	0.0007638	0.00007789	2.9554067	14.0934899
0.00007625	107.0353469	1403742.	10.1754546	0.0007759	0.00006675	2.9916325	14.1718012
0.00007875	110.5115362	1403321.	10.0064961	0.0007880	0.00005564	3.0275837	14.2505913
0.00008125	113.9845227	1402886.	9.8481383	0.0008002	0.00004454	3.0632589	14.3298605
0.00008375	117.4542035	1402438.	9.6994322	0.0008123	0.00003345	3.0986570	14.4096093
0.00008625	120.9204753	1401977.	9.5595385	0.0008245	0.00002239	3.1337764	14.4898379
0.00008875	124.3832349	1401501.	9.4277128	0.0008367	0.00001133	3.1686161	14.5705468
0.00009125	127.8423788	1401012.	9.3032921	0.0008489	3.00402E-07	3.2031745	14.6517363
0.00009375	131.2977578	1400509.	9.1856837	0.0008612	-0.00001072	3.2374505	14.7334059
0.00009625	134.7489327	1399989.	9.0743543	0.0008734	-0.00002172	3.2714418	14.8155487
0.00009875	138.1952352	1399445.	8.9688230	0.0008857	-0.00003270	3.3051461	14.8981529
0.0001013	141.6359189	1398873.	8.8686554	0.0008980	-0.00004367	3.3385606	14.9812041
0.0001038	145.0702338	1398267.	8.7734589	0.0009102	-0.00005463	3.3716829	15.0646878
0.0001063	148.4974477	1397623.	8.6828777	0.0009226	-0.00006557	3.4045102	15.1485891
0.0001088	151.9168589	1396937.	8.5965890	0.0009349	-0.00007650	3.4370401	15.2328934
0.0001113	155.3278034	1396205.	8.5142990	0.0009472	-0.00008741	3.4692702	15.3175868
0.0001138	158.7296688	1395426.	8.4357400	0.0009596	-0.00009831	3.5011981	15.4026559
0.0001163	162.1218839	1394597.	8.3606677	0.0009719	-0.000109	3.5328217	15.4880882
0.0001188	161.7373417	1361999.	8.2628470	0.0009812	-0.000123	3.5562790	15.4842931 C
0.0001213	164.3683409	1355615.	8.1893165	0.0009930	-0.000135	3.5857484	15.5517290 C
0.0001238	166.9369825	1348986.	8.1184149	0.0010047	-0.000146	3.6148081	15.6179349 C
0.0001263	169.4417110	1342113.	8.0499642	0.0010163	-0.000158	3.6434548	15.6828337 C
0.0001288	171.8675599	1334894.	7.9836872	0.0010279	-0.000169	3.6716497	15.7459230 C
0.0001313	174.2421530	1327559.	7.9196650	0.0010395	-0.000181	3.6994627	15.8079846 C
0.0001338	176.5711528	1320158.	7.8578129	0.0010510	-0.000193	3.7269101	15.8691803 C
0.0001363	178.8173796	1312421.	7.7977022	0.0010624	-0.000205	3.7538943	15.9282880 C
0.0001388	181.0240821	1304678.	7.7395696	0.0010739	-0.000217	3.7805284	15.9866393 C
0.0001413	183.1831919	1296872.	7.6832443	0.0010853	-0.000228	3.8067928	16.0439642 C
0.0001438	185.2761749	1288878.	7.6284696	0.0010966	-0.000240	3.8326364	16.0995824 C
0.0001463	187.3438949	1280984.	7.5754893	0.0011079	-0.000252	3.8581715	16.1548738 C
0.0001488	189.3378955	1272860.	7.5238147	0.0011192	-0.000264	3.8832660	16.2081167 C
0.0001588	196.9344101	1240532.	7.3315281	0.0011639	-0.000312	3.9802214	16.4124987 C
0.0001688	203.9051888	1208327.	7.1588488	0.0012081	-0.000361	4.0716776	16.6013052 C
0.0001788	210.3444391	1176752.	7.0028999	0.0012518	-0.000411	4.1579373	16.7766854 C
0.0001888	216.3012946	1145967.	6.8611464	0.0012950	-0.000460	4.2391788	16.9393189 C
0.0001988	221.8543795	1116248.	6.7318460	0.0013380	-0.000510	4.3156686	17.0915130 C
0.0002088	227.0199958	1087521.	6.6131558	0.0013805	-0.000561	4.3874912	17.2329432 C
0.0002188	231.8687445	1059971.	6.5040327	0.0014228	-0.000612	4.4548931	17.3662234 C
0.0002288	236.4262020	1033557.	6.4033104	0.0014648	-0.000663	4.5179833	17.4919403 C
0.0002388	240.7175025	1008241.	6.3100326	0.0015065	-0.000714	4.5768678	17.6107847 C
0.0002488	244.7671368	983988.	6.2234118	0.0015481	-0.000765	4.6316476	17.7235482 C
0.0002588	248.5988373	960768.	6.1427977	0.0015894	-0.000817	4.6824187	17.8311448 C
0.0002688	252.2353926	938550.	6.0676529	0.0016307	-0.000869	4.7292695	17.9346116 C
0.0002788	255.6984947	917304.	5.9975338	0.0016718	-0.000921	4.7722801	18.0351200 C
0.0002888	258.9539697	896810.	5.9315449	0.0017127	-0.000973	4.8113794	18.1295455 C
0.0002988	262.0648954	877205.	5.8697801	0.0017536	-0.001025	4.8467506	18.2222938 C
0.0003088	265.0520670	858468.	5.8120150	0.0017945	-0.001077	4.8784520	18.3150307 C
0.0003188	267.8521733	840321.	5.7572358	0.0018351	-0.001129	4.9063520	18.4018653 C
0.0003288	270.5546677	822980.	5.7059770	0.0018758	-0.001182	4.9306540	18.4904899 C
0.0003388	273.1088940	806226.	5.6574350	0.0019165	-0.001234	4.9512631	18.5760735 C
0.0003488	275.5622779	790143.	5.6118053	0.0019571	-0.001286	4.9682644	18.6629571 C
0.0003588	277.8807011	774580.	5.5685030	0.0019977	-0.001339	4.9816106	18.7475901 C
0.0003688	280.1173948	759640.	5.5278563	0.0020384	-0.001391	4.9913602	18.8355045 C
0.0003788	282.2098516	745109.	5.4890078	0.0020790	-0.001443	4.9974565	18.9195961 C
0.0003888	284.2322634	731144.	5.4525798	0.0021197	-0.001496	4.9999401	19.0084428 C
0.0003988	286.1311308	717570.	5.4179096	0.0021604	-0.001548	4.9999806	19.0964894 C
0.0004088	287.9229740	704399.	5.3851277	0.0022012	-0.001600	4.9999913	19.1868087 C
0.0004188	289.6304788	691655.	5.3543663	0.0022421	-0.001652	4.9999894	19.2826520 C
0.0004288	291.2109567	679209.	5.3249770	0.0022831	-0.001704	4.9999689	19.3777146 C
0.0004388	292.6979581	667118.	5.2972091	0.0023242	-0.001756	4.9999051	19.4763500 C

0.0004488	294.1071563	655392.	5.2710957	0.0023654	-0.001808	4.9997544	19.5804313 C
0.0004588	295.4266544	643982.	5.2463334	0.0024068	-0.001860	4.9994490	19.6873343 C
0.0004688	296.6460438	632845.	5.2226380	0.0024481	-0.001911	4.9988951	19.7943768 C
0.0004788	297.7989656	622034.	5.2002946	0.0024896	-0.001963	4.9989914	19.9064463 C
0.0004888	298.8819292	611523.	5.1792380	0.0025314	-0.002014	4.9999012	20.0237931 C
0.0004988	299.8982351	601300.	5.1593143	0.0025732	-0.002065	4.9994188	20.1453145 C
0.0005088	300.8282095	591309.	5.1400767	0.0026150	-0.002116	4.9983758	20.2653996 C
0.0005188	301.7008103	581592.	5.1218962	0.0026570	-0.002167	4.9999490	20.3902329 C
0.0005288	302.5156360	572134.	5.1047181	0.0026991	-0.002218	4.9993270	20.5198922 C
0.0005388	303.2834506	562939.	5.0884434	0.0027414	-0.002269	4.9978317	20.6537033 C
0.0005488	303.9969044	553981.	5.0730558	0.0027838	-0.002320	4.9997787	20.7921925 C
0.0006088	307.2326831	504694.	4.9942734	0.0030403	-0.002621	4.9999913	21.6747943 C
0.0006688	309.0725234	462165.	4.9354151	0.0033006	-0.002919	4.9994978	22.6696366 C
0.0007288	309.8673001	425204.	4.8913912	0.0035646	-0.003213	4.9999976	23.7731607 C
0.0007888	309.8052857	392780.	4.8579126	0.0038317	-0.003504	4.9999988	24.9646932 C

Axial Thrust Force = 144.500 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	1.7632094	1410567.	338.9162859	0.0004236	0.0004120	1.8068406	12.1491797	
0.00000250	3.5213827	1408553.	171.7855785	0.0004295	0.0004062	1.8286318	12.1813832	
0.00000375	5.2795309	1407875.	116.0764338	0.0004353	0.0004004	1.8503637	12.2137053	
0.00000500	7.0376413	1407528.	88.2226797	0.0004411	0.0003946	1.8720363	12.2461461	
0.00000625	8.7957013	1407312.	71.5110820	0.0004469	0.0003888	1.8936494	12.2787055	
0.00000750	10.5536980	1407160.	60.3705624	0.0004528	0.0003830	1.9152028	12.3113836	
0.00000875	12.3116191	1407042.	52.4135161	0.0004586	0.0003772	1.9366963	12.3441804	
0.00001000	14.0694516	1406945.	46.4461406	0.0004645	0.0003715	1.9581299	12.3770958	
0.00001125	15.8271831	1406861.	41.8052123	0.0004703	0.0003657	1.9795032	12.4101299	
0.00001250	17.5848009	1406784.	38.0927970	0.0004762	0.0003599	2.0008162	12.4432824	
0.00001375	19.3422922	1406712.	35.0556640	0.0004820	0.0003541	2.0220688	12.4765539	
0.00001500	21.0996443	1406643.	32.5249928	0.0004879	0.0003484	2.0432607	12.5099441	
0.00001625	22.8568448	1406575.	30.3839074	0.0004937	0.0003426	2.0643919	12.5434530	
0.00001750	24.6138808	1406507.	28.5489253	0.0004996	0.0003369	2.0854620	12.5770806	
0.00001875	26.3707397	1406439.	26.9588258	0.0005055	0.0003311	2.1064710	12.6108270	
0.00002000	28.1274089	1406370.	25.5676935	0.0005114	0.0003254	2.1274188	12.6446920	
0.00002125	29.8838757	1406300.	24.3404165	0.0005172	0.0003196	2.1483051	12.6786758	
0.00002250	31.6401274	1406228.	23.2496855	0.0005231	0.0003139	2.1691298	12.7127784	
0.00002375	33.3961513	1406154.	22.2739409	0.0005290	0.0003081	2.1898928	12.7469997	
0.00002500	35.1519346	1406077.	21.3959345	0.0005349	0.0003024	2.2105939	12.7813401	
0.00002625	36.9074650	1405999.	20.6017038	0.0005408	0.0002967	2.2312329	12.8157989	
0.00002750	38.6627295	1405917.	19.8798249	0.0005467	0.0002909	2.2518096	12.8503767	
0.00002875	40.4177156	1405834.	19.2208605	0.0005526	0.0002852	2.2723239	12.8850732	
0.00003000	42.1724104	1405747.	18.6169465	0.0005585	0.0002795	2.2927757	12.9198885	
0.00003125	43.9268015	1405658.	18.0614767	0.0005644	0.0002738	2.3131648	12.9548228	
0.00003250	45.6808759	1405565.	17.5488615	0.0005703	0.0002681	2.3334910	12.9898758	
0.00003375	47.4346211	1405470.	17.0743393	0.0005763	0.0002624	2.3537541	13.0250478	
0.00003500	49.1880244	1405372.	16.6338287	0.0005822	0.0002567	2.3739541	13.0603387	
0.00003625	50.9410730	1405271.	16.2238112	0.0005881	0.0002510	2.3940907	13.0957485	
0.00003750	52.6937543	1405167.	15.8412376	0.0005940	0.0002453	2.4141638	13.1312772	
0.00003875	54.4460555	1405059.	15.4834520	0.0006000	0.0002396	2.4341732	13.1669249	
0.00004000	56.1979640	1404949.	15.1481306	0.0006059	0.0002339	2.4541188	13.2026916	
0.00004125	57.9494669	1404836.	14.8332312	0.0006119	0.0002282	2.4740003	13.2385773	
0.00004250	59.7005516	1404719.	14.5369519	0.0006178	0.0002226	2.4938178	13.2745820	
0.00004375	61.4512054	1404599.	14.2576966	0.0006238	0.0002169	2.5135709	13.3107058	
0.00004500	63.2014156	1404476.	13.9940468	0.0006297	0.0002112	2.5332595	13.3469487	
0.00004625	64.9511693	1404350.	13.7447371	0.0006357	0.0002056	2.5528835	13.3833106	
0.00004750	66.7004540	1404220.	13.5086354	0.0006417	0.0001999	2.5724427	13.4197917	
0.00004875	68.4492567	1404087.	13.2847258	0.0006476	0.0001943	2.5919369	13.4563919	
0.00005125	71.9453656	1403812.	12.8699145	0.0006596	0.0001830	2.6307299	13.5299499	
0.00005375	75.4393940	1403524.	12.4939962	0.0006716	0.0001717	2.6692611	13.6039849	
0.00005625	78.9312398	1403222.	12.1517854	0.0006835	0.0001604	2.7075292	13.6784970	
0.00005875	82.4208008	1402907.	11.8389791	0.0006955	0.0001492	2.7455330	13.7534865	
0.00006125	85.9079747	1402579.	11.5519770	0.0007076	0.0001379	2.7832711	13.8289536	
0.00006375	89.3926591	1402238.	11.2877433	0.0007196	0.0001267	2.8207423	13.9048987	
0.00006625	92.8747517	1401883.	11.0437007	0.0007316	0.0001155	2.8579453	13.9813220	

0.00006875	96.3541498	1401515.	10.8176466	0.0007437	0.0001043	2.8948787	14.0582238
0.00007125	99.8307507	1401133.	10.6076877	0.0007558	0.00009317	2.9315413	14.1356043
0.00007375	103.3044517	1400738.	10.4121873	0.0007679	0.00008202	2.9679318	14.2134639
0.00007625	106.7751498	1400330.	10.2297234	0.0007800	0.00007089	3.0040488	14.2918030
0.00007875	110.2427421	1399908.	10.0590546	0.0007922	0.00005978	3.0398912	14.3706218
0.00008125	113.7071254	1399472.	9.8990922	0.0008043	0.00004868	3.0754574	14.4499207
0.00008375	117.1681965	1399023.	9.7488777	0.0008165	0.00003759	3.1107464	14.5297001
0.00008625	120.6258519	1398561.	9.6075635	0.0008287	0.00002653	3.1457567	14.6099602
0.00008875	124.0799882	1398084.	9.4743976	0.0008409	0.00001548	3.1804870	14.6907016
0.00009125	127.5305016	1397595.	9.3487104	0.0008531	0.00000444	3.2149360	14.7719246
0.00009375	130.9772829	1397091.	9.2299038	0.0008653	-0.00000657	3.2491024	14.8536294
0.00009625	134.4200174	1396572.	9.1174402	0.0008776	-0.00001757	3.2829845	14.9358120
0.00009875	137.8581058	1396031.	9.0108341	0.0008898	-0.00002856	3.3165798	15.0184621
0.0001013	141.2908344	1395465.	8.9096472	0.0009021	-0.00003952	3.3498859	15.1015662
0.0001038	144.7174606	1394867.	8.8134829	0.0009144	-0.00005048	3.3829001	15.1851101
0.0001063	148.1372500	1394233.	8.7219819	0.0009267	-0.00006141	3.4156198	15.2690791
0.0001088	151.5494960	1393559.	8.6348181	0.0009390	-0.00007234	3.4480425	15.3534586
0.0001113	154.9535286	1392841.	8.5516947	0.0009514	-0.00008325	3.4801658	15.4382347
0.0001138	158.3487176	1392077.	8.4723412	0.0009637	-0.00009415	3.5119873	15.5233939
0.0001163	161.7344703	1391264.	8.3965105	0.0009761	-0.000105	3.5435048	15.6089231
0.0001188	161.6568787	1361321.	8.3001745	0.0009856	-0.000119	3.5675515	15.6128417 C
0.0001213	164.3215224	1355229.	8.2262180	0.0009974	-0.000130	3.5970095	15.6814839 C
0.0001238	166.9048420	1348726.	8.1547636	0.0010092	-0.000142	3.6260119	15.7483814 C
0.0001263	169.4224330	1341960.	8.0857675	0.0010208	-0.000153	3.6545960	15.8139187 C
0.0001288	171.8843015	1335024.	8.0191558	0.0010325	-0.000165	3.6827872	15.8783540 C
0.0001313	174.2917055	1327937.	7.9547961	0.0010441	-0.000177	3.7105897	15.9417023 C
0.0001338	176.6187368	1320514.	7.8923430	0.0010556	-0.000188	3.7379365	16.0031140 C
0.0001363	178.9020684	1313043.	7.8319682	0.0010671	-0.000200	3.7649216	16.0636817 C
0.0001388	181.1366777	1305490.	7.7735173	0.0010786	-0.000212	3.7915337	16.1232362 C
0.0001413	183.2998786	1297698.	7.7166940	0.0010900	-0.000224	3.8177121	16.1809828 C
0.0001438	185.4324732	1289965.	7.6617302	0.0011014	-0.000236	3.8435656	16.2382415 C
0.0001463	187.4992245	1282046.	7.6082443	0.0011127	-0.000247	3.8690009	16.2937984 C
0.0001488	189.5278924	1274137.	7.5563707	0.0011240	-0.000259	3.8940918	16.3485551 C
0.0001588	197.1941152	1242168.	7.3628639	0.0011689	-0.000308	3.9908461	16.5567576 C
0.0001688	204.2371935	1210294.	7.1891834	0.0012132	-0.000356	4.0821073	16.7497575 C
0.0001788	210.7325067	1178923.	7.0322673	0.0012570	-0.000405	4.1681215	16.9289209 C
0.0001888	216.7337736	1148258.	6.8895885	0.0013004	-0.000455	4.2490764	17.0950056 C
0.0001988	222.3326924	1118655.	6.7595048	0.0013435	-0.000505	4.3252780	17.2509319 C
0.0002088	227.5565789	1090091.	6.6402474	0.0013862	-0.000555	4.3968410	17.3969475 C
0.0002188	232.4332737	1062552.	6.5303926	0.0014285	-0.000606	4.4638837	17.5334440 C
0.0002288	237.0189417	1036148.	6.4290280	0.0014706	-0.000657	4.5266057	17.6625451 C
0.0002388	241.3386017	1010842.	6.3351877	0.0015125	-0.000708	4.5851116	17.7849510 C
0.0002488	245.4166441	986600.	6.2480763	0.0015542	-0.000759	4.6395015	17.9014701 C
0.0002588	249.2766765	963388.	6.1670369	0.0015957	-0.000811	4.6898696	18.0130291 C
0.0002688	252.9413036	941177.	6.0915261	0.0016371	-0.000862	4.7363025	18.1206766 C
0.0002788	256.3859268	919770.	6.0206579	0.0016783	-0.000914	4.7787562	18.2220491 C
0.0002888	259.6673448	899281.	5.9543832	0.0017193	-0.000966	4.8174039	18.3207880 C
0.0002988	262.8056592	879684.	5.8923991	0.0017604	-0.001018	4.8523089	18.4182590 C
0.0003088	265.7734083	860805.	5.8340046	0.0018012	-0.001070	4.8834197	18.5119202 C
0.0003188	268.5992765	842664.	5.7790731	0.0018421	-0.001122	4.9108146	18.6037228 C
0.0003288	271.3101093	825278.	5.7275361	0.0018829	-0.001174	4.9345554	18.6960293 C
0.0003388	273.8612998	808447.	5.6786287	0.0019236	-0.001227	4.9545662	18.7842756 C
0.0003488	276.3255380	792331.	5.6328176	0.0019644	-0.001279	4.9709724	18.8754704 C
0.0003588	278.6370038	776689.	5.5891732	0.0020051	-0.001331	4.9836812	18.9626373 C
0.0003688	280.8646781	761667.	5.5481993	0.0020459	-0.001383	4.9927756	19.0530475 C
0.0003788	282.9681463	747111.	5.5092596	0.0020866	-0.001436	4.9982107	19.1420373 C
0.0003888	284.9689113	733039.	5.4724192	0.0021274	-0.001488	4.9998177	19.2321075 C
0.0003988	286.8836783	719458.	5.4378193	0.0021683	-0.001540	4.9987538	19.3267199 C
0.0004088	288.6503941	706178.	5.4046757	0.0022092	-0.001592	4.9987904	19.4185261 C
0.0004188	290.3330757	693333.	5.3735709	0.0022502	-0.001644	4.9987020	19.5158681 C
0.0004288	291.9265524	680878.	5.3442895	0.0022914	-0.001696	4.9986618	19.6178411 C
0.0004388	293.3906036	668697.	5.3162015	0.0023325	-0.001748	4.9999992	19.7180159 C
0.0004488	294.7750643	656880.	5.2897912	0.0023738	-0.001800	4.9999541	19.8237286 C
0.0004588	296.0845892	645416.	5.2649344	0.0024153	-0.001851	4.9997919	19.9347985 C
0.0004688	297.2985232	634237.	5.2412133	0.0024568	-0.001903	4.9994236	20.0468854 C
0.0004788	298.4270612	623346.	5.2186111	0.0024984	-0.001954	4.9987398	20.1607476 C
0.0004888	299.4924452	612772.	5.1972798	0.0025402	-0.002005	4.9999997	20.2795140 C
0.0004988	300.4888392	602484.	5.1771706	0.0025821	-0.002056	4.9997850	20.4035837 C
0.0005088	301.4220035	592476.	5.1580861	0.0026242	-0.002107	4.9990645	20.5311022 C

0.0005188	302.2763770	582701.	5.1396646	0.0026662	-0.002158	4.9988990	20.6575340 C
0.0005288	303.0703669	573183.	5.1222671	0.0027084	-0.002209	4.9997407	20.7889827 C
0.0005388	303.8154536	563927.	5.1057912	0.0027507	-0.002260	4.9986564	20.9247404 C
0.0005488	304.5138637	554923.	5.0901783	0.0027932	-0.002310	4.9999758	21.0646751 C
0.0006088	307.6648098	505404.	5.0107319	0.0030503	-0.002611	4.9972595	21.9653475 C
0.0006688	309.4365292	462709.	4.9513551	0.0033112	-0.002908	4.9998766	22.9787696 C
0.0007288	310.1437423	425583.	4.9065497	0.0035756	-0.003202	4.9961951	24.0935156 C
0.0007888	307.8579453	390311.	4.8784347	0.0038479	-0.003488	4.9961898	25.4341180 C

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	95.600	289.532	0.00300000	-0.00340784
2	143.200	306.725	0.00300000	-0.00257376
3	144.500	307.048	0.00300000	-0.00255222

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	95.600000	289.531700	62.140000	188.195605	999966.
2	0.65	143.200000	306.724599	93.080000	199.370989	1229275.
3	0.65	144.500000	307.048429	93.925000	199.581479	1231364.
1	0.75	95.600000	289.531700	71.700000	217.148775	802324.
2	0.75	143.200000	306.724599	107.400000	230.043449	1070342.
3	0.75	144.500000	307.048429	108.375000	230.286322	1074676.
1	0.90	95.600000	289.531700	86.040000	260.578530	578525.
2	0.90	143.200000	306.724599	128.880000	276.052139	786855.
3	0.90	144.500000	307.048429	130.050000	276.343586	792209.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4216.
2	4.4000	4.7007	Yes	No	4216.	219451.
3	23.4000	23.4000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
for Layer n. Layering correction equivalent depths are computed only
for soil types with both shallow-depth and deep-depth expressions for
peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 34100.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 143200.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.4654	-2440903.	34100.	0.00	0.00	6.99E+09	0.00	0.00	0.00
0.3140	1.4630	-2312059.	34083.	-0.00128	0.00	6.99E+09	-8.980	23.1283	0.00
0.6280	1.4558	-2182670.	34030.	-0.00249	0.00	7.06E+09	-19.453	50.3508	0.00
0.9420	1.4442	-2052929.	33936.	-0.00362	0.00	7.08E+09	-30.287	79.0203	0.00
1.2560	1.4285	-1923028.	33802.	-0.00467	0.00	7.11E+09	-40.654	107.2324	0.00
1.5700	1.4090	-1793155.	33630.	-0.00565	0.00	7.14E+09	-50.612	135.3454	0.00
1.8840	1.3859	-1663489.	33423.	-0.00656	0.00	7.17E+09	-59.511	161.7957	0.00
2.1980	1.3596	-1534197.	33185.	-0.00740	0.00	7.20E+09	-66.853	185.2832	0.00
2.5120	1.3301	-1405421.	32917.	-0.00817	0.00	7.24E+09	-75.089	212.7100	0.00
2.8260	1.2980	-1277317.	32617.	-0.00887	0.00	7.29E+09	-84.494	245.2819	0.00
3.1400	1.2633	-1150055.	32277.	-0.00949	0.00	7.34E+09	-95.571	285.0471	0.00
3.4540	1.2265	-1023833.	31897.	-0.01005	0.00	7.40E+09	-106.106	325.9835	0.00
3.7680	1.1876	-898835.	31470.	-0.01053	0.00	7.47E+09	-120.685	382.9004	0.00
4.0820	1.1471	-775306.	30983.	-0.01095	0.00	7.56E+09	-137.857	452.8398	0.00
4.3960	1.1051	-653526.	30429.	-0.01131	0.00	7.67E+09	-155.984	531.8608	0.00
4.7100	1.0619	-533787.	29822.	-0.01160	0.00	7.80E+09	-166.424	590.5507	0.00
5.0240	1.0177	-416272.	29161.	-0.01182	0.00	8.05E+09	-184.586	683.4340	0.00
5.3380	0.9728	-301273.	28429.	-0.01199	0.00	8.05E+09	-203.694	789.0062	0.00
5.6520	0.9273	-189089.	27624.	-0.01211	0.00	8.05E+09	-223.748	909.1649	0.00
5.9660	0.8815	-80035.	26741.	-0.01217	0.00	8.06E+09	-244.750	1046.	0.00
6.2800	0.8356	25565.	25778.	-0.01218	0.00	8.06E+09	-266.699	1203.	0.00
6.5940	0.7897	127372.	24730.	-0.01215	0.00	8.05E+09	-289.597	1382.	0.00
6.9080	0.7441	225034.	23593.	-0.01206	0.00	8.05E+09	-313.444	1587.	0.00
7.2220	0.6988	318190.	22366.	-0.01194	0.00	8.05E+09	-338.241	1824.	0.00
7.5360	0.6541	406464.	21043.	-0.01177	0.00	8.05E+09	-363.990	2097.	0.00
7.8500	0.6101	489467.	19621.	-0.01155	0.00	7.85E+09	-390.689	2413.	0.00
8.1640	0.5671	566796.	18097.	-0.01130	0.00	7.76E+09	-418.342	2780.	0.00
8.4780	0.5250	638037.	16466.	-0.01101	0.00	7.68E+09	-446.949	3208.	0.00
8.7920	0.4841	702763.	14727.	-0.01067	0.00	7.62E+09	-476.511	3709.	0.00
9.1060	0.4446	760536.	12874.	-0.01031	0.00	7.57E+09	-507.030	4298.	0.00
9.4200	0.4064	810907.	10904.	-0.00992	0.00	7.53E+09	-538.508	4993.	0.00
9.7340	0.3698	853413.	8879.	-0.00950	0.00	7.50E+09	-536.256	5464.	0.00
10.0480	0.3348	888073.	6877.	-0.00906	0.00	7.48E+09	-526.566	5926.	0.00
10.3620	0.3015	915016.	4914.	-0.00861	0.00	7.46E+09	-515.212	6439.	0.00
10.6760	0.2699	934395.	3011.	-0.00814	0.00	7.45E+09	-494.875	6908.	0.00
10.9900	0.2401	946493.	1194.	-0.00767	0.00	7.44E+09	-469.497	7367.	0.00
11.3040	0.2122	951666.	-527.744	-0.00718	0.00	7.44E+09	-444.419	7893.	0.00
11.6180	0.1860	950269.	-2156.	-0.00670	0.00	7.44E+09	-419.854	8506.	0.00
11.9320	0.1616	942652.	-3688.	-0.00622	0.00	7.44E+09	-393.457	9172.	0.00
12.2460	0.1391	929191.	-5084.	-0.00575	0.00	7.45E+09	-347.470	9413.	0.00
12.5600	0.1183	910543.	-6310.	-0.00529	0.00	7.46E+09	-303.128	9655.	0.00
12.8740	0.09926	887344.	-7372.	-0.00483	0.00	7.48E+09	-260.673	9896.	0.00

13.1880	0.08189	860202.	-8278.	-0.00439	0.00	7.50E+09	-220.309	10137.	0.00
13.5020	0.06615	829699.	-9037.	-0.00397	0.00	7.52E+09	-182.207	10379.	0.00
13.8160	0.05198	796384.	-9656.	-0.00356	0.00	7.54E+09	-146.505	10620.	0.00
14.1300	0.03931	760775.	-10145.	-0.00317	0.00	7.57E+09	-113.308	10861.	0.00
14.4440	0.02806	723353.	-10515.	-0.00281	0.00	7.60E+09	-82.691	11103.	0.00
14.7580	0.01817	684564.	-10774.	-0.00246	0.00	7.64E+09	-54.700	11344.	0.00
15.0720	0.00955	644815.	-10932.	-0.00213	0.00	7.68E+09	-29.353	11585.	0.00
15.3860	0.00212	604479.	-11000.	-0.00182	0.00	7.72E+09	-6.644	11827.	0.00
15.7000	-0.00420	563890.	-10987.	-0.00154	0.00	7.77E+09	13.4558	12068.	0.00
16.0140	-0.00949	523344.	-10903.	-0.00128	0.00	7.81E+09	30.9972	12310.	0.00
16.3280	-0.01382	483102.	-10758.	-0.00104	0.00	7.87E+09	46.0489	12551.	0.00
16.6420	-0.01729	443389.	-10561.	-8.14E-04	0.00	7.92E+09	58.6954	12792.	0.00
16.9560	-0.01996	404396.	-10320.	-6.14E-04	0.00	8.05E+09	69.0349	13034.	0.00
17.2700	-0.02191	366280.	-10044.	-4.33E-04	0.00	8.05E+09	77.2042	13275.	0.00
17.5840	-0.02322	329168.	-9742.	-2.71E-04	0.00	8.05E+09	83.3077	13516.	0.00
17.8980	-0.02395	293156.	-9420.	-1.25E-04	0.00	8.05E+09	87.4604	13758.	0.00
18.2120	-0.02417	258311.	-9086.	3.86E-06	0.00	8.05E+09	89.7867	13999.	0.00
18.5260	-0.02392	224676.	-8747.	1.17E-04	0.00	8.05E+09	90.4194	14240.	0.00
18.8400	-0.02329	192269.	-8408.	2.14E-04	0.00	8.05E+09	89.4990	14482.	0.00
19.1540	-0.02231	161083.	-8075.	2.97E-04	0.00	8.05E+09	87.1725	14723.	0.00
19.4680	-0.02105	131094.	-7753.	3.65E-04	0.00	8.05E+09	83.5932	14965.	0.00
19.7820	-0.01956	102259.	-7447.	4.20E-04	0.00	8.05E+09	78.9199	15206.	0.00
20.0960	-0.01788	74519.	-7160.	4.61E-04	0.00	8.06E+09	73.3164	15447.	0.00
20.4100	-0.01608	47801.	-6896.	4.90E-04	0.00	8.06E+09	66.9519	15689.	0.00
20.7240	-0.01419	22021.	-6657.	5.06E-04	0.00	8.06E+09	60.0000	15930.	0.00
21.0380	-0.01227	-2912.	-6445.	5.11E-04	0.00	8.06E+09	52.6397	16171.	0.00
21.3520	-0.01034	-27097.	-6261.	5.04E-04	0.00	8.06E+09	45.0550	16413.	0.00
21.6660	-0.00847	-50636.	-6105.	4.85E-04	0.00	8.06E+09	37.4351	16654.	0.00
21.9800	-0.00669	-73631.	-5978.	4.56E-04	0.00	8.06E+09	29.9753	16895.	0.00
22.2940	-0.00503	-96181.	-5879.	4.17E-04	0.00	8.05E+09	22.8772	17137.	0.00
22.6080	-0.00354	-118382.	-5805.	3.67E-04	0.00	8.05E+09	16.3489	17378.	0.00
22.9220	-0.00227	-140321.	-5754.	3.06E-04	0.00	8.05E+09	10.6060	17619.	0.00
23.2360	-0.00124	-162074.	-5723.	2.35E-04	0.00	8.05E+09	5.8721	17861.	0.00
23.5500	-4.95E-04	-183703.	4302.	1.54E-04	0.00	8.05E+09	5315.	4.05E+07	0.00
23.8640	-7.53E-05	-129818.	15839.	8.11E-05	0.00	8.05E+09	808.0568	4.05E+07	0.00
24.1780	1.16E-04	-64428.	15020.	3.56E-05	0.00	8.06E+09	-1243.	4.05E+07	0.00
24.4920	1.93E-04	-16666.	8770.	-1.70E-06	0.00	1.41E+09	-2074.	4.05E+07	0.00
24.8060	1.03E-04	1667.	2780.	-2.17E-05	0.00	1.41E+09	-1105.	4.05E+07	0.00
25.1200	2.93E-05	4310.	105.1579	-1.38E-05	0.00	1.41E+09	-314.996	4.05E+07	0.00
25.4340	-8.91E-07	2474.	-470.264	-4.72E-06	0.00	1.41E+09	9.5705	4.05E+07	0.00
25.7480	-6.26E-06	770.7967	-325.585	-3.98E-07	0.00	1.41E+09	67.2232	4.05E+07	0.00
26.0620	-3.89E-06	20.8662	-120.214	6.57E-07	0.00	1.41E+09	41.7843	4.05E+07	0.00
26.3760	-1.31E-06	-135.848	-14.936	5.03E-07	0.00	1.41E+09	14.0961	4.05E+07	0.00
26.6900	-9.80E-08	-92.233	13.6038	2.00E-07	0.00	1.41E+09	1.0523	4.05E+07	0.00
27.0040	1.91E-07	-33.545	11.7260	3.20E-08	0.00	1.41E+09	-2.049	4.05E+07	0.00
27.3180	1.43E-07	-3.900	4.9755	-1.79E-08	0.00	1.41E+09	-1.534	4.05E+07	0.00
27.6320	5.58E-08	3.9698	0.9572	-1.78E-08	0.00	1.41E+09	-0.599	4.05E+07	0.00
27.9460	8.51E-09	3.3330	-0.343	-8.10E-09	0.00	1.41E+09	-0.09136	4.05E+07	0.00
28.2600	-5.29E-09	1.3942	-0.408	-1.80E-09	0.00	1.41E+09	0.05674	4.05E+07	0.00
28.5740	-5.08E-09	0.2591	-0.198	4.00E-10	0.00	1.41E+09	0.05454	4.05E+07	0.00
28.8880	-2.27E-09	-0.102	-0.04975	6.09E-10	0.00	1.41E+09	0.02441	4.05E+07	0.00
29.2020	-4.91E-10	-0.116	0.00618	3.18E-10	0.00	1.41E+09	0.00527	4.05E+07	0.00
29.5160	1.22E-10	-0.05582	0.01365	8.83E-11	0.00	1.41E+09	-0.00131	4.05E+07	0.00
29.8300	1.74E-10	-0.01366	0.00766	-4.26E-12	0.00	1.41E+09	-0.00187	4.05E+07	0.00
30.1440	8.97E-11	0.00194	0.00233	-1.99E-11	0.00	1.41E+09	-9.62E-04	4.05E+07	0.00
30.4580	2.45E-11	0.00388	1.66E-05	-1.21E-11	0.00	1.41E+09	-2.63E-04	4.05E+07	0.00
30.7720	-1.61E-12	0.00208	-4.47E-04	-4.16E-12	0.00	1.41E+09	1.72E-05	4.05E+07	0.00
31.0860	-6.83E-12	5.21E-04	-2.76E-04	0.00	0.00	1.41E+09	7.33E-05	4.05E+07	0.00
31.4000	-6.83E-12	0.00	0.00	0.00	0.00	1.41E+09	7.33E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.46544720 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -2440903. inch-lbs
Maximum shear force              =         34100. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =              9
Number of zero deflection points =              7
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 24200.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 95600.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7988	-1549139.	24200.	0.00	0.00	7.12E+09	0.00	0.00	0.00
0.3140	0.7972	-1457806.	24183.	-7.95E-04	0.00	7.12E+09	-9.023	42.6449	0.00
0.6280	0.7928	-1366323.	24129.	-0.00154	0.00	7.17E+09	-19.547	92.9031	0.00
0.9420	0.7856	-1274859.	24035.	-0.00223	0.00	7.19E+09	-30.433	145.9643	0.00
1.2560	0.7759	-1183586.	23901.	-0.00288	0.00	7.22E+09	-40.851	198.3748	0.00
1.5700	0.7639	-1092671.	23728.	-0.00347	0.00	7.25E+09	-50.859	250.8498	0.00
1.8840	0.7498	-1002273.	23519.	-0.00401	0.00	7.28E+09	-59.804	300.5351	0.00
2.1980	0.7337	-912538.	23280.	-0.00451	0.00	7.32E+09	-67.186	345.0348	0.00
2.5120	0.7158	-823587.	23011.	-0.00495	0.00	7.37E+09	-75.467	397.2343	0.00
2.8260	0.6964	-735556.	22709.	-0.00535	0.00	7.42E+09	-84.924	459.4987	0.00
3.1400	0.6755	-648596.	22368.	-0.00570	0.00	7.49E+09	-96.063	535.8194	0.00
3.4540	0.6534	-562883.	21986.	-0.00600	0.00	7.57E+09	-106.659	615.0331	0.00
3.7680	0.6303	-478583.	21557.	-0.00626	0.00	7.67E+09	-121.322	725.2766	0.00
4.0820	0.6063	-395920.	21067.	-0.00647	0.00	7.79E+09	-138.593	861.3658	0.00
4.3960	0.5815	-315157.	20511.	-0.00664	0.00	8.10E+09	-156.827	1016.	0.00
4.7100	0.5562	-236567.	19900.	-0.00677	0.00	8.11E+09	-167.335	1134.	0.00
5.0240	0.5305	-160313.	19235.	-0.00686	0.00	8.11E+09	-185.609	1318.	0.00
5.3380	0.5045	-86668.	18499.	-0.00692	0.00	8.11E+09	-204.838	1530.	0.00
5.6520	0.4783	-15916.	17689.	-0.00694	0.00	8.11E+09	-225.023	1773.	0.00
5.9660	0.4521	51643.	16802.	-0.00694	0.00	8.11E+09	-246.163	2051.	0.00
6.2800	0.4261	115699.	15833.	-0.00690	0.00	8.11E+09	-268.260	2372.	0.00
6.5940	0.4002	175927.	14781.	-0.00683	0.00	8.11E+09	-289.787	2729.	0.00
6.9080	0.3746	232011.	13674.	-0.00673	0.00	8.11E+09	-298.067	2998.	0.00
7.2220	0.3494	283824.	12537.	-0.00661	0.00	8.10E+09	-305.101	3290.	0.00
7.5360	0.3247	331258.	11377.	-0.00647	0.00	8.10E+09	-310.874	3607.	0.00
7.8500	0.3006	374222.	10197.	-0.00630	0.00	7.82E+09	-315.389	3953.	0.00
8.1640	0.2772	412644.	9002.	-0.00611	0.00	7.75E+09	-318.684	4331.	0.00
8.4780	0.2546	446469.	7798.	-0.00590	0.00	7.70E+09	-320.807	4748.	0.00
8.7920	0.2327	475660.	6587.	-0.00568	0.00	7.66E+09	-321.821	5210.	0.00
9.1060	0.2118	500198.	5374.	-0.00544	0.00	7.63E+09	-321.806	5726.	0.00
9.4200	0.1917	520078.	4163.	-0.00519	0.00	7.61E+09	-320.854	6305.	0.00
9.7340	0.1727	535310.	2958.	-0.00492	0.00	7.59E+09	-319.015	6961.	0.00
10.0480	0.1546	545917.	1762.	-0.00466	0.00	7.58E+09	-315.723	7693.	0.00
10.3620	0.1376	551944.	619.2731	-0.00438	0.00	7.57E+09	-290.883	7965.	0.00
10.6760	0.1216	553742.	-427.743	-0.00411	0.00	7.57E+09	-264.858	8206.	0.00
10.9900	0.1067	551680.	-1377.	-0.00383	0.00	7.58E+09	-239.110	8448.	0.00
11.3040	0.09273	546124.	-2231.	-0.00356	0.00	7.58E+09	-213.830	8689.	0.00
11.6180	0.07982	537435.	-2990.	-0.00329	0.00	7.59E+09	-189.190	8930.	0.00
11.9320	0.06793	525964.	-3658.	-0.00303	0.00	7.61E+09	-165.344	9172.	0.00
12.2460	0.05701	512051.	-4238.	-0.00277	0.00	7.62E+09	-142.426	9413.	0.00

12.5600	0.04705	496025.	-4733.	-0.00252	0.00	7.64E+09	-120.554	9655.	0.00
12.8740	0.03801	478199.	-5148.	-0.00228	0.00	7.66E+09	-99.826	9896.	0.00
13.1880	0.02986	458871.	-5488.	-0.00205	0.00	7.69E+09	-80.324	10137.	0.00
13.5020	0.02255	438322.	-5756.	-0.00183	0.00	7.72E+09	-62.110	10379.	0.00
13.8160	0.01605	416814.	-5958.	-0.00162	0.00	7.75E+09	-45.232	10620.	0.00
14.1300	0.01031	394590.	-6099.	-0.00143	0.00	7.79E+09	-29.721	10861.	0.00
14.4440	0.00529	371876.	-6185.	-0.00124	0.00	7.83E+09	-15.595	11103.	0.00
14.7580	9.49E-04	348876.	-6220.	-0.00107	0.00	7.88E+09	-2.856	11344.	0.00
15.0720	-0.00277	325776.	-6209.	-9.10E-04	0.00	8.10E+09	8.5069	11585.	0.00
15.3860	-0.00591	302742.	-6158.	-7.64E-04	0.00	8.10E+09	18.5536	11827.	0.00
15.7000	-0.00853	279920.	-6072.	-6.29E-04	0.00	8.10E+09	27.3040	12068.	0.00
16.0140	-0.01065	257439.	-5955.	-5.04E-04	0.00	8.10E+09	34.7872	12310.	0.00
16.3280	-0.01232	235409.	-5812.	-3.89E-04	0.00	8.11E+09	41.0402	12551.	0.00
16.6420	-0.01358	213922.	-5648.	-2.85E-04	0.00	8.11E+09	46.1074	12792.	0.00
16.9560	-0.01447	193054.	-5466.	-1.90E-04	0.00	8.11E+09	50.0400	13034.	0.00
17.2700	-0.01501	172864.	-5272.	-1.05E-04	0.00	8.11E+09	52.8945	13275.	0.00
17.5840	-0.01526	153396.	-5070.	-2.92E-05	0.00	8.11E+09	54.7331	13516.	0.00
17.8980	-0.01523	134680.	-4862.	3.77E-05	0.00	8.11E+09	55.6219	13758.	0.00
18.2120	-0.01497	116731.	-4652.	9.62E-05	0.00	8.11E+09	55.6311	13999.	0.00
18.5260	-0.01451	99552.	-4444.	1.46E-04	0.00	8.11E+09	54.8342	14240.	0.00
18.8400	-0.01387	83134.	-4240.	1.89E-04	0.00	8.11E+09	53.3077	14482.	0.00
19.1540	-0.01309	67460.	-4044.	2.24E-04	0.00	8.11E+09	51.1303	14723.	0.00
19.4680	-0.01218	52501.	-3856.	2.52E-04	0.00	8.11E+09	48.3831	14965.	0.00
19.7820	-0.01119	38219.	-3680.	2.73E-04	0.00	8.11E+09	45.1492	15206.	0.00
20.0960	-0.01013	24572.	-3517.	2.87E-04	0.00	8.11E+09	41.5133	15447.	0.00
20.4100	-0.00902	11511.	-3368.	2.96E-04	0.00	8.11E+09	37.5623	15689.	0.00
20.7240	-0.00790	-1019.	-3234.	2.98E-04	0.00	8.11E+09	33.3845	15930.	0.00
21.0380	-0.00677	-13075.	-3116.	2.95E-04	0.00	8.11E+09	29.0702	16171.	0.00
21.3520	-0.00567	-24716.	-3015.	2.86E-04	0.00	8.11E+09	24.7119	16413.	0.00
21.6660	-0.00462	-36002.	-2930.	2.72E-04	0.00	8.11E+09	20.4039	16654.	0.00
21.9800	-0.00362	-46993.	-2861.	2.53E-04	0.00	8.11E+09	16.2432	16895.	0.00
22.2940	-0.00271	-57745.	-2807.	2.28E-04	0.00	8.11E+09	12.3296	17137.	0.00
22.6080	-0.00190	-68312.	-2767.	1.99E-04	0.00	8.11E+09	8.7657	17378.	0.00
22.9220	-0.00121	-78743.	-2740.	1.65E-04	0.00	8.11E+09	5.6574	17619.	0.00
23.2360	-6.57E-04	-89081.	-2724.	1.26E-04	0.00	8.11E+09	3.1145	17861.	0.00
23.5500	-2.60E-04	-99359.	2546.	8.22E-05	0.00	8.11E+09	2794.	4.05E+07	0.00
23.8640	-3.75E-05	-69952.	8569.	4.29E-05	0.00	8.11E+09	402.6555	4.05E+07	0.00
24.1780	6.27E-05	-34817.	8059.	1.85E-05	0.00	8.11E+09	-673.303	4.05E+07	0.00
24.4920	1.02E-04	-9235.	4728.	-9.52E-07	0.00	1.53E+09	-1095.	4.05E+07	0.00
24.8060	5.55E-05	813.9112	1543.	-1.13E-05	0.00	1.53E+09	-596.246	4.05E+07	0.00
25.1200	1.67E-05	2397.	82.2312	-7.37E-06	0.00	1.53E+09	-178.854	4.05E+07	0.00
25.4340	-8.55E-09	1439.	-254.557	-2.66E-06	0.00	1.53E+09	0.09181	4.05E+07	0.00
25.7480	-3.35E-06	480.7183	-186.647	-2.96E-07	0.00	1.53E+09	35.9533	4.05E+07	0.00
26.0620	-2.24E-06	32.5538	-73.671	3.35E-07	0.00	1.53E+09	24.0128	4.05E+07	0.00
26.3760	-8.23E-07	-74.710	-11.786	2.83E-07	0.00	1.53E+09	8.8351	4.05E+07	0.00
26.6900	-1.01E-07	-56.469	6.9065	1.22E-07	0.00	1.53E+09	1.0866	4.05E+07	0.00
27.0040	9.75E-08	-22.751	6.9815	2.48E-08	0.00	1.53E+09	-1.047	4.05E+07	0.00
27.3180	8.55E-08	-3.875	3.2804	-7.95E-09	0.00	1.53E+09	-0.918	4.05E+07	0.00
27.6320	3.76E-08	1.9757	0.7916	-1.03E-08	0.00	1.53E+09	-0.403	4.05E+07	0.00
27.9460	7.96E-09	2.0982	-0.129	-5.28E-09	0.00	1.53E+09	-0.08542	4.05E+07	0.00
28.2600	-2.22E-09	1.0059	-0.245	-1.46E-09	0.00	1.53E+09	0.02384	4.05E+07	0.00
28.5740	-3.08E-09	0.2513	-0.138	8.06E-11	0.00	1.53E+09	0.03308	4.05E+07	0.00
28.8880	-1.61E-09	-0.03389	-0.04301	3.48E-10	0.00	1.53E+09	0.01733	4.05E+07	0.00
29.2020	-4.60E-10	-0.07308	-0.00106	2.16E-10	0.00	1.53E+09	0.00494	4.05E+07	0.00
29.5160	1.62E-11	-0.04205	0.00792	7.48E-11	0.00	1.53E+09	-1.74E-04	4.05E+07	0.00
29.8300	1.03E-10	-0.01343	0.00551	6.60E-12	0.00	1.53E+09	-0.00111	4.05E+07	0.00
30.1440	6.59E-11	-5.45E-04	0.00209	-1.06E-11	0.00	1.53E+09	-7.07E-04	4.05E+07	0.00
30.4580	2.35E-11	0.00230	2.80E-04	-8.42E-12	0.00	1.53E+09	-2.52E-04	4.05E+07	0.00
30.7720	2.40E-12	0.00157	-2.43E-04	-3.66E-12	0.00	1.53E+09	-2.58E-05	4.05E+07	0.00
31.0860	-4.10E-12	4.74E-04	-2.09E-04	-1.14E-12	0.00	1.53E+09	4.40E-05	4.05E+07	0.00
31.4000	-6.22E-12	0.00	0.00	0.00	0.00	1.53E+09	6.68E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.79876819 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -1549139. inch-lbs
Maximum shear force = 24200. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 37100.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 144500.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.7379	-2729212.	37100.	0.00	0.00	6.53E+09	0.00	0.00	0.00
0.3140	1.7349	-2588990.	37083.	-0.00154	0.00	6.53E+09	-8.980	19.5033	0.00
0.6280	1.7263	-2448082.	37030.	-0.00294	0.00	6.98E+09	-19.453	42.4603	0.00
0.9420	1.7128	-2306730.	36936.	-0.00422	0.00	7.04E+09	-30.287	66.6302	0.00
1.2560	1.6945	-2165136.	36802.	-0.00542	0.00	7.06E+09	-40.653	90.3973	0.00
1.5700	1.6719	-2023491.	36630.	-0.00653	0.00	7.09E+09	-50.609	114.0553	0.00
1.8840	1.6453	-1881978.	36423.	-0.00757	0.00	7.12E+09	-59.506	136.2791	0.00
2.1980	1.6149	-1740769.	36185.	-0.00852	0.00	7.15E+09	-66.846	155.9695	0.00
2.5120	1.5811	-1600009.	35917.	-0.00940	0.00	7.19E+09	-75.080	178.9307	0.00
2.8260	1.5441	-1459858.	35617.	-0.01020	0.00	7.23E+09	-84.482	206.1628	0.00
3.1400	1.5042	-1320492.	35278.	-0.01092	0.00	7.27E+09	-95.556	239.3672	0.00
3.4540	1.4617	-1182111.	34898.	-0.01157	0.00	7.33E+09	-106.087	273.4659	0.00
3.7680	1.4170	-1044905.	34470.	-0.01214	0.00	7.39E+09	-120.661	320.8562	0.00
4.0820	1.3702	-909121.	33983.	-0.01264	0.00	7.47E+09	-137.827	379.0044	0.00
4.3960	1.3218	-775046.	33430.	-0.01306	0.00	7.56E+09	-155.947	444.5609	0.00
4.7100	1.2718	-642973.	32823.	-0.01341	0.00	7.68E+09	-166.382	492.9272	0.00
5.0240	1.2207	-513092.	32162.	-0.01369	0.00	7.83E+09	-184.535	569.6037	0.00
5.3380	1.1687	-385696.	31430.	-0.01390	0.00	8.05E+09	-203.634	656.5500	0.00
5.6520	1.1159	-261093.	30625.	-0.01406	0.00	8.05E+09	-223.678	755.2527	0.00
5.9660	1.0628	-139599.	29743.	-0.01415	0.00	8.05E+09	-244.669	867.4739	0.00
6.2800	1.0093	-21543.	28780.	-0.01419	0.00	8.05E+09	-266.605	995.2952	0.00
6.5940	0.9558	92733.	27732.	-0.01417	0.00	8.05E+09	-289.489	1141.	0.00
6.9080	0.9025	202875.	26596.	-0.01410	0.00	8.05E+09	-313.321	1308.	0.00
7.2220	0.8496	308517.	25369.	-0.01398	0.00	8.05E+09	-338.101	1500.	0.00
7.5360	0.7972	409280.	24046.	-0.01381	0.00	8.05E+09	-363.831	1720.	0.00
7.8500	0.7455	504773.	22625.	-0.01360	0.00	7.84E+09	-390.511	1974.	0.00
8.1640	0.6947	594590.	21102.	-0.01333	0.00	7.73E+09	-418.142	2268.	0.00
8.4780	0.6450	678312.	19472.	-0.01302	0.00	7.64E+09	-446.725	2610.	0.00
8.7920	0.5966	755509.	17733.	-0.01266	0.00	7.58E+09	-476.262	3008.	0.00
9.1060	0.5496	825740.	15881.	-0.01227	0.00	7.52E+09	-506.754	3474.	0.00
9.4200	0.5042	888552.	13913.	-0.01184	0.00	7.48E+09	-538.202	4022.	0.00
9.7340	0.4604	943478.	11824.	-0.01137	0.00	7.45E+09	-570.610	4670.	0.00
10.0480	0.4184	990042.	9611.	-0.01088	0.00	7.42E+09	-603.978	5439.	0.00
10.3620	0.3784	1027758.	7323.	-0.01037	0.00	7.40E+09	-610.221	6077.	0.00
10.6760	0.3403	1056525.	5071.	-0.00984	0.00	7.38E+09	-585.217	6480.	0.00
10.9900	0.3042	1076690.	2925.	-0.00930	0.00	7.38E+09	-554.084	6863.	0.00
11.3040	0.2702	1088688.	895.1513	-0.00874	0.00	7.37E+09	-523.159	7295.	0.00
11.6180	0.2383	1092955.	-1019.	-0.00818	0.00	7.37E+09	-492.701	7789.	0.00

11.9320	0.2085	1089923.	-2819.	-0.00763	0.00	7.37E+09	-462.953	8365.	0.00
12.2460	0.1809	1080015.	-4509.	-0.00707	0.00	7.37E+09	-434.137	9045.	0.00
12.5600	0.1553	1063642.	-6077.	-0.00652	0.00	7.38E+09	-397.798	9655.	0.00
12.8740	0.1317	1041326.	-7478.	-0.00599	0.00	7.39E+09	-345.864	9896.	0.00
13.1880	0.1101	1013810.	-8688.	-0.00546	0.00	7.41E+09	-296.291	10137.	0.00
13.5020	0.09051	981807.	-9715.	-0.00496	0.00	7.43E+09	-249.308	10379.	0.00
13.8160	0.07277	945993.	-10572.	-0.00447	0.00	7.45E+09	-205.103	10620.	0.00
14.1300	0.05683	907006.	-11267.	-0.00400	0.00	7.47E+09	-163.823	10861.	0.00
14.4440	0.04262	865445.	-11812.	-0.00355	0.00	7.50E+09	-125.581	11103.	0.00
14.7580	0.03004	821863.	-12219.	-0.00313	0.00	7.53E+09	-90.453	11344.	0.00
15.0720	0.01902	776774.	-12499.	-0.00273	0.00	7.56E+09	-58.478	11585.	0.00
15.3860	0.00945	730643.	-12666.	-0.00236	0.00	7.60E+09	-29.668	11827.	0.00
15.7000	0.00125	683894.	-12729.	-0.00201	0.00	7.64E+09	-4.004	12068.	0.00
16.0140	-0.00568	636904.	-12702.	-0.00168	0.00	7.69E+09	18.5620	12310.	0.00
16.3280	-0.01144	590009.	-12595.	-0.00138	0.00	7.74E+09	38.0991	12551.	0.00
16.6420	-0.01611	543497.	-12420.	-0.00111	0.00	7.79E+09	54.6995	12792.	0.00
16.9560	-0.01980	497620.	-12188.	-8.58E-04	0.00	7.85E+09	68.4742	13034.	0.00
17.2700	-0.02258	452584.	-11909.	-6.31E-04	0.00	7.91E+09	79.5505	13275.	0.00
17.5840	-0.02455	408560.	-11593.	-4.28E-04	0.00	8.05E+09	88.0685	13516.	0.00
17.8980	-0.02580	365683.	-11250.	-2.46E-04	0.00	8.05E+09	94.2084	13758.	0.00
18.2120	-0.02641	324050.	-10887.	-8.50E-05	0.00	8.05E+09	98.1129	13999.	0.00
18.5260	-0.02644	283728.	-10514.	5.72E-05	0.00	8.05E+09	99.9358	14240.	0.00
18.8400	-0.02598	244752.	-10138.	1.81E-04	0.00	8.05E+09	99.8405	14482.	0.00
19.1540	-0.02508	207131.	-9765.	2.87E-04	0.00	8.05E+09	97.9996	14723.	0.00
19.4680	-0.02382	170849.	-9402.	3.75E-04	0.00	8.05E+09	94.5934	14965.	0.00
19.7820	-0.02225	135866.	-9055.	4.47E-04	0.00	8.05E+09	89.8101	15206.	0.00
20.0960	-0.02045	102124.	-8728.	5.02E-04	0.00	8.05E+09	83.8445	15447.	0.00
20.4100	-0.01847	69546.	-8425.	5.43E-04	0.00	8.05E+09	76.8983	15689.	0.00
20.7240	-0.01636	38043.	-8150.	5.68E-04	0.00	8.05E+09	69.1797	15930.	0.00
21.0380	-0.01419	7512.	-7905.	5.78E-04	0.00	8.06E+09	60.9036	16171.	0.00
21.3520	-0.01201	-22157.	-7691.	5.75E-04	0.00	8.05E+09	52.2915	16413.	0.00
21.6660	-0.00986	-51077.	-7511.	5.58E-04	0.00	8.05E+09	43.5720	16654.	0.00
21.9800	-0.00780	-79366.	-7363.	5.27E-04	0.00	8.05E+09	34.9812	16895.	0.00
22.2940	-0.00588	-107138.	-7247.	4.84E-04	0.00	8.05E+09	26.7632	17137.	0.00
22.6080	-0.00416	-134502.	-7160.	4.27E-04	0.00	8.05E+09	19.1707	17378.	0.00
22.9220	-0.00267	-161560.	-7100.	3.58E-04	0.00	8.05E+09	12.4657	17619.	0.00
23.2360	-0.00146	-188400.	-7064.	2.76E-04	0.00	8.05E+09	6.9198	17861.	0.00
23.5500	-5.86E-04	-215094.	4801.	1.82E-04	0.00	8.05E+09	6291.	4.05E+07	0.00
23.8640	-9.13E-05	-152417.	18500.	9.56E-05	0.00	8.05E+09	980.4755	4.05E+07	0.00
24.1780	1.35E-04	-75782.	17625.	4.22E-05	0.00	8.05E+09	-1445.	4.05E+07	0.00
24.4920	2.27E-04	-19644.	10312.	-1.80E-06	0.00	1.41E+09	-2436.	4.05E+07	0.00
24.8060	1.21E-04	1929.	3273.	-2.55E-05	0.00	1.41E+09	-1299.	4.05E+07	0.00
25.1200	3.45E-05	5051.	126.7161	-1.62E-05	0.00	1.41E+09	-370.775	4.05E+07	0.00
25.4340	-1.02E-06	2902.	-551.119	-5.56E-06	0.00	1.41E+09	10.9898	4.05E+07	0.00
25.7480	-7.34E-06	904.0947	-381.864	-4.70E-07	0.00	1.41E+09	78.8482	4.05E+07	0.00
26.0620	-4.57E-06	24.5670	-140.973	7.70E-07	0.00	1.41E+09	49.0134	4.05E+07	0.00
26.3760	-1.54E-06	-159.113	-17.500	5.91E-07	0.00	1.41E+09	16.5239	4.05E+07	0.00
26.6900	-1.14E-07	-107.958	15.9439	2.34E-07	0.00	1.41E+09	1.2277	4.05E+07	0.00
27.0040	2.24E-07	-39.215	13.7296	3.74E-08	0.00	1.41E+09	-2.403	4.05E+07	0.00
27.3180	1.67E-07	-4.533	5.8181	-2.11E-08	0.00	1.41E+09	-1.796	4.05E+07	0.00
27.6320	6.52E-08	4.6528	1.1153	-2.09E-08	0.00	1.41E+09	-0.700	4.05E+07	0.00
27.9460	9.88E-09	3.8954	-0.403	-9.47E-09	0.00	1.41E+09	-0.106	4.05E+07	0.00
28.2600	-6.21E-09	1.6257	-0.477	-2.10E-09	0.00	1.41E+09	0.06667	4.05E+07	0.00
28.5740	-5.94E-09	0.3002	-0.232	4.72E-10	0.00	1.41E+09	0.06379	4.05E+07	0.00
28.8880	-2.65E-09	-0.120	-0.05778	7.13E-10	0.00	1.41E+09	0.02847	4.05E+07	0.00
29.2020	-5.69E-10	-0.136	0.00736	3.71E-10	0.00	1.41E+09	0.00611	4.05E+07	0.00
29.5160	1.44E-10	-0.06496	0.01596	1.03E-10	0.00	1.41E+09	-0.00155	4.05E+07	0.00
29.8300	2.04E-10	-0.01580	0.00893	-5.27E-12	0.00	1.41E+09	-0.00219	4.05E+07	0.00
30.1440	1.04E-10	0.00232	0.00270	-2.33E-11	0.00	1.41E+09	-0.00112	4.05E+07	0.00
30.4580	2.84E-11	0.00454	1.07E-05	-1.41E-11	0.00	1.41E+09	-3.04E-04	4.05E+07	0.00
30.7720	-1.99E-12	0.00242	-5.23E-04	-4.82E-12	0.00	1.41E+09	2.13E-05	4.05E+07	0.00
31.0860	-7.98E-12	6.02E-04	-3.21E-04	0.00	0.00	1.41E+09	8.56E-05	4.05E+07	0.00
31.4000	-7.90E-12	0.00	0.00	0.00	0.00	1.41E+09	8.49E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the

magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

```
Pile-head deflection             =     1.73790798 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -2729212. inch-lbs
Maximum shear force              =         37100. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             10
Number of zero deflection points =              7
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

```
Shear force at pile head                              =      38200.0 lbs
Rotation of pile head                                 =    0.000E+00 radians
Axial load at pile head                               =     143200.0 lbs
```

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.8515	-2832175.	38200.	0.00	0.00	6.17E+09	0.00	0.00	0.00
0.3140	1.8482	-2687771.	38183.	-0.00169	0.00	6.17E+09	-8.991	18.3308	0.00
0.6280	1.8388	-2542608.	38129.	-0.00320	0.00	6.90E+09	-19.477	39.9130	0.00
0.9420	1.8241	-2396972.	38036.	-0.00454	0.00	7.01E+09	-30.323	62.6391	0.00
1.2560	1.8045	-2251072.	37902.	-0.00579	0.00	7.05E+09	-40.701	84.9865	0.00
1.5700	1.7805	-2105100.	37730.	-0.00695	0.00	7.07E+09	-50.668	107.2279	0.00
1.8840	1.7522	-1959243.	37522.	-0.00803	0.00	7.10E+09	-59.575	128.1145	0.00
2.1980	1.7200	-1813671.	37284.	-0.00903	0.00	7.13E+09	-66.923	146.6106	0.00
2.5120	1.6841	-1668531.	37016.	-0.00995	0.00	7.17E+09	-75.165	168.1699	0.00
2.8260	1.6450	-1523986.	36715.	-0.01078	0.00	7.21E+09	-84.577	193.7285	0.00
3.1400	1.6029	-1380212.	36375.	-0.01154	0.00	7.25E+09	-95.663	224.8796	0.00
3.4540	1.5581	-1237409.	35995.	-0.01222	0.00	7.30E+09	-106.206	256.8467	0.00
3.7680	1.5108	-1095769.	35567.	-0.01282	0.00	7.36E+09	-120.796	301.2660	0.00
4.0820	1.4615	-955542.	35080.	-0.01334	0.00	7.44E+09	-137.981	355.7434	0.00
4.3960	1.4103	-817012.	34526.	-0.01379	0.00	7.53E+09	-156.122	417.1200	0.00
4.7100	1.3576	-680479.	33918.	-0.01416	0.00	7.64E+09	-166.568	462.3109	0.00
5.0240	1.3036	-546129.	33256.	-0.01446	0.00	7.79E+09	-184.743	533.9865	0.00
5.3380	1.2486	-414260.	32524.	-0.01469	0.00	8.05E+09	-203.864	615.1991	0.00
5.6520	1.1929	-285180.	31718.	-0.01485	0.00	8.05E+09	-223.933	707.3151	0.00
5.9660	1.1367	-159208.	30834.	-0.01495	0.00	8.05E+09	-244.949	811.9543	0.00
6.2800	1.0802	-36673.	29870.	-0.01500	0.00	8.06E+09	-266.914	931.0290	0.00
6.5940	1.0237	82081.	28821.	-0.01499	0.00	8.05E+09	-289.828	1067.	0.00
6.9080	0.9673	196700.	27684.	-0.01492	0.00	8.05E+09	-313.692	1222.	0.00
7.2220	0.9112	306815.	26455.	-0.01481	0.00	8.05E+09	-338.507	1400.	0.00
7.5360	0.8557	412047.	25131.	-0.01464	0.00	8.03E+09	-364.274	1604.	0.00
7.8500	0.8009	512002.	23709.	-0.01442	0.00	7.82E+09	-390.993	1840.	0.00
8.1640	0.7470	606273.	22183.	-0.01415	0.00	7.71E+09	-418.666	2112.	0.00
8.4780	0.6943	694441.	20552.	-0.01383	0.00	7.63E+09	-447.296	2428.	0.00
8.7920	0.6428	776072.	18810.	-0.01346	0.00	7.56E+09	-476.882	2795.	0.00
9.1060	0.5928	850724.	16956.	-0.01305	0.00	7.50E+09	-507.428	3225.	0.00
9.4200	0.5445	917941.	14985.	-0.01261	0.00	7.46E+09	-538.934	3730.	0.00
9.7340	0.4978	977256.	12893.	-0.01213	0.00	7.42E+09	-571.404	4325.	0.00
10.0480	0.4531	1028191.	10677.	-0.01162	0.00	7.40E+09	-604.840	5030.	0.00
10.3620	0.4103	1070256.	8333.	-0.01108	0.00	7.37E+09	-639.246	5871.	0.00
10.6760	0.3695	1102949.	5955.	-0.01053	0.00	7.36E+09	-623.031	6353.	0.00
10.9900	0.3309	1126492.	3670.	-0.00996	0.00	7.35E+09	-589.609	6714.	0.00

11.3040	0.2945	1141353.	1511.	-0.00938	0.00	7.34E+09	-556.351	7119.	0.00
11.6180	0.2603	1147998.	-523.327	-0.00879	0.00	7.34E+09	-523.538	7580.	0.00
11.9320	0.2283	1146893.	-2436.	-0.00820	0.00	7.34E+09	-491.431	8112.	0.00
12.2460	0.1985	1138492.	-4229.	-0.00761	0.00	7.34E+09	-460.270	8738.	0.00
12.5600	0.1709	1123242.	-5906.	-0.00703	0.00	7.35E+09	-430.164	9485.	0.00
12.8740	0.1455	1101573.	-7436.	-0.00646	0.00	7.36E+09	-382.062	9896.	0.00
13.1880	0.1222	1074176.	-8775.	-0.00591	0.00	7.37E+09	-328.723	10137.	0.00
13.5020	0.1010	1041815.	-9919.	-0.00537	0.00	7.39E+09	-278.097	10379.	0.00
13.8160	0.08174	1005219.	-10877.	-0.00485	0.00	7.41E+09	-230.393	10620.	0.00
14.1300	0.06445	965077.	-11661.	-0.00435	0.00	7.43E+09	-185.778	10861.	0.00
14.4440	0.04900	922033.	-12283.	-0.00387	0.00	7.46E+09	-144.380	11103.	0.00
14.7580	0.03530	876688.	-12755.	-0.00341	0.00	7.49E+09	-106.287	11344.	0.00
15.0720	0.02327	829595.	-13090.	-0.00299	0.00	7.52E+09	-71.551	11585.	0.00
15.3860	0.01280	781262.	-13301.	-0.00258	0.00	7.56E+09	-40.190	11827.	0.00
15.7000	0.00381	732149.	-13399.	-0.00221	0.00	7.60E+09	-12.189	12068.	0.00
16.0140	-0.00382	682667.	-13399.	-0.00186	0.00	7.64E+09	12.4939	12310.	0.00
16.3280	-0.01019	633180.	-13311.	-0.00153	0.00	7.69E+09	33.9299	12551.	0.00
16.6420	-0.01538	584008.	-13149.	-0.00124	0.00	7.74E+09	52.2123	12792.	0.00
16.9560	-0.01950	535423.	-12924.	-9.65E-04	0.00	7.80E+09	67.4564	13034.	0.00
17.2700	-0.02265	487657.	-12646.	-7.18E-04	0.00	7.86E+09	79.7952	13275.	0.00
17.5840	-0.02492	440898.	-12327.	-4.97E-04	0.00	7.92E+09	89.3776	13516.	0.00
17.8980	-0.02639	395294.	-11977.	-2.99E-04	0.00	8.05E+09	96.3645	13758.	0.00
18.2120	-0.02717	350959.	-11606.	-1.25E-04	0.00	8.05E+09	100.9513	13999.	0.00
18.5260	-0.02733	307968.	-11221.	2.94E-05	0.00	8.05E+09	103.2995	14240.	0.00
18.8400	-0.02695	266366.	-10831.	1.64E-04	0.00	8.05E+09	103.5819	14482.	0.00
19.1540	-0.02610	226168.	-10444.	2.79E-04	0.00	8.05E+09	101.9807	14723.	0.00
19.4680	-0.02485	187361.	-10066.	3.76E-04	0.00	8.05E+09	98.6871	14965.	0.00
19.7820	-0.02327	149907.	-9703.	4.55E-04	0.00	8.05E+09	93.9005	15206.	0.00
20.0960	-0.02142	113749.	-9361.	5.16E-04	0.00	8.05E+09	87.8282	15447.	0.00
20.4100	-0.01938	78809.	-9043.	5.61E-04	0.00	8.05E+09	80.6847	15689.	0.00
20.7240	-0.01719	44994.	-8754.	5.90E-04	0.00	8.06E+09	72.6920	15930.	0.00
21.0380	-0.01493	12201.	-8496.	6.04E-04	0.00	8.06E+09	64.0791	16171.	0.00
21.3520	-0.01265	-19686.	-8272.	6.02E-04	0.00	8.06E+09	55.0825	16413.	0.00
21.6660	-0.01040	-50786.	-8082.	5.85E-04	0.00	8.06E+09	45.9466	16654.	0.00
21.9800	-0.00823	-81221.	-7925.	5.54E-04	0.00	8.05E+09	36.9237	16895.	0.00
22.2940	-0.00622	-111111.	-7803.	5.09E-04	0.00	8.05E+09	28.2752	17137.	0.00
22.6080	-0.00440	-140572.	-7711.	4.51E-04	0.00	8.05E+09	20.2714	17378.	0.00
22.9220	-0.00282	-169709.	-7648.	3.78E-04	0.00	8.05E+09	13.1929	17619.	0.00
23.2360	-0.00155	-198616.	-7609.	2.92E-04	0.00	8.05E+09	7.3306	17861.	0.00
23.5500	-6.22E-04	-227369.	4980.	1.92E-04	0.00	8.05E+09	6675.	4.05E+07	0.00
23.8640	-9.78E-05	-161296.	19534.	1.01E-04	0.00	8.05E+09	1050.	4.05E+07	0.00
24.1780	1.42E-04	-80274.	18643.	4.48E-05	0.00	8.05E+09	-1523.	4.05E+07	0.00
24.4920	2.40E-04	-20852.	10920.	-1.81E-06	0.00	1.41E+09	-2576.	4.05E+07	0.00
24.8060	1.28E-04	2020.	3473.	-2.70E-05	0.00	1.41E+09	-1376.	4.05E+07	0.00
25.1200	3.67E-05	5349.	138.2175	-1.71E-05	0.00	1.41E+09	-393.761	4.05E+07	0.00
25.4340	-1.03E-06	3080.	-582.884	-5.90E-06	0.00	1.41E+09	11.0112	4.05E+07	0.00
25.7480	-7.77E-06	962.5926	-405.034	-5.07E-07	0.00	1.41E+09	83.3888	4.05E+07	0.00
26.0620	-4.84E-06	27.9745	-149.963	8.13E-07	0.00	1.41E+09	51.9993	4.05E+07	0.00
26.3760	-1.64E-06	-168.407	-18.849	6.26E-07	0.00	1.41E+09	17.5942	4.05E+07	0.00
26.6900	-1.25E-07	-114.747	16.8293	2.49E-07	0.00	1.41E+09	1.3433	4.05E+07	0.00
27.0040	2.36E-07	-41.850	14.5783	4.02E-08	0.00	1.41E+09	-2.538	4.05E+07	0.00
27.3180	1.78E-07	-4.928	6.2020	-2.21E-08	0.00	1.41E+09	-1.908	4.05E+07	0.00
27.6320	6.96E-08	4.9122	1.2006	-2.22E-08	0.00	1.41E+09	-0.747	4.05E+07	0.00
27.9460	1.07E-08	4.1440	-0.423	-1.01E-08	0.00	1.41E+09	-0.115	4.05E+07	0.00
28.2600	-6.53E-09	1.7381	-0.507	-2.26E-09	0.00	1.41E+09	0.07011	4.05E+07	0.00
28.5740	-6.31E-09	0.3251	-0.247	4.91E-10	0.00	1.41E+09	0.06779	4.05E+07	0.00
28.8880	-2.83E-09	-0.126	-0.06223	7.56E-10	0.00	1.41E+09	0.03042	4.05E+07	0.00
29.2020	-6.15E-10	-0.145	0.00752	3.96E-10	0.00	1.41E+09	0.00661	4.05E+07	0.00
29.5160	1.50E-10	-0.06954	0.01695	1.10E-10	0.00	1.41E+09	-0.00161	4.05E+07	0.00
29.8300	2.16E-10	-0.01710	0.00954	-5.04E-12	0.00	1.41E+09	-0.00232	4.05E+07	0.00
30.1440	1.12E-10	0.00237	0.00291	-2.47E-11	0.00	1.41E+09	-0.00120	4.05E+07	0.00
30.4580	3.07E-11	0.00482	2.68E-05	-1.51E-11	0.00	1.41E+09	-3.29E-04	4.05E+07	0.00
30.7720	-1.92E-12	0.00259	-5.54E-04	-5.19E-12	0.00	1.41E+09	2.06E-05	4.05E+07	0.00
31.0860	-8.48E-12	6.49E-04	-3.44E-04	0.00	0.00	1.41E+09	9.11E-05	4.05E+07	0.00
31.4000	-8.52E-12	0.00	0.00	0.00	0.00	1.41E+09	9.15E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual

stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

Pile-head deflection = 1.85146471 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -2832175. inch-lbs
Maximum shear force = 38200. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 10
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 1.000000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 95600.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0000	-1834834.	27644.	0.00	0.00	7.07E+09	0.00	0.00	0.00
0.3140	0.9982	-1730567.	27608.	-9.50E-04	0.00	7.07E+09	-8.945	33.7657	0.00
0.6280	0.9928	-1626095.	27555.	-0.00184	0.00	7.11E+09	-19.377	73.5390	0.00
0.9420	0.9843	-1521587.	27461.	-0.00268	0.00	7.13E+09	-30.168	115.4896	0.00
1.2560	0.9727	-1417218.	27328.	-0.00345	0.00	7.15E+09	-40.493	156.8655	0.00
1.5700	0.9583	-1313155.	27157.	-0.00417	0.00	7.18E+09	-50.410	198.2165	0.00
1.8840	0.9413	-1209560.	26950.	-0.00483	0.00	7.21E+09	-59.272	237.2745	0.00
2.1980	0.9219	-1106578.	26713.	-0.00543	0.00	7.24E+09	-66.581	272.1431	0.00
2.5120	0.9003	-1004334.	26447.	-0.00598	0.00	7.28E+09	-74.781	312.9766	0.00
2.8260	0.8768	-902964.	26147.	-0.00647	0.00	7.32E+09	-84.143	361.6060	0.00
3.1400	0.8515	-802622.	25810.	-0.00691	0.00	7.38E+09	-95.169	421.1280	0.00
3.4540	0.8247	-703483.	25431.	-0.00729	0.00	7.44E+09	-105.654	482.7252	0.00
3.7680	0.7965	-605716.	25006.	-0.00762	0.00	7.52E+09	-120.164	568.4277	0.00
4.0820	0.7672	-509546.	24521.	-0.00790	0.00	7.62E+09	-137.252	674.0566	0.00
4.3960	0.7370	-415233.	23970.	-0.00813	0.00	7.75E+09	-155.288	793.9412	0.00
4.7100	0.7060	-323053.	23365.	-0.00831	0.00	8.10E+09	-165.669	884.2230	0.00
5.0240	0.6744	-233171.	22707.	-0.00843	0.00	8.11E+09	-183.734	1027.	0.00
5.3380	0.6424	-145858.	21979.	-0.00852	0.00	8.11E+09	-202.736	1189.	0.00
5.6520	0.6102	-61399.	21177.	-0.00857	0.00	8.11E+09	-222.676	1375.	0.00
5.9660	0.5778	19909.	20299.	-0.00858	0.00	8.11E+09	-243.553	1588.	0.00
6.2800	0.5455	97755.	19340.	-0.00855	0.00	8.11E+09	-265.368	1833.	0.00
6.5940	0.5134	171818.	18297.	-0.00849	0.00	8.11E+09	-288.120	2115.	0.00
6.9080	0.4815	241760.	17167.	-0.00839	0.00	8.10E+09	-311.809	2440.	0.00
7.2220	0.4501	307236.	15946.	-0.00827	0.00	8.10E+09	-336.435	2816.	0.00
7.5360	0.4192	367883.	14630.	-0.00811	0.00	7.83E+09	-361.999	3254.	0.00
7.8500	0.3890	423327.	13229.	-0.00792	0.00	7.74E+09	-381.317	3694.	0.00
8.1640	0.3596	473283.	11787.	-0.00770	0.00	7.66E+09	-384.362	4028.	0.00
8.4780	0.3310	517698.	10336.	-0.00745	0.00	7.61E+09	-385.829	4392.	0.00
8.7920	0.3034	556542.	8882.	-0.00718	0.00	7.57E+09	-385.788	4791.	0.00
9.1060	0.2769	589809.	7431.	-0.00690	0.00	7.53E+09	-384.331	5230.	0.00
9.4200	0.2514	617514.	5988.	-0.00660	0.00	7.51E+09	-381.568	5718.	0.00
9.7340	0.2272	639689.	4558.	-0.00628	0.00	7.49E+09	-377.625	6264.	0.00
10.0480	0.2041	656387.	3144.	-0.00595	0.00	7.47E+09	-372.640	6879.	0.00
10.3620	0.1823	667675.	1751.	-0.00562	0.00	7.47E+09	-366.764	7581.	0.00
10.6760	0.1618	673634.	396.7320	-0.00528	0.00	7.46E+09	-352.286	8206.	0.00
10.9900	0.1425	674469.	-868.860	-0.00494	0.00	7.46E+09	-319.472	8448.	0.00
11.3040	0.1245	670646.	-2012.	-0.00460	0.00	7.46E+09	-287.149	8689.	0.00

11.6180	0.1078	662624.	-3034.	-0.00426	0.00	7.47E+09	-255.548	8930.	0.00
11.9320	0.09238	650853.	-3939.	-0.00393	0.00	7.48E+09	-224.874	9172.	0.00
12.2460	0.07818	635771.	-4731.	-0.00361	0.00	7.49E+09	-195.308	9413.	0.00
12.5600	0.06518	617801.	-5414.	-0.00329	0.00	7.51E+09	-167.009	9655.	0.00
12.8740	0.05335	597349.	-5992.	-0.00299	0.00	7.53E+09	-140.114	9896.	0.00
13.1880	0.04265	574799.	-6472.	-0.00270	0.00	7.55E+09	-114.735	10137.	0.00
13.5020	0.03302	550517.	-6860.	-0.00242	0.00	7.57E+09	-90.963	10379.	0.00
13.8160	0.02443	524844.	-7161.	-0.00215	0.00	7.60E+09	-68.868	10620.	0.00
14.1300	0.01682	498101.	-7382.	-0.00190	0.00	7.63E+09	-48.498	10861.	0.00
14.4440	0.01014	470580.	-7530.	-0.00166	0.00	7.67E+09	-29.883	11103.	0.00
14.7580	0.00433	442551.	-7611.	-0.00143	0.00	7.71E+09	-13.035	11344.	0.00
15.0720	-6.67E-04	414260.	-7631.	-0.00123	0.00	7.75E+09	2.0500	11585.	0.00
15.3860	-0.00490	385925.	-7598.	-0.00103	0.00	7.80E+09	15.3936	11827.	0.00
15.7000	-0.00844	357741.	-7518.	-8.52E-04	0.00	7.85E+09	27.0290	12068.	0.00
16.0140	-0.01133	329879.	-7398.	-6.90E-04	0.00	8.10E+09	37.0023	12310.	0.00
16.3280	-0.01364	302488.	-7243.	-5.43E-04	0.00	8.10E+09	45.4197	12551.	0.00
16.6420	-0.01542	275690.	-7058.	-4.08E-04	0.00	8.10E+09	52.3335	12792.	0.00
16.9560	-0.01671	249590.	-6851.	-2.86E-04	0.00	8.10E+09	57.8044	13034.	0.00
17.2700	-0.01757	224268.	-6625.	-1.76E-04	0.00	8.11E+09	61.9009	13275.	0.00
17.5840	-0.01804	199788.	-6387.	-7.73E-05	0.00	8.11E+09	64.6983	13516.	0.00
17.8980	-0.01815	176192.	-6140.	1.01E-05	0.00	8.11E+09	66.2776	13758.	0.00
18.2120	-0.01796	153508.	-5890.	8.68E-05	0.00	8.11E+09	66.7252	13999.	0.00
18.5260	-0.01750	131746.	-5639.	1.53E-04	0.00	8.11E+09	66.1319	14240.	0.00
18.8400	-0.01681	110901.	-5393.	2.09E-04	0.00	8.11E+09	64.5926	14482.	0.00
19.1540	-0.01592	90954.	-5154.	2.56E-04	0.00	8.11E+09	62.2056	14723.	0.00
19.4680	-0.01487	71875.	-4926.	2.94E-04	0.00	8.11E+09	59.0723	14965.	0.00
19.7820	-0.01370	53623.	-4710.	3.23E-04	0.00	8.11E+09	55.2970	15206.	0.00
20.0960	-0.01244	36147.	-4510.	3.44E-04	0.00	8.11E+09	50.9865	15447.	0.00
20.4100	-0.01111	19389.	-4327.	3.57E-04	0.00	8.11E+09	46.2503	15689.	0.00
20.7240	-0.00975	3284.	-4162.	3.62E-04	0.00	8.11E+09	41.2003	15930.	0.00
21.0380	-0.00838	-12236.	-4017.	3.60E-04	0.00	8.11E+09	35.9510	16171.	0.00
21.3520	-0.00703	-27244.	-3891.	3.51E-04	0.00	8.11E+09	30.6197	16413.	0.00
21.6660	-0.00573	-41813.	-3786.	3.35E-04	0.00	8.11E+09	25.3267	16654.	0.00
21.9800	-0.00450	-56015.	-3700.	3.12E-04	0.00	8.11E+09	20.1957	16895.	0.00
22.2940	-0.00338	-69921.	-3633.	2.83E-04	0.00	8.11E+09	15.3538	17137.	0.00
22.6080	-0.00237	-83597.	-3583.	2.47E-04	0.00	8.11E+09	10.9322	17378.	0.00
22.9220	-0.00151	-97104.	-3550.	2.05E-04	0.00	8.11E+09	7.0665	17619.	0.00
23.2360	-8.22E-04	-110495.	-3529.	1.57E-04	0.00	8.11E+09	3.8970	17861.	0.00
23.5500	-3.27E-04	-123811.	3084.	1.03E-04	0.00	8.11E+09	3506.	4.05E+07	0.00
23.8640	-4.79E-05	-87327.	10659.	5.37E-05	0.00	8.11E+09	514.5151	4.05E+07	0.00
24.1780	7.78E-05	-43524.	10055.	2.32E-05	0.00	8.11E+09	-835.002	4.05E+07	0.00
24.4920	1.27E-04	-11568.	5908.	-1.11E-06	0.00	1.53E+09	-1366.	4.05E+07	0.00
24.8060	6.94E-05	1002.	1931.	-1.41E-05	0.00	1.53E+09	-745.204	4.05E+07	0.00
25.1200	2.09E-05	2990.	104.7802	-9.21E-06	0.00	1.53E+09	-223.900	4.05E+07	0.00
25.4340	1.35E-08	1798.	-317.320	-3.32E-06	0.00	1.53E+09	-0.145	4.05E+07	0.00
25.7480	-4.18E-06	601.5544	-233.123	-3.73E-07	0.00	1.53E+09	44.8349	4.05E+07	0.00
26.0620	-2.79E-06	41.2923	-92.141	4.18E-07	0.00	1.53E+09	29.9967	4.05E+07	0.00
26.3760	-1.03E-06	-93.119	-14.804	3.54E-07	0.00	1.53E+09	11.0524	4.05E+07	0.00
26.6900	-1.27E-07	-70.527	8.5955	1.53E-07	0.00	1.53E+09	1.3678	4.05E+07	0.00
27.0040	1.21E-07	-28.453	8.7161	3.11E-08	0.00	1.53E+09	-1.304	4.05E+07	0.00
27.3180	1.07E-07	-4.865	4.1009	-9.88E-09	0.00	1.53E+09	-1.146	4.05E+07	0.00
27.6320	4.70E-08	2.4582	0.9919	-1.28E-08	0.00	1.53E+09	-0.504	4.05E+07	0.00
27.9460	9.98E-09	2.6193	-0.160	-6.60E-09	0.00	1.53E+09	-0.107	4.05E+07	0.00
28.2600	-2.76E-09	1.2575	-0.306	-1.83E-09	0.00	1.53E+09	0.02961	4.05E+07	0.00
28.5740	-3.85E-09	0.3148	-0.172	9.83E-11	0.00	1.53E+09	0.04128	4.05E+07	0.00
28.8880	-2.02E-09	-0.04190	-0.05384	4.34E-10	0.00	1.53E+09	0.02165	4.05E+07	0.00
29.2020	-5.76E-10	-0.09119	-0.00139	2.70E-10	0.00	1.53E+09	0.00619	4.05E+07	0.00
29.5160	1.95E-11	-0.05254	0.00988	9.36E-11	0.00	1.53E+09	-2.09E-04	4.05E+07	0.00
29.8300	1.29E-10	-0.01681	0.00688	8.33E-12	0.00	1.53E+09	-0.00138	4.05E+07	0.00
30.1440	8.23E-11	-6.99E-04	0.00261	-1.32E-11	0.00	1.53E+09	-8.84E-04	4.05E+07	0.00
30.4580	2.94E-11	0.00287	3.52E-04	-1.05E-11	0.00	1.53E+09	-3.15E-04	4.05E+07	0.00
30.7720	3.03E-12	0.00196	-3.03E-04	-4.58E-12	0.00	1.53E+09	-3.25E-05	4.05E+07	0.00
31.0860	-5.12E-12	5.92E-04	-2.61E-04	-1.43E-12	0.00	1.53E+09	5.49E-05	4.05E+07	0.00
31.4000	-7.77E-12	0.00	0.00	0.00	0.00	1.53E+09	8.35E-05	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be inter-

polated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

Pile-head deflection = 1.00000000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -1834834. inch-lbs
Maximum shear force = 27644. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 7

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 6

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 42000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 144500.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.9108	-3069627.	42000.	0.00	0.00	1.89E+09	0.00	0.00	0.00
0.3140	2.8992	-2909701.	41983.	-0.00597	0.00	1.89E+09	-8.974	11.6639	0.00
0.6280	2.8657	-2746736.	41930.	-0.00969	0.00	6.37E+09	-19.440	25.5607	0.00
0.9420	2.8261	-2583163.	41836.	-0.01122	0.00	6.84E+09	-30.264	40.3501	0.00
1.2560	2.7812	-2419245.	41702.	-0.01258	0.00	6.99E+09	-40.620	55.0321	0.00
1.5700	2.7313	-2255194.	41531.	-0.01384	0.00	7.05E+09	-50.564	69.7554	0.00
1.8840	2.6769	-2091204.	41323.	-0.01500	0.00	7.08E+09	-59.450	83.6808	0.00
2.1980	2.6183	-1927452.	41086.	-0.01606	0.00	7.11E+09	-66.778	96.0999	0.00
2.5120	2.5559	-1764092.	40818.	-0.01704	0.00	7.15E+09	-74.998	110.5665	0.00
2.8260	2.4899	-1601290.	40518.	-0.01792	0.00	7.19E+09	-84.384	127.6988	0.00
3.1400	2.4208	-1439229.	40179.	-0.01872	0.00	7.23E+09	-95.438	148.5503	0.00
3.4540	2.3489	-1278115.	39800.	-0.01942	0.00	7.29E+09	-105.949	169.9612	0.00
3.7680	2.2744	-1118145.	39373.	-0.02004	0.00	7.35E+09	-120.495	199.6220	0.00
4.0820	2.1978	-959574.	38887.	-0.02057	0.00	7.43E+09	-137.626	235.9479	0.00
4.3960	2.1194	-802692.	38334.	-0.02101	0.00	7.54E+09	-155.707	276.8252	0.00
4.7100	2.0395	-647803.	37728.	-0.02137	0.00	7.67E+09	-166.112	306.8983	0.00
5.0240	1.9583	-495099.	37068.	-0.02165	0.00	7.85E+09	-184.220	354.4556	0.00
5.3380	1.8763	-344880.	36338.	-0.02185	0.00	8.05E+09	-203.268	408.2053	0.00
5.6520	1.7937	-197460.	35534.	-0.02198	0.00	8.05E+09	-223.256	469.0018	0.00
5.9660	1.7107	-53159.	34654.	-0.02204	0.00	8.05E+09	-244.183	537.8493	0.00
6.2800	1.6276	87688.	33693.	-0.02203	0.00	8.05E+09	-266.049	615.9272	0.00
6.5940	1.5447	224736.	32647.	-0.02196	0.00	8.05E+09	-288.855	704.6258	0.00
6.9080	1.4621	357625.	31514.	-0.02182	0.00	8.05E+09	-312.600	805.5913	0.00
7.2220	1.3802	485985.	30290.	-0.02162	0.00	7.87E+09	-337.284	920.7811	0.00
7.5360	1.2992	609430.	28970.	-0.02135	0.00	7.72E+09	-362.907	1053.	0.00
7.8500	1.2193	727560.	27553.	-0.02103	0.00	7.60E+09	-389.470	1204.	0.00
8.1640	1.1408	839964.	26034.	-0.02063	0.00	7.51E+09	-416.972	1377.	0.00
8.4780	1.0638	946219.	24409.	-0.02018	0.00	7.45E+09	-445.414	1578.	0.00
8.7920	0.9886	1045889.	22675.	-0.01968	0.00	7.39E+09	-474.795	1810.	0.00
9.1060	0.9155	1138527.	20829.	-0.01912	0.00	7.35E+09	-505.117	2079.	0.00
9.4200	0.8446	1223677.	18867.	-0.01851	0.00	7.31E+09	-536.378	2393.	0.00
9.7340	0.7760	1300867.	16785.	-0.01786	0.00	7.28E+09	-568.580	2761.	0.00
10.0480	0.7100	1369618.	14580.	-0.01717	0.00	7.26E+09	-601.723	3194.	0.00
10.3620	0.6466	1429439.	12249.	-0.01644	0.00	7.24E+09	-635.806	3705.	0.00
10.6760	0.5861	1479828.	9806.	-0.01568	0.00	7.22E+09	-660.755	4248.	0.00

10.9900	0.5284	1520415.	7281.	-0.01490	0.00	7.21E+09	-679.395	4845.	0.00
11.3040	0.4738	1550924.	4686.	-0.01410	0.00	7.20E+09	-698.039	5552.	0.00
11.6180	0.4222	1571080.	2021.	-0.01328	0.00	7.20E+09	-716.685	6396.	0.00
11.9320	0.3737	1580613.	-645.202	-0.01245	0.00	7.19E+09	-698.361	7041.	0.00
12.2460	0.3283	1579780.	-3185.	-0.01163	0.00	7.19E+09	-649.517	7454.	0.00
12.5600	0.2861	1569275.	-5543.	-0.01080	0.00	7.20E+09	-602.071	7930.	0.00
12.8740	0.2469	1549774.	-7725.	-0.00999	0.00	7.20E+09	-556.329	8489.	0.00
13.1880	0.2108	1521933.	-9739.	-0.00918	0.00	7.21E+09	-512.564	9160.	0.00
13.5020	0.1777	1486382.	-11592.	-0.00840	0.00	7.22E+09	-471.014	9986.	0.00
13.8160	0.1476	1443721.	-13263.	-0.00763	0.00	7.23E+09	-415.872	10620.	0.00
14.1300	0.1202	1394746.	-14699.	-0.00689	0.00	7.25E+09	-346.499	10861.	0.00
14.4440	0.09559	1340457.	-15883.	-0.00618	0.00	7.27E+09	-281.672	11103.	0.00
14.7580	0.07360	1281790.	-16831.	-0.00551	0.00	7.29E+09	-221.576	11344.	0.00
15.0720	0.05410	1219617.	-17561.	-0.00486	0.00	7.31E+09	-166.339	11585.	0.00
15.3860	0.03697	1154739.	-18093.	-0.00425	0.00	7.34E+09	-116.037	11827.	0.00
15.7000	0.02207	1087892.	-18445.	-0.00368	0.00	7.37E+09	-70.695	12068.	0.00
16.0140	0.00927	1019738.	-18636.	-0.00314	0.00	7.40E+09	-30.291	12310.	0.00
16.3280	-0.00157	950871.	-18683.	-0.00264	0.00	7.44E+09	5.2403	12551.	0.00
16.6420	-0.01060	881817.	-18605.	-0.00217	0.00	7.49E+09	36.0022	12792.	0.00
16.9560	-0.01796	813032.	-18420.	-0.00175	0.00	7.53E+09	62.1357	13034.	0.00
17.2700	-0.02379	744908.	-18145.	-0.00136	0.00	7.59E+09	83.8136	13275.	0.00
17.5840	-0.02822	677772.	-17797.	-0.00101	0.00	7.65E+09	101.2379	13516.	0.00
17.8980	-0.03140	611892.	-17390.	-6.93E-04	0.00	7.71E+09	114.6359	13758.	0.00
18.2120	-0.03345	547477.	-16940.	-4.11E-04	0.00	7.79E+09	124.2566	13999.	0.00
18.5260	-0.03450	484682.	-16460.	-1.63E-04	0.00	7.86E+09	130.3673	14240.	0.00
18.8400	-0.03467	423611.	-15963.	5.36E-05	0.00	7.97E+09	133.2498	14482.	0.00
19.1540	-0.03409	364323.	-15461.	2.39E-04	0.00	8.05E+09	133.2071	14723.	0.00
19.4680	-0.03287	306834.	-14965.	3.96E-04	0.00	8.05E+09	130.5390	14965.	0.00
19.7820	-0.03111	251119.	-14482.	5.27E-04	0.00	8.05E+09	125.5312	15206.	0.00
20.0960	-0.02890	197123.	-14022.	6.31E-04	0.00	8.05E+09	118.4825	15447.	0.00
20.4100	-0.02635	144759.	-13592.	7.11E-04	0.00	8.05E+09	109.7044	15689.	0.00
20.7240	-0.02354	93916.	-13198.	7.67E-04	0.00	8.05E+09	99.5202	15930.	0.00
21.0380	-0.02057	44462.	-12844.	8.00E-04	0.00	8.05E+09	88.2657	16171.	0.00
21.3520	-0.01751	-3751.	-12534.	8.09E-04	0.00	8.06E+09	76.2889	16413.	0.00
21.6660	-0.01447	-50879.	-12270.	7.96E-04	0.00	8.05E+09	63.9502	16654.	0.00
21.9800	-0.01151	-97086.	-12053.	7.62E-04	0.00	8.05E+09	51.6236	16895.	0.00
22.2940	-0.00873	-142536.	-11880.	7.06E-04	0.00	8.05E+09	39.6967	17137.	0.00
22.6080	-0.00620	-187386.	-11752.	6.28E-04	0.00	8.05E+09	28.5721	17378.	0.00
22.9220	-0.00399	-231782.	-11663.	5.30E-04	0.00	8.05E+09	18.6676	17619.	0.00
23.2360	-0.00220	-275855.	-11608.	4.12E-04	0.00	8.05E+09	10.4179	17861.	0.00
23.5500	-8.90E-04	-319709.	6409.	2.72E-04	0.00	8.05E+09	9553.	4.05E+07	0.00
23.8640	-1.46E-04	-227853.	27350.	1.44E-04	0.00	8.05E+09	1562.	4.05E+07	0.00
24.1780	1.97E-04	-113758.	26308.	6.43E-05	0.00	8.05E+09	-2116.	4.05E+07	0.00
24.4920	3.39E-04	-29669.	15463.	-2.05E-06	0.00	1.41E+09	-3640.	4.05E+07	0.00
24.8060	1.82E-04	2777.	4932.	-3.81E-05	0.00	1.41E+09	-1950.	4.05E+07	0.00
25.1200	5.21E-05	7539.	205.2001	-2.43E-05	0.00	1.41E+09	-559.268	4.05E+07	0.00
25.4340	-1.36E-06	4350.	-820.964	-8.37E-06	0.00	1.41E+09	14.5952	4.05E+07	0.00
25.7480	-1.10E-05	1362.	-571.918	-7.27E-07	0.00	1.41E+09	117.5948	4.05E+07	0.00
26.0620	-6.84E-06	40.9863	-211.996	1.15E-06	0.00	1.41E+09	73.4465	4.05E+07	0.00
26.3760	-2.32E-06	-237.077	-26.769	8.84E-07	0.00	1.41E+09	24.8694	4.05E+07	0.00
26.6900	-1.78E-07	-161.705	23.6836	3.52E-07	0.00	1.41E+09	1.9099	4.05E+07	0.00
27.0040	3.33E-07	-58.980	20.5441	5.69E-08	0.00	1.41E+09	-3.576	4.05E+07	0.00
27.3180	2.51E-07	-6.946	8.7394	-3.12E-08	0.00	1.41E+09	-2.689	4.05E+07	0.00
27.6320	9.80E-08	6.9143	1.6908	-3.12E-08	0.00	1.41E+09	-1.052	4.05E+07	0.00
27.9460	1.50E-08	5.8295	-0.595	-1.42E-08	0.00	1.41E+09	-0.162	4.05E+07	0.00
28.2600	-9.21E-09	2.4423	-0.714	-3.18E-09	0.00	1.41E+09	0.09888	4.05E+07	0.00
28.5740	-8.89E-09	0.4554	-0.348	6.94E-10	0.00	1.41E+09	0.09541	4.05E+07	0.00
28.8880	-3.98E-09	-0.177	-0.08725	1.07E-09	0.00	1.41E+09	0.04274	4.05E+07	0.00
29.2020	-8.62E-10	-0.203	0.01070	5.56E-10	0.00	1.41E+09	0.00925	4.05E+07	0.00
29.5160	2.12E-10	-0.09749	0.02383	1.55E-10	0.00	1.41E+09	-0.00228	4.05E+07	0.00
29.8300	3.04E-10	-0.02387	0.01338	-7.37E-12	0.00	1.41E+09	-0.00327	4.05E+07	0.00
30.1440	1.57E-10	0.00339	0.00406	-3.47E-11	0.00	1.41E+09	-0.00168	4.05E+07	0.00
30.4580	4.28E-11	0.00677	2.88E-05	-2.11E-11	0.00	1.41E+09	-4.59E-04	4.05E+07	0.00
30.7720	-2.82E-12	0.00363	-7.80E-04	-7.26E-12	0.00	1.41E+09	3.03E-05	4.05E+07	0.00
31.0860	-1.19E-11	9.06E-04	-4.82E-04	-1.20E-12	0.00	1.41E+09	1.28E-04	4.05E+07	0.00
31.4000	-1.19E-11	0.00	0.00	0.00	0.00	1.41E+09	1.28E-04	2.02E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses

```
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.

* WARNING: Some values of computed curvature exceeded the maximum curvature calculated or entered by the user
  Depth =      0.00  ft   Computed Curv. =   0.00161  rad/in   Maximum Curv. =  7.29E-04  rad/in
  Depth =    0.3140  ft   Computed Curv. =   0.00153  rad/in   Maximum Curv. =  7.29E-04  rad/in


Output Summary for Load Case No. 6:

Pile-head deflection             =     2.91075421 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -3069627. inch-lbs
Maximum shear force              =         42000. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             42
Number of zero deflection points =              7


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load               Load                 Axial    Pile-head  Pile-head  Max Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs      in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
  1  V, lb     34100.   S, rad         0.00    143200.     1.4654       0.00     34100.  -2440903.
  2  V, lb     24200.   S, rad         0.00     95600.     0.7988       0.00     24200.  -1549139.
  3  V, lb     37100.   S, rad         0.00    144500.     1.7379       0.00     37100.  -2729212.
  4  V, lb     38200.   S, rad         0.00    143200.     1.8515       0.00     38200.  -2832175.
  5  y, in     1.0000   S, rad         0.00     95600.     1.0000       0.00     27644.  -1834834.
  6  V, lb     42000.   S, rad         0.00    144500.     2.9108       0.00     42000.  -3069627.


Maximum pile-head deflection = 2.9107542113 inches
Maximum pile-head rotation   = -0.0000000000 radians = -0.000000 deg.

--------------------------------------------------------------------------------
                           Summary of Warning Messages
--------------------------------------------------------------------------------

The following warning was reported 3744 times


**** Warning ****

This warning is for an input value for uniaxial compressive strength that
has been specified for a soil defined using the vuggy limestone criteria.
The input value is outside of the range of 1,000 to 2,500 psi
(6,895 to 17,237 kPa) which were used in actual field tests
on which this theory is based. Higher or lower values may be applicable
but the user is warned about the theoretical and testing limitations.


The analysis ended normally.
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==========================================================================

          GROUP for Windows, Version 2022.12.7   - Flexible Cap

                  Serial Number : 449541211

                  Analysis of A Group of Piles
               Subjected to Axial and Lateral Loading

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                      All Rights Reserved

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--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  September 12, 2025     Time:  09:15:17



            *****     COMPUTATION RESULTS     *****


MICROPILE W-38-011



            *****     LOAD CASES RESULTS      *****


LOAD CASE :     1
CASE NAME : Strengh I
LOAD TYPE : Dead, DL

  REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
  ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

       GROUP NO     P-FACTOR     Y-FACTOR

           1           1.0000       1.0000
           2           0.9976       1.0000
           3           0.8397       1.0000
           4           0.8056       1.0000


* TABLE L *   COMPUTATION ON PILE CAP


* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *


      VERT. LOAD,KIPS    HOR. LOAD Y,KIPS   HOR. LOAD Z,KIPS
            196.710            120.430            0.00000

     MOMENT X ,KIP-IN    MOMENT Y,KIP-IN    MOMENT Z,KIP-IN
            0.00000            0.00000            0.00000


* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *
```

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0319399	1.29323	-6.39748E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-4.71773E-03	-1.35763E-04	-2.85132E-03

* TABLE M * COMPUTATION ON INDIVIDUAL PILE

THE GLOBAL STRUCTURAL COORDINATE SYSTEM

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
1	0.087337	1.4489	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
2	0.096298	1.1375	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
3	-0.029974	1.3640	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
4	-0.023458	1.1375	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
MINIMUM	-0.029974	1.1375	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.096298	1.4489	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	FOR. X,KIP	FOR. Y,KIP	FOR. Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
1	129.91	34.107	-2.6147	-7.4376E-06	170.01	2161.7
2	143.18	28.681	-2.9111	-7.4376E-06	181.94	1711.1
3	-42.813	31.063	2.6909	-7.4376E-06	-187.02	1902.5
4	-33.567	26.578	2.8350	-7.4376E-06	-192.71	1563.6
MINIMUM	-42.813	26.578	-2.9111	-7.4376E-06	-192.71	1563.6
Pile N.	3	4	2	1	4	4
MAXIMUM	143.18	34.107	2.8350	-7.4376E-06	181.94	2161.7
Pile N.	2	1	4	1	2	1

THE PILE COORDINATE SYSTEM (LOCAL AXES)

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
1	0.087337	1.4489	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
2	0.096298	1.1375	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
3	-0.029974	1.3640	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
4	-0.023458	1.1375	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
MINIMUM	-0.029974	1.1375	-0.1055	-4.7177E-03	-1.3576E-04	-2.8513E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.096298	1.4489	0.092675	-4.7177E-03	-1.3576E-04	-2.8513E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	AXIAL,KIP	LAT. y,KIP	LAT. z,KIP	MOM x,KIP-IN	MOM y,KIP-IN	MOM z,KIP-IN
1	129.91	34.107	-2.6147	-7.4376E-06	170.01	2161.7
2	143.18	28.681	-2.9111	-7.4376E-06	181.94	1711.1
3	-42.813	31.063	2.6909	-7.4376E-06	-187.02	1902.5
4	-33.567	26.578	2.8350	-7.4376E-06	-192.71	1563.6

```
      MINIMUM        -42.813       26.578      -2.9111  -7.4376E-06      -192.71       1563.6
      Pile N.          3             4            2           1            4             4
      MAXIMUM         143.18        34.107       2.8350  -7.4376E-06       181.94       2161.7
      Pile N.          2             1            4           1            2             1

     PILE GROUP   STRESS,KIP/IN**2
     **********  ****************
         1           54.313
         2           45.212
         3           44.104
         4           36.257

      MINIMUM         36.257
      Pile N.          4
      MAXIMUM         54.313
      Pile N.          1

      * EFFECTS FOR LATERALLY LOADED PILE *

      * MINIMUM VALUES AND LOCATIONS *

    PILE     DISPL.      DISPL.      MOMENT      MOMENT       SHEAR       SHEAR    SOIL REACT  SOIL REACT     TOTAL
  FLEX. RIG.  FLEX. RIG.
             y-DIR       z-DIR       z-DIR       y-DIR       y-DIR       z-DIR       y-DIR       z-DIR      STRESS
     z-DIR       y-DIR
              IN          IN        KIP-IN      KIP-IN        KIP         KIP       KIP/IN      KIP/IN
KIP/IN**2   KIP-IN**2   KIP-IN**2
    ******  **********  **********  **********  **********  **********  **********  **********  **********
**********  **********  **********
       1    -0.031055     -0.1055     -2161.7     -69.725     -11.511     -2.6147     -1.6757   -0.043023
1.9125  1.5738E+06  1.5738E+06
     x(FT)      17.270      0.0000      0.0000      10.676      14.130      0.0000      23.550      8.7920
31.400      24.492      24.492
       2    -0.025880     -0.1055     -1711.1     -72.131     -9.2544     -2.9111     -1.2144   -0.044523
2.1078  1.5738E+06  1.5738E+06
     x(FT)      16.956      0.0000      0.0000      10.362      13.816      0.0000      23.550      7.8500
31.400      24.492      24.492
       3    -0.025953 -1.8322E-03     -1902.5     -187.02     -9.3061     -0.6923     -1.6214     -0.1291
0.6303  1.5738E+06  1.5738E+06
     x(FT)      17.898      18.212      0.0000      0.0000      14.758      15.386      23.550      23.550
31.400      24.492      24.492
       4    -0.022578 -1.9012E-03     -1563.6     -192.71     -7.6997     -0.6899     -1.3058     -0.1268
0.4941  1.5738E+06  1.5738E+06
     x(FT)      17.584      17.898      0.0000      0.0000      14.758      15.072      23.550      23.550
31.400      24.492      24.492

     Min.   -0.031055     -0.1055     -2161.7     -192.71     -11.511     -2.9111     -1.6757     -0.1291
0.4941  1.5738E+06  1.5738E+06
  Pile N.       1           1           1           4           1           2           1           3           4
       1           1

      * MAXIMUM VALUES AND LOCATIONS *

    PILE     DISPL.      DISPL.      MOMENT      MOMENT       SHEAR       SHEAR    SOIL REACT  SOIL REACT     TOTAL
  FLEX. RIG.  FLEX. RIG.
             y-DIR       z-DIR       z-DIR       y-DIR       y-DIR       z-DIR       y-DIR       z-DIR      STRESS
     z-DIR       y-DIR
              IN          IN        KIP-IN      KIP-IN        KIP         KIP       KIP/IN      KIP/IN
KIP/IN**2   KIP-IN**2   KIP-IN**2
    ******  **********  **********  **********  **********  **********  **********  **********  **********
**********  **********  **********
       1       1.4489  2.2807E-03      943.51      170.01      34.107      0.8523      0.5677      0.1264
54.313  7.1204E+06  7.1204E+06
     x(FT)      0.0000      17.270      10.362      0.0000      0.0000      14.444      8.7920      23.550
0.0000      0.0000      0.0000
       2       1.1375  2.4325E-03      759.95      181.94      28.681      0.8802      0.4493      0.1202
45.212  7.1204E+06  7.1204E+06
     x(FT)      0.0000      16.956      10.048      0.0000      0.0000      14.130      7.8500      23.550
0.0000      0.0000      0.0000
```

```
        3       1.3640    0.093000      824.52      60.868      31.063      2.6909      0.4920    0.039603
44.104  7.1204E+06  7.1204E+06
     x(FT)      0.0000      0.3140      10.676      11.304      0.0000      0.0000      24.806      8.7920
0.0000      0.0000      0.0000
        4       1.1375    0.092994      690.26      61.323      26.578      2.8350      0.3980    0.039176
36.257  7.1204E+06  7.1204E+06
     x(FT)      0.0000      0.3140      10.362      10.990      0.0000      0.0000      24.806      8.7920
0.0000      0.0000      0.0000

      Max.      1.4489    0.093000      943.51      181.94      34.107      2.8350      0.5677      0.1264
54.313  7.1204E+06  7.1204E+06
   Pile N.       1           3           1           2           1           4           1           1           1
        1           1
```

LOAD CASE : 2
CASE NAME : Service I
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS
ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.9976	1.0000
3	0.8397	1.0000
4	0.8056	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD,KIPS	HOR. LOAD Y,KIPS	HOR. LOAD Z,KIPS
148.850	84.0700	0.00000

MOMENT X ,KIP-IN	MOMENT Y,KIP-IN	MOMENT Z,KIP-IN
0.00000	0.00000	0.00000

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0244781	0.73405	-1.93451E-03

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-2.43334E-03	-6.34102E-05	-1.79127E-03

* TABLE M * COMPUTATION ON INDIVIDUAL PILE

THE GLOBAL STRUCTURAL COORDINATE SYSTEM

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
1	0.060002	0.8144	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
2	0.064187	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
3	-0.014090	0.7705	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03

4	-0.011046	0.6538	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
MINIMUM	-0.014090	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.064187	0.8144	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	FOR. X,KIP	FOR. Y,KIP	FOR. Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
1	89.445	24.179	-1.6862	-3.8362E-06	99.244	1370.7
2	95.641	20.142	-1.8124	-3.8362E-06	103.44	1082.9
3	-20.277	21.490	1.7253	-3.8362E-06	-109.66	1205.2
4	-15.959	18.258	1.7733	-3.8362E-06	-111.05	989.02
MINIMUM	-20.277	18.258	-1.8124	-3.8362E-06	-111.05	989.02
Pile N.	3	4	2	1	4	4
MAXIMUM	95.641	24.179	1.7733	-3.8362E-06	103.44	1370.7
Pile N.	2	1	4	1	2	1

THE PILE COORDINATE SYSTEM (LOCAL AXES)

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
1	0.060002	0.8144	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
2	0.064187	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
3	-0.014090	0.7705	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
4	-0.011046	0.6538	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
MINIMUM	-0.014090	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.064187	0.8144	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	AXIAL,KIP	LAT. y,KIP	LAT. z,KIP	MOM x,KIP-IN	MOM y,KIP-IN	MOM z,KIP-IN
1	89.445	24.179	-1.6862	-3.8362E-06	99.244	1370.7
2	95.641	20.142	-1.8124	-3.8362E-06	103.44	1082.9
3	-20.277	21.490	1.7253	-3.8362E-06	-109.66	1205.2
4	-15.959	18.258	1.7733	-3.8362E-06	-111.05	989.02
MINIMUM	-20.277	18.258	-1.8124	-3.8362E-06	-111.05	989.02
Pile N.	3	4	2	1	4	4
MAXIMUM	95.641	24.179	1.7733	-3.8362E-06	103.44	1370.7
Pile N.	2	1	4	1	2	1

PILE GROUP	STRESS,KIP/IN**2
1	34.796
2	28.852
3	27.560
4	22.628
MINIMUM	22.628
Pile N.	4
MAXIMUM	34.796
Pile N.	1

* EFFECTS FOR LATERALLY LOADED PILE *

* MINIMUM VALUES AND LOCATIONS *

PILE	DISPL.	DISPL.	MOMENT	MOMENT	SHEAR	SHEAR	SOIL REACT	SOIL REACT	TOTAL
FLEX. RIG.	FLEX. RIG.								
	y-DIR	z-DIR	z-DIR	y-DIR	y-DIR	z-DIR	y-DIR	z-DIR	STRESS
z-DIR	y-DIR								
	IN	IN	KIP-IN	KIP-IN	KIP	KIP	KIP/IN	KIP/IN	
KIP/IN**2	KIP-IN**2	KIP-IN**2							
******	**********	**********	**********	**********	**********	**********	**********	**********	
**********	**********	**********							
1	-0.019085	-0.053035	-1370.7	-37.219	-6.7345	-1.6862	-0.8351	-0.023826	
1.3167	1.5738E+06	1.5738E+06							
x(FT)	16.642	0.0000	0.0000	10.048	13.502	0.0000	23.550	8.1640	
31.400	24.492	24.492							
2	-0.015725	-0.053035	-1082.9	-37.879	-5.4476	-1.8124	-0.6312	-0.025579	
1.4079	1.5738E+06	1.5738E+06							
x(FT)	16.642	0.0000	0.0000	9.7340	13.502	0.0000	23.550	8.4780	
31.400	24.492	24.492							
3	-0.016743	-1.1005E-03	-1205.2	-109.66	-5.5630	-0.3824	-0.8472	-0.063667	
0.2985	1.5738E+06	1.5738E+06							
x(FT)	17.270	17.584	0.0000	0.0000	14.130	14.444	23.550	23.550	
31.400	24.492	24.492							
4	-0.014390	-1.1107E-03	-989.02	-111.05	-4.6283	-0.3767	-0.7038	-0.063418	
0.2349	1.5738E+06	1.5738E+06							
x(FT)	17.270	17.584	0.0000	0.0000	14.130	14.444	23.550	23.550	
31.400	24.492	24.492							
Min.	-0.019085	-0.053035	-1370.7	-111.05	-6.7345	-1.8124	-0.8472	-0.063667	
0.2349	1.5738E+06	1.5738E+06							
Pile N.	1	1	1	4	1	2	3	3	4
1	1								

* MAXIMUM VALUES AND LOCATIONS *

PILE	DISPL.	DISPL.	MOMENT	MOMENT	SHEAR	SHEAR	SOIL REACT	SOIL REACT	TOTAL
FLEX. RIG.	FLEX. RIG.								
	y-DIR	z-DIR	z-DIR	y-DIR	y-DIR	z-DIR	y-DIR	z-DIR	STRESS
z-DIR	y-DIR								
	IN	IN	KIP-IN	KIP-IN	KIP	KIP	KIP/IN	KIP/IN	
KIP/IN**2	KIP-IN**2	KIP-IN**2							
******	**********	**********	**********	**********	**********	**********	**********	**********	
**********	**********	**********							
1	0.8144	1.2546E-03	561.81	99.244	24.179	0.4475	0.3458	0.057361	
34.796	7.1204E+06	7.1204E+06							
x(FT)	0.0000	16.956	9.7340	0.0000	0.0000	13.816	8.1640	23.550	
0.0000	0.0000	0.0000							
2	0.6538	1.2940E-03	455.56	103.44	20.142	0.4543	0.2879	0.055659	
28.852	7.1204E+06	7.1204E+06							
x(FT)	0.0000	16.642	9.4200	0.0000	0.0000	13.502	8.1640	23.550	
0.0000	0.0000	0.0000							
3	0.7705	0.049295	494.93	33.791	21.490	1.7253	0.2930	0.022950	
27.560	7.1204E+06	7.1204E+06							
x(FT)	0.0000	0.3140	10.048	10.362	0.0000	0.0000	8.4780	9.1060	
0.0000	0.0000	0.0000							
4	0.6538	0.049294	416.31	33.633	18.258	1.7733	0.2487	0.023638	
22.628	7.1204E+06	7.1204E+06							
x(FT)	0.0000	0.3140	9.7340	10.362	0.0000	0.0000	8.7920	9.1060	
0.0000	0.0000	0.0000							
Max.	0.8144	0.049295	561.81	103.44	24.179	1.7733	0.3458	0.057361	
34.796	7.1204E+06	7.1204E+06							
Pile N.	1	3	1	2	1	4	1	1	1
1	1								

LOAD CASE : 3
CASE NAME : Extreme II
LOAD TYPE : Dead, DL

REDUCTION FACTORS FOR CLOSELY-SPACED PILE GROUPS, COMBINED Y AND Z DIRECTIONS

ESTIMATED USING MOVEMENT IN THE DIRECTION OF PILE CAP DISPLACEMENTS

GROUP NO	P-FACTOR	Y-FACTOR
1	1.0000	1.0000
2	0.9976	1.0000
3	0.8397	1.0000
4	0.8057	1.0000

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

VERT. LOAD,KIPS	HOR. LOAD Y,KIPS	HOR. LOAD Z,KIPS
145.520	131.390	0.00000

MOMENT X ,KIP-IN	MOMENT Y,KIP-IN	MOMENT Z,KIP-IN
0.00000	0.00000	0.00000

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

VERTICAL ,IN	HORIZONTAL Y,IN	HORIZONTAL Z,IN
0.0225405	1.49383	-0.0121309

ANGLE ROT. X,RAD	ANGLE ROT. Y,RAD	ANGLE ROT. Z,RAD
-5.53055E-03	-2.18198E-04	-3.21024E-03

* TABLE M * COMPUTATION ON INDIVIDUAL PILE

THE GLOBAL STRUCTURAL COORDINATE SYSTEM

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
1	0.082755	1.6763	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
2	0.097156	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
3	-0.048148	1.5768	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
4	-0.037674	1.3113	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
MINIMUM	-0.048148	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.097156	1.6763	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	FOR. X,KIP	FOR. Y,KIP	FOR. Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
1	123.13	37.060	-2.8843	-8.7190E-06	189.04	2408.4
2	144.45	31.181	-3.2314	-8.7190E-06	203.87	1909.5
3	-68.371	34.022	2.9735	-8.7190E-06	-214.15	2119.9
4	-53.685	29.127	3.1422	-8.7190E-06	-221.26	1744.6
MINIMUM	-68.371	29.127	-3.2314	-8.7190E-06	-221.26	1744.6
Pile N.	3	4	2	1	4	4
MAXIMUM	144.45	37.060	3.1422	-8.7190E-06	203.87	2408.4
Pile N.	2	1	4	1	2	1

THE PILE COORDINATE SYSTEM (LOCAL AXES)

* PILE TOP DISPLACEMENTS *

PILE GROUP	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
1	0.082755	1.6763	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
2	0.097156	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
3	-0.048148	1.5768	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
4	-0.037674	1.3113	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
MINIMUM	-0.048148	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.097156	1.6763	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS *

PILE GROUP	AXIAL,KIP	LAT. y,KIP	LAT. z,KIP	MOM x,KIP-IN	MOM y,KIP-IN	MOM z,KIP-IN
1	123.13	37.060	-2.8843	-8.7190E-06	189.04	2408.4
2	144.45	31.181	-3.2314	-8.7190E-06	203.87	1909.5
3	-68.371	34.022	2.9735	-8.7190E-06	-214.15	2119.9
4	-53.685	29.127	3.1422	-8.7190E-06	-221.26	1744.6
MINIMUM	-68.371	29.127	-3.2314	-8.7190E-06	-221.26	1744.6
Pile N.	3	4	2	1	4	4
MAXIMUM	144.45	37.060	3.1422	-8.7190E-06	203.87	2408.4
Pile N.	2	1	4	1	2	1

PILE GROUP	STRESS,KIP/IN**2
1	59.371
2	49.648
3	50.245
4	41.326
MINIMUM	41.326
Pile N.	4
MAXIMUM	59.371
Pile N.	1

* EFFECTS FOR LATERALLY LOADED PILE *

* MINIMUM VALUES AND LOCATIONS *

	PILE FLEX. RIG. z-DIR	DISPL. FLEX. RIG. y-DIR	DISPL. z-DIR	MOMENT z-DIR	MOMENT y-DIR	SHEAR y-DIR	SHEAR z-DIR	SOIL REACT y-DIR	SOIL REACT z-DIR	TOTAL STRESS y-DIR
	IN	IN	KIP-IN	KIP-IN	KIP	KIP	KIP/IN	KIP/IN	KIP/IN**2	KIP-IN**2	KIP-IN**2
	******	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
1	-0.034318	-0.1283	-2408.4	-82.093	-13.035	-2.8843	-2.0047	-0.050426	1.8126	1.5738E+06	1.5738E+06
x(FT)	17.584	0.0000	0.0000	10.676	14.444	0.0000	23.550	24.806	31.400	24.492	24.492
2	-0.028959	-0.1283	-1909.5	-85.558	-10.507	-3.2314	-1.4443	-0.052235	2.1265	1.5738E+06	1.5738E+06
x(FT)	16.956	0.0000	0.0000	10.362	14.130	0.0000	23.550	8.1640	31.400	24.492	24.492
3	-0.028180	-1.9484E-03	-2119.9	-214.15	-10.473	-0.7730	-1.9087	-0.1509	1.0065	1.5738E+06	1.5738E+06
x(FT)	17.898	18.526	0.0000	0.0000	15.072	15.700	23.550	23.550	31.400	24.492	24.492
4	-0.024776	-2.0530E-03	-1744.6	-221.26	-8.6900	-0.7736	-1.5306	-0.1479			

```
0.7903  1.5738E+06  1.5738E+06
     x(FT)      17.898      18.212      0.0000      0.0000      14.758      15.386      23.550      23.550
31.400      24.492      24.492

      Min.   -0.034318     -0.1283     -2408.4     -221.26     -13.035     -3.2314     -2.0047     -0.1509
0.7903  1.5738E+06  1.5738E+06
   Pile N.       1           1           1           4           1           2           1           3           4
        1           1

       * MAXIMUM VALUES AND LOCATIONS *

     PILE     DISPL.      DISPL.      MOMENT      MOMENT       SHEAR       SHEAR    SOIL REACT  SOIL REACT     TOTAL
   FLEX. RIG.  FLEX. RIG.
             y-DIR       z-DIR       z-DIR       y-DIR       y-DIR       z-DIR       y-DIR       z-DIR      STRESS
      z-DIR       y-DIR
               IN          IN        KIP-IN      KIP-IN        KIP         KIP       KIP/IN      KIP/IN
KIP/IN**2   KIP-IN**2   KIP-IN**2
    ******  **********  **********  **********  **********  **********  **********  **********  **********
**********  **********  **********
       1       1.6763  2.6348E-03      1067.5      189.04      37.060      1.0028      0.6527      0.1552
59.371  7.1204E+06  7.1204E+06
     x(FT)      0.0000      17.584      10.676      0.0000      0.0000      14.444      24.806      23.550
0.0000      0.0000      0.0000
       2       1.3113  2.8568E-03      860.68      203.87      31.181      1.0459      0.5118      0.1471
49.648  7.1204E+06  7.1204E+06
     x(FT)      0.0000      17.270      10.362      0.0000      0.0000      14.130      8.1640      23.550
0.0000      0.0000      0.0000
       3       1.5768      0.1048      930.36      68.011      34.022      2.9735      0.5678    0.045152
50.245  7.1204E+06  7.1204E+06
     x(FT)      0.0000      0.6280      10.990      11.618      0.0000      0.0000      24.806      9.4200
0.0000      0.0000      0.0000
       4       1.3113      0.1048      780.36      68.778      29.127      3.1422      0.4590    0.044781
41.326  7.1204E+06  7.1204E+06
     x(FT)      0.0000      0.6280      10.676      11.304      0.0000      0.0000      24.806      8.7920
0.0000      0.0000      0.0000

      Max.      1.6763      0.1048      1067.5      203.87      37.060      3.1422      0.6527      0.1552
59.371  7.1204E+06  7.1204E+06
   Pile N.       1           3           1           2           1           4           1           1           1
        1           1



               *****     LOAD COMBINATIONS RESULTS      *****


     LOAD COMB. :     1
     COMB. NAME :  STRENGTH I
     NOTE: LOAD COMB WILL NOT BE ANALYZED



               *****     SUMMARY FOR LOAD CASES AND COMBINATIONS      *****


               *****     LOAD CASES RESULTS      *****

     LOAD CASE :     1

     * TABLE L *   COMPUTATION ON PILE CAP

     * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *
          LOAD X,KIP     LOAD Y,KIP     LOAD Z,KIP    MOM X,KIP-IN   MOM Y,KIP-IN   MOM Z,KIP-IN
              196.710        120.430        0.00000        0.00000        0.00000        0.00000

     * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *
```

```
      DISP X,IN      DISP Y,IN      DISP Z,IN      ROT X,RAD      ROT Y,RAD      ROT Z,RAD
       0.0319399        1.29323   -6.39748E-03   -4.71773E-03   -1.35763E-04   -2.85132E-03

  * TABLE M *   COMPUTATION ON INDIVIDUAL PILE

    * PILE TOP DISPLACEMENTS, GLOBAL *
                DISP. X,IN   DISP. Y,IN   DISP. Z,IN   ROT. X,RAD   ROT. Y,RAD   ROT. Z,RAD
               ***********  ***********  ***********  ***********  ***********  ***********
    MINIMUM      -0.029974       1.1375      -0.1055  -4.7177E-03  -1.3576E-04  -2.8513E-03
    Pile N.          3            2            1            1            1            1
    MAXIMUM       0.096298       1.4489     0.092675  -4.7177E-03  -1.3576E-04  -2.8513E-03
    Pile N.          2            1            3            1            1            1

    * PILE TOP REACTIONS, GLOBAL *
                FOR. X,KIP   FOR. Y,KIP   FOR. Z,KIP MOM X,KIP-IN MOM Y,KIP-IN MOM Z,KIP-IN
               ***********  ***********  ***********  ***********  ***********  ***********
    MINIMUM        -42.813       26.578      -2.9111  -7.4376E-06      -192.71       1563.6
    Pile N.          3            4            2            1            4            4
    MAXIMUM         143.18       34.107       2.8350  -7.4376E-06       181.94       2161.7
    Pile N.          2            1            4            1            2            1

    * PILE TOP DISPLACEMENTS, LOCAL *
                DISP. x,IN   DISP. y,IN   DISP. z,IN   ROT. x,RAD   ROT. y,RAD   ROT. z,RAD
               ***********  ***********  ***********  ***********  ***********  ***********
    MINIMUM      -0.029974       1.1375      -0.1055  -4.7177E-03  -1.3576E-04  -2.8513E-03
    Pile N.          3            2            1            1            1            1
    MAXIMUM       0.096298       1.4489     0.092675  -4.7177E-03  -1.3576E-04  -2.8513E-03
    Pile N.          2            1            3            1            1            1

    * PILE TOP REACTIONS, LOCAL *
                AXIAL,KIP    LAT. y,KIP   LAT. z,KIP MOM x,KIP-IN MOM y,KIP-IN MOM z,KIP-IN
               ***********  ***********  ***********  ***********  ***********  ***********
    MINIMUM        -42.813       26.578      -2.9111  -7.4376E-06      -192.71       1563.6
    Pile N.          3            4            2            1            4            4
    MAXIMUM         143.18       34.107       2.8350  -7.4376E-06       181.94       2161.7
    Pile N.          2            1            4            1            2            1

    * EFFECTS FOR LATERALLY LOADED PILE *

    PILE     DISPL.       DISPL.       MOMENT       MOMENT       SHEAR        SHEAR     SOIL REACT  SOIL REACT     TOTAL

              y-DIR        z-DIR        z-DIR        y-DIR        y-DIR        z-DIR        y-DIR        z-DIR      STRESS

                IN           IN         KIP-IN       KIP-IN         KIP          KIP        KIP/IN       KIP/IN
KIP/IN**2
    ******  **********  **********  **********  **********  **********  **********  **********  **********
**********
      Min.   -0.031055     -0.1055     -2161.7     -192.71     -11.511     -2.9111     -1.6757     -0.1291
0.4941
   Pile N.       1           1           1           4           1           2           1           3           4
      Max.      1.4489    0.093000      943.51      181.94      34.107      2.8350      0.5677      0.1264
54.313
   Pile N.       1           3           1           2           1           4           1           1           1

    LOAD CASE :     2

    * TABLE L *   COMPUTATION ON PILE CAP

    * EQUIVALENT CONCENTRATED LOAD AT ORIGIN *
         LOAD X,KIP     LOAD Y,KIP     LOAD Z,KIP    MOM X,KIP-IN   MOM Y,KIP-IN   MOM Z,KIP-IN
             148.850        84.0700        0.00000        0.00000        0.00000        0.00000

    * DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *
      DISP X,IN      DISP Y,IN      DISP Z,IN      ROT X,RAD      ROT Y,RAD      ROT Z,RAD
       0.0244781        0.73405   -1.93451E-03   -2.43334E-03   -6.34102E-05   -1.79127E-03

    * TABLE M *   COMPUTATION ON INDIVIDUAL PILE

      * PILE TOP DISPLACEMENTS, GLOBAL *
```

	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
MINIMUM	-0.014090	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.064187	0.8144	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS, GLOBAL *

	FOR. X,KIP	FOR. Y,KIP	FOR. Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
MINIMUM	-20.277	18.258	-1.8124	-3.8362E-06	-111.05	989.02
Pile N.	3	4	2	1	4	4
MAXIMUM	95.641	24.179	1.7733	-3.8362E-06	103.44	1370.7
Pile N.	2	1	4	1	2	1

* PILE TOP DISPLACEMENTS, LOCAL *

	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
MINIMUM	-0.014090	0.6538	-0.053035	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.064187	0.8144	0.049166	-2.4333E-03	-6.3410E-05	-1.7913E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS, LOCAL *

	AXIAL,KIP	LAT. y,KIP	LAT. z,KIP	MOM x,KIP-IN	MOM y,KIP-IN	MOM z,KIP-IN
MINIMUM	-20.277	18.258	-1.8124	-3.8362E-06	-111.05	989.02
Pile N.	3	4	2	1	4	4
MAXIMUM	95.641	24.179	1.7733	-3.8362E-06	103.44	1370.7
Pile N.	2	1	4	1	2	1

* EFFECTS FOR LATERALLY LOADED PILE *

PILE	DISPL. y-DIR	DISPL. z-DIR	MOMENT z-DIR	MOMENT y-DIR	SHEAR y-DIR	SHEAR z-DIR	SOIL REACT y-DIR	SOIL REACT z-DIR	TOTAL STRESS
	IN	IN	KIP-IN	KIP-IN	KIP	KIP	KIP/IN	KIP/IN	KIP/IN**2
******	**********	**********	**********	**********	**********	**********	**********	**********	**********
Min.	-0.019085	-0.053035	-1370.7	-111.05	-6.7345	-1.8124	-0.8472	-0.063667	0.2349
Pile N.	1	1	1	4	1	2	3	3	4
Max.	0.8144	0.049295	561.81	103.44	24.179	1.7733	0.3458	0.057361	34.796
Pile N.	1	3	1	2	1	4	1	1	1

LOAD CASE : 3

* TABLE L * COMPUTATION ON PILE CAP

* EQUIVALENT CONCENTRATED LOAD AT ORIGIN *

LOAD X,KIP	LOAD Y,KIP	LOAD Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
145.520	131.390	0.00000	0.00000	0.00000	0.00000

* DISPLACEMENT OF GROUPED PILE FOUNDATION AT ORIGIN *

DISP X,IN	DISP Y,IN	DISP Z,IN	ROT X,RAD	ROT Y,RAD	ROT Z,RAD
0.0225405	1.49383	-0.0121309	-5.53055E-03	-2.18198E-04	-3.21024E-03

* TABLE M * COMPUTATION ON INDIVIDUAL PILE

* PILE TOP DISPLACEMENTS, GLOBAL *

	DISP. X,IN	DISP. Y,IN	DISP. Z,IN	ROT. X,RAD	ROT. Y,RAD	ROT. Z,RAD
MINIMUM	-0.048148	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.097156	1.6763	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS, GLOBAL *

	FOR. X,KIP	FOR. Y,KIP	FOR. Z,KIP	MOM X,KIP-IN	MOM Y,KIP-IN	MOM Z,KIP-IN
MINIMUM	-68.371	29.127	-3.2314	-8.7190E-06	-221.26	1744.6
Pile N.	3	4	2	1	4	4
MAXIMUM	144.45	37.060	3.1422	-8.7190E-06	203.87	2408.4
Pile N.	2	1	4	1	2	1

* PILE TOP DISPLACEMENTS, LOCAL *

	DISP. x,IN	DISP. y,IN	DISP. z,IN	ROT. x,RAD	ROT. y,RAD	ROT. z,RAD
MINIMUM	-0.048148	1.3113	-0.1283	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	3	2	1	1	1	1
MAXIMUM	0.097156	1.6763	0.1040	-5.5306E-03	-2.1820E-04	-3.2102E-03
Pile N.	2	1	3	1	1	1

* PILE TOP REACTIONS, LOCAL *

	AXIAL,KIP	LAT. y,KIP	LAT. z,KIP	MOM x,KIP-IN	MOM y,KIP-IN	MOM z,KIP-IN
MINIMUM	-68.371	29.127	-3.2314	-8.7190E-06	-221.26	1744.6
Pile N.	3	4	2	1	4	4
MAXIMUM	144.45	37.060	3.1422	-8.7190E-06	203.87	2408.4
Pile N.	2	1	4	1	2	1

* EFFECTS FOR LATERALLY LOADED PILE *

PILE	DISPL. y-DIR	DISPL. z-DIR	MOMENT z-DIR	MOMENT y-DIR	SHEAR y-DIR	SHEAR z-DIR	SOIL REACT y-DIR	SOIL REACT z-DIR	TOTAL STRESS
	IN	IN	KIP-IN	KIP-IN	KIP	KIP	KIP/IN	KIP/IN	KIP/IN**2
******	**********	**********	**********	**********	**********	**********	**********	**********	**********
Min.	-0.034318	-0.1283	-2408.4	-221.26	-13.035	-3.2314	-2.0047	-0.1509	0.7903
Pile N.	1	1	1	4	1	2	1	3	4
Max.	1.6763	0.1048	1067.5	203.87	37.060	3.1422	0.6527	0.1552	59.371
Pile N.	1	3	1	2	1	4	1	1	1

***** LOAD COMBINATIONS RESULTS *****

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Summary of Micropile Resistance	Checked by:	JG	Date:	11/2025

Summary of Micropile Resistance - Temporary Pedestrian Bridge

Based on BB-1,

Steel Casing: 10.75 in. O.D. x 0.595 in., Fy = 52 ksi, Wall Thickness = 0.595 in.

Steel Reinforcing Bar: #14, Threaded, Grade 60

Compressive strength of micropile grout at 28 days: f'c = 5 ksi

Rock Socket Diameter = 9.3 in.

Design Factored Axial Load per Pile	= 60.0 kips	
Estimated Bonded Length into Rock (Grout into Rock)	= 2.0 ft.	
Plunge Length (Casing into Rock)	= 1.0 ft.	
Nominal Geotechnical Pile Resistance per Pile	= 140 kips	
Side Resistance Factor, φ_{stat}	= 0.55	
Factored Geotechnical Pile Resistance per Pile	= 77 kips	> 60 k OK
Nominal Uplift Resistance per Pile	= 70 kips	
Resistance Factor, φ_{up}	= 0.55	
Factored Uplift Resistance per Pile	= 39 kips	
Nominal Structural Pile Resistance per Pile	= 1097 k	(Portion of Cased Length)
Nominal Structural Pile Resistance per Pile	= 352 k	(Portion of Uncased Length)
Compression Resistance Factor, φ_C	= 0.75	
Factored Structural Pile Resistance per Pile	= 823 k	(Portion of Cased Length)
Factored Structural Pile Resistance per Pile	= 264 k	(Portion of Uncased Length)

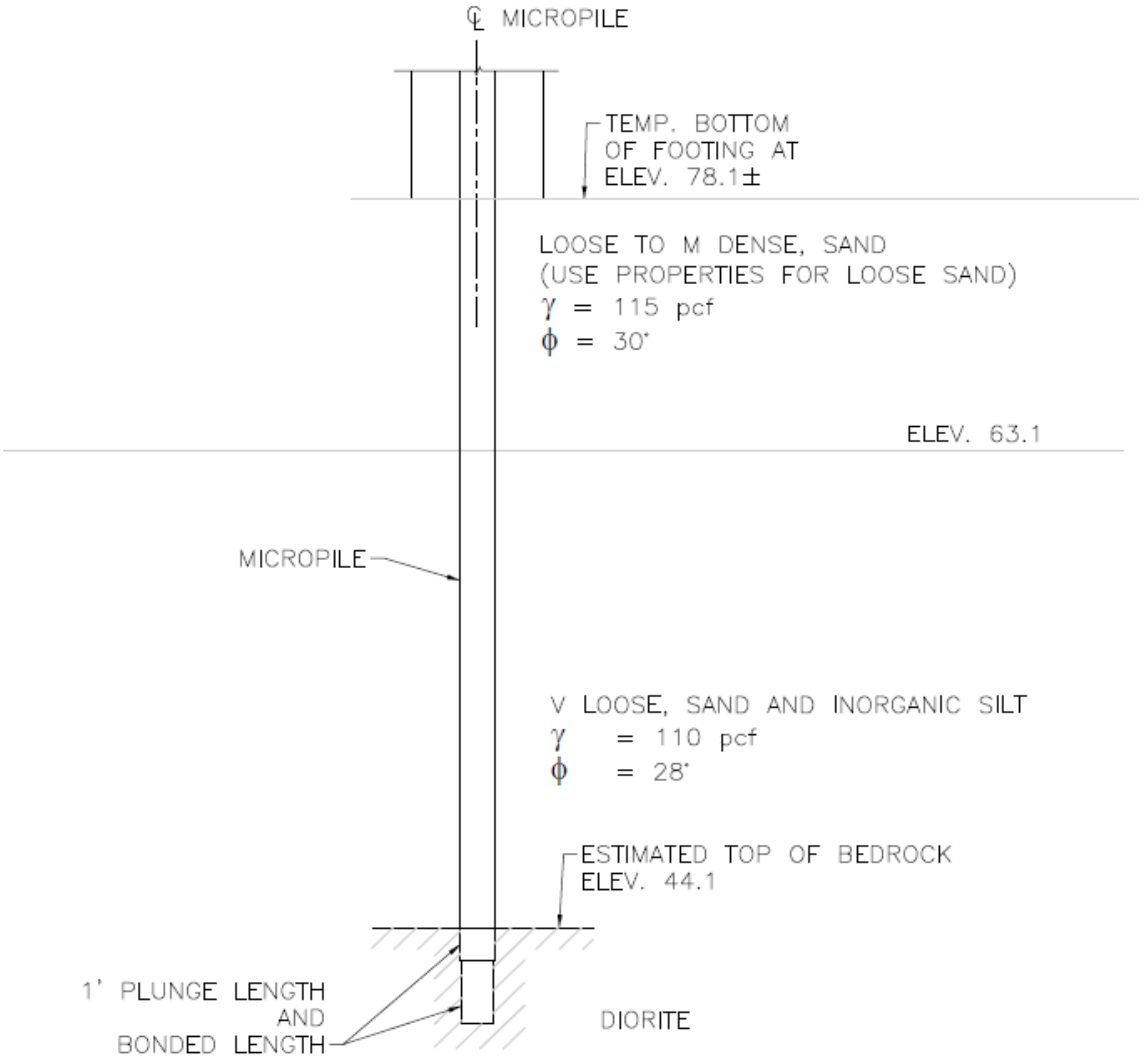
LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Summary of Micropile Resistance	Checked by:	JG	Date:	11/2025

Summary of Micropile Resistance - Temporary Pedestrian Bridge

Nominal Tension Resistance	= 995 k	(Portion of Cased Length)
Nominal Tension Resistance	= 135 k	(Portion of Uncased Length)
Tension Resistance Factor, φ_T	= 0.80	
Factored Tension Resistance	= 796 k	(Portion of Cased Length)
Factored Tension Resistance	= 108 k	(Portion of Uncased Length)

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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	7/2025
Detail:	Micropile Section	Checked by:	JG	Date:	7/2025

Micropile Section
(Based on controlling boring BB-1)



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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	7/2025
Detail:	Lateral Earth Pressure Coefficient	Checked by:	JG	Date:	7/2025

Lateral Earth Pressure Coefficient

Effective angle of internal friction ϕ'_f	=	32	degree
Friction angle between fill and wall, δ	=	21	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	90	degree

Active pressure coefficient, K_a

$$= \frac{\sin^2(\theta+\phi'_f)}{\sin^2\theta \sin(\theta-\delta)\left[1+\sqrt{\frac{\sin(\phi'_f+\delta)\sin(\phi'_f-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2}$$

$$= 0.275$$

At-rest pressure coefficient, K_o

$$= 1 - \sin\phi'_f = 1 - \sin(32)$$

$$= 0.470$$

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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

Axial Compression Resistance

Based on Boring BB-1 $O.D.$ = 10.75 in. t_{wall} = 0.595 in.

R_R = Factored Resistance of a micropile

= φR_n = $\varphi_{qp} R_p + \varphi_{qs} R_s$

in which:

R_p = $q_p A_p$ (tip resistance is neglected)

R_s = $q_s A_s$

where:

R_p = nominal tip resistance
(Per AASHTO C10.9.3.5.1, tip resistance is neglected for conservative)

R_s = nominal grout to ground bond resistance

φ_{qp} = resistance factor for tip resistance (AASHTO 10.5.5.2.5-1)
(tip resistance is neglected)

φ_{qs} = resistance factor for grout-to-ground resistance (AASHTO 10.5.5.2.5-1)
= 0.55

d_p = diameter of micropile tip
= 9.300 in.

A_p = area of micropile tip = $\pi D^2/4$
= 67.93 $in.^2$ = 0.47 ft^2

R_s = $\pi d_b \alpha_b L_b$

in which:

d_b = diameter of micropile drill hole through bonded length
= 9.300 in. = 0.78 ft

α_b = nominal micropile grout-to-ground bond strength

= 28.8 ksf Based on slightly fractured, hard, diorite from Boring BB-1
(AASHTO Table C10.9.3.5.2 - 1)

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Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

L_b = micropile bonded length

= 2 ft into Rock

$\varphi_{qs} R_s$ = 0.55 x 3.141 x 0.78 x [28.8 x 2]

= 77.1 kips

R_n = 77.13 / 0.55 = 140 kips

R_R = 77 kips

Uplift Resistance

Uplift Resistance = 50 % of the compression resistance

= 0.5 x 77.1 = 39 kips

φ_{up} = resistance factor

= 0.55 (AASHTO 10.5.5.2.5-1)

Nominal Resistance = 38.6 / 0.55 = 70 kips

Structural Resistance

Axial Compression Resistance

R_C = Factored Structural Resistance of a micropile

= $\varphi_c R_n$

in which:

φ_C = compression resistance factor

= 0.75 (AASHTO 10.5.5.2.5-2)

R_n = Nominal axial compression resistance

- For the cased length

F_y = 52 ksi

f_y = 60 ksi

R_n = 0.85 [0.85 f'_c A_g + f_y (A_b + A'_c)]

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

where:

f'_c = specified compressive strength of micropile grout at 28 days

= 5.0 ksi

f_y = specified minimum yield strength of reinforcement bar or steel casing, or stress in steel reinforcement bar or casing at a strain of 0.003, whichever is less

Min. (F_y , f_y) = 52.0 ksi

d_b = 1.69 in. #14 threaded bar

A_b = cross-section area of steel reinforcing bar

= 2.25 $in.^2$

A_c = cross-section area of steel casing

= 18.98 $in.^2$

A'_c = cross-section area of steel casing with 1/16" section loss on outside of the casing

= 16.88 $in.^2$ Section loss = 0.063 in.

A_g = cross-section area of grout within micropile

= $A_{ID} - A_b$ = 71.78 - 2.25

= 69.53 $in.^2$

R_n = 0.85 x [0.85 x 5 x 69.53 + 52 x (2.25 + 16.88)]

= 1096.9 kips

R_{CC} = 0.75 x 1096.9 = 823 kips

- For the uncased length

R_n = 0.85 [0.85 f'_c A'_g + f_y A_b]

f_y = specified minimum yield strength of reinforcement bar or stress in steel reinforcement bar at a strain of 0.003, whichever is less

= 60.0 ksi

= 60 ksi

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	Micropile Vertical Resistance	Checked by:	JG	Date:	11/2025

A'_g = cross-section area of grout for the uncased length

= $A_p - A_b$ = 67.93 - 2.25

= 65.68 $in.^2$

R_n = 0.85 x [0.85 x 5 x 65.68 + 60 x 2.25]

= 352.1 kips

R_{CU} = 0.75 x 352.1 = **264 kips**

Axial Tension Resistance

R_T = factored Structural Resistance of a micropile

= $\varphi_T R_n$

in which:

φ_T = tension resistance factor

= 0.80 (AASHTO 10.5.5.2.5-2)

R_n = nominal axial tension resistance

- For the cased length

R_n = $f_y (A_b + A'_c)]$

= 52 x (2.25 + 16.88) = 995.0 kips

R_{TC} = 0.8 x 995 = **796 kips**

- For the uncased length

R_n = $f_y A_b$

= 60 x 2.25 = 135.1 kips

R_{TU} = 0.8 x 135.1 = **108 kips**

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	**Job No:**		**Preliminary Sheet No:**	
Subject:	10.75 dia.Micropile - Temp Bridge	**Prepared by:**	JJL	**Date:**	11/2025
Detail:	Micropile Vertical Resistance	**Checked by:**	JG	**Date:**	11/2025

Soil/Rock Description	Typical Range of Grout-to-Ground Bond Nominal Resistance for Micropile Types[1] (ksf)				
	Type A	Type B	Type C	Type D	Type E
Silt & Clay (some sand) (soft medium plastic)	0.7–1.4	0.7–2.0	0.7–2.5	0.7–3.0	0.7–2.0
Silt & Clay (some sand) (stiff, dense to very dense)	0.7–2.5	1.4–4.0	2.0–4.0	2.0–4.0	1.4–4.0
Sand (some silt) (fine, loose-medium dense)	1.4–3.0	1.4–4.0	2.0–4.0	2.0–5.0	1.4–5.0
Sand (some silt, gravel) (fine-coarse, medium-very dense)	2.0–4.5	2.5–7.5	3.0–7.5	3.0–8.0	2.5–7.5
Gravel (some sand) (medium-very dense)	2.0–5.5	2.5–7.5	3.0–7.5	3.0–8.0	2.5–7.5
Glacial Till (silt, sand, gravel) (medium-very dense, cemented)	2.0–4.0	2.0–6.5	2.5–6.5	2.5–7.0	2.0–6.5
Soft Shales (fresh-moderate fracturing, little to no weathering)	4.3–11.5	N/A	N/A	N/A	N/A
Slates and Hard Shales (fresh-moderate fracturing, little to no weathering)	10.8–28.8	N/A	N/A	N/A	N/A
Limestone (fresh-moderate fracturing, little to no weathering)	21.6–43.2	N/A	N/A	N/A	N/A
Sandstone (fresh-moderate fracturing, little to no weathering)	10.8–36.0	N/A	N/A	N/A	N/A
Granite and Basalt (fresh-moderate fracturing, little to no weathering)	28.8–87.7	N/A	N/A	N/A	N/A

Based on Boring BB-1, the rock core is slightly fractured, hard, diorite. Geologically, diorite is between a grabbro and a granite. Use the lower bond value for granite and basalt bond resistance of 28.8 ksf for conservative. The micropile resistance will be verified by load tests.

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

A_{sc}: compression area of steel tube A_{bc}: compression area of reinforcement if present
A_{cc}: compression area of concrete infill A_{st}: tension area of steel tube, A_{bt}: tension area of reinforcement

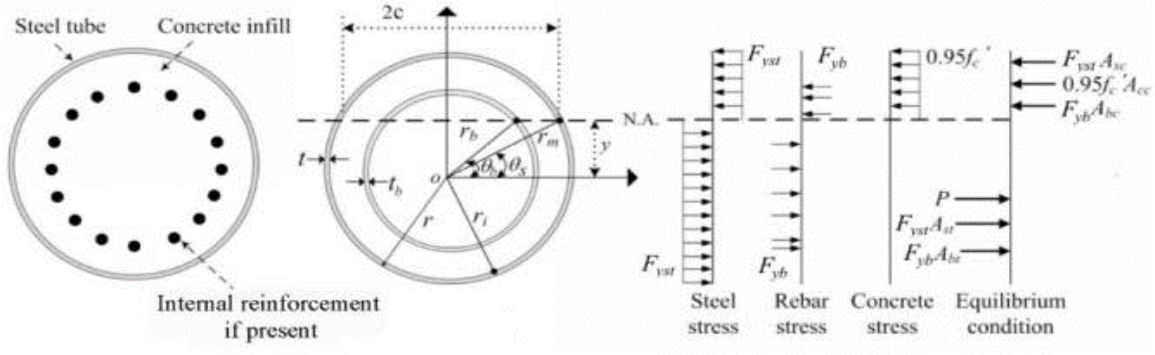


Figure C6.12.2.3.3-1—PSDM Model

$$P_n = F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] + t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95 f'_c)(\pi + 2\theta_b) \right] + \frac{0.95 f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right] \quad \text{(C6.12.2.3.3-1)}$$

$$M_n = 0.95 f'_c c \left[\left(r_i^2 - y^2 \right) - \frac{c^2}{3} \right] + 4 F_{yst} t c \frac{r_m^2}{r_i} + 4 F_{yb} t_b c_b r_b \quad \text{(C6.12.2.3.3-2)}$$

in which:

$$r_m = r - \frac{t}{2} \quad \text{(C6.12.2.3.3-3)}$$

$$\theta_s = \sin^{-1}\left(\frac{y}{r_m} \right) \quad \text{(C6.12.2.3.3-4)}$$

$$\theta_b = \sin^{-1}\left(\frac{y}{r_b} \right) \quad \text{(C6.12.2.3.3-5)}$$

$$c = r_i \cos\theta_s \quad \text{(C6.12.2.3.3-6)}$$

$$c_b = r_b \cos\theta_b \quad \text{(C6.12.2.3.3-7)}$$

$$t_b = \frac{n A_b}{2\pi r_b} \quad \text{(C6.12.2.3.3-8)}$$

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

Steel Pipe with 1/16" loss

Yield Strength, F_{yst} =	52.00	ksi				
Strength of Concrete, f'_c =	5.00	ksi				
Resistance factor for CFST in compression, ϕ_c =	0.90	(AASHTO 6.5.4.2)				
Yield Strength, F_{yb} =	60.00	ksi				
(AASHTO 6.9.6.2 Limitations) D/t =	20.0	<	0.15 E / F_{yst} =	83.7		**OK**
Concrete shall be greater than 3 ksi or 0.075 F_{yst} =	3.9	ksi	<	5.00	ksi	**OK**

A_s =	2.25	in^2	Cover =	3.93	in.
r =	5.313	in.	D =	10.63	in.
r_m =	5.046	in.	t =	0.53	in.
r_i =	4.780	in.			
r_b =	0.423	in.			
Number of reinforcing bars, n =	1.0				
t_b = n A_s / (2 π r_b) =	0.376	in.			

Temp Abutment

Strength V

				Factored Moment Capacity =	236.0	k-ft	
Factored Moment =	54.4	k-ft	from Lpile	Factored Lateral Resistance =	41.8	k	from Lpile
Factored Axial Load =	60.0	k	from Green	Factored Lateral Load =	12.0	k	from Green

Service I

Factored Moment =	44.2	k-ft	from Lpile	Service Lateral Resistance =	31.9	k	from Lpile
Factored Axial Load =	46.0	k	from Green	Unfactored Lateral Load =	10.0	k	from Green

Extreme I

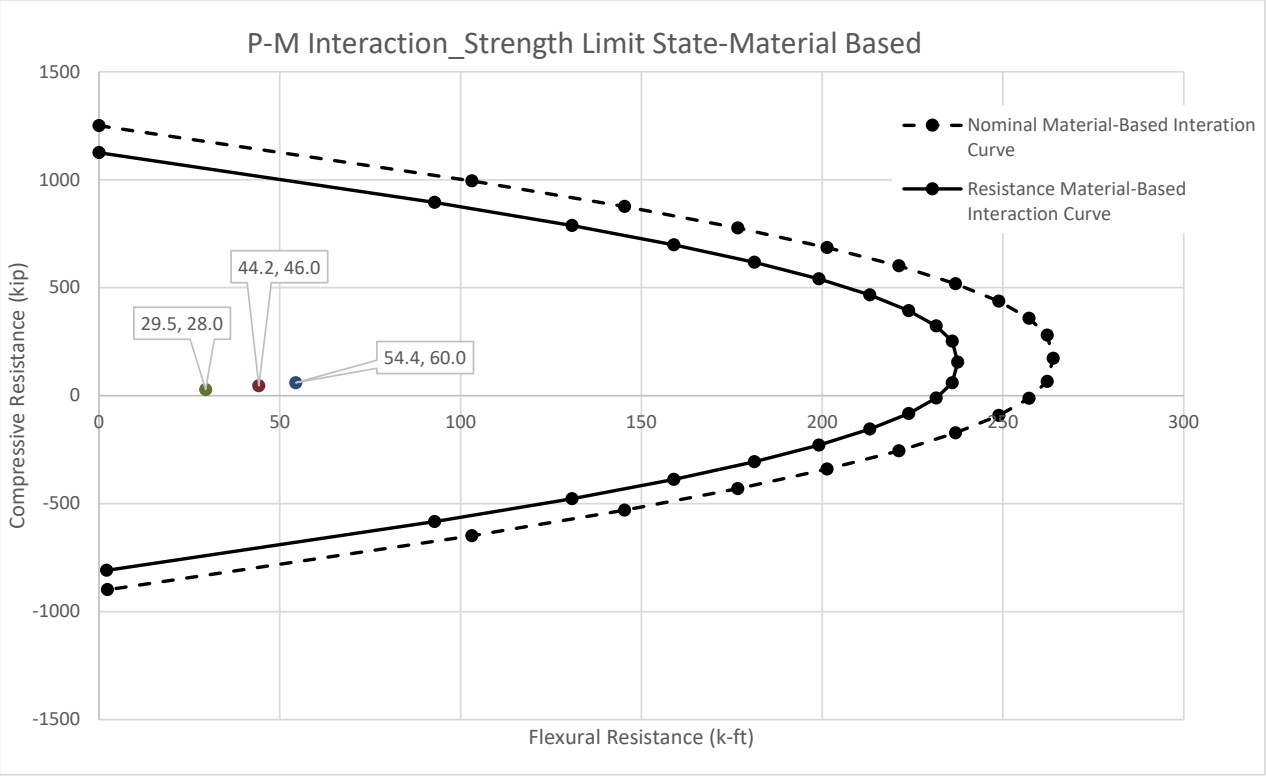
				Factored Moment Capacity =	263.0	k-ft	
Factored Moment =	29.5	k-ft	from Lpile	Factored Lateral Resistance =	46.0	k	from Lpile
Factored Axial Load =	28.0	k	from Green	Factored Lateral Load =	7.0	k	from Green

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength	Checked by:	JG	Date:	11/2025

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2\,\theta_s$	$\pi + 2\,\theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c\, M_n$ (kips-ft)	$\phi_c\ P_n$ (kips)
-5.05	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	1250.10	0.00	1125.09
-4.54	-1.12	-1.57	2.08	0.00	5.38	0.90	103.09	994.01	92.78	894.61
-4.04	-0.93	-1.57	2.87	0.00	5.00	1.29	145.35	875.59	130.81	788.03
-3.53	-0.78	-1.57	3.41	0.00	4.69	1.59	176.62	776.48	158.95	698.83
-3.03	-0.64	-1.57	3.82	0.00	4.43	1.85	201.36	686.17	181.23	617.55
-2.52	-0.52	-1.57	4.14	0.00	4.19	2.09	221.20	600.76	199.08	540.68
-2.02	-0.41	-1.57	4.38	0.00	3.96	2.32	236.88	518.34	213.19	466.50
-1.51	-0.30	-1.57	4.56	0.00	3.75	2.53	248.81	437.82	223.93	394.04
-1.01	-0.20	-1.57	4.68	0.00	3.54	2.74	257.20	358.51	231.48	322.66
-0.50	-0.10	-1.57	4.76	0.00	3.34	2.94	262.20	279.92	235.98	251.93
0.00	0.00	0.00	4.78	0.42	3.14	3.14	263.86	172.85	237.47	155.57
0.50	0.10	1.57	4.76	0.00	2.94	3.34	262.20	65.78	235.98	59.21
1.01	0.20	1.57	4.68	0.00	2.74	3.54	257.20	-12.81	231.48	-11.53
1.51	0.30	1.57	4.56	0.00	2.53	3.75	248.81	-92.12	223.93	-82.90
2.02	0.41	1.57	4.38	0.00	2.32	3.96	236.88	-172.63	213.19	-155.37
2.52	0.52	1.57	4.14	0.00	2.09	4.19	221.20	-255.05	199.08	-229.54
3.03	0.64	1.57	3.82	0.00	1.85	4.43	201.36	-340.46	181.23	-306.42
3.53	0.78	1.57	3.41	0.00	1.59	4.69	176.62	-430.78	158.95	-387.70
4.04	0.93	1.57	2.87	0.00	1.29	5.00	145.35	-529.88	130.81	-476.89
4.54	1.12	1.57	2.08	0.00	0.90	5.38	103.09	-648.30	92.78	-583.47
5.05	1.56	1.57	0.05	0.00	0.02	6.26	2.30	-898.86	2.07	-808.98

Steel Pipe with 1/16" loss



LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

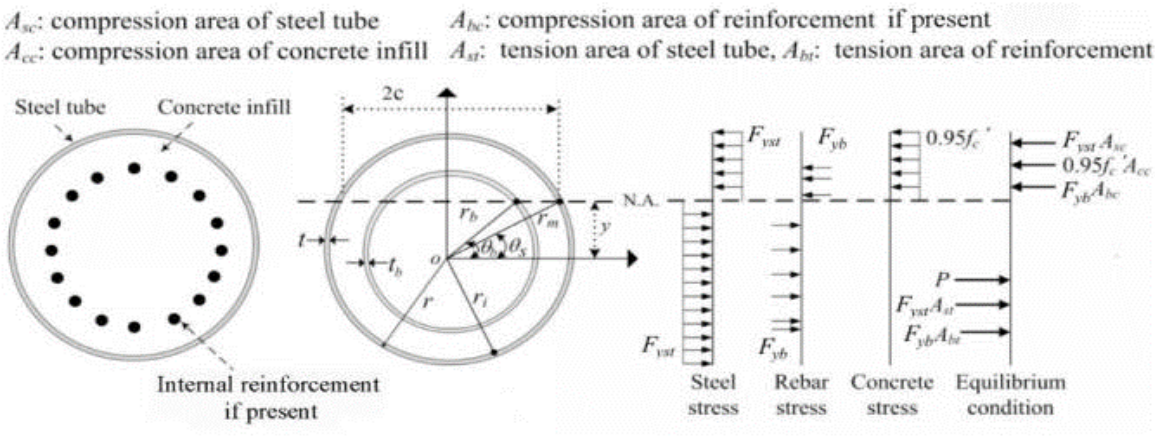


Figure C6.12.2.3.3-1—PSDM Model

$$P_n = F_{yst} t r_m \left[(\pi - 2\theta_s) - (\pi + 2\theta_s) \right] + t_b r_b \left[F_{yb} (\pi - 2\theta_b) - (F_{yb} - 0.95 f'_c)(\pi + 2\theta_b) \right] + \frac{0.95 f'_c}{2} \left[(\pi - 2\theta_s) r_i^2 - 2yc \right] \quad \text{(C6.12.2.3.3-1)}$$

$$M_n = 0.95 f'_c c \left[\left(r_i^2 - y^2 \right) - \frac{c^2}{3} \right] + 4 F_{yst} t c \frac{r_m^2}{r_i} + 4 F_{yb} t_b c_b r_b \quad \text{(C6.12.2.3.3-2)}$$

in which:

$$r_m = r - \frac{t}{2} \quad \text{(C6.12.2.3.3-3)}$$

$$\theta_s = \sin^{-1}\left(\frac{y}{r_m} \right) \quad \text{(C6.12.2.3.3-4)}$$

$$\theta_b = \sin^{-1}\left(\frac{y}{r_b} \right) \quad \text{(C6.12.2.3.3-5)}$$

$$c = r_i \cos\theta_s \quad \text{(C6.12.2.3.3-6)}$$

$$c_b = r_b \cos\theta_b \quad \text{(C6.12.2.3.3-7)}$$

$$t_b = \frac{n A_b}{2\pi r_b} \quad \text{(C6.12.2.3.3-8)}$$

LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

Steel Pipe at Threaded Casing Joint (Consider wall thickness reduced to 50%)

Yield Strength, F_{yst} =	52.00	ksi				
Strength of Concrete, f'_c =	5.00	ksi				
Resistance factor for CFST in compression, ϕ_c =	0.90	(AASHTO 6.5.4.2)				
Yield Strength, F_{yb} =	60.00	ksi				
(AASHTO 6.9.6.2 Limitations) D/t =	35.7	<	0.15 E / F_{yst} =	83.7		**OK**
Concrete shall be greater than 3 ksi or 0.075 F_{yst} =	3.9	ksi	<	5.00	ksi	**OK**

A_s =	2.25	in^2	Cover =	3.934	in.
r =	5.078	in.	D =	10.155	in.
r_m =	4.929	in.	t =	0.298	in.
r_i =	4.780	in.			
r_b =	0.000	in.	Internal reinforcement is not considered.		
Number of reinforcing bars, n =	1.0				
t_b = n A_s / (2 π r_b) =	0	in.			

Temp Abutment

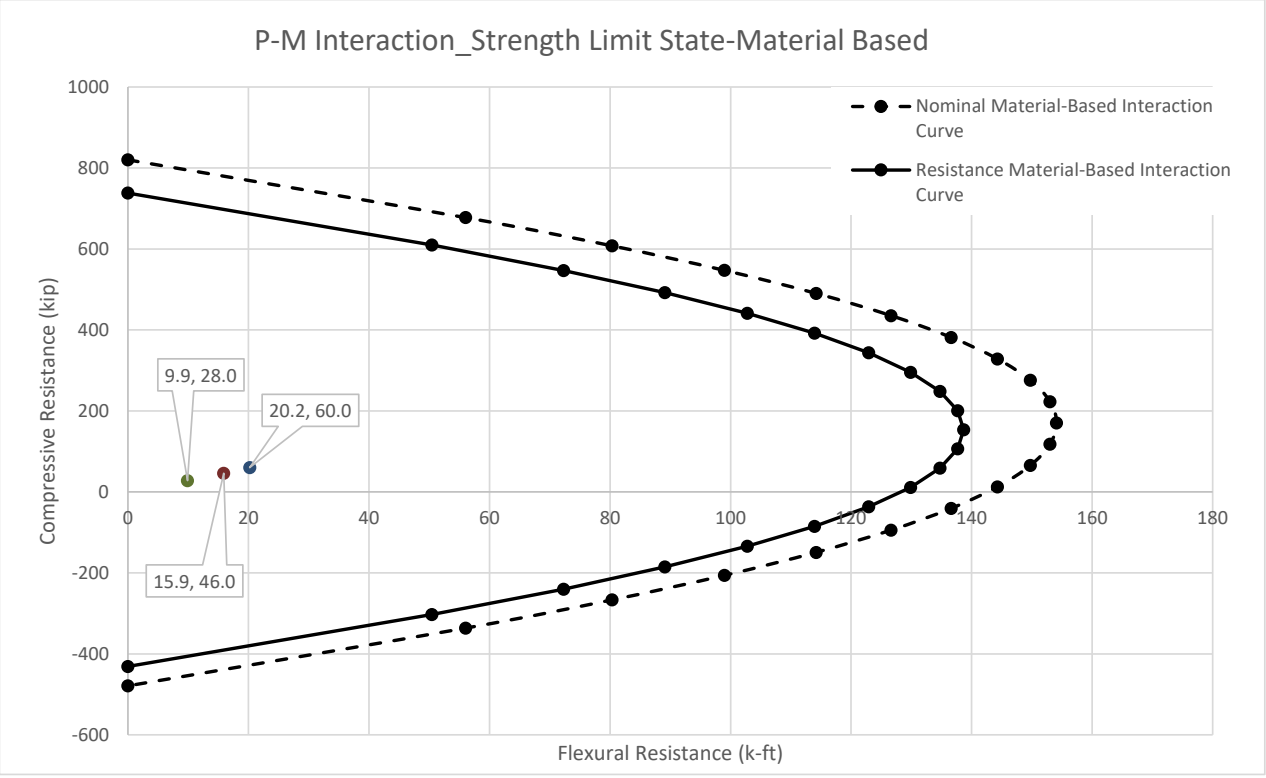
Strength V							
Factored Moment =	20.2	k-ft	from Lpile (at depth of 3')				
Factored Axial Load =	60.0	k	from Green	Factored Lateral Load =	12.0	k	from Green
Service I							
Factored Moment =	15.9	k-ft	from Lpile (at depth of 3')				
Factored Axial Load =	46.0	k	from Green	Factored Lateral Load =	10.0	k	from Green
Extreme I							
Factored Moment =	9.9	k-ft	from Lpile (at depth of 3')				
Factored Axial Load =	28.0	k	from Green	Factored Lateral Load =	7.0	k	from Green

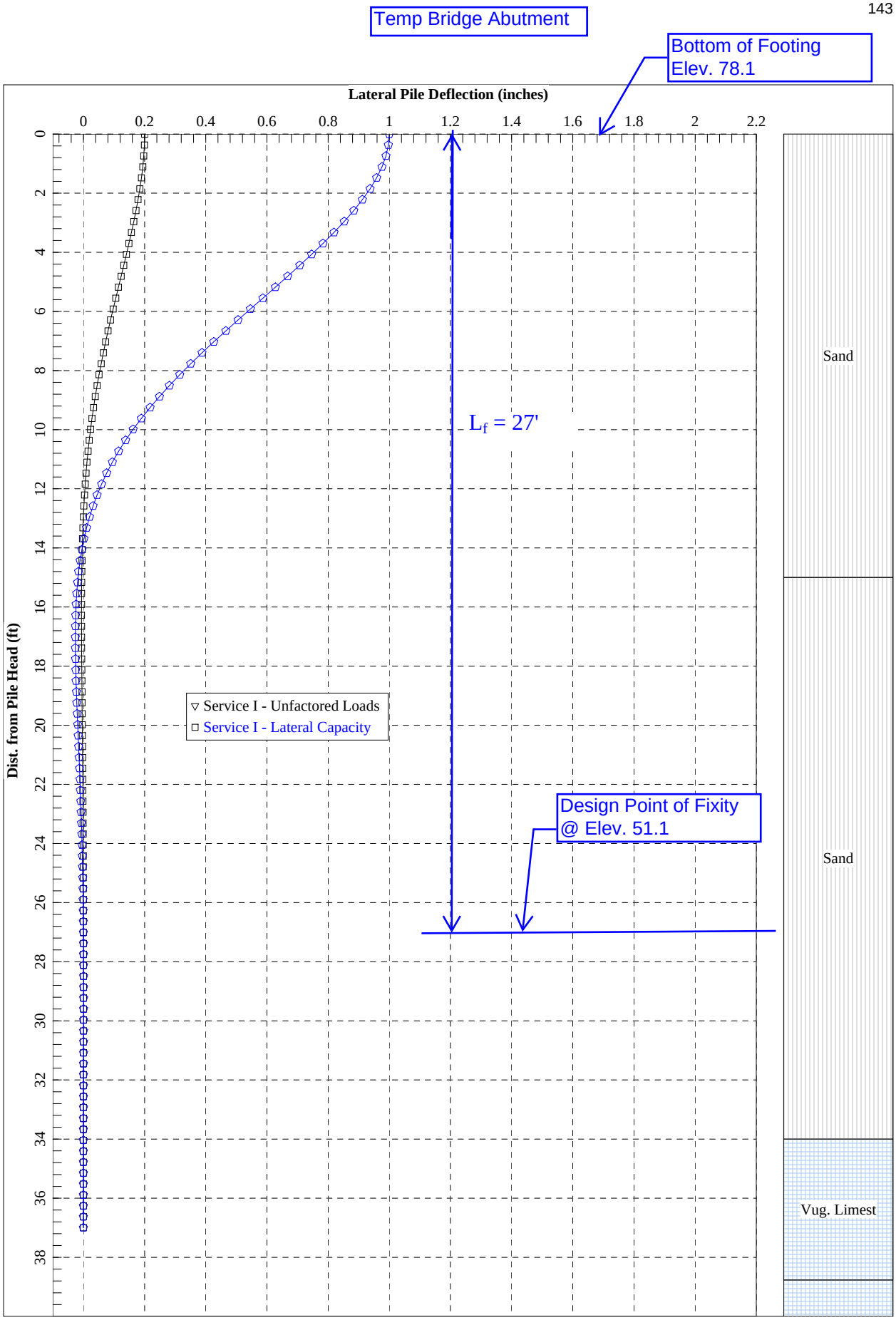
LAMSON ENGINEERING CORPORATION				Final Page No:	
Project:	Bridge W-38-011, Wilmington	Job No:		Preliminary Sheet No:	
Subject:	10.75 dia.Micropile - Temp Bridge	Prepared by:	JJL	Date:	11/2025
Detail:	P-M Strength at Threaded Casing Joint	Checked by:	JG	Date:	11/2025

Composite Concrete-Filled Steel Tubes (CFSTs) (AASHTO LRFD 6.12.2.3.3)

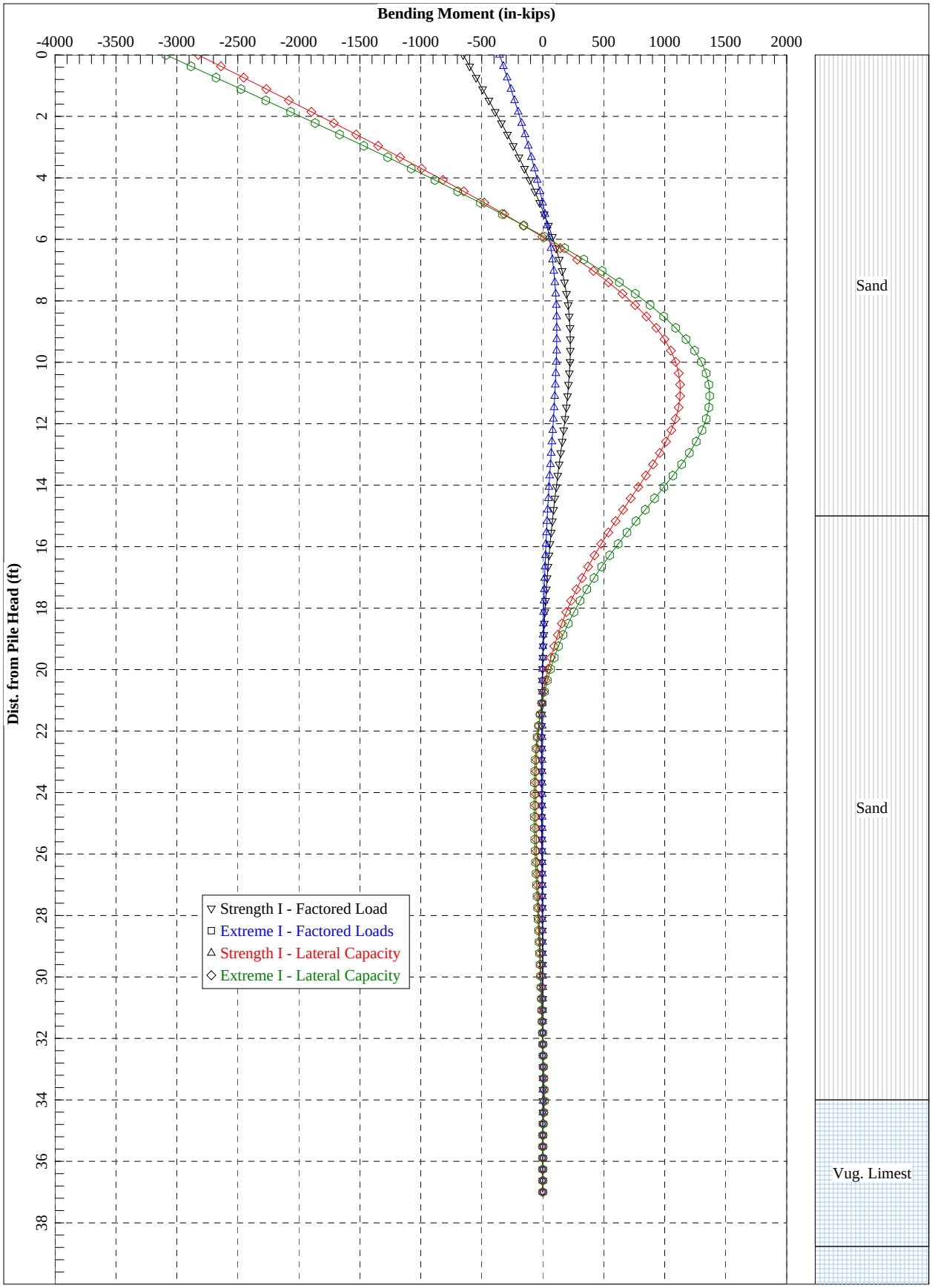
y (in.)	θ_s (rad)	θ_b (rad)	$c = r_i \cos \theta_b$	$c_b = r_b \cos \theta_b$	$\pi - 2\,\theta_s$	$\pi + 2\,\theta_s$	M_n (kips-ft)	P_n (kips)	$\phi_c\, M_n$ (kips-ft)	$\phi_c\ P_n$ (kips)
-4.93	-1.57	-1.57	0.00	0.00	6.28	0.00	0.00	820.04	0.00	738.03
-4.44	-1.12	-1.57	2.08	0.00	5.38	0.90	56.03	677.43	50.42	609.69
-3.94	-0.93	-1.57	2.87	0.00	5.00	1.29	80.34	607.65	72.30	546.88
-3.45	-0.78	-1.57	3.41	0.00	4.69	1.59	99.00	547.06	89.10	492.36
-2.96	-0.64	-1.57	3.82	0.00	4.43	1.85	114.18	490.30	102.77	441.27
-2.46	-0.52	-1.57	4.14	0.00	4.19	2.09	126.61	435.45	113.95	391.91
-1.97	-0.41	-1.57	4.38	0.00	3.96	2.32	136.60	381.68	122.94	343.51
-1.48	-0.30	-1.57	4.56	0.00	3.75	2.53	144.28	328.50	129.85	295.65
-0.99	-0.20	-1.57	4.68	0.00	3.54	2.74	149.74	275.67	134.77	248.11
-0.49	-0.10	-1.57	4.76	0.00	3.34	2.94	153.00	223.03	137.70	200.73
0.00	0.00	1.57	4.78	0.00	3.14	3.14	154.09	170.48	138.68	153.43
0.49	0.10	1.57	4.76	0.00	2.94	3.34	153.00	117.92	137.70	106.13
0.99	0.20	1.57	4.68	0.00	2.74	3.54	149.74	65.28	134.77	58.76
1.48	0.30	1.57	4.56	0.00	2.53	3.75	144.28	12.46	129.85	11.21
1.97	0.41	1.57	4.38	0.00	2.32	3.96	136.60	-40.72	122.94	-36.65
2.46	0.52	1.57	4.14	0.00	2.09	4.19	126.61	-94.50	113.95	-85.05
2.96	0.64	1.57	3.82	0.00	1.85	4.43	114.18	-149.34	102.77	-134.40
3.45	0.78	1.57	3.41	0.00	1.59	4.69	99.00	-206.11	89.10	-185.50
3.94	0.93	1.57	2.87	0.00	1.29	5.00	80.34	-266.69	72.30	-240.02
4.44	1.12	1.57	2.08	0.00	0.90	5.38	56.03	-336.47	50.42	-302.82
4.93	1.57	1.57	0.00	0.00	0.00	6.28	0.00	-479.08	0.00	-431.17

Steel Pipe at Threaded Casing Joint (Consider wall thickness reduced to 50%)

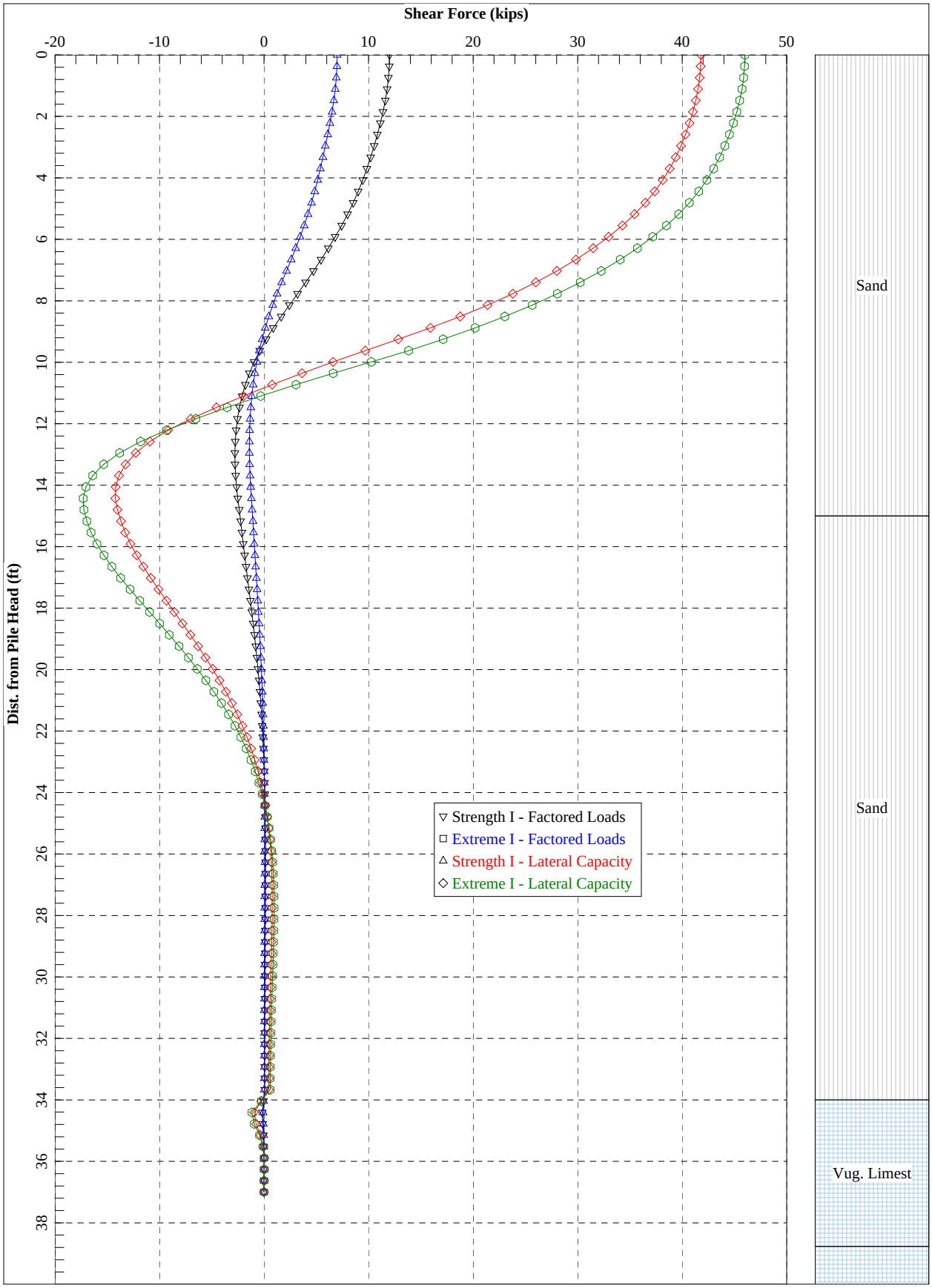



Temp Bridge Abutment
Bottom of Footing
Elev. 78.1
Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
Dist. from Pile Head (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
L_f = 27'
Service I - Unfactored Loads
Service I - Lateral Capacity
Design Point of Fixity
@ Elev. 51.1
Sand
Sand
Vug. Limest

Temp Bridge Abutment



Temp Bridge Abutment



```
================================================================================

                    LPile for Windows, Version 2022-12.007

                Analysis of Individual Piles and Drilled Shafts
               Subjected to Lateral Loading Using the p-y Method
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================================================================================

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--------------------------------------------------------------------------------
                            Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Green- Willmington Culvert\Micropile\Lpile\Temp Abut\

Name of input data file:
Micropile.lp12d

Name of output report file:
Micropile.lp12o

Name of plot output file:
Micropile.lp12p

Name of runtime message file:
Micropile.lp12r



--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  November 24, 2025          Time:   7:55:05



--------------------------------------------------------------------------------
                                 Problem Title
--------------------------------------------------------------------------------

Bridge W-38-011, Willmington


Job Number:


Client: MassDOT
```

Engineer: Lamson Engineering Corporation

Description: 10.75 Micropile

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	1000
- Deflection tolerance for convergence	=	1.0000E-02 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:
- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	2
Total length of pile	=	37.000 ft
Depth of ground surface below top of pile	=	0.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.6250
2	35.000	10.6250
3	35.000	9.3000
4	37.000	9.3000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                =    35.000000 ft
   Casing outside diameter                          =    10.625000 in

Pile Section No. 2:

   Section 2 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                =     2.000000 ft
   Shaft Diameter                                   =     9.300000 in




--------------------------------------------------------------------------------
                      Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                  =        0.000 degrees
                                                    =        0.000 radians

Pile Batter Angle                                   =        0.000 degrees
                                                    =        0.000 radians


--------------------------------------------------------------------------------
                      Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =       0.0000 ft
   Distance from top of pile to bottom of layer     =    15.000000 ft
   Effective unit weight at top of layer            =    52.600000 pcf
   Effective unit weight at bottom of layer         =    52.600000 pcf
   Friction angle at top of layer                   =    30.000000 deg.
   Friction angle at bottom of layer                =    30.000000 deg.
   Subgrade k at top of layer                       =    30.000000 pci
   Subgrade k at bottom of layer                    =    30.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer        =    15.000000 ft
   Distance from top of pile to bottom of layer     =    34.000000 ft
   Effective unit weight at top of layer            =    47.600000 pcf
   Effective unit weight at bottom of layer         =    47.600000 pcf
   Friction angle at top of layer                   =    28.000000 deg.
   Friction angle at bottom of layer                =    28.000000 deg.
   Subgrade k at top of layer                       =    20.000000 pci
   Subgrade k at bottom of layer                    =    20.000000 pci


Layer 3 is strong rock (vuggy limestone)

   Distance from top of pile to top of layer        =    34.000000 ft
   Distance from top of pile to bottom of layer     =    60.000000 ft
   Effective unit weight at top of layer            =   168.000000 pcf
   Effective unit weight at bottom of layer         =   168.000000 pcf
   Uniaxial compressive strength at top of layer    =       12630. psi
   Uniaxial compressive strength at bottom of layer =       12630. psi
```

(Depth of the lowest soil layer extends 23.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 168.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	kpy pci
1	Sand	0.00	52.6000	30.0000	--	30.0000
	(Reese, et al.)	15.0000	52.6000	30.0000	--	30.0000
2	Sand	15.0000	47.6000	28.0000	--	20.0000
	(Reese, et al.)	34.0000	47.6000	28.0000	--	20.0000
3	Strong Rock	34.0000	168.0000	--	12630.	--
	(Vuggy Limestone)	60.0000	168.0000	--	12630.	--

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	1.0000	1.0000
2	120.000	1.0000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 6

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	2	V =	12000. lbs	S =	0.0000 in/in	60000.	No	Yes
2	2	V =	10000. lbs	S =	0.0000 in/in	46000.	No	Yes
3	2	V =	7000. lbs	S =	0.0000 in/in	28000.	No	Yes
4	2	V =	41800. lbs	S =	0.0000 in/in	60000.	No	Yes
5	5	y =	1.000000 in	S =	0.0000 in/in	46000.	N.A.	Yes

6	2	V =	46000. lbs	S =	0.0000 in/in	28000.	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	35.000000 ft
Outer Diameter of Casing	=	10.625000 in
Concrete Cover Thickness Inside Casing	=	3.803000 in
Casing Wall Thickness	=	0.532500 in
Moment of Inertia of Steel Casing	=	215.567404 in^4
Yield Stress of Casing	=	52000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	2.250000 sq. in.
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Pile	=	88.664090 sq. in.
Area of Concrete	=	69.530366 sq. in.
Cross-sectional Area of Steel Casing	=	16.883724 sq. in.
Area of All Steel (Casing and Bars)	=	19.133724 sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.58 percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1308.458 kips
Tensile Load for Cracking of Concrete	=	-96.019 kips
Nominal Axial Tensile Capacity	=	-1012.954 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

```
Compressive Strength of Concrete                        =        5000. psi
Modulus of Elasticity of Concrete                       =     4030509. psi
Modulus of Rupture of Concrete                          =   -530.33009 psi
Compression Strain at Peak Stress                       =     0.002109
Tensile Strain at Fracture of Concrete                  =   -0.0001150
Maximum Coarse Aggregate Size                           =       0.0000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

   Number     Axial Thrust Force
                    kips
   ------     ------------------
      1               28.000
      2               46.000
      3               60.000


Definitions of Run Messages and Notes:
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  C = concrete in section has cracked in tension.
  Y = stress in reinforcing steel has reached yield stress.
  T = ACI 318 criteria for tension-controlled section met, tensile strain in
      reinforcement exceeds 0.005 while simultaneously compressive strain in
      concrete more than 0.003. See ACI 318-14, Section 21.2.3.
  Z = depth of tensile zone in concrete section is less than 10 percent of
      section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =     28.000 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens      Max Conc      Max Steel
Max Casing  Run
   Curvature      Moment       Stiffness      N Axis        Strain        Strain        Stress        Stress
Stress    Msg
    rad/in.       in-kip        kip-in2         in           in/in         in/in          ksi           ksi
  ksi
------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------
------------ ---
   0.00000125    10.2215189      8177215.    30.7072576    0.00003838    0.00002510     0.1800431     0.9494467
1.1112123
   0.00000250    20.4426636      8177065.    18.0108539    0.00004503    0.00001846     0.2106129     0.9784041
1.3019353
   0.00000375    30.6637971      8177013.    13.7791557    0.00005167    0.00001183     0.2410930     1.0074090
1.4927058
   0.00000500    40.8849136      8176983.    11.6636339    0.00005832    0.00000519     0.2714834     1.0364613
1.6835238
   0.00000625    51.1060076      8176961.    10.3945825    0.00006497   -0.00000144     0.3017839     1.0655611
1.8743892
   0.00000750    61.3270084      8176934.     9.5487644    0.00007162   -0.00000807     0.3319944     1.0947078
2.0653016
   0.00000875    71.5469718      8176797.     8.9447657    0.00007827   -0.00001470     0.3621138     1.1238945
2.2562538
   0.00001000    81.7645605      8176456.     8.4918657    0.00008492   -0.00002133     0.3921402     1.1531098
2.4472348
   0.00001125    91.9789200      8175904.     8.1396733    0.00009157   -0.00002796     0.4220724     1.1823458
2.6382364
   0.00001250   102.1895434      8175163.     7.8579610    0.00009822   -0.00003459     0.4519093     1.2115969
2.8292531
   0.00001375   112.3961228      8174263.     7.6274976     0.0001049   -0.00004122     0.4816505     1.2408592
3.0202811
   0.00001500   122.5984656      8173231.     7.4354648     0.0001115   -0.00004784     0.5112954     1.2701304
3.2113179
```

```
   0.00001625   132.7964460      8172089.     7.2729902     0.0001182   -0.00005447     0.5408439     1.2994084
3.4023615
   0.00001750   142.9899799      8170856.     7.1337371     0.0001248   -0.00006110     0.5702956     1.3286920
3.5934107
   0.00001875   153.1790093      8169547.     7.0130595     0.0001315   -0.00006772     0.5996504     1.3579801
3.7844644
   0.00002000   163.3634936      8168175.     6.9074731     0.0001381   -0.00007435     0.6289082     1.3872719
3.9755219
   0.00002125   173.5434032      8166748.     6.8143137     0.0001448   -0.00008098     0.6580689     1.4165670
4.1665826
   0.00002250   183.7187163      8165276.     6.7315096     0.0001515   -0.00008760     0.6871324     1.4458648
4.3576460
   0.00002375   193.8894159      8163765.     6.6574251     0.0001581   -0.00009423     0.7160987     1.4751649
4.5487118
   0.00002500   204.0554913      8162220.     6.5907519     0.0001648     -0.000101     0.7449677     1.5044671
4.7397796
   0.00002625   214.2169317      8160645.     6.5304310     0.0001714     -0.000107     0.7737394     1.5337711
4.9308493
   0.00002750   206.6594673      7514890.     6.2431148     0.0001717     -0.000121     0.7745913     1.3776725
4.9365163 C
   0.00002875   215.4876390      7495222.     6.1846326     0.0001778     -0.000128     0.8009489     1.3915346
5.1121440 C
   0.00003000   224.3095443      7476985.     6.1308886     0.0001839     -0.000135     0.8272065     1.4052790
5.2876540 C
   0.00003125   233.1251307      7460004.     6.0812987     0.0001900     -0.000142     0.8533621     1.4188915
5.4630322 C
   0.00003250   241.9356443      7444174.     6.0354258     0.0001962     -0.000149     0.8794218     1.4324120
5.6383183 C
   0.00003375   250.7429812      7429422.     5.9929135     0.0002023     -0.000156     0.9053940     1.4458962
5.8135681 C
   0.00003500   259.5437497      7415536.     5.9532845     0.0002084     -0.000164     0.9312610     1.4592242
5.9886617 C
   0.00003625   268.3429871      7402565.     5.9164085     0.0002145     -0.000171     0.9570493     1.4725736
6.1637767 C
   0.00003750   277.1383260      7390355.     5.8819257     0.0002206     -0.000178     0.9827451     1.4858519
6.3388207 C
   0.00003875   285.9291318      7378816.     5.8495823     0.0002267     -0.000185     1.0083450     1.4990345
6.5137689 C
   0.00004000   294.7184068      7367960.     5.8192785     0.0002328     -0.000192     1.0338661     1.5122380
6.6887380 C
   0.00004125   303.5061502      7357725.     5.7908288     0.0002389     -0.000199     1.0593085     1.5254626
6.8637282 C
   0.00004250   312.2881390      7347956.     5.7639203     0.0002450     -0.000207     1.0846454     1.5385241
7.0385553 C
   0.00004375   321.0685688      7338710.     5.7385649     0.0002511     -0.000214     1.1099034     1.5516051
7.2134020 C
   0.00004500   329.8474699      7329944.     5.7146343     0.0002572     -0.000221     1.1350826     1.5647072
7.3882697 C
   0.00004625   338.6248415      7321618.     5.6920128     0.0002633     -0.000228     1.1601832     1.5778302
7.5631584 C
   0.00004750   347.3985415      7313654.     5.6705202     0.0002693     -0.000235     1.1851898     1.5908683
7.7379620 C
   0.00004875   356.1695594      7306042.     5.6501042     0.0002754     -0.000243     1.2101095     1.6038701
7.9127295 C
   0.00005125   373.7070141      7291844.     5.6123023     0.0002876     -0.000257     1.2597130     1.6299368
8.2623274 C
   0.00005375   391.2383515      7278853.     5.5780706     0.0002998     -0.000271     1.3090015     1.6560876
8.6120095 C
   0.00005625   408.7586310      7266820.     5.5467599     0.0003120     -0.000286     1.3579353     1.6820390
8.9614921 C
   0.00005875   426.2728073      7255707.     5.5181635     0.0003242     -0.000300     1.4065543     1.7080751
9.3110595 C
   0.00006125   443.7808678      7245402.     5.4919491     0.0003364     -0.000314     1.4548583     1.7341958
9.6607114 C
   0.00006375   461.2821935      7235799.     5.4678139     0.0003486     -0.000329     1.5028412     1.7603594
10.0104062 C
   0.00006625   478.7744806      7226785.     5.4454408     0.0003608     -0.000343     1.5504817     1.7864089
10.3599870 C
   0.00006875   496.2606482      7218337.     5.4247375     0.0003730     -0.000358     1.5978070     1.8125433
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0.00007375 531.2145961 7202910. 5.3876610 0.0003973 -0.000386 1.6915107 1.8650673
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0.0001038 740.3935529 7136323. 5.2418452 0.0005438 -0.000559 2.2268402 -2.610180
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0.0001138 809.9161642 7120142. 5.2109913 0.0005928 -0.000616 2.3950483 -2.963543
-17.684215 C
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-18.918911 C
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-21.796783 C
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-22.207617 C
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-22.618400 C
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-23.029095 C
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-23.439699 C
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-25.081219 C
0.0001688 1190. 7054744. 5.1115851 0.0008626 -0.000930 3.2284770 -4.882934
-26.721293 C

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    0.0001788        1259.      7045323.     5.1009485     0.0009118     -0.000987     3.3632197     -5.227431
-28.359915 C
    0.0001888        1328.      7036355.     5.0917059     0.0009611     -0.001044     3.4927647     -5.570466
-29.997075 C
    0.0001988        1397.      7027770.     5.0836486     0.0010104     -0.001101     3.6170961     -5.912030
-31.632765 C
    0.0002088        1465.      7019509.     5.0766075     0.0010597     -0.001158     3.7361979     -6.252116
-33.266975 C
    0.0002188        1534.      7011526.     5.0704446     0.0011092     -0.001215     3.8500541     -6.590714
-34.899698 C
    0.0002288        1602.      7003782.     5.0650462     0.0011586     -0.001272     3.9586485     -6.927816
-36.530925 C
    0.0002388        1670.      6996244.     5.0603174     0.0012082     -0.001329     4.0619645     -7.263412
-38.160646 C
    0.0002488        1738.      6988886.     5.0561788     0.0012577     -0.001385     4.1599856     -7.597493
-39.788852 C
    0.0002588        1807.      6981685.     5.0525632     0.0013074     -0.001442     4.2526953     -7.930051
-41.415535 C
    0.0002688        1874.      6974620.     5.0494133     0.0013570     -0.001498     4.3400765     -8.261076
-43.040685 C
    0.0002788        1942.      6967676.     5.0466791     0.0014068     -0.001555     4.4221118     -8.590567
-44.664302 C
    0.0002888        2010.      6960836.     5.0443065     0.0014565     -0.001611     4.4987789     -8.918617
-46.286476 C
    0.0002988        2078.      6954090.     5.0422739     0.0015064     -0.001668     4.5700675     -9.245096
-47.907081 C
    0.0003088        2145.      6947427.     5.0405495     0.0015563     -0.001724     4.6359600     -9.569995
-49.526105 C
    0.0003188        2212.      6940836.     5.0391053     0.0016062     -0.001781     4.6964386     -9.893305
-51.143539 C
    0.0003288        2279.      6932366.     5.0373890     0.0016560     -0.001837     4.7513020    -10.220046
-52.000000 CY
    0.0003388        2342.      6914084.     5.0331636     0.0017050     -0.001894     4.7998634    -10.572434
-52.000000 CY
    0.0003488        2400.      6882795.     5.0253961     0.0017526     -0.001953     4.8420451    -10.963090
-52.000000 CY
    0.0003588        2453.      6836773.     5.0134092     0.0017986     -0.002013     4.8780074    -11.402154
-52.000000 CY
    0.0003688        2500.      6779393.     4.9991455     0.0018434     -0.002075     4.9086402    -11.872520
52.0000000 CY
    0.0003788        2543.      6713061.     4.9847072     0.0018880     -0.002136     4.9346617    -12.353069
52.0000000 CY
    0.0003888        2581.      6638080.     4.9706763     0.0019324     -0.002198     4.9562740    -12.837403
52.0000000 CY
    0.0003988        2615.      6556840.     4.9579507     0.0019770     -0.002260     4.9736432    -13.314790
52.0000000 CY
    0.0004088        2645.      6470305.     4.9468287     0.0020220     -0.002321     4.9867376    -13.780538
52.0000000 CY
    0.0004188        2672.      6380480.     4.9368969     0.0020673     -0.002382     4.9954188    -14.238286
52.0000000 CY
    0.0004288        2696.      6289014.     4.9277568     0.0021128     -0.002443     4.9995977    -14.691951
52.0000000 CY
    0.0004388        2719.      6196997.     4.9192385     0.0021583     -0.002503     4.9995264    -15.143009
52.0000000 CY
    0.0004488        2740.      6105158.     4.9112155     0.0022039     -0.002564     4.9993413    -15.592552
52.0000000 CY
    0.0004588        2759.      6013705.     4.9038115     0.0022496     -0.002625     4.9989957    -16.038516
52.0000000 CY
    0.0004688        2776.      5923095.     4.8969556     0.0022954     -0.002685     4.9984116    -16.481326
52.0000000 CY
    0.0004788        2793.      5833931.     4.8904129     0.0023413     -0.002745     4.9984621    -16.923770
52.0000000 CY
    0.0004888        2809.      5746313.     4.8842357     0.0023872     -0.002806     4.9999391    -17.364806
52.0000000 CY
    0.0004988        2823.      5659532.     4.8784618     0.0024331     -0.002866     4.9995399    -17.803619
52.0000000 CY
    0.0005088        2836.      5574733.     4.8728960     0.0024791     -0.002926     4.9986039    -18.242706
52.0000000 CY
    0.0005188        2849.      5491625.     4.8678320     0.0025252     -0.002987     4.9987166    -18.677470
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52.0000000 CY
0.0005288 2861. 5410047. 4.8630256 0.0025713 -0.003047 4.9997431 -19.111209
52.0000000 CY
0.0005388 2872. 5330292. 4.8583295 0.0026174 -0.003107 4.9985999 -19.546020
52.0000000 CY
0.0005488 2882. 5252248. 4.8542729 0.0026638 -0.003167 4.9995686 -19.973380
52.0000000 CY
0.0006088 2934. 4819300. 4.8335425 0.0029424 -0.003526 4.9982307 -22.523226
52.0000000 CY
0.0006688 2971. 4443114. 4.8197777 0.0032232 -0.003882 4.9962063 -25.010126
52.0000000 CY
0.0007288 2999. 4115876. 4.8111671 0.0035061 -0.004237 4.9986050 -27.435999
52.0000000 CY
0.0007888 3021. 3829976. 4.8064463 0.0037911 -0.004589 4.9985570 -29.802862
52.0000000 CY
0.0008488 3038. 3578821. 4.8046618 0.0040780 -0.004940 4.9959526 -32.113882
52.0000000 CY

Axial Thrust Force = 46.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.1981527	8158522.	47.1079779	0.00005888	0.00004560	0.2750150	1.5439728	1.7057384	
0.00000250	20.3956925	8158277.	26.2112176	0.00006553	0.00003897	0.3052817	1.5729305	1.8964617	
0.00000375	30.5932209	8158192.	19.2460688	0.00007217	0.00003233	0.3354586	1.6019357	2.0872326	
0.00000500	40.7907324	8158146.	15.7638228	0.00007882	0.00002569	0.3655458	1.6309886	2.2780511	
0.00000625	50.9882213	8158115.	13.6747380	0.00008547	0.00001906	0.3955430	1.6600892	2.4689173	
0.00000750	61.1856819	8158091.	12.2822338	0.00009212	0.00001243	0.4254504	1.6892374	2.6598311	
0.00000875	71.3831085	8158070.	11.2877756	0.00009877	0.00000580	0.4552677	1.7184332	2.8507926	
0.00001000	81.5804954	8158050.	10.5420961	0.0001054	-8.29039E-07	0.4849949	1.7476766	3.0418016	
0.00001125	91.7778359	8158030.	9.9622692	0.0001121	-0.00000746	0.5146319	1.7769677	3.2328583	
0.00001250	101.9748838	8157991.	9.4985342	0.0001187	-0.00001408	0.5441785	1.8063046	3.4239609	
0.00001375	112.1707643	8157874.	9.1192131	0.0001254	-0.00002070	0.5736334	1.8356808	3.6151027	
0.00001500	122.3646037	8157640.	8.8031859	0.0001320	-0.00002733	0.6029956	1.8650890	3.8062765	
0.00001625	132.5557392	8157276.	8.5358336	0.0001387	-0.00003395	0.6322640	1.8945234	3.9974765	
0.00001750	142.7436877	8156782.	8.3067166	0.0001454	-0.00004057	0.6614379	1.9239790	4.1886978	
0.00001875	152.9280994	8156165.	8.1081809	0.0001520	-0.00004719	0.6905168	1.9534523	4.3799367	
0.00002000	163.1087174	8155436.	7.9344875	0.0001587	-0.00005381	0.7195001	1.9829403	4.5711903	
0.00002125	173.2853542	8154605.	7.7812489	0.0001654	-0.00006043	0.7483876	2.0124408	4.7624564	
0.00002250	183.4578649	8153683.	7.6450529	0.0001720	-0.00006705	0.7771787	2.0419518	4.9537330	
0.00002375	193.6261428	8152680.	7.5232065	0.0001787	-0.00007367	0.8058734	2.0714714	5.1450183	
0.00002500	203.7901043	8151604.	7.4135557	0.0001853	-0.00008029	0.8344715	2.1009998	5.3363123	

0.00002625	213.9496852	8150464.	7.3143568	0.0001920	-0.00008690	0.8629727	2.1305341
5.5276122							
0.00002750	224.1048337	8149267.	7.2241836	0.0001987	-0.00009352	0.8913771	2.1600755
5.7189193							
0.00002875	234.2555100	8148018.	7.1418580	0.0002053	-0.000100	0.9196844	2.1896218
5.9102312							
0.00003000	244.4016798	8146723.	7.0663983	0.0002120	-0.000107	0.9478945	2.2191729
6.1015479							
0.00003125	240.1285622	7684114.	6.8415932	0.0002138	-0.000118	0.9553248	2.1079088
6.1520494 C							
0.00003250	249.0219080	7662213.	6.7691007	0.0002200	-0.000125	0.9814239	2.1239010
6.3298072 C							
0.00003375	257.9011561	7641516.	6.7017328	0.0002262	-0.000132	1.0074035	2.1396531
6.5073249 C							
0.00003500	266.7724315	7622069.	6.6390663	0.0002324	-0.000140	1.0332825	2.1552930
6.6847305 C							
0.00003625	275.6258859	7603473.	6.5803977	0.0002385	-0.000147	1.0590279	2.1705924
6.8617955 C							
0.00003750	284.4753254	7586009.	6.5256074	0.0002447	-0.000154	1.0846843	2.1858560
7.0388247 C							
0.00003875	293.3107230	7569309.	6.4741070	0.0002509	-0.000161	1.1102173	2.2008443
7.2155787 C							
0.00004000	302.1439059	7553598.	6.4258304	0.0002570	-0.000168	1.1356675	2.2158384
7.3923384 C							
0.00004125	310.9629424	7538496.	6.3802291	0.0002632	-0.000175	1.1609913	2.2305328
7.5687984 C							
0.00004250	319.7804105	7524245.	6.3373280	0.0002693	-0.000182	1.1862349	2.2452491
7.7452804 C							
0.00004375	328.5890624	7510607.	6.2967383	0.0002755	-0.000189	1.2113700	2.2597876
7.9215845 C							
0.00004500	337.3917940	7497595.	6.2583282	0.0002816	-0.000197	1.2364080	2.2742278
8.0977903 C							
0.00004625	346.1929594	7485253.	6.2220105	0.0002878	-0.000204	1.2613661	2.2886897
8.2740179 C							
0.00004750	354.9843230	7473354.	6.1874415	0.0002939	-0.000211	1.2862095	2.3029273
8.4500211 C							
0.00004875	363.7722833	7461996.	6.1546218	0.0003000	-0.000218	1.3109653	2.3171307
8.6259900 C							
0.00005125	381.3392258	7440765.	6.0937344	0.0003123	-0.000232	1.3602184	2.3454642
8.9778548 C							
0.00005375	398.8879798	7421172.	6.0383163	0.0003246	-0.000247	1.4090984	2.3734944
9.3294163 C							
0.00005625	416.4264348	7403137.	5.9877878	0.0003368	-0.000261	1.4576398	2.4014651
9.6809183 C							
0.00005875	433.9497157	7386378.	5.9414219	0.0003491	-0.000275	1.5058188	2.4292011
10.0321854 C							
0.00006125	451.4667628	7370886.	5.8988892	0.0003613	-0.000289	1.5536795	2.4570227
10.3835383 C							
0.00006375	468.9676879	7356356.	5.8595257	0.0003735	-0.000304	1.6011687	2.4845363
10.7345832 C							
0.00006625	486.4618733	7342821.	5.8231670	0.0003858	-0.000318	1.6483371	2.5121150
11.0856931 C							
0.00006875	503.9495439	7330175.	5.7894891	0.0003980	-0.000332	1.6951856	2.5397668
11.4368762 C							
0.00007125	521.4230709	7318219.	5.7580447	0.0004103	-0.000347	1.7416690	2.5671498
11.7877904 C							
0.00007375	538.8903767	7306988.	5.7287722	0.0004225	-0.000361	1.7878343	2.5946187
12.1387906 C							
0.00007625	556.3514516	7296412.	5.7014581	0.0004347	-0.000375	1.8336815	2.6221734
12.4898766 C							
0.00007875	573.8041597	7286402.	5.6758680	0.0004470	-0.000390	1.8791961	2.6497052
12.8409396 C							
0.00008125	591.2464782	7276880.	5.6517990	0.0004592	-0.000404	1.9243650	2.6771102
13.1918759 C							
0.00008375	608.6825655	7267852.	5.6292024	0.0004714	-0.000418	1.9692156	2.7046013
13.5428982 C							
0.00008625	626.1124141	7259274.	5.6079501	0.0004837	-0.000433	2.0137476	2.7321785
13.8940066 C							
0.00008875	643.5360163	7251110.	5.5879287	0.0004959	-0.000447	2.0579609	2.7598420

14.2452013 C
0.00009125 660.9510987 7243300. 5.5689859 0.0005082 -0.000461 2.1018383 2.7874565
14.5963471 C
0.00009375 678.3575595 7235814. 5.5510329 0.0005204 -0.000476 2.1453793 2.8150156
14.9474375 C
0.00009625 695.7577718 7228652. 5.5340437 0.0005327 -0.000490 2.1886013 2.8426614
15.2986145 C
0.00009875 713.1517280 7221790. 5.5179449 0.0005449 -0.000504 2.2315041 2.8703939
15.6498782 C
0.0001013 730.5394204 7215204. 5.5026707 0.0005571 -0.000519 2.2740875 2.8982132
16.0012289 C
0.0001038 747.9208414 7208876. 5.4881615 0.0005694 -0.000533 2.3163514 2.9261196
16.3526665 C
0.0001063 765.2959833 7202786. 5.4743634 0.0005817 -0.000547 2.3582954 2.9541130
16.7041911 C
0.0001088 782.6622059 7196894. 5.4611672 0.0005939 -0.000562 2.3998969 2.9820041
17.0556135 C
0.0001113 800.0215501 7191205. 5.4485778 0.0006062 -0.000576 2.4411734 3.0099394
17.4070801 C
0.0001138 817.3746105 7185711. 5.4365684 0.0006184 -0.000590 2.4821299 3.0379623
17.7586342 C
0.0001163 834.7213793 7180399. 5.4251015 0.0006307 -0.000604 2.5227660 3.0660729
18.1102761 C
0.0001188 852.0618489 7175258. 5.4141429 0.0006429 -0.000619 2.5630815 3.0942713
18.4620057 C
0.0001213 869.3960114 7170276. 5.4036612 0.0006552 -0.000633 2.6030763 3.1225577
18.8138233 C
0.0001238 886.7238591 7165445. 5.3936276 0.0006675 -0.000647 2.6427500 3.1509321
19.1657290 C
0.0001263 904.0453842 7160756. 5.3840154 0.0006797 -0.000662 2.6821025 3.1793947
19.5177229 C
0.0001288 921.3605789 7156199. 5.3748002 0.0006920 -0.000676 2.7211334 3.2079456
19.8698050 C
0.0001313 938.6694353 7151767. 5.3659592 0.0007043 -0.000690 2.7598426 3.2365850
20.2219756 C
0.0001338 955.9699744 7147439. 5.3574252 0.0007166 -0.000705 2.7982104 3.2651331
20.5740549 C
0.0001363 973.2640955 7143223. 5.3492251 0.0007288 -0.000719 2.8362555 3.2937628
20.9262159 C
0.0001388 990.5518703 7139113. 5.3413426 0.0007411 -0.000733 2.8739785 3.3224816
21.2784659 C
0.0001413 1008. 7135103. 5.3337609 0.0007534 -0.000747 2.9113792 3.3512895
21.6308051 C
0.0001438 1025. 7131189. 5.3264643 0.0007657 -0.000762 2.9484574 3.3801867
21.9832336 C
0.0001463 1042. 7127364. 5.3194382 0.0007780 -0.000776 2.9852126 3.4091716
22.3357498 C
0.0001488 1060. 7123626. 5.3126691 0.0007903 -0.000790 3.0216451 3.4382495
22.6883589 C
0.0001588 1129. 7109447. 5.2879197 0.0008395 -0.000847 3.1641395 -3.781774
-24.326009 C
0.0001688 1198. 7096339. 5.2663984 0.0008887 -0.000904 3.3014460 -4.125316
-25.963676 C
0.0001788 1266. 7084106. 5.2474968 0.0009380 -0.000961 3.4335169 -4.467760
-27.600245 C
0.0001888 1335. 7072612. 5.2308296 0.0009873 -0.001018 3.5603545 -4.808937
-29.235547 C
0.0001988 1404. 7061751. 5.2160953 0.0010367 -0.001075 3.6819618 -5.148640
-30.869375 C
0.0002088 1472. 7051429. 5.2030175 0.0010861 -0.001132 3.7983227 -5.486861
-32.501721 C
0.0002188 1540. 7041570. 5.1913704 0.0011356 -0.001189 3.9094211 -5.823591
-34.132576 C
0.0002288 1609. 7032112. 5.1809677 0.0011851 -0.001245 4.0152405 -6.158821
-35.761931 C
0.0002388 1677. 7023000. 5.1716544 0.0012347 -0.001302 4.1157646 -6.492542
-37.389777 C
0.0002488 1745. 7014192. 5.1633003 0.0012844 -0.001359 4.2109766 -6.824745
-39.016105 C

0.0002588	1813.	7005650.	5.1557955	0.0013341	-0.001415	4.3008598	-7.155421
-40.640906 C							
0.0002688	1881.	6997339.	5.1490221	0.0013838	-0.001472	4.3853866	-7.484749
-42.264359 C							
0.0002788	1948.	6989234.	5.1429122	0.0014336	-0.001528	4.4645460	-7.812643
-43.886377 C							
0.0002888	2016.	6981313.	5.1374122	0.0014834	-0.001585	4.5383281	-8.138973
-45.506832 C							
0.0002988	2083.	6973555.	5.1324619	0.0015333	-0.001641	4.6067153	-8.463730
-47.125714 C							
0.0003088	2151.	6965944.	5.1280090	0.0015833	-0.001697	4.6696900	-8.786905
-48.743014 C							
0.0003188	2218.	6958462.	5.1240078	0.0016333	-0.001753	4.7272344	-9.108487
-50.358722 C							
0.0003288	2285.	6951097.	5.1204180	0.0016833	-0.001810	4.7793305	-9.428468
-51.972827 C							
0.0003388	2350.	6937435.	5.1154507	0.0017329	-0.001866	4.8254342	-9.764064
-52.000000 CY							
0.0003488	2411.	6913317.	5.1078479	0.0017814	-0.001924	4.8653502	-10.129194
-52.000000 CY							
0.0003588	2466.	6873093.	5.0964041	0.0018283	-0.001983	4.8990637	-10.538695
52.0000000 CY							
0.0003688	2514.	6818231.	5.0832298	0.0018744	-0.002044	4.9274333	-10.973341
52.0000000 CY							
0.0003788	2557.	6750945.	5.0696814	0.0019201	-0.002104	4.9509425	-11.419736
52.0000000 CY							
0.0003888	2595.	6674566.	5.0569570	0.0019659	-0.002165	4.9698825	-11.864702
52.0000000 CY							
0.0003988	2628.	6591039.	5.0456747	0.0020120	-0.002225	4.9843103	-12.300366
52.0000000 CY							
0.0004088	2658.	6502605.	5.0355576	0.0020583	-0.002285	4.9941159	-12.728765
52.0000000 CY							
0.0004188	2685.	6411417.	5.0262726	0.0021048	-0.002344	4.9992159	-13.152927
52.0000000 CY							
0.0004288	2709.	6318882.	5.0175805	0.0021513	-0.002404	4.9992424	-13.575103
52.0000000 CY							
0.0004388	2732.	6225931.	5.0093561	0.0021979	-0.002464	4.9991434	-13.996370
52.0000000 CY							
0.0004488	2752.	6133158.	5.0015681	0.0022445	-0.002524	4.9988958	-14.416725
52.0000000 CY							
0.0004588	2771.	6040679.	4.9944162	0.0022912	-0.002583	4.9984554	-14.833132
52.0000000 CY							
0.0004688	2789.	5949376.	4.9875669	0.0023379	-0.002643	4.9978331	-15.249578
52.0000000 CY							
0.0004788	2805.	5859537.	4.9809843	0.0023846	-0.002702	4.9999817	-15.666296
52.0000000 CY							
0.0004888	2821.	5770966.	4.9749434	0.0024315	-0.002761	4.9997486	-16.079154
52.0000000 CY							
0.0004988	2835.	5683815.	4.9692104	0.0024784	-0.002821	4.9991210	-16.491054
52.0000000 CY							
0.0005088	2848.	5598382.	4.9634971	0.0025252	-0.002880	4.9979019	-16.905998
52.0000000 CY							
0.0005188	2861.	5514414.	4.9584615	0.0025722	-0.002940	4.9999695	-17.314060
52.0000000 CY							
0.0005288	2872.	5432486.	4.9536211	0.0026192	-0.002999	4.9993847	-17.722040
52.0000000 CY							
0.0005388	2883.	5351919.	4.9489005	0.0026662	-0.003058	4.9978493	-18.130973
52.0000000 CY							
0.0005488	2894.	5273327.	4.9445953	0.0027133	-0.003117	4.9999322	-18.536013
52.0000000 CY							
0.0006088	2945.	4837382.	4.9229377	0.0029968	-0.003471	4.9971971	-20.945067
52.0000000 CY							
0.0006688	2982.	4458641.	4.9083479	0.0032825	-0.003823	4.9994942	-23.292418
52.0000000 CY							
0.0007288	3009.	4129215.	4.8986017	0.0035699	-0.004173	4.9973076	-25.588178
52.0000000 CY							
0.0007888	3030.	3841681.	4.8928428	0.0038592	-0.004521	4.9970199	-27.826652
52.0000000 CY							

Axial Thrust Force = 60.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	10.1799200	8143936.	59.9056778	0.00007488	0.00006160	0.3484665	2.0078894	2.1696550	
0.00000250	20.3590406	8143616.	32.6100704	0.00008153	0.00005496	0.3784966	2.0368473	2.3603785	
0.00000375	30.5381498	8143507.	23.5119738	0.00008817	0.00004833	0.4084370	2.0658529	2.5511498	
0.00000500	40.7172419	8143448.	18.9632548	0.00009482	0.00004169	0.4382876	2.0949063	2.7419688	
0.00000625	50.8963114	8143410.	16.2342870	0.0001015	0.00003506	0.4680482	2.1240075	2.9328356	
0.00000750	61.0753526	8143380.	14.4151947	0.0001081	0.00002843	0.4977188	2.1531563	3.1237500	
0.00000875	71.2543596	8143355.	13.1160313	0.0001148	0.00002180	0.5272994	2.1823530	3.3147123	
0.00001000	81.4333269	8143333.	12.1418234	0.0001214	0.00001517	0.5567899	2.2115974	3.5057224	
0.00001125	91.6122487	8143311.	11.3842526	0.0001281	0.00000854	0.5861901	2.2408897	3.6967803	
0.00001250	101.7911193	8143290.	10.7783276	0.0001347	0.00000192	0.6155001	2.2702297	3.8878859	
0.00001375	111.9699332	8143268.	10.2826907	0.0001414	-0.00000471	0.6447197	2.2996174	4.0790393	
0.00001500	122.1486722	8143245.	9.8697695	0.0001480	-0.00001133	0.6738489	2.3290528	4.2702403	
0.00001625	132.3270053	8143200.	9.5204708	0.0001547	-0.00001795	0.7028872	2.3585336	4.4614867	
0.00001750	142.5042036	8143097.	9.2211503	0.0001614	-0.00002457	0.7318337	2.3880541	4.6527728	
0.00001875	152.6795707	8142910.	8.9618019	0.0001680	-0.00003118	0.7606876	2.4176087	4.8440931	
0.00002000	162.8525356	8142627.	8.7349222	0.0001747	-0.00003780	0.7894479	2.4471924	5.0354424	
0.00002125	173.0226496	8142242.	8.5347748	0.0001814	-0.00004442	0.8181141	2.4768011	5.2268167	
0.00002250	183.1895602	8141758.	8.3568987	0.0001880	-0.00005103	0.8466856	2.5064312	5.4182124	
0.00002375	193.3529957	8141179.	8.1977734	0.0001947	-0.00005765	0.8751618	2.5360798	5.6096266	
0.00002500	203.5127368	8140509.	8.0545828	0.0002014	-0.00006426	0.9035426	2.5657445	5.8010570	
0.00002625	213.6686155	8139757.	7.9250480	0.0002080	-0.00007087	0.9318274	2.5954233	5.9925014	
0.00002750	223.8204951	8138927.	7.8073046	0.0002147	-0.00007749	0.9600160	2.6251146	6.1839583	
0.00002875	233.9682654	8138027.	7.6998130	0.0002214	-0.00008410	0.9881083	2.6548168	6.3754262	
0.00003000	244.1118378	8137061.	7.6012903	0.0002280	-0.00009071	1.0161040	2.6845289	6.5669039	
0.00003125	254.2511411	8136037.	7.5106590	0.0002347	-0.00009732	1.0440028	2.7142492	6.7583899	
0.00003250	264.3861159	8134957.	7.4270079	0.0002414	-0.000104	1.0718050	2.7439784	6.9498847	
0.00003375	274.5167143	8133829.	7.3495604	0.0002480	-0.000111	1.0995099	2.7737139	7.1413858	
0.00003500	271.5614044	7758897.	7.1558307	0.0002505	-0.000121	1.1093040	2.6798089	7.2092464	C
0.00003625	280.5074910	7738138.	7.0813424	0.0002567	-0.000128	1.1351033	2.6972105	7.3884136	C

0.00003750	289.4331978	7718219.	7.0115328	0.0002629	-0.000136	1.1607721	2.7142999
7.5672686 C							
0.00003875	298.3474212	7699288.	6.9460868	0.0002692	-0.000143	1.1863328	2.7312316
7.7459660 C							
0.00004000	307.2425094	7681063.	6.8844660	0.0002754	-0.000150	1.2117644	2.7478557
7.9243557 C							
0.00004125	316.1265911	7663675.	6.8264423	0.0002816	-0.000157	1.2370876	2.7643153
8.1025809 C							
0.00004250	324.9982920	7647019.	6.7716758	0.0002878	-0.000164	1.2622986	2.7805827
8.2806140 C							
0.00004375	333.8587452	7631057.	6.7198959	0.0002940	-0.000171	1.2873994	2.7966688
8.4584657 C							
0.00004500	342.7089334	7615754.	6.6708694	0.0003002	-0.000178	1.3123931	2.8125941
8.6361566 C							
0.00004625	351.5516895	7601118.	6.6244120	0.0003064	-0.000185	1.3372871	2.8284107
8.8137388 C							
0.00004750	360.3821866	7586993.	6.5802415	0.0003126	-0.000192	1.3620664	2.8440093
8.9911031 C							
0.00004875	369.2110974	7573561.	6.5383522	0.0003187	-0.000199	1.3867647	2.8596307
9.1684901 C							
0.00005125	386.8360881	7548021.	6.4602943	0.0003311	-0.000213	1.4358251	2.8902649
9.5226555 C							
0.00005375	404.4387330	7524442.	6.3892914	0.0003434	-0.000228	1.4845060	2.9205776
9.8764995 C							
0.00005625	422.0234723	7502640.	6.3244710	0.0003558	-0.000242	1.5328235	2.9506802
10.2301333 C							
0.00005875	439.5799442	7482212.	6.2648602	0.0003681	-0.000256	1.5807360	2.9802596
10.5832440 C							
0.00006125	457.1270649	7463299.	6.2101150	0.0003804	-0.000270	1.6283150	3.0098380
10.9363536 C							
0.00006375	474.6500999	7445492.	6.1594203	0.0003927	-0.000285	1.6755006	3.0389667
11.2890136 C							
0.00006625	492.1667974	7428933.	6.1125972	0.0004050	-0.000299	1.7223652	3.0681812
11.6417593 C							
0.00006875	509.6623673	7413271.	6.0689773	0.0004172	-0.000313	1.7688443	3.0969949
11.9941043 C							
0.00007125	527.1504799	7398603.	6.0284423	0.0004295	-0.000328	1.8149980	3.1258577
12.3464983 C							
0.00007375	544.6279845	7384786.	5.9906231	0.0004418	-0.000342	1.8608107	3.1546513
12.6988232 C							
0.00007625	562.0907432	7371682.	5.9551841	0.0004541	-0.000356	1.9062632	3.1832245
13.0509276 C							
0.00007875	579.5471929	7359329.	5.9220334	0.0004664	-0.000370	1.9513953	3.2118846
13.4031190 C							
0.00008125	596.9953504	7347635.	5.8909254	0.0004786	-0.000385	1.9961967	3.2405519
13.7553175 C							
0.00008375	614.4290216	7336466.	5.8615742	0.0004909	-0.000399	2.0406356	3.2689739
14.1072707 C							
0.00008625	631.8563917	7325871.	5.8339592	0.0005032	-0.000413	2.0847542	3.2974833
14.4593114 C							
0.00008875	649.2774467	7315802.	5.8079338	0.0005155	-0.000428	2.1285523	3.3260797
14.8114391 C							
0.00009125	666.6897849	7306189.	5.7833260	0.0005277	-0.000442	2.1720162	3.3546537
15.1635443 C							
0.00009375	684.0902585	7296963.	5.7599692	0.0005400	-0.000456	2.2151282	3.3830609
15.5154827 C							
0.00009625	701.4844180	7288150.	5.7378570	0.0005523	-0.000470	2.2579196	3.4115552
15.8675083 C							
0.00009875	718.8722554	7279719.	5.7168949	0.0005645	-0.000485	2.3003902	3.4401367
16.2196211 C							
0.0001013	736.2537631	7271642.	5.6969977	0.0005768	-0.000499	2.3425397	3.4688056
16.5718212 C							
0.0001038	753.6268901	7263874.	5.6780527	0.0005891	-0.000513	2.3843553	3.4974546
16.9240015 C							
0.0001063	770.9896866	7256374.	5.6599596	0.0006014	-0.000528	2.4258248	3.5259811
17.2760593 C							
0.0001088	788.3461527	7249160.	5.6427261	0.0006136	-0.000542	2.4669732	3.5545952
17.6282046 C							
0.0001113	805.6962805	7242214.	5.6262943	0.0006259	-0.000556	2.5078002	3.5832971

17.9804377 C
0.0001138 823.0400623 7235517. 5.6106115 0.0006382 -0.000570 2.5483056 3.6120868
18.3327587 C
0.0001163 840.3774903 7229054. 5.5956292 0.0006505 -0.000585 2.5884891 3.6409645
18.6851676 C
0.0001188 857.7085565 7222809. 5.5813034 0.0006628 -0.000599 2.6283504 3.6699303
19.0376647 C
0.0001213 875.0298559 7216741. 5.5675337 0.0006751 -0.000613 2.6678660 3.6987743
19.3900399 C
0.0001238 892.3437930 7210859. 5.5543277 0.0006873 -0.000627 2.7070525 3.7276446
19.7424415 C
0.0001263 909.6513655 7205159. 5.5416689 0.0006996 -0.000642 2.7459167 3.7566034
20.0949316 C
0.0001288 926.9525657 7199632. 5.5295254 0.0007119 -0.000656 2.7844584 3.7856509
20.4475103 C
0.0001313 944.2473855 7194266. 5.5178678 0.0007242 -0.000670 2.8226772 3.8147871
20.8001777 C
0.0001338 961.5358170 7189053. 5.5066690 0.0007365 -0.000685 2.8605731 3.8440121
21.1529340 C
0.0001363 978.8178523 7183984. 5.4959036 0.0007488 -0.000699 2.8981458 3.8733262
21.5057793 C
0.0001388 996.0934834 7179052. 5.4855483 0.0007611 -0.000713 2.9353949 3.9027294
21.8587137 C
0.0001413 1013. 7174249. 5.4755814 0.0007734 -0.000727 2.9723203 3.9322218
22.2117374 C
0.0001438 1031. 7169556. 5.4659490 0.0007857 -0.000742 3.0089073 3.9616637
22.5647106 C
0.0001463 1048. 7164971. 5.4566467 0.0007980 -0.000756 3.0451615 3.9911088
22.9176870 C
0.0001488 1065. 7160497. 5.4476779 0.0008103 -0.000770 3.0810918 4.0206438
23.2707531 C
0.0001588 1134. 7143606. 5.4148231 0.0008596 -0.000827 3.2215677 4.1396837
24.6839180 C
0.0001688 1203. 7128105. 5.3861577 0.0009089 -0.000884 3.3568402 4.2601700
26.0985294 C
0.0001788 1272. 7113749. 5.3609536 0.0009583 -0.000941 3.4868809 4.3819727
27.5144571 C
0.0001888 1340. 7100331. 5.3385830 0.0010077 -0.000998 3.6116385 4.5046668
28.9312762 C
0.0001988 1409. 7087736. 5.3187195 0.0010571 -0.001055 3.7311505 4.6288342
30.3495686 C
0.0002088 1477. 7075845. 5.3010044 0.0011066 -0.001111 3.8454017 -4.893673
-31.908532 C
0.0002188 1545. 7064556. 5.2851443 0.0011561 -0.001168 3.9543751 -5.228713
-33.537697 C
0.0002288 1614. 7053791. 5.2708974 0.0012057 -0.001225 4.0580545 -5.562250
-35.165360 C
0.0002388 1682. 7043478. 5.2580544 0.0012554 -0.001281 4.1564198 -5.894330
-36.791565 C
0.0002488 1750. 7033550. 5.2463938 0.0013050 -0.001338 4.2494305 -6.225330
-38.416689 C
0.0002588 1817. 7023973. 5.2358392 0.0013548 -0.001394 4.3371012 -6.554794
-40.040278 C
0.0002688 1885. 7014706. 5.2262682 0.0014046 -0.001451 4.4194150 -6.882713
-41.662322 C
0.0002788 1953. 7005713. 5.2175762 0.0014544 -0.001507 4.4963546 -7.209078
-43.282812 C
0.0002888 2020. 6996963. 5.2096730 0.0015043 -0.001564 4.5679027 -7.533879
-44.901738 C
0.0002988 2088. 6988430. 5.2024806 0.0015542 -0.001620 4.6340417 -7.857106
-46.519090 C
0.0003088 2155. 6980092. 5.1959308 0.0016042 -0.001676 4.6947539 -8.178750
-48.134859 C
0.0003188 2222. 6971927. 5.1899644 0.0016543 -0.001732 4.7500216 -8.498800
-49.749035 C
0.0003288 2289. 6963919. 5.1845292 0.0017044 -0.001789 4.7998266 -8.817248
-51.361607 C
0.0003388 2356. 6953643. 5.1789260 0.0017544 -0.001845 4.8439655 -9.140498
-52.000000 CY

```
    0.0003488         2418.      6932878.     5.1708125     0.0018033     -0.001902     4.8818953     -9.492385
-52.000000 CY
    0.0003588         2475.      6898191.     5.1605245     0.0018513     -0.001960     4.9139666     -9.871603
52.0000000 CY
    0.0003688         2524.      6844054.     5.1483587     0.0018985     -0.002020     4.9405041    -10.276868
52.0000000 CY
    0.0003788         2567.      6776334.     5.1359331     0.0019452     -0.002079     4.9620205    -10.692044
52.0000000 CY
    0.0003888         2604.      6698848.     5.1244969     0.0019921     -0.002138     4.9787702    -11.103270
52.0000000 CY
    0.0003988         2637.      6613853.     5.1142376     0.0020393     -0.002197     4.9907319    -11.507521
52.0000000 CY
    0.0004088         2667.      6524158.     5.1047061     0.0020865     -0.002256     4.9978155    -11.909094
52.0000000 CY
    0.0004188         2693.      6432171.     5.0957956     0.0021339     -0.002315     4.9988010    -12.308654
52.0000000 CY
    0.0004288         2718.      6339074.     5.0873689     0.0021812     -0.002374     4.9982427    -12.707368
52.0000000 CY
    0.0004388         2740.      6245319.     5.0795765     0.0022287     -0.002433     4.9985781    -13.102901
52.0000000 CY
    0.0004488         2761.      6151873.     5.0721848     0.0022761     -0.002492     4.9998452    -13.497735
52.0000000 CY
    0.0004588         2780.      6059273.     5.0651176     0.0023236     -0.002551     4.9999759    -13.892538
52.0000000 CY
    0.0004688         2797.      5967662.     5.0582097     0.0023710     -0.002609     4.9998433    -14.289278
52.0000000 CY
    0.0004788         2814.      5877001.     5.0517640     0.0024185     -0.002668     4.9995033    -14.683607
52.0000000 CY
    0.0004888         2829.      5787813.     5.0456822     0.0024661     -0.002727     4.9988264    -15.076515
52.0000000 CY
    0.0004988         2843.      5700481.     5.0397623     0.0025136     -0.002786     4.9976452    -15.470610
52.0000000 CY
    0.0005088         2856.      5614540.     5.0343725     0.0025612     -0.002844     4.9999426    -15.860319
52.0000000 CY
    0.0005188         2869.      5530122.     5.0290146     0.0026088     -0.002903     4.9993671    -16.252675
52.0000000 CY
    0.0005288         2880.      5447681.     5.0239841     0.0026564     -0.002962     4.9979818    -16.643110
52.0000000 CY
    0.0005388         2891.      5366908.     5.0194387     0.0027042     -0.003020     4.9999630    -17.028897
52.0000000 CY
    0.0005488         2902.      5287861.     5.0147414     0.0027518     -0.003079     4.9991449    -17.419725
52.0000000 CY
    0.0006088         2952.      4849763.     4.9927811     0.0030394     -0.003429     4.9999382    -19.712069
52.0000000 CY
    0.0006688         2989.      4469241.     4.9772006     0.0033285     -0.003777     4.9993595    -21.957117
52.0000000 CY
    0.0007288         3016.      4138430.     4.9667320     0.0036195     -0.004123     4.9996842    -24.148330
52.0000000 CY
    0.0007888         3036.      3849498.     4.9602273     0.0039124     -0.004468     4.9992622    -26.285314
52.0000000 CY


-------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
-------------------------------------------------------------------------------

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.      Max. Tens.
  No.              kips                 in-kip               Strain          Strain
 ----         ----------------     ------------------     ------------    ------------
   1               28.000              2941.455           0.00300000     -0.00359869
   2               46.000              2945.165           0.00300000     -0.00347503
   3               60.000              2945.370           0.00300000     -0.00338071

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).
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In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	28.000000	2941.	18.200000	1912.	6970778.
2	0.65	46.000000	2945.	29.900000	1914.	6993291.
3	0.65	60.000000	2945.	39.000000	1914.	7010812.
1	0.75	28.000000	2941.	21.000000	2206.	6941452.
2	0.75	46.000000	2945.	34.500000	2209.	6959478.
3	0.75	60.000000	2945.	45.000000	2209.	6973540.
1	0.90	28.000000	2941.	25.200000	2647.	6461774.
2	0.90	46.000000	2945.	41.400000	2651.	6524269.
3	0.90	60.000000	2945.	54.000000	2651.	6572593.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	2.000000 ft
Shaft Diameter	=	9.300000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.803000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	67.929087 sq. in.
Total Area of Reinforcing Steel	=	2.250000 sq. in.
Area Ratio of Steel Reinforcement	=	3.31 percent
Edge-to-Edge Bar Spacing	=	-1.69300 in
Maximum Concrete Aggregate Size	=	0.0000 in
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	414.136 kips
Tensile Load for Cracking of Concrete	=	-37.939 kips
Nominal Axial Tensile Capacity	=	-135.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.693000	2.250000	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

```
Compressive Strength of Concrete                        =        5000. psi
Modulus of Elasticity of Concrete                       =     4030509. psi
Modulus of Rupture of Concrete                          =   -530.33009 psi
Compression Strain at Peak Stress                       =     0.002109
Tensile Strain at Fracture of Concrete                  =   -0.0001150
Maximum Coarse Aggregate Size                           =       0.0000 in


Number of Axial Thrust Force Values Determined from Pile-head Loadings = 3

   Number     Axial Thrust Force
                    kips
   ------     ------------------
      1               28.000
      2               46.000
      3               60.000


Definitions of Run Messages and Notes:
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  C = concrete in section has cracked in tension.
  Y = stress in reinforcing steel has reached yield stress.
  T = ACI 318 criteria for tension-controlled section met, tensile strain in
      reinforcement exceeds 0.005 while simultaneously compressive strain in
      concrete more than 0.003. See ACI 318-14, Section 21.2.3.
  Z = depth of tensile zone in concrete section is less than 10 percent of
      section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.


Axial Thrust Force =     28.000 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens      Max Conc      Max Steel  Run
   Curvature      Moment       Stiffness      N Axis        Strain        Strain        Stress        Stress    Msg
    rad/in.       in-kip        kip-in2         in          in/in         in/in          ksi           ksi
------------- ------------- ------------- ------------- ------------- ------------- ------------- ------------- ---
   0.00000125     2.1120825      1689666.    65.0101083    0.00008126    0.00006964     0.3776402     2.2200808
   0.00000250     4.2232613      1689305.    34.8321533    0.00008708    0.00006383     0.4038621     2.2522599
   0.00000375     6.3344184      1689178.    24.7737751    0.00009290    0.00005803     0.4300254     2.2845412
   0.00000500     8.4455429      1689109.    19.7452912    0.00009873    0.00005223     0.4561300     2.3169247
   0.00000625    10.5566239      1689060.    16.7287650     0.0001046    0.00004643     0.4821757     2.3494105
   0.00000750    12.6676504      1689020.    14.7182176     0.0001104    0.00004064     0.5081624     2.3819986
   0.00000875    14.7786117      1688984.    13.2825153     0.0001162    0.00003485     0.5340900     2.4146889
   0.00001000    16.8894968      1688950.    12.2060911     0.0001221    0.00002906     0.5599582     2.4474815
   0.00001125    19.0002948      1688915.    11.3691858     0.0001279    0.00002328     0.5857670     2.4803763
   0.00001250    21.1109947      1688880.    10.6999436     0.0001337    0.00001750     0.6115163     2.5133734
   0.00001375    23.2215857      1688843.    10.1526383     0.0001396    0.00001172     0.6372058     2.5464727
   0.00001500    25.3320568      1688804.     9.6967857     0.0001455    0.00000595     0.6628355     2.5796743
   0.00001625    27.4423972      1688763.     9.3112812     0.0001513   1.83320E-07     0.6884053     2.6129782
   0.00001750    29.5525423      1688717.     8.9810485     0.0001572    -0.00000558     0.7139147     2.6463834
   0.00001875    31.6620869      1688645.     8.6950200     0.0001630    -0.00001134     0.7393628     2.6798828
   0.00002000    33.7704608      1688523.     8.4448890     0.0001689    -0.00001710     0.7647476     2.7134657
   0.00002125    35.8771496      1688336.     8.2243038     0.0001748    -0.00002286     0.7900674     2.7471210
   0.00002250    37.9817231      1688077.     8.0283260     0.0001806    -0.00002861     0.8153210     2.7808410
   0.00002375    40.0838336      1687740.     7.8530587     0.0001865    -0.00003436     0.8405069     2.8146170
   0.00002500    42.1832011      1687328.     7.6953862     0.0001924    -0.00004012     0.8656242     2.8484426
   0.00002625    44.2796028      1686842.     7.5527875     0.0001983    -0.00004586     0.8906719     2.8823114
   0.00002750    46.3728543      1686286.     7.4232009     0.0002041    -0.00005161     0.9156492     2.9162191
   0.00002875    48.4628107      1685663.     7.3049245     0.0002100    -0.00005736     0.9405555     2.9501615
   0.00003000    50.5493518      1684978.     7.1965403     0.0002159    -0.00006310     0.9653902     2.9841351
   0.00003125    52.6323783      1684236.     7.0968580     0.0002218    -0.00006885     0.9901528     3.0181370
   0.00003250    54.7118096      1683440.     7.0048708     0.0002277    -0.00007459     1.0148429     3.0521646
   0.00003375    56.7875782      1682595.     6.9197214     0.0002335    -0.00008033     1.0394603     3.0862156
   0.00003500    58.8596276      1681704.     6.8406754     0.0002394    -0.00008608     1.0640044     3.1202881
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0.00003625	60.9279116	1680770.	6.7670998	0.0002453	-0.00009182	1.0884752	3.1543806
0.00003750	62.9923916	1679797.	6.6984461	0.0002512	-0.00009756	1.1128722	3.1884909
0.00003875	65.0530311	1678788.	6.6342370	0.0002571	-0.000103	1.1371956	3.2226196
0.00004000	67.1098010	1677745.	6.5740548	0.0002630	-0.000109	1.1614448	3.2567636
0.00004125	52.9095609	1282656.	6.1868397	0.0002552	-0.000128	1.1289147	2.8953313 C
0.00004250	53.6910749	1263319.	6.1149171	0.0002599	-0.000135	1.1481612	2.8944241 C
0.00004375	54.4530911	1244642.	6.0464556	0.0002645	-0.000142	1.1672420	2.8926938 C
0.00004500	55.1983577	1226630.	5.9812512	0.0002692	-0.000149	1.1861735	2.8902504 C
0.00004625	55.9239714	1209167.	5.9189218	0.0002738	-0.000156	1.2049341	2.8869358 C
0.00004750	56.6297066	1192204.	5.8592031	0.0002783	-0.000163	1.2235173	2.8826987 C
0.00004875	57.3250676	1175899.	5.8022227	0.0002829	-0.000171	1.2419899	2.8780030 C
0.00005125	58.6648782	1144681.	5.6949362	0.0002919	-0.000185	1.2784504	2.8661384 C
0.00005375	59.9547917	1115438.	5.5960386	0.0003008	-0.000199	1.3143849	2.8517935 C
0.00005625	61.2004830	1088009.	5.5045297	0.0003096	-0.000213	1.3498256	2.8351611 C
0.00005875	62.4080347	1062264.	5.4196129	0.0003184	-0.000228	1.3848117	2.8164912 C
0.00006125	63.5842095	1038110.	5.3406659	0.0003271	-0.000243	1.4193929	2.7961123 C
0.00006375	64.7294337	1015364.	5.2669519	0.0003358	-0.000257	1.4535638	2.7739606 C
0.00006625	65.8489898	993947.	5.1980139	0.0003444	-0.000272	1.4873636	2.7502963 C
0.00006875	66.9500234	973819.	5.1335559	0.0003529	-0.000286	1.5208564	2.7255679 C
0.00007125	68.0344682	954870.	5.0731635	0.0003615	-0.000301	1.5540603	2.6998936 C
0.00007375	69.0951057	936883.	5.0161290	0.0003699	-0.000316	1.5868923	2.6726443 C
0.00007625	70.1467031	919957.	4.9626302	0.0003784	-0.000331	1.6195062	2.6449416 C
0.00007875	71.1801239	903875.	4.9119925	0.0003868	-0.000346	1.6518001	2.6160179 C
0.00008125	72.2041676	888667.	4.8642437	0.0003952	-0.000360	1.6838677	2.5865585 C
0.00008375	73.2143839	874202.	4.8189621	0.0004036	-0.000375	1.7156575	2.5561674 C
0.00008625	74.2172529	860490.	4.7761476	0.0004119	-0.000390	1.7472421	2.5253812 C
0.00008875	75.2062366	847394.	4.7353512	0.0004203	-0.000405	1.7785410	2.4935809 C
0.00009125	76.1934759	834997.	4.6968385	0.0004286	-0.000420	1.8097053	2.4619084 C
0.00009375	77.1632184	823074.	4.6598411	0.0004369	-0.000435	1.8405278	2.4287715 C
0.00009625	78.1310979	811752.	4.6248056	0.0004451	-0.000450	1.8712150	-2.536393 C
0.00009875	79.0920757	800932.	4.5913912	0.0004534	-0.000465	1.9016962	-2.697964 C
0.0001013	80.0423281	790542.	4.5593351	0.0004616	-0.000480	1.9319184	-2.860391 C
0.0001038	80.9908821	780635.	4.5288652	0.0004699	-0.000495	1.9620083	-3.022695 C
0.0001063	81.9330453	771135.	4.4996902	0.0004781	-0.000510	1.9918957	-3.185426 C
0.0001088	82.8656220	761983.	4.4716004	0.0004863	-0.000525	2.0215333	-3.348966 C
0.0001113	83.7965210	753227.	4.4448111	0.0004945	-0.000540	2.0510396	-3.512383 C
0.0001138	84.7257380	744842.	4.4192367	0.0005027	-0.000555	2.0804144	-3.675676 C
0.0001163	85.6429764	736714.	4.3944065	0.0005108	-0.000570	2.1094931	-3.840170 C
0.0001188	86.5577866	728908.	4.3706284	0.0005190	-0.000585	2.1384290	-4.004641 C
0.0001213	87.4709357	721410.	4.3478656	0.0005272	-0.000600	2.1672343	-4.168989 C
0.0001238	88.3824541	714202.	4.3260566	0.0005353	-0.000616	2.1959094	-4.333212 C
0.0001263	89.2833567	707195.	4.3048010	0.0005435	-0.000631	2.2242999	-4.498574 C
0.0001288	90.1819165	700442.	4.2843768	0.0005516	-0.000646	2.2525485	-4.663913 C
0.0001313	91.0788332	693934.	4.2647627	0.0005598	-0.000661	2.2806674	-4.829131 C
0.0001338	91.9741028	687657.	4.2459132	0.0005679	-0.000676	2.3086563	-4.994227 C
0.0001363	92.8659990	681585.	4.2277184	0.0005760	-0.000691	2.3364829	-5.159469 C
0.0001388	93.7497038	675674.	4.2099553	0.0005841	-0.000706	2.3640579	-5.325613 C
0.0001413	94.6317824	669960.	4.1928506	0.0005922	-0.000721	2.3915038	-5.491635 C
0.0001438	95.5122308	664433.	4.1763701	0.0006004	-0.000737	2.4188204	-5.657535 C
0.0001463	96.3910450	659084.	4.1604819	0.0006085	-0.000752	2.4460074	-5.823313 C
0.0001488	97.2682210	653904.	4.1451560	0.0006166	-0.000767	2.4730648	-5.988968 C
0.0001588	100.7357869	634556.	4.0880016	0.0006490	-0.000827	2.5794981	-6.654713 C
0.0001688	104.1705153	617307.	4.0377612	0.0006814	-0.000888	2.6837178	-7.319771 C
0.0001788	107.5598456	601733.	3.9927788	0.0007137	-0.000949	2.7854393	-7.986713 C
0.0001888	110.9231555	587672.	3.9529276	0.0007461	-0.001009	2.8850890	-8.651658 C
0.0001988	114.2420218	574803.	3.9167005	0.0007784	-0.001070	2.9822138	-9.318828 C
0.0002088	117.5346251	563040.	3.8842724	0.0008108	-0.001131	3.0772571	-9.984011 C
0.0002188	120.7986674	552222.	3.8550352	0.0008433	-0.001191	3.1701495	-10.647761 C
0.0002288	124.0242852	542183.	3.8281631	0.0008757	-0.001252	3.2606198	-11.312778 C
0.0002388	127.2235292	532873.	3.8038464	0.0009082	-0.001312	3.3489945	-11.975688 C
0.0002488	130.3961285	524206.	3.7817802	0.0009407	-0.001373	3.4352602	-12.636468 C
0.0002588	133.5392537	516094.	3.7615876	0.0009733	-0.001433	3.5193234	-13.295987 C
0.0002688	136.6476780	508456.	3.7428303	0.0010059	-0.001493	3.6010203	-13.956031 C
0.0002788	139.7290609	501270.	3.7256935	0.0010385	-0.001554	3.6805856	-14.613855 C
0.0002888	142.7831212	494487.	3.7100121	0.0010713	-0.001614	3.7580047	-15.269431 C
0.0002988	145.8095596	488065.	3.6956429	0.0011041	-0.001674	3.8332628	-15.922734 C
0.0003088	148.8080803	481969.	3.6824616	0.0011370	-0.001734	3.9063450	-16.573735 C
0.0003188	151.7768433	476163.	3.6702776	0.0011699	-0.001794	3.9771802	-17.223162 C
0.0003288	154.7131044	470610.	3.6588677	0.0012029	-0.001855	4.0456663	-17.872275 C

0.0003388	157.6208768	465301.	3.6483779	0.0012359	-0.001914	4.1119463	-18.518967 C
0.0003488	160.4998360	460215.	3.6387322	0.0012690	-0.001974	4.1760039	-19.163207 C
0.0003588	163.3496555	455330.	3.6298631	0.0013022	-0.002034	4.2378225	-19.804962 C
0.0003688	166.1699894	450630.	3.6217103	0.0013355	-0.002094	4.2973852	-20.444200 C
0.0003788	168.9604939	446100.	3.6142204	0.0013689	-0.002153	4.3546748	-21.080886 C
0.0003888	171.7208149	441726.	3.6073451	0.0014024	-0.002213	4.4096737	-21.714987 C
0.0003988	174.4505901	437494.	3.6010414	0.0014359	-0.002272	4.4623639	-22.346467 C
0.0004088	177.1494488	433393.	3.5952703	0.0014696	-0.002332	4.5127271	-22.975290 C
0.0004188	179.8170116	429414.	3.5899967	0.0015033	-0.002391	4.5607446	-23.601417 C
0.0004288	182.4528903	425546.	3.5851889	0.0015371	-0.002450	4.6063974	-24.224811 C
0.0004388	185.0566871	421782.	3.5808183	0.0015711	-0.002509	4.6496658	-24.845433 C
0.0004488	187.6268375	418110.	3.5767557	0.0016051	-0.002568	4.6904755	-25.464580 C
0.0004588	190.1641857	414527.	3.5730811	0.0016392	-0.002627	4.7288657	-26.080922 C
0.0004688	192.6684006	411026.	3.5697813	0.0016733	-0.002686	4.7648201	-26.694299 C
0.0004788	195.1390358	407601.	3.5668363	0.0017076	-0.002745	4.7983170	-27.304666 C
0.0004888	197.5756345	404247.	3.5642276	0.0017420	-0.002803	4.8293341	-27.911974 C
0.0004988	199.9777238	400958.	3.5619383	0.0017765	-0.002862	4.8578486	-28.516175 C
0.0005088	202.3448215	397729.	3.5599530	0.0018111	-0.002920	4.8838372	-29.117218 C
0.0005188	204.6764312	394557.	3.5582576	0.0018458	-0.002979	4.9072759	-29.715052 C
0.0005288	206.9720428	391436.	3.5568391	0.0018807	-0.003037	4.9281403	-30.309623 C
0.0005388	209.2311317	388364.	3.5556856	0.0019156	-0.003095	4.9464051	-30.900876 C
0.0005488	211.4531515	385336.	3.5547862	0.0019507	-0.003153	4.9620447	-31.488756 C
0.0006088	223.9703065	367918.	3.5542342	0.0021636	-0.003498	4.9989750	-34.941462 C
0.0006688	234.9012424	351254.	3.5612344	0.0023816	-0.003838	4.9999415	-38.249623 C
0.0007288	244.2064625	335103.	3.5744123	0.0026049	-0.004173	4.9998281	-41.402867 C
0.0007888	252.0555120	319563.	3.5918058	0.0028330	-0.004502	4.9976116	-44.413826 C
0.0008488	258.6333469	304723.	3.6122000	0.0030659	-0.004828	4.9990062	-47.290395 C
0.0009088	264.0919047	290610.	3.6348998	0.0033032	-0.005148	4.9989092	-50.035232 C
0.0009688	268.5643913	277228.	3.6592431	0.0035449	-0.005464	4.9971250	-52.654907 C
0.0010288	272.1907813	264584.	3.6842848	0.0037902	-0.005777	4.9968944	-55.169020 C
0.0010888	265.0299354	243426.	3.7322533	0.0040635	-0.006062	4.9995560	-56.872111 C

Axial Thrust Force = 46.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	2.0613901	1649112.	104.8033505	0.0001310	0.0001194	0.6016399	3.6625858	
0.00000250	4.1212840	1648514.	54.7288174	0.0001368	0.0001136	0.6272181	3.6947680	
0.00000375	6.1811559	1648308.	38.0382658	0.0001426	0.0001078	0.6527377	3.7270545	
0.00000500	8.2409945	1648199.	29.6937096	0.0001485	0.0001020	0.6781984	3.7594454	
0.00000625	10.3007887	1648126.	24.6875516	0.0001543	0.00009617	0.7036002	3.7919406	
0.00000750	12.3605274	1648070.	21.3505926	0.0001601	0.00009038	0.7289429	3.8245402	
0.00000875	14.4201994	1648023.	18.9674618	0.0001660	0.00008459	0.7542263	3.8572441	
0.00001000	16.4797937	1647979.	17.1804735	0.0001718	0.00007880	0.7794503	3.8900523	
0.00001125	18.5392990	1647938.	15.7909135	0.0001776	0.00007302	0.8046149	3.9229649	
0.00001250	20.5987044	1647896.	14.6795535	0.0001835	0.00006724	0.8297197	3.9559819	
0.00001375	22.6579985	1647854.	13.7705206	0.0001893	0.00006147	0.8547648	3.9891032	
0.00001500	24.7171704	1647811.	13.0132331	0.0001952	0.00005570	0.8797499	4.0223290	
0.00001625	26.7762088	1647767.	12.3726729	0.0002011	0.00004993	0.9046750	4.0556590	
0.00001750	28.8351026	1647720.	11.8238270	0.0002069	0.00004417	0.9295398	4.0890935	
0.00001875	30.8938407	1647672.	11.3483525	0.0002128	0.00003841	0.9543443	4.1226323	
0.00002000	32.9524120	1647621.	10.9324922	0.0002186	0.00003265	0.9790882	4.1562756	
0.00002125	35.0108053	1647567.	10.5657262	0.0002245	0.00002690	1.0037716	4.1900232	
0.00002250	37.0690095	1647512.	10.2398719	0.0002304	0.00002115	1.0283941	4.2238752	
0.00002375	39.1270134	1647453.	9.9484697	0.0002363	0.00001540	1.0529557	4.2578317	
0.00002500	41.1848058	1647392.	9.6863517	0.0002422	0.00000966	1.0774563	4.2918926	
0.00002625	43.2423758	1647329.	9.4493346	0.0002480	0.00000392	1.1018956	4.3260579	
0.00002750	45.2997117	1647262.	9.2339954	0.0002539	-0.00000182	1.1262737	4.3603276	
0.00002875	47.3567301	1647191.	9.0375050	0.0002598	-0.00000755	1.1505900	4.3947005	
0.00003000	49.4131569	1647105.	8.8575019	0.0002657	-0.00001327	1.1748439	4.4291717	
0.00003125	51.4686497	1646997.	8.6920004	0.0002716	-0.00001900	1.1990341	4.4637341	
0.00003250	53.5228683	1646857.	8.5393204	0.0002775	-0.00002472	1.2231598	4.4983827	
0.00003375	55.5755025	1646682.	8.3980308	0.0002834	-0.00003044	1.2472199	4.5331104	
0.00003500	57.6262658	1646465.	8.2669053	0.0002893	-0.00003616	1.2712134	4.5679111	
0.00003625	59.6749112	1646204.	8.1448873	0.0002953	-0.00004187	1.2951395	4.6027795	
0.00003750	61.7212185	1645899.	8.0310616	0.0003012	-0.00004759	1.3189974	4.6377106	

0.00003875	63.7649915	1645548.	7.9246311	0.0003071	-0.00005330	1.3427864	4.6726998
0.00004000	65.8060617	1645152.	7.8248992	0.0003130	-0.00005900	1.3665058	4.7077431
0.00004125	67.8442809	1644710.	7.7312538	0.0003189	-0.00006471	1.3901550	4.7428367
0.00004250	69.8795189	1644224.	7.6431551	0.0003248	-0.00007042	1.4137335	4.7779774
0.00004375	71.9116611	1643695.	7.5601253	0.0003308	-0.00007612	1.4372409	4.8131621
0.00004500	73.9406061	1643125.	7.4817399	0.0003367	-0.00008182	1.4606766	4.8483881
0.00004625	75.9662652	1642514.	7.4076204	0.0003426	-0.00008752	1.4840403	4.8836529
0.00004750	77.9885633	1641864.	7.3374286	0.0003485	-0.00009322	1.5073316	4.9189542
0.00004875	80.0074304	1641178.	7.2708608	0.0003545	-0.00009892	1.5305502	4.9542902
0.00005125	84.0346235	1639700.	7.1475316	0.0003663	-0.000110	1.5767682	5.0250583
0.00005375	75.3239689	1401376.	6.8466424	0.0003680	-0.000132	1.5829637	4.8011721 C
0.00005625	77.2552081	1373426.	6.7204012	0.0003780	-0.000145	1.6216582	4.8185508 C
0.00005875	79.0941446	1346283.	6.6030784	0.0003879	-0.000158	1.6597168	4.8328203 C
0.00006125	80.8531646	1320052.	6.4937630	0.0003977	-0.000172	1.6971892	4.8443005 C
0.00006375	82.5385237	1294722.	6.3915763	0.0004075	-0.000185	1.7340973	4.8531099 C
0.00006625	84.1564087	1270285.	6.2957801	0.0004171	-0.000199	1.7704642	4.8593793 C
0.00006875	85.7129374	1246734.	6.2057508	0.0004266	-0.000213	1.8063148	4.8632562 C
0.00007125	87.2141167	1224058.	6.1209604	0.0004361	-0.000227	1.8416757	4.8649037 C
0.00007375	88.6658197	1202248.	6.0409600	0.0004455	-0.000240	1.8765747	4.8645013 C
0.00007625	90.0737606	1181295.	5.9653674	0.0004549	-0.000254	1.9110418	4.8622456 C
0.00007875	91.4434698	1161187.	5.8938570	0.0004641	-0.000268	1.9451082	4.8583518 C
0.00008125	92.7709135	1141796.	5.8259329	0.0004734	-0.000282	1.9787418	4.8525390 C
0.00008375	94.0599466	1123104.	5.7613195	0.0004825	-0.000296	2.0119607	4.8449180 C
0.00008625	95.3235612	1105201.	5.6999982	0.0004916	-0.000311	2.0448534	4.8361626 C
0.00008875	96.5556867	1087951.	5.6415434	0.0005007	-0.000325	2.0773748	4.8258933 C
0.00009125	97.7557462	1071296.	5.5856738	0.0005097	-0.000339	2.1095130	4.8139889 C
0.00009375	98.9420956	1055382.	5.5325882	0.0005187	-0.000353	2.1414077	4.8015526 C
0.00009625	100.0886189	1039882.	5.4814618	0.0005276	-0.000368	2.1728514	4.7868873 C
0.00009875	101.2276603	1025090.	5.4328561	0.0005365	-0.000382	2.2040975	4.7720276 C
0.0001013	102.3361859	1010728.	5.3860582	0.0005453	-0.000396	2.2349584	4.7554280 C
0.0001038	103.4385018	996998.	5.3414722	0.0005542	-0.000411	2.2656322	4.7386979 C
0.0001063	104.5126924	983649.	5.2984387	0.0005630	-0.000425	2.2959328	4.7202864 C
0.0001088	105.5848071	970895.	5.2574331	0.0005717	-0.000440	2.3260832	4.7020306 C
0.0001113	106.6296323	958469.	5.2177345	0.0005805	-0.000454	2.3558589	4.6820457 C
0.0001138	107.6704112	946553.	5.1797818	0.0005892	-0.000469	2.3854683	4.6620638 C
0.0001163	108.6967860	935026.	5.1432166	0.0005979	-0.000483	2.4148138	4.6412560 C
0.0001188	109.7088607	923864.	5.1079521	0.0006066	-0.000498	2.4438977	4.6196260 C
0.0001213	110.7189079	913146.	5.0741843	0.0006152	-0.000512	2.4728343	4.5981452 C
0.0001238	111.7085159	902695.	5.0413901	0.0006239	-0.000527	2.5014441	4.5752622 C
0.0001263	112.6922815	892612.	5.0098463	0.0006325	-0.000542	2.5298708	4.5522021 C
0.0001288	113.6740418	882905.	4.9795668	0.0006411	-0.000556	2.5581515	4.5292885 C
0.0001313	114.6364637	873421.	4.9500705	0.0006497	-0.000571	2.5861089	4.5049624 C
0.0001338	115.5941871	864256.	4.9216501	0.0006583	-0.000586	2.6138941	4.4805367 C
0.0001363	116.5499269	855412.	4.8943092	0.0006668	-0.000600	2.6415347	4.4562550 C
0.0001388	117.4936584	846801.	4.8677497	0.0006754	-0.000615	2.6689226	4.4311529 C
0.0001413	118.4274263	838424.	4.8419771	0.0006839	-0.000630	2.6960808	4.4054227 C
0.0001438	119.3592355	830325.	4.8171350	0.0006925	-0.000644	2.7230956	4.3798346 C
0.0001463	120.2890798	822489.	4.7931758	0.0007010	-0.000659	2.7499667	4.3543889 C
0.0001488	121.2033814	814813.	4.7697289	0.0007095	-0.000674	2.7765405	4.3276790 C
0.0001588	124.8219117	786280.	4.6831815	0.0007435	-0.000733	2.8811860	4.2201730 C
0.0001688	128.3615560	760661.	4.6062518	0.0007773	-0.000792	2.9829841	-4.537720 C
0.0001788	131.8220849	737466.	4.5372229	0.0008110	-0.000851	3.0819053	-5.164451 C
0.0001888	135.2247390	716422.	4.4752541	0.0008447	-0.000911	3.1782020	-5.792573 C
0.0001988	138.5784803	697250.	4.4194799	0.0008784	-0.000970	3.2719958	-6.420934 C
0.0002088	141.8655301	679595.	4.3685344	0.0009119	-0.001029	3.3630192	-7.052415 C
0.0002188	145.1194247	663403.	4.3225311	0.0009456	-0.001089	3.4517447	-7.682083 C
0.0002288	148.3124846	648361.	4.2801330	0.0009791	-0.001148	3.5377533	-8.314523 C
0.0002388	151.4751115	634451.	4.2416149	0.0010127	-0.001208	3.6214993	-8.944688 C
0.0002488	154.5882335	621460.	4.2060195	0.0010462	-0.001267	3.7026713	-9.576112 C
0.0002588	157.6635306	609328.	4.1733003	0.0010798	-0.001327	3.7814560	-10.206597 C
0.0002688	160.7079988	597983.	4.1433159	0.0011135	-0.001386	3.8579555	-10.834746 C
0.0002788	163.7041873	587280.	4.1153065	0.0011471	-0.001445	3.9318676	-11.464321 C
0.0002888	166.6659197	577198.	4.0894302	0.0011808	-0.001505	4.0034252	-12.092279 C
0.0002988	169.5963755	567687.	4.0655648	0.0012146	-0.001564	4.0726721	-12.717823 C
0.0003088	172.4937462	558684.	4.0434753	0.0012484	-0.001623	4.1395654	-13.341308 C
0.0003188	175.3452691	550103.	4.0226346	0.0012822	-0.001682	4.2038721	-13.966061 C
0.0003288	178.1649923	541947.	4.0033250	0.0013161	-0.001741	4.2658388	-14.588305 C
0.0003388	180.9525462	534177.	3.9854141	0.0013501	-0.001800	4.3254478	-15.208008 C
0.0003488	183.7075530	526760.	3.9687847	0.0013841	-0.001859	4.3826812	-15.825138 C

0.0003588	186.4296274	519664.	3.9533328	0.0014183	-0.001918	4.4375206	-16.439663 C
0.0003688	189.1086312	512837.	3.9386500	0.0014524	-0.001977	4.4897710	-17.054927 C
0.0003788	191.7538277	506281.	3.9249695	0.0014866	-0.002036	4.5395986	-17.667696 C
0.0003888	194.3653995	499975.	3.9122352	0.0015209	-0.002094	4.5869950	-18.277733 C
0.0003988	196.9429292	493901.	3.9003791	0.0015553	-0.002153	4.6319404	-18.885000 C
0.0004088	199.4859890	488039.	3.8893401	0.0015898	-0.002212	4.6744145	-19.489459 C
0.0004188	201.9941413	482374.	3.8790629	0.0016244	-0.002270	4.7143967	-20.091070 C
0.0004288	204.4669378	476891.	3.8694974	0.0016590	-0.002328	4.7518657	-20.689791 C
0.0004388	206.9039196	471576.	3.8605984	0.0016938	-0.002387	4.7868002	-21.285581 C
0.0004488	209.3000495	466407.	3.8521388	0.0017286	-0.002445	4.8191028	-21.880814 C
0.0004588	211.6591447	461382.	3.8442512	0.0017636	-0.002503	4.8488300	-22.473342 C
0.0004688	213.9814099	456494.	3.8369292	0.0017986	-0.002561	4.8759709	-23.062758 C
0.0004788	216.2663362	451731.	3.8301406	0.0018337	-0.002619	4.9005014	-23.649014 C
0.0004888	218.5134005	447086.	3.8238564	0.0018689	-0.002676	4.9223971	-24.232059 C
0.0004988	220.7220659	442551.	3.8180499	0.0019043	-0.002734	4.9416331	-24.811841 C
0.0005088	222.8917807	438117.	3.8126964	0.0019397	-0.002792	4.9581835	-25.388305 C
0.0005188	225.0219566	433777.	3.8077734	0.0019753	-0.002849	4.9720221	-25.961401 C
0.0005288	227.1120743	429526.	3.8032604	0.0020110	-0.002906	4.9831220	-26.531060 C
0.0005388	229.1614512	425358.	3.7991381	0.0020468	-0.002964	4.9914553	-27.097239 C
0.0005488	231.1695494	421266.	3.7953891	0.0020827	-0.003021	4.9969937	-27.659861 C
0.0006088	242.2518036	397950.	3.7801253	0.0023012	-0.003360	4.9999607	-30.953637 C
0.0006688	251.5964815	376219.	3.7753838	0.0025248	-0.003695	4.9971238	-34.096465 C
0.0007288	259.3714188	355913.	3.7784063	0.0027535	-0.004024	4.9996682	-37.091711 C
0.0007888	265.7724720	336954.	3.7871175	0.0029871	-0.004348	4.9983121	-39.946315 C
0.0008488	271.0033897	319297.	3.7999106	0.0032252	-0.004668	4.9991009	-42.670133 C
0.0009088	275.2159089	302851.	3.8156914	0.0034675	-0.004984	4.9985525	-45.270697 C
0.0009688	278.5437954	287529.	3.8336347	0.0037138	-0.005296	4.9957041	-47.755590 C
0.0010288	275.5069384	267807.	3.8659577	0.0039771	-0.005590	4.9988686	-49.749036 C

Axial Thrust Force = 60.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
0.00000125	2.0212341	1616987.	136.3270609	0.0001704	0.0001588	0.7751405	4.8053203	
0.00000250	4.0405009	1616200.	70.4907079	0.0001762	0.0001530	0.8002088	4.8375051	
0.00000375	6.0597452	1615932.	48.5462322	0.0001820	0.0001472	0.8252184	4.8697959	
0.00000500	8.0789557	1615791.	37.5747258	0.0001879	0.0001414	0.8501691	4.9021928	
0.00000625	10.0981210	1615699.	30.9924072	0.0001937	0.0001356	0.8750607	4.9346957	
0.00000750	12.1172300	1615631.	26.6046825	0.0001995	0.0001298	0.8998932	4.9673047	
0.00000875	14.1362712	1615574.	23.4710114	0.0002054	0.0001240	0.9246664	5.0000198	
0.00001000	16.1552333	1615523.	21.1211238	0.0002112	0.0001182	0.9493801	5.0328409	
0.00001125	18.1741051	1615476.	19.2937587	0.0002171	0.0001124	0.9740342	5.0657682	
0.00001250	20.1928752	1615430.	17.8321592	0.0002229	0.0001067	0.9986286	5.0988015	
0.00001375	22.2115322	1615384.	16.6365711	0.0002288	0.0001009	1.0231631	5.1319409	
0.00001500	24.2300650	1615338.	15.6404916	0.0002346	0.00009511	1.0476375	5.1651864	
0.00001625	26.2484621	1615290.	14.7978803	0.0002405	0.00008934	1.0720518	5.1985380	
0.00001750	28.2667122	1615241.	14.0758510	0.0002463	0.00008358	1.0964058	5.2319957	
0.00001875	30.2848041	1615190.	13.4502875	0.0002522	0.00007782	1.1206993	5.2655595	
0.00002000	32.3027264	1615136.	12.9031024	0.0002581	0.00007206	1.1449323	5.2992294	
0.00002125	34.3204677	1615081.	12.4204642	0.0002639	0.00006631	1.1691045	5.3330055	
0.00002250	36.3380168	1615023.	11.9916151	0.0002698	0.00006056	1.1932158	5.3668877	
0.00002375	38.3553623	1614963.	11.6080622	0.0002757	0.00005482	1.2172661	5.4008760	
0.00002500	40.3724929	1614900.	11.2630110	0.0002816	0.00004908	1.2412552	5.4349705	
0.00002625	42.3893972	1614834.	10.9509612	0.0002875	0.00004334	1.2651831	5.4691712	
0.00002750	44.4060640	1614766.	10.6674127	0.0002934	0.00003760	1.2890495	5.5034780	
0.00002875	46.4224820	1614695.	10.4086480	0.0002992	0.00003187	1.3128542	5.5378910	
0.00003000	48.4386396	1614621.	10.1715691	0.0003051	0.00002615	1.3365973	5.5724102	
0.00003125	50.4545257	1614545.	9.9535736	0.0003110	0.00002042	1.3602785	5.6070356	
0.00003250	52.4701290	1614466.	9.7524598	0.0003170	0.00001470	1.3838976	5.6417672	
0.00003375	54.4854379	1614383.	9.5663518	0.0003229	0.00000899	1.4074546	5.6766050	
0.00003500	56.5004413	1614298.	9.3936419	0.0003288	0.00000328	1.4309493	5.7115491	
0.00003625	58.5151271	1614210.	9.2329441	0.0003347	-0.00000243	1.4543816	5.7465994	
0.00003750	60.5294207	1614118.	9.0830561	0.0003406	-0.00000814	1.4777511	5.7817548	
0.00003875	62.5431220	1614016.	8.9429287	0.0003465	-0.00001384	1.5010572	5.8170118	
0.00004000	64.5559744	1613899.	8.8116427	0.0003525	-0.00001953	1.5242992	5.8523657	
0.00004125	66.5677226	1613763.	8.6883904	0.0003584	-0.00002523	1.5474762	5.8878115	

0.00004250	68.5781116	1613603.	8.5724587	0.0003643	-0.00003092	1.5705874	5.9233442
0.00004375	70.5869053	1613415.	8.4632164	0.0003703	-0.00003661	1.5936321	5.9589591
0.00004500	72.5938865	1613197.	8.3601026	0.0003762	-0.00004230	1.6166096	5.9946515
0.00004625	74.5988569	1612948.	8.2626171	0.0003821	-0.00004798	1.6395189	6.0304161
0.00004750	76.6016313	1612666.	8.1703127	0.0003881	-0.00005366	1.6623599	6.0662513
0.00004875	78.6020464	1612350.	8.0827882	0.0003940	-0.00005934	1.6851317	6.1021519
0.00005125	82.5952151	1611614.	7.9206706	0.0004059	-0.00007069	1.7304656	6.1741357
0.00005375	86.5773249	1610741.	7.7737768	0.0004178	-0.00008203	1.7755166	6.2463426
0.00005625	90.5475415	1609734.	7.6400641	0.0004298	-0.00009337	1.8202815	6.3187514
0.00005875	94.5051629	1608599.	7.5178388	0.0004417	-0.000105	1.8647571	6.3913435
0.00006125	89.0990296	1454678.	7.2871137	0.0004463	-0.000123	1.8818051	6.2534902 C
0.00006375	91.3249859	1432549.	7.1656018	0.0004568	-0.000136	1.9204606	6.2840896 C
0.00006625	93.4549665	1410641.	7.0518152	0.0004672	-0.000149	1.9585209	6.3119121 C
0.00006875	95.4949599	1389018.	6.9449502	0.0004775	-0.000162	1.9960023	6.3370336 C
0.00007125	97.4510743	1367734.	6.8443226	0.0004877	-0.000175	2.0329233	6.3595513 C
0.00007375	99.3294077	1346839.	6.7493483	0.0004978	-0.000188	2.0693027	6.3795662 C
0.00007625	101.1361134	1326375.	6.6595259	0.0005078	-0.000201	2.1051618	6.3972028 C
0.00007875	102.8773006	1306378.	6.5744248	0.0005177	-0.000215	2.1405230	6.4125974 C
0.00008125	104.5590252	1286880.	6.4936738	0.0005276	-0.000228	2.1754101	6.4259024 C
0.00008375	106.1872570	1267908.	6.4169529	0.0005374	-0.000241	2.2098485	6.4372868 C
0.00008625	107.7678508	1249482.	6.3439859	0.0005472	-0.000255	2.2438649	6.4469360 C
0.00008875	109.3065233	1231623.	6.2745345	0.0005569	-0.000269	2.2774881	6.4550540 C
0.00009125	110.7891025	1214127.	6.2080349	0.0005665	-0.000282	2.3106338	6.4609117 C
0.00009375	112.2352994	1197177.	6.1445602	0.0005761	-0.000296	2.3434075	6.4653512 C
0.00009625	113.6528881	1180809.	6.0840021	0.0005856	-0.000310	2.3758543	6.4687279 C
0.00009875	115.0232371	1164792.	6.0257959	0.0005950	-0.000323	2.4078610	6.4700588 C
0.0001013	116.3661321	1149295.	5.9700859	0.0006045	-0.000337	2.4395413	6.4702792 C
0.0001038	117.6828187	1134292.	5.9167116	0.0006139	-0.000351	2.4709047	6.4694492 C
0.0001063	118.9607722	1119631.	5.8652649	0.0006232	-0.000365	2.5018669	6.4668197 C
0.0001088	120.2262721	1105529.	5.8160696	0.0006325	-0.000379	2.5325970	6.4638304 C
0.0001113	121.4487228	1091674.	5.7684185	0.0006417	-0.000393	2.5628914	6.4586897 C
0.0001138	122.6655108	1078378.	5.7228613	0.0006510	-0.000407	2.5929984	6.4535472 C
0.0001163	123.8415449	1065304.	5.6786301	0.0006601	-0.000421	2.6226775	6.4462688 C
0.0001188	125.0120787	1052733.	5.6362588	0.0006693	-0.000435	2.6521716	6.4389823 C
0.0001213	126.1503857	1040416.	5.5951461	0.0006784	-0.000449	2.6812902	6.4299770 C
0.0001238	127.2771047	1028502.	5.5555797	0.0006875	-0.000463	2.7101815	6.4205600 C
0.0001263	128.3859576	1016918.	5.5173444	0.0006966	-0.000478	2.7387968	6.4102793 C
0.0001288	129.4713418	1005603.	5.4802606	0.0007056	-0.000492	2.7670961	6.3987539 C
0.0001313	130.5544244	994700.	5.4446348	0.0007146	-0.000506	2.7952359	6.3874009 C
0.0001338	131.6068343	983976.	5.4098675	0.0007236	-0.000520	2.8229993	6.3742122 C
0.0001363	132.6531552	973601.	5.3763504	0.0007325	-0.000535	2.8505758	6.3609216 C
0.0001388	133.6941141	963561.	5.3440255	0.0007415	-0.000549	2.8779699	6.3475687 C
0.0001413	134.7072520	953680.	5.3124185	0.0007504	-0.000563	2.9050034	6.3324692 C
0.0001438	135.7181472	944126.	5.2819505	0.0007593	-0.000578	2.9318810	6.3175346 C
0.0001463	136.7250652	934872.	5.2525307	0.0007682	-0.000592	2.9585880	6.3026281 C
0.0001488	137.7057202	925753.	5.2236954	0.0007770	-0.000606	2.9849404	6.2859771 C
0.0001588	141.5663512	891757.	5.1170564	0.0008123	-0.000664	3.0884611	6.2176244 C
0.0001688	145.2970476	861020.	5.0218929	0.0008474	-0.000722	3.1886919	6.1435795 C
0.0001788	148.9164141	833099.	4.9364881	0.0008824	-0.000780	3.2857822	6.0649223 C
0.0001888	152.4411013	807635.	4.8594969	0.0009172	-0.000838	3.3798748	5.9827914 C
0.0001988	155.8853771	784329.	4.7898501	0.0009520	-0.000896	3.4711015	5.8983346 C
0.0002088	159.2369887	762812.	4.7261929	0.0009866	-0.000955	3.5593217	5.8097412 C
0.0002188	162.5286052	742988.	4.6682430	0.0010212	-0.001013	3.6448596	5.7204331 C
0.0002288	165.7602586	724635.	4.6152490	0.0010557	-0.001072	3.7277193	-6.091447 C
0.0002388	168.9237570	707534.	4.5663845	0.0010902	-0.001130	3.8077939	-6.696065 C
0.0002488	172.0427650	691629.	4.5215956	0.0011247	-0.001189	3.8853479	-7.299625 C
0.0002588	175.0996051	676713.	4.4800389	0.0011592	-0.001247	3.9601653	-7.904909 C
0.0002688	178.1124105	662744.	4.4417043	0.0011937	-0.001306	4.0324564	-8.509183 C
0.0002788	181.0805870	649616.	4.4062192	0.0012282	-0.001364	4.1021986	-9.112658 C
0.0002888	183.9930396	637205.	4.3730614	0.0012627	-0.001423	4.1692594	-9.717227 C
0.0002988	186.8709157	625509.	4.3424211	0.0012973	-0.001481	4.2338827	-10.319216 C
0.0003088	189.7043123	614427.	4.3138462	0.0013319	-0.001539	4.2959346	-10.920474 C
0.0003188	192.4869350	603881.	4.2870119	0.0013665	-0.001598	4.3553374	-11.522224 C
0.0003288	195.2344195	593869.	4.2620896	0.0014012	-0.001656	4.4122721	-12.121308 C
0.0003388	197.9463358	584343.	4.2389135	0.0014359	-0.001714	4.4667192	-12.717693 C
0.0003488	200.6093977	575224.	4.2170366	0.0014707	-0.001773	4.5185048	-13.314381 C
0.0003588	203.2300738	566495.	4.1964981	0.0015055	-0.001831	4.5677055	-13.909832 C
0.0003688	205.8145172	558141.	4.1773361	0.0015404	-0.001889	4.6143827	-14.502477 C
0.0003788	208.3622688	550131.	4.1594448	0.0015754	-0.001947	4.6585154	-15.092278 C

0.0003888	210.8728587	542438.	4.1427297	0.0016105	-0.002005	4.7000824	-15.679196 C
0.0003988	213.3358678	535012.	4.1268499	0.0016456	-0.002063	4.7389514	-16.266149 C
0.0004088	215.7577219	527848.	4.1119087	0.0016807	-0.002121	4.7751904	-16.851186 C
0.0004188	218.1415730	520935.	4.0979301	0.0017160	-0.002178	4.8088193	-17.433201 C
0.0004288	220.4869114	514255.	4.0848502	0.0017514	-0.002236	4.8398150	-18.012148 C
0.0004388	222.7932144	507791.	4.0726113	0.0017869	-0.002294	4.8681537	-18.587982 C
0.0004488	225.0599464	501526.	4.0611606	0.0018224	-0.002351	4.8938112	-19.160655 C
0.0004588	227.2865580	495448.	4.0504504	0.0018581	-0.002408	4.9167628	-19.730120 C
0.0004688	229.4685298	489533.	4.0403141	0.0018939	-0.002465	4.9369524	-20.297994 C
0.0004788	231.6058656	483772.	4.0307283	0.0019297	-0.002523	4.9543695	-20.864115 C
0.0004888	233.7019802	478163.	4.0217749	0.0019656	-0.002580	4.9690211	-21.426817 C
0.0004988	235.7561697	472694.	4.0134197	0.0020017	-0.002637	4.9808795	-21.986061 C
0.0005088	237.7678021	467357.	4.0056314	0.0020379	-0.002694	4.9899164	-22.541790 C
0.0005188	239.7362487	462142.	3.9983814	0.0020742	-0.002750	4.9961030	-23.093939 C
0.0005288	241.6608321	457042.	3.9916431	0.0021106	-0.002807	4.9994094	-23.642450 C
0.0005388	243.5385206	452044.	3.9854007	0.0021471	-0.002863	4.9984662	-24.187124 C
0.0005488	245.3677404	447139.	3.9796348	0.0021838	-0.002920	4.9999970	-24.727821 C
0.0006088	255.2470191	419297.	3.9541038	0.0024071	-0.003254	4.9998032	-27.882263 C
0.0006688	263.3776926	393836.	3.9406355	0.0026353	-0.003584	4.9999942	-30.891614 C
0.0007288	269.9905408	370484.	3.9363510	0.0028686	-0.003909	4.9995638	-33.753745 C
0.0007888	275.3209514	349060.	3.9387166	0.0031067	-0.004229	4.9966861	-36.478674 C
0.0008488	279.5466982	329363.	3.9459722	0.0033491	-0.004544	4.9956536	-39.075014 C
0.0009088	282.8349356	311235.	3.9566462	0.0035956	-0.004856	4.9965865	-41.556008 C
0.0009688	283.2839297	292422.	3.9743633	0.0038502	-0.005159	4.9997272	-43.801995 C

Summary of Results for Nominal Moment Capacity for Section 2

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	28.000	256.773	0.00300000	-0.00473554
2	46.000	266.056	0.00300000	-0.00436563
3	60.000	272.933	0.00300000	-0.00408535

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	28.000000	256.772744	18.200000	166.902284	449442.
2	0.65	46.000000	266.056139	29.900000	172.936490	557352.
3	0.65	60.000000	272.932531	39.000000	177.406145	666019.
1	0.75	28.000000	256.772744	21.000000	192.579558	411150.
2	0.75	46.000000	266.056139	34.500000	199.542104	487912.
3	0.75	60.000000	272.932531	45.000000	204.699398	561746.
1	0.90	28.000000	256.772744	25.200000	231.095470	357056.
2	0.90	46.000000	266.056139	41.400000	239.450525	403843.
3	0.90	60.000000	272.932531	54.000000	245.639278	446374.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	107093.
2	15.0000	16.3627	Yes	No	107093.	413928.
3	34.0000	34.0000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 12000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 60000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2541	-652961.	12000.	0.00	0.00	7.31E+09	0.00	0.00	0.00
0.3700	0.2532	-599628.	11977.	-3.80E-04	0.00	7.31E+09	-10.496	184.0516	0.00
0.7400	0.2507	-546405.	11903.	-7.26E-04	0.00	7.38E+09	-22.481	398.1551	0.00
1.1100	0.2467	-493538.	11777.	-0.00104	0.00	7.43E+09	-34.276	616.7729	0.00
1.4800	0.2415	-441268.	11602.	-0.00132	0.00	7.48E+09	-44.870	825.0143	0.00
1.8500	0.2351	-389812.	11383.	-0.00156	0.00	7.54E+09	-53.903	1018.	0.00
2.2200	0.2276	-339359.	11128.	-0.00178	0.00	7.62E+09	-60.626	1183.	0.00
2.5900	0.2193	-290047.	10846.	-0.00196	0.00	7.72E+09	-66.462	1346.	0.00
2.9600	0.2102	-242002.	10536.	-0.00211	0.00	8.14E+09	-73.084	1544.	0.00
3.3300	0.2006	-195362.	10201.	-0.00223	0.00	8.14E+09	-78.001	1727.	0.00
3.7000	0.1904	-150231.	9842.	-0.00232	0.00	8.14E+09	-83.777	1953.	0.00
4.0700	0.1800	-106730.	9448.	-0.00239	0.00	8.14E+09	-93.615	2310.	0.00
4.4400	0.1692	-65059.	9012.	-0.00244	0.00	8.14E+09	-102.777	2697.	0.00
4.8100	0.1583	-25405.	8531.	-0.00246	0.00	8.14E+09	-113.896	3194.	0.00
5.1800	0.1473	12008.	8001.	-0.00247	0.00	8.14E+09	-124.609	3755.	0.00
5.5500	0.1364	46962.	7426.	-0.00245	0.00	8.14E+09	-134.745	4386.	0.00
5.9200	0.1256	79254.	6807.	-0.00242	0.00	8.14E+09	-144.140	5096.	0.00
6.2900	0.1150	108692.	6148.	-0.00236	0.00	8.14E+09	-152.640	5896.	0.00
6.6600	0.1046	135105.	5453.	-0.00230	0.00	8.14E+09	-160.100	6797.	0.00
7.0300	0.09454	158343.	4729.	-0.00222	0.00	8.14E+09	-166.390	7814.	0.00
7.4000	0.08489	178277.	3979.	-0.00213	0.00	8.14E+09	-171.392	8965.	0.00
7.7700	0.07566	194807.	3210.	-0.00202	0.00	8.14E+09	-175.000	10269.	0.00
8.1400	0.06691	207859.	2428.	-0.00191	0.00	8.14E+09	-177.126	11754.	0.00
8.5100	0.05866	217389.	1640.	-0.00180	0.00	8.14E+09	-177.693	13450.	0.00
8.8800	0.05093	223384.	884.4047	-0.00168	0.00	8.14E+09	-162.826	14194.	0.00
9.2500	0.04375	226136.	199.4952	-0.00156	0.00	8.14E+09	-145.692	14785.	0.00

9.6200	0.03712	225984.	-409.304	-0.00143	0.00	8.14E+09	-128.542	15377.	0.00
9.9900	0.03103	223265.	-942.404	-0.00131	0.00	8.14E+09	-111.593	15968.	0.00
10.3600	0.02548	218314.	-1401.	-0.00119	0.00	8.14E+09	-95.039	16559.	0.00
10.7300	0.02046	211457.	-1788.	-0.00107	0.00	8.14E+09	-79.050	17151.	0.00
11.1000	0.01596	203011.	-2105.	-9.59E-04	0.00	8.14E+09	-63.770	17742.	0.00
11.4700	0.01194	193279.	-2356.	-8.51E-04	0.00	8.14E+09	-49.321	18334.	0.00
11.8400	0.00840	182546.	-2545.	-7.49E-04	0.00	8.14E+09	-35.796	18925.	0.00
12.2100	0.00529	171081.	-2676.	-6.52E-04	0.00	8.14E+09	-23.270	19516.	0.00
12.5800	0.00260	159132.	-2754.	-5.62E-04	0.00	8.14E+09	-11.793	20108.	0.00
12.9500	2.99E-04	146928.	-2783.	-4.79E-04	0.00	8.14E+09	-1.395	20699.	0.00
13.3200	-0.00165	134675.	-2768.	-4.02E-04	0.00	8.14E+09	7.9109	21291.	0.00
13.6900	-0.00327	122559.	-2715.	-3.32E-04	0.00	8.14E+09	16.1294	21882.	0.00
14.0600	-0.00460	110742.	-2628.	-2.69E-04	0.00	8.14E+09	23.2786	22474.	0.00
14.4300	-0.00566	99368.	-2511.	-2.11E-04	0.00	8.14E+09	29.3883	23065.	0.00
14.8000	-0.00647	88560.	-2369.	-1.60E-04	0.00	8.14E+09	34.4983	23656.	0.00
15.1700	-0.00708	78418.	-2235.	-1.14E-04	0.00	8.14E+09	25.7702	16165.	0.00
15.5400	-0.00749	68773.	-2116.	-7.44E-05	0.00	8.14E+09	27.9407	16559.	0.00
15.9100	-0.00774	59669.	-1988.	-3.94E-05	0.00	8.14E+09	29.5488	16954.	0.00
16.2800	-0.00784	51139.	-1855.	-9.14E-06	0.00	8.14E+09	30.6365	17348.	0.00
16.6500	-0.00782	43205.	-1717.	1.66E-05	0.00	8.14E+09	31.2476	17742.	0.00
17.0200	-0.00769	35881.	-1578.	3.81E-05	0.00	8.14E+09	31.4278	18137.	0.00
17.3900	-0.00748	29172.	-1439.	5.59E-05	0.00	8.14E+09	31.2230	18531.	0.00
17.7600	-0.00720	23073.	-1302.	7.01E-05	0.00	8.14E+09	30.6794	18925.	0.00
18.1300	-0.00686	17577.	-1167.	8.12E-05	0.00	8.14E+09	29.8425	19319.	0.00
18.5000	-0.00648	12665.	-1037.	8.94E-05	0.00	8.14E+09	28.7565	19714.	0.00
18.8700	-0.00606	8319.	-912.304	9.52E-05	0.00	8.14E+09	27.4637	20108.	0.00
19.2400	-0.00563	4513.	-793.604	9.87E-05	0.00	8.14E+09	26.0048	20502.	0.00
19.6100	-0.00519	1220.	-681.666	1.00E-04	0.00	8.14E+09	24.4176	20896.	0.00
19.9800	-0.00474	-1593.	-576.982	1.00E-04	0.00	8.14E+09	22.7374	21291.	0.00
20.3500	-0.00430	-3957.	-479.892	9.86E-05	0.00	8.14E+09	20.9968	21685.	0.00
20.7200	-0.00387	-5907.	-390.599	9.59E-05	0.00	8.14E+09	19.2253	22079.	0.00
21.0900	-0.00345	-7477.	-309.182	9.23E-05	0.00	8.14E+09	17.4492	22474.	0.00
21.4600	-0.00305	-8702.	-235.608	8.79E-05	0.00	8.14E+09	15.6919	22868.	0.00
21.8300	-0.00267	-9616.	-169.750	8.29E-05	0.00	8.14E+09	13.9739	23262.	0.00
22.2000	-0.00231	-10253.	-111.394	7.74E-05	0.00	8.14E+09	12.3125	23656.	0.00
22.5700	-0.00198	-10646.	-60.257	7.18E-05	0.00	8.14E+09	10.7222	24051.	0.00
22.9400	-0.00167	-10827.	-15.997	6.59E-05	0.00	8.14E+09	9.2150	24445.	0.00
23.3100	-0.00139	-10824.	21.7769	6.00E-05	0.00	8.14E+09	7.8001	24839.	0.00
23.6800	-0.00114	-10665.	53.4886	5.41E-05	0.00	8.14E+09	6.4845	25233.	0.00
24.0500	-9.14E-04	-10377.	79.5898	4.84E-05	0.00	8.14E+09	5.2728	25628.	0.00
24.4200	-7.11E-04	-9984.	100.5486	4.29E-05	0.00	8.14E+09	4.1681	26022.	0.00
24.7900	-5.33E-04	-9507.	116.8416	3.75E-05	0.00	8.14E+09	3.1711	26416.	0.00
25.1600	-3.78E-04	-8967.	128.9465	3.25E-05	0.00	8.14E+09	2.2815	26810.	0.00
25.5300	-2.44E-04	-8380.	137.3356	2.78E-05	0.00	8.14E+09	1.4974	27205.	0.00
25.9000	-1.31E-04	-7762.	142.4703	2.34E-05	0.00	8.14E+09	0.8156	27599.	0.00
26.2700	-3.68E-05	-7127.	144.7962	1.93E-05	0.00	8.14E+09	0.2321	27993.	0.00
26.6400	4.03E-05	-6486.	144.7394	1.56E-05	0.00	8.14E+09	-0.258	28388.	0.00
27.0100	1.02E-04	-5850.	142.7030	1.22E-05	0.00	8.14E+09	-0.660	28782.	0.00
27.3800	1.49E-04	-5226.	139.0650	9.22E-06	0.00	8.14E+09	-0.979	29176.	0.00
27.7500	1.84E-04	-4620.	134.1761	6.54E-06	0.00	8.14E+09	-1.223	29570.	0.00
28.1200	2.07E-04	-4038.	128.3586	4.18E-06	0.00	8.14E+09	-1.397	29965.	0.00
28.4900	2.21E-04	-3482.	121.9055	2.13E-06	0.00	8.14E+09	-1.509	30359.	0.00
28.8600	2.26E-04	-2956.	115.0802	3.73E-07	0.00	8.14E+09	-1.565	30753.	0.00
29.2300	2.24E-04	-2461.	108.1164	-1.10E-06	0.00	8.14E+09	-1.572	31147.	0.00
29.6000	2.16E-04	-1996.	101.2180	-2.32E-06	0.00	8.14E+09	-1.536	31542.	0.00
29.9700	2.03E-04	-1561.	94.5601	-3.29E-06	0.00	8.14E+09	-1.463	31936.	0.00
30.3400	1.87E-04	-1154.	88.2890	-4.03E-06	0.00	8.14E+09	-1.361	32330.	0.00
30.7100	1.68E-04	-774.528	82.5229	-4.55E-06	0.00	8.14E+09	-1.236	32725.	0.00
31.0800	1.47E-04	-419.039	77.3528	-4.88E-06	0.00	8.14E+09	-1.093	33119.	0.00
31.4500	1.24E-04	-85.036	72.8426	-5.02E-06	0.00	8.14E+09	-0.939	33513.	0.00
31.8200	1.02E-04	230.4760	69.0299	-4.98E-06	0.00	8.14E+09	-0.779	33907.	0.00
32.1900	8.02E-05	530.6017	65.9262	-4.77E-06	0.00	8.14E+09	-0.619	34302.	0.00
32.5600	5.96E-05	818.4421	63.5171	-4.40E-06	0.00	8.14E+09	-0.466	34696.	0.00
32.9300	4.11E-05	1097.	61.7622	-3.88E-06	0.00	8.14E+09	-0.325	35090.	0.00
33.3000	2.52E-05	1369.	60.5950	-3.21E-06	0.00	8.14E+09	-0.201	35484.	0.00
33.6700	1.26E-05	1637.	59.9226	-2.39E-06	0.00	8.14E+09	-0.102	35879.	0.00
34.0400	3.96E-06	1902.	-51.433	-1.42E-06	0.00	8.14E+09	-50.059	5.61E+07	0.00
34.4100	-5.44E-08	1181.	-161.037	-5.83E-07	0.00	8.14E+09	0.6873	5.61E+07	0.00
34.7800	-1.21E-06	472.6406	-125.473	-1.32E-07	0.00	8.14E+09	15.3328	5.61E+07	0.00

35.1500	-1.23E-06	66.6740	-56.961	8.81E-08	0.00	1.62E+09	15.5283	5.61E+07	0.00
35.5200	-4.32E-07	-33.223	-10.373	1.34E-07	0.00	1.62E+09	5.4574	5.61E+07	0.00
35.8900	-3.98E-08	-25.510	2.8570	5.33E-08	0.00	1.62E+09	0.5021	5.61E+07	0.00
36.2600	4.16E-08	-7.881	2.8058	7.50E-09	0.00	1.62E+09	-0.525	5.61E+07	0.00
36.6300	2.68E-08	-0.599	0.8872	-4.14E-09	0.00	1.62E+09	-0.339	5.61E+07	0.00
37.0000	4.80E-09	0.00	0.00	-4.96E-09	0.00	1.62E+09	-0.06063	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.25407572 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -652961. inch-lbs
Maximum shear force = 12000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 10000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 46000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2001	-530787.	10000.	0.00	0.00	7.31E+09	0.00	0.00	0.00
0.3700	0.1994	-486355.	9978.	-3.09E-04	0.00	7.31E+09	-9.700	216.0037	0.00
0.7400	0.1974	-442053.	9911.	-5.89E-04	0.00	7.38E+09	-20.718	466.1067	0.00
1.1100	0.1941	-398105.	9795.	-8.41E-04	0.00	7.42E+09	-31.526	720.9968	0.00
1.4800	0.1899	-354730.	9634.	-0.00107	0.00	7.47E+09	-41.178	962.8904	0.00
1.8500	0.1847	-312123.	9433.	-0.00126	0.00	7.54E+09	-49.331	1186.	0.00
2.2200	0.1787	-270452.	9200.	-0.00143	0.00	7.62E+09	-55.362	1376.	0.00
2.5900	0.1719	-229840.	8944.	-0.00158	0.00	8.15E+09	-60.178	1554.	0.00
2.9600	0.1647	-190388.	8665.	-0.00169	0.00	8.15E+09	-65.388	1763.	0.00
3.3300	0.1569	-152205.	8367.	-0.00178	0.00	8.16E+09	-68.692	1943.	0.00
3.7000	0.1488	-115358.	8053.	-0.00186	0.00	8.16E+09	-72.797	2172.	0.00
4.0700	0.1405	-79934.	7712.	-0.00191	0.00	8.16E+09	-80.922	2558.	0.00
4.4400	0.1319	-46097.	7336.	-0.00194	0.00	8.16E+09	-88.315	2973.	0.00
4.8100	0.1232	-13995.	6923.	-0.00196	0.00	8.16E+09	-97.779	3524.	0.00
5.1800	0.1145	16181.	6469.	-0.00196	0.00	8.16E+09	-106.871	4145.	0.00
5.5500	0.1058	44248.	5975.	-0.00194	0.00	8.16E+09	-115.442	4845.	0.00
5.9200	0.09723	70035.	5445.	-0.00191	0.00	8.16E+09	-123.353	5633.	0.00
6.2900	0.08883	93382.	4882.	-0.00187	0.00	8.16E+09	-130.472	6522.	0.00
6.6600	0.08065	114146.	4289.	-0.00181	0.00	8.16E+09	-136.676	7525.	0.00
7.0300	0.07275	132204.	3670.	-0.00174	0.00	8.16E+09	-141.856	8658.	0.00
7.4000	0.06516	147450.	3031.	-0.00167	0.00	8.16E+09	-145.911	9942.	0.00
7.7700	0.05794	159803.	2377.	-0.00158	0.00	8.16E+09	-148.757	11400.	0.00
8.1400	0.05110	169207.	1715.	-0.00149	0.00	8.15E+09	-149.739	13011.	0.00
8.5100	0.04467	175639.	1078.	-0.00140	0.00	8.15E+09	-136.845	13602.	0.00

8.8800	0.03866	179354.	500.1551	-0.00130	0.00	8.15E+09	-123.595	14194.	0.00
9.2500	0.03309	180613.	-18.845	-0.00121	0.00	8.15E+09	-110.189	14785.	0.00
9.6200	0.02795	179680.	-478.384	-0.00111	0.00	8.15E+09	-96.811	15377.	0.00
9.9900	0.02325	176817.	-878.955	-0.00101	0.00	8.15E+09	-83.627	15968.	0.00
10.3600	0.01898	172287.	-1222.	-9.16E-04	0.00	8.15E+09	-70.785	16559.	0.00
10.7300	0.01512	166342.	-1509.	-8.23E-04	0.00	8.16E+09	-58.413	17151.	0.00
11.1000	0.01167	159228.	-1742.	-7.35E-04	0.00	8.16E+09	-46.620	17742.	0.00
11.4700	0.00860	151176.	-1924.	-6.50E-04	0.00	8.16E+09	-35.497	18334.	0.00
11.8400	0.00589	142408.	-2059.	-5.70E-04	0.00	8.16E+09	-25.112	18925.	0.00
12.2100	0.00353	133129.	-2149.	-4.95E-04	0.00	8.16E+09	-15.520	19516.	0.00
12.5800	0.00149	123529.	-2198.	-4.26E-04	0.00	8.16E+09	-6.757	20108.	0.00
12.9500	-2.49E-04	113782.	-2211.	-3.61E-04	0.00	8.16E+09	1.1586	20699.	0.00
13.3200	-0.00171	104045.	-2190.	-3.02E-04	0.00	8.16E+09	8.2191	21291.	0.00
13.6900	-0.00293	94459.	-2140.	-2.48E-04	0.00	8.16E+09	14.4308	21882.	0.00
14.0600	-0.00391	85147.	-2064.	-1.99E-04	0.00	8.16E+09	19.8107	22474.	0.00
14.4300	-0.00469	76216.	-1965.	-1.55E-04	0.00	8.16E+09	24.3843	23065.	0.00
14.8000	-0.00529	67757.	-1849.	-1.16E-04	0.00	8.16E+09	28.1845	23656.	0.00
15.1700	-0.00572	59846.	-1740.	-8.10E-05	0.00	8.16E+09	20.8328	16165.	0.00
15.5400	-0.00601	52340.	-1644.	-5.05E-05	0.00	8.16E+09	22.4134	16559.	0.00
15.9100	-0.00617	45269.	-1542.	-2.40E-05	0.00	8.16E+09	23.5620	16954.	0.00
16.2800	-0.00622	38658.	-1436.	-1.12E-06	0.00	8.16E+09	24.3119	17348.	0.00
16.6500	-0.00618	32521.	-1327.	1.82E-05	0.00	8.16E+09	24.6977	17742.	0.00
17.0200	-0.00606	26868.	-1217.	3.44E-05	0.00	8.16E+09	24.7550	18137.	0.00
17.3900	-0.00588	21701.	-1108.	4.76E-05	0.00	8.16E+09	24.5201	18531.	0.00
17.7600	-0.00564	17014.	-999.824	5.82E-05	0.00	8.16E+09	24.0287	18925.	0.00
18.1300	-0.00536	12798.	-894.718	6.63E-05	0.00	8.16E+09	23.3162	19319.	0.00
18.5000	-0.00505	9041.	-793.191	7.22E-05	0.00	8.16E+09	22.4169	19714.	0.00
18.8700	-0.00472	5725.	-695.998	7.62E-05	0.00	8.16E+09	21.3636	20108.	0.00
19.2400	-0.00437	2830.	-603.754	7.86E-05	0.00	8.16E+09	20.1876	20502.	0.00
19.6100	-0.00402	331.8509	-516.940	7.94E-05	0.00	8.16E+09	18.9181	20896.	0.00
19.9800	-0.00367	-1793.	-435.909	7.90E-05	0.00	8.16E+09	17.5821	21291.	0.00
20.3500	-0.00332	-3571.	-360.902	7.76E-05	0.00	8.16E+09	16.2047	21685.	0.00
20.7200	-0.00298	-5030.	-292.054	7.52E-05	0.00	8.16E+09	14.8082	22079.	0.00
21.0900	-0.00265	-6195.	-229.403	7.22E-05	0.00	8.16E+09	13.4128	22474.	0.00
21.4600	-0.00234	-7096.	-172.906	6.86E-05	0.00	8.16E+09	12.0363	22868.	0.00
21.8300	-0.00204	-7759.	-122.445	6.45E-05	0.00	8.16E+09	10.6940	23262.	0.00
22.2000	-0.00176	-8210.	-77.839	6.02E-05	0.00	8.16E+09	9.3991	23656.	0.00
22.5700	-0.00151	-8475.	-38.852	5.56E-05	0.00	8.16E+09	8.1624	24051.	0.00
22.9400	-0.00127	-8578.	-5.207	5.10E-05	0.00	8.16E+09	6.9929	24445.	0.00
23.3100	-0.00105	-8542.	23.4087	4.63E-05	0.00	8.16E+09	5.8972	24839.	0.00
23.6800	-8.59E-04	-8389.	47.3349	4.17E-05	0.00	8.16E+09	4.8804	25233.	0.00
24.0500	-6.84E-04	-8138.	66.9294	3.72E-05	0.00	8.16E+09	3.9459	25628.	0.00
24.4200	-5.28E-04	-7810.	82.5617	3.29E-05	0.00	8.16E+09	3.0956	26022.	0.00
24.7900	-3.92E-04	-7419.	94.6066	2.87E-05	0.00	8.16E+09	2.3300	26416.	0.00
25.1600	-2.73E-04	-6981.	103.4385	2.48E-05	0.00	8.16E+09	1.6483	26810.	0.00
25.5300	-1.71E-04	-6510.	109.4266	2.12E-05	0.00	8.16E+09	1.0490	27205.	0.00
25.9000	-8.52E-05	-6018.	112.9304	1.77E-05	0.00	8.16E+09	0.5293	27599.	0.00
26.2700	-1.37E-05	-5515.	114.2965	1.46E-05	0.00	8.16E+09	0.08606	27993.	0.00
26.6400	4.45E-05	-5009.	113.8556	1.17E-05	0.00	8.16E+09	-0.285	28388.	0.00
27.0100	9.06E-05	-4509.	111.9197	9.15E-06	0.00	8.16E+09	-0.587	28782.	0.00
27.3800	1.26E-04	-4019.	108.7809	6.83E-06	0.00	8.16E+09	-0.827	29176.	0.00
27.7500	1.51E-04	-3545.	104.7096	4.77E-06	0.00	8.16E+09	-1.007	29570.	0.00
28.1200	1.68E-04	-3091.	99.9539	2.97E-06	0.00	8.16E+09	-1.135	29965.	0.00
28.4900	1.78E-04	-2659.	94.7388	1.40E-06	0.00	8.16E+09	-1.214	30359.	0.00
28.8600	1.81E-04	-2250.	89.2661	6.54E-08	0.00	8.16E+09	-1.251	30753.	0.00
29.2300	1.78E-04	-1866.	83.7143	-1.05E-06	0.00	8.16E+09	-1.250	31147.	0.00
29.6000	1.71E-04	-1507.	78.2390	-1.97E-06	0.00	8.16E+09	-1.216	31542.	0.00
29.9700	1.61E-04	-1171.	72.9732	-2.70E-06	0.00	8.16E+09	-1.156	31936.	0.00
30.3400	1.47E-04	-857.496	68.0276	-3.25E-06	0.00	8.16E+09	-1.072	32330.	0.00
30.7100	1.32E-04	-565.310	63.4913	-3.64E-06	0.00	8.16E+09	-0.971	32725.	0.00
31.0800	1.15E-04	-292.207	59.4322	-3.87E-06	0.00	8.16E+09	-0.857	33119.	0.00
31.4500	9.74E-05	-35.970	55.8976	-3.96E-06	0.00	8.16E+09	-0.735	33513.	0.00
31.8200	7.97E-05	205.7828	52.9143	-3.92E-06	0.00	8.16E+09	-0.609	33907.	0.00
32.1900	6.26E-05	435.5088	50.4890	-3.74E-06	0.00	8.16E+09	-0.484	34302.	0.00
32.5600	4.65E-05	655.6538	48.6088	-3.45E-06	0.00	8.16E+09	-0.363	34696.	0.00
32.9300	3.20E-05	868.5623	47.2407	-3.03E-06	0.00	8.16E+09	-0.253	35090.	0.00
33.3000	1.96E-05	1076.	46.3317	-2.50E-06	0.00	8.16E+09	-0.157	35484.	0.00
33.6700	9.79E-06	1281.	45.8085	-1.86E-06	0.00	8.16E+09	-0.07909	35879.	0.00
34.0400	3.08E-06	1484.	-40.647	-1.11E-06	0.00	8.16E+09	-38.865	5.61E+07	0.00

34.4100	-4.68E-08	920.5130	-125.617	-4.53E-07	0.00	8.16E+09	0.5906	5.61E+07	0.00
34.7800	-9.46E-07	368.6384	-97.768	-1.02E-07	0.00	8.16E+09	11.9539	5.61E+07	0.00
35.1500	-9.55E-07	52.3773	-44.441	6.85E-08	0.00	1.65E+09	12.0670	5.61E+07	0.00
35.5200	-3.38E-07	-26.028	-8.168	1.04E-07	0.00	1.65E+09	4.2723	5.61E+07	0.00
35.8900	-3.22E-08	-20.197	2.2203	4.17E-08	0.00	1.65E+09	0.4071	5.61E+07	0.00
36.2600	3.24E-08	-6.328	2.2169	6.03E-09	0.00	1.65E+09	-0.409	5.61E+07	0.00
36.6300	2.13E-08	-0.513	0.7125	-3.18E-09	0.00	1.65E+09	-0.269	5.61E+07	0.00
37.0000	4.11E-09	0.00	0.00	-3.87E-09	0.00	1.65E+09	-0.05194	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.20009350 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -530787. inch-lbs
Maximum shear force = 10000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 7000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 28000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1250	-353808.	7000.	0.00	0.00	7.31E+09	0.00	0.00	0.00
0.3700	0.1245	-322715.	6981.	-2.06E-04	0.00	7.31E+09	-8.490	302.7584	0.00
0.7400	0.1232	-291765.	6922.	-3.91E-04	0.00	7.37E+09	-18.028	649.9343	0.00
1.1100	0.1210	-261148.	6822.	-5.57E-04	0.00	7.41E+09	-27.303	1002.	0.00
1.4800	0.1182	-231050.	6682.	-7.04E-04	0.00	7.46E+09	-35.450	1332.	0.00
1.8500	0.1148	-201634.	6510.	-8.28E-04	0.00	8.16E+09	-42.143	1630.	0.00
2.2200	0.1109	-173034.	6312.	-9.30E-04	0.00	8.17E+09	-46.948	1880.	0.00
2.5900	0.1065	-145349.	6097.	-0.00102	0.00	8.17E+09	-50.020	2085.	0.00
2.9600	0.1018	-118640.	5869.	-0.00109	0.00	8.17E+09	-52.901	2307.	0.00
3.3300	0.09686	-92966.	5632.	-0.00115	0.00	8.18E+09	-53.696	2461.	0.00
3.7000	0.09166	-68344.	5390.	-0.00119	0.00	8.18E+09	-55.293	2678.	0.00
4.0700	0.08630	-44808.	5132.	-0.00122	0.00	8.18E+09	-60.776	3127.	0.00
4.4400	0.08083	-22466.	4852.	-0.00124	0.00	8.18E+09	-65.564	3602.	0.00
4.8100	0.07530	-1416.	4545.	-0.00124	0.00	8.18E+09	-72.471	4273.	0.00
5.1800	0.06977	18206.	4209.	-0.00124	0.00	8.18E+09	-79.072	5032.	0.00
5.5500	0.06429	36268.	3844.	-0.00123	0.00	8.18E+09	-85.256	5888.	0.00
5.9200	0.05889	52647.	3453.	-0.00120	0.00	8.18E+09	-90.921	6855.	0.00
6.2900	0.05362	67229.	3038.	-0.00117	0.00	8.18E+09	-95.971	7947.	0.00
6.6600	0.04851	79916.	2602.	-0.00113	0.00	8.18E+09	-100.318	9181.	0.00
7.0300	0.04360	90619.	2149.	-0.00108	0.00	8.18E+09	-103.883	10580.	0.00
7.4000	0.03890	99268.	1688.	-0.00103	0.00	8.18E+09	-103.628	11828.	0.00
7.7700	0.03444	105868.	1244.	-9.75E-04	0.00	8.17E+09	-96.341	12420.	0.00

8.1400	0.03024	110561.	833.8201	-9.16E-04	0.00	8.17E+09	-88.613	13011.	0.00
8.5100	0.02630	113500.	458.2025	-8.56E-04	0.00	8.17E+09	-80.584	13602.	0.00
8.8800	0.02264	114843.	118.6224	-7.94E-04	0.00	8.17E+09	-72.380	14194.	0.00
9.2500	0.01926	114751.	-184.417	-7.31E-04	0.00	8.17E+09	-64.124	14785.	0.00
9.6200	0.01615	113387.	-450.923	-6.69E-04	0.00	8.17E+09	-55.924	15377.	0.00
9.9900	0.01331	110913.	-681.367	-6.08E-04	0.00	8.17E+09	-47.879	15968.	0.00
10.3600	0.01075	107488.	-876.631	-5.49E-04	0.00	8.17E+09	-40.077	16559.	0.00
10.7300	0.00844	103265.	-1038.	-4.92E-04	0.00	8.18E+09	-32.593	17151.	0.00
11.1000	0.00638	98393.	-1167.	-4.37E-04	0.00	8.18E+09	-25.488	17742.	0.00
11.4700	0.00456	93012.	-1265.	-3.85E-04	0.00	8.18E+09	-18.814	18334.	0.00
11.8400	0.00296	87253.	-1335.	-3.36E-04	0.00	8.18E+09	-12.612	18925.	0.00
12.2100	0.00157	81240.	-1378.	-2.90E-04	0.00	8.18E+09	-6.908	19516.	0.00
12.5800	3.80E-04	75086.	-1398.	-2.48E-04	0.00	8.18E+09	-1.721	20108.	0.00
12.9500	-6.30E-04	68892.	-1395.	-2.09E-04	0.00	8.18E+09	2.9384	20699.	0.00
13.3200	-0.00147	62752.	-1373.	-1.73E-04	0.00	8.18E+09	7.0709	21291.	0.00
13.6900	-0.00217	56747.	-1333.	-1.41E-04	0.00	8.18E+09	10.6827	21882.	0.00
14.0600	-0.00272	50948.	-1279.	-1.11E-04	0.00	8.18E+09	13.7867	22474.	0.00
14.4300	-0.00316	45418.	-1212.	-8.53E-05	0.00	8.18E+09	16.4008	23065.	0.00
14.8000	-0.00348	40208.	-1134.	-6.20E-05	0.00	8.18E+09	18.5469	23656.	0.00
15.1700	-0.00371	35361.	-1063.	-4.15E-05	0.00	8.18E+09	13.4999	16165.	0.00
15.5400	-0.00385	30778.	-1001.	-2.36E-05	0.00	8.18E+09	14.3576	16559.	0.00
15.9100	-0.00392	26476.	-936.180	-8.01E-06	0.00	8.18E+09	14.9571	16954.	0.00
16.2800	-0.00392	22467.	-868.966	5.28E-06	0.00	8.18E+09	15.3192	17348.	0.00
16.6500	-0.00387	18758.	-800.625	1.65E-05	0.00	8.18E+09	15.4655	17742.	0.00
17.0200	-0.00377	15353.	-732.063	2.57E-05	0.00	8.18E+09	15.4181	18137.	0.00
17.3900	-0.00364	12251.	-664.093	3.32E-05	0.00	8.18E+09	15.1992	18531.	0.00
17.7600	-0.00348	9448.	-597.426	3.91E-05	0.00	8.18E+09	14.8308	18925.	0.00
18.1300	-0.00329	6936.	-532.679	4.36E-05	0.00	8.18E+09	14.3345	19319.	0.00
18.5000	-0.00309	4707.	-470.374	4.67E-05	0.00	8.18E+09	13.7311	19714.	0.00
18.8700	-0.00288	2748.	-410.941	4.87E-05	0.00	8.18E+09	13.0405	20108.	0.00
19.2400	-0.00266	1046.	-354.726	4.98E-05	0.00	8.18E+09	12.2814	20502.	0.00
19.6100	-0.00244	-414.487	-301.995	5.00E-05	0.00	8.18E+09	11.4714	20896.	0.00
19.9800	-0.00222	-1648.	-252.937	4.94E-05	0.00	8.18E+09	10.6268	21291.	0.00
20.3500	-0.00200	-2673.	-207.673	4.82E-05	0.00	8.18E+09	9.7622	21685.	0.00
20.7200	-0.00179	-3505.	-166.263	4.65E-05	0.00	8.18E+09	8.8911	22079.	0.00
21.0900	-0.00159	-4161.	-128.708	4.45E-05	0.00	8.18E+09	8.0254	22474.	0.00
21.4600	-0.00139	-4659.	-94.962	4.21E-05	0.00	8.18E+09	7.1753	22868.	0.00
21.8300	-0.00121	-5015.	-64.936	3.94E-05	0.00	8.18E+09	6.3499	23262.	0.00
22.2000	-0.00104	-5245.	-38.504	3.67E-05	0.00	8.18E+09	5.5568	23656.	0.00
22.5700	-8.87E-04	-5366.	-15.507	3.38E-05	0.00	8.18E+09	4.8021	24051.	0.00
22.9400	-7.43E-04	-5391.	4.2351	3.09E-05	0.00	8.18E+09	4.0908	24445.	0.00
23.3100	-6.13E-04	-5336.	20.9242	2.79E-05	0.00	8.18E+09	3.4268	24839.	0.00
23.6800	-4.95E-04	-5212.	34.7758	2.51E-05	0.00	8.18E+09	2.8127	25233.	0.00
24.0500	-3.90E-04	-5033.	46.0155	2.23E-05	0.00	8.18E+09	2.2502	25628.	0.00
24.4200	-2.97E-04	-4809.	54.8744	1.96E-05	0.00	8.18E+09	1.7402	26022.	0.00
24.7900	-2.16E-04	-4551.	61.5853	1.71E-05	0.00	8.18E+09	1.2827	26416.	0.00
25.1600	-1.45E-04	-4267.	66.3798	1.47E-05	0.00	8.18E+09	0.8770	26810.	0.00
25.5300	-8.52E-05	-3965.	69.4850	1.25E-05	0.00	8.18E+09	0.5218	27205.	0.00
25.9000	-3.46E-05	-3653.	71.1214	1.04E-05	0.00	8.18E+09	0.2153	27599.	0.00
26.2700	7.07E-06	-3336.	71.5005	8.49E-06	0.00	8.18E+09	-0.04458	27993.	0.00
26.6400	4.07E-05	-3020.	70.8233	6.76E-06	0.00	8.18E+09	-0.260	28388.	0.00
27.0100	6.71E-05	-2709.	69.2790	5.21E-06	0.00	8.18E+09	-0.435	28782.	0.00
27.3800	8.70E-05	-2406.	67.0440	3.82E-06	0.00	8.18E+09	-0.572	29176.	0.00
27.7500	1.01E-04	-2114.	64.2810	2.59E-06	0.00	8.18E+09	-0.673	29570.	0.00
28.1200	1.10E-04	-1836.	61.1388	1.52E-06	0.00	8.18E+09	-0.742	29965.	0.00
28.4900	1.15E-04	-1572.	57.7519	5.95E-07	0.00	8.18E+09	-0.783	30359.	0.00
28.8600	1.15E-04	-1323.	54.2403	-1.91E-07	0.00	8.18E+09	-0.799	30753.	0.00
29.2300	1.13E-04	-1090.	50.7100	-8.46E-07	0.00	8.18E+09	-0.792	31147.	0.00
29.6000	1.08E-04	-872.532	47.2528	-1.38E-06	0.00	8.18E+09	-0.766	31542.	0.00
29.9700	1.01E-04	-670.076	43.9465	-1.80E-06	0.00	8.18E+09	-0.724	31936.	0.00
30.3400	9.18E-05	-481.840	40.8558	-2.11E-06	0.00	8.18E+09	-0.669	32330.	0.00
30.7100	8.19E-05	-306.752	38.0321	-2.32E-06	0.00	8.18E+09	-0.603	32725.	0.00
31.0800	7.12E-05	-143.537	35.5139	-2.45E-06	0.00	8.18E+09	-0.531	33119.	0.00
31.4500	6.01E-05	9.2204	33.3276	-2.48E-06	0.00	8.18E+09	-0.454	33513.	0.00
31.8200	4.91E-05	153.0288	31.4870	-2.44E-06	0.00	8.18E+09	-0.375	33907.	0.00
32.1900	3.85E-05	289.4312	29.9942	-2.32E-06	0.00	8.18E+09	-0.297	34302.	0.00
32.5600	2.85E-05	419.9535	28.8392	-2.13E-06	0.00	8.18E+09	-0.223	34696.	0.00
32.9300	1.96E-05	546.0520	28.0004	-1.86E-06	0.00	8.18E+09	-0.155	35090.	0.00
33.3000	1.20E-05	669.0603	27.4440	-1.53E-06	0.00	8.18E+09	-0.09574	35484.	0.00

33.6700	5.97E-06	790.1360	27.1243	-1.14E-06	0.00	8.18E+09	-0.04827	35879.	0.00
34.0400	1.87E-06	910.2069	-25.498	-6.76E-07	0.00	8.18E+09	-23.655	5.61E+07	0.00
34.4100	-3.35E-08	563.8857	-77.074	-2.76E-07	0.00	8.18E+09	0.4226	5.61E+07	0.00
34.7800	-5.80E-07	225.8578	-59.861	-6.19E-08	0.00	8.18E+09	7.3311	5.61E+07	0.00
35.1500	-5.83E-07	32.3368	-27.241	4.19E-08	0.00	1.69E+09	7.3626	5.61E+07	0.00
35.5200	-2.08E-07	-16.052	-5.059	6.33E-08	0.00	1.69E+09	2.6290	5.61E+07	0.00
35.8900	-2.06E-08	-12.607	1.3559	2.57E-08	0.00	1.69E+09	0.2608	5.61E+07	0.00
36.2600	1.98E-08	-4.017	1.3805	3.83E-09	0.00	1.69E+09	-0.250	5.61E+07	0.00
36.6300	1.33E-08	-0.349	0.4523	-1.91E-09	0.00	1.69E+09	-0.168	5.61E+07	0.00
37.0000	2.80E-09	0.00	0.00	-2.37E-09	0.00	1.69E+09	-0.03542	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 3:

Pile-head deflection = 0.12498553 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -353808. inch-lbs
Maximum shear force = 7000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 41800.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 60000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.6186	-2824812.	41800.	0.00	0.00	6.04E+09	0.00	0.00	0.00
0.3700	1.6140	-2638943.	41772.	-0.00201	0.00	6.04E+09	-12.702	34.9435	0.00
0.7400	1.6007	-2452808.	41683.	-0.00377	0.00	6.91E+09	-27.489	76.2479	0.00
1.1100	1.5805	-2266795.	41527.	-0.00528	0.00	6.97E+09	-42.394	119.0949	0.00
1.4800	1.5539	-2081233.	41308.	-0.00666	0.00	6.99E+09	-56.349	161.0099	0.00
1.8500	1.5214	-1896430.	41030.	-0.00792	0.00	7.01E+09	-69.036	201.4748	0.00
2.2200	1.4835	-1712668.	40700.	-0.00906	0.00	7.04E+09	-79.347	237.4737	0.00
2.5900	1.4409	-1530182.	40323.	-0.01008	0.00	7.07E+09	-90.623	279.2467	0.00
2.9600	1.3940	-1349226.	39888.	-0.01099	0.00	7.10E+09	-105.184	335.0176	0.00
3.3300	1.3434	-1170119.	39388.	-0.01177	0.00	7.14E+09	-120.206	397.3008	0.00
3.7000	1.2895	-993189.	38815.	-0.01244	0.00	7.18E+09	-137.958	475.0233	0.00
4.0700	1.2329	-818814.	38150.	-0.01300	0.00	7.24E+09	-161.619	582.0468	0.00
4.4400	1.1740	-647491.	37376.	-0.01345	0.00	7.32E+09	-186.908	706.8552	0.00
4.8100	1.1135	-479748.	36482.	-0.01379	0.00	7.44E+09	-215.702	860.1337	0.00
5.1800	1.0516	-316182.	35456.	-0.01402	0.00	7.67E+09	-246.535	1041.	0.00
5.5500	0.9889	-157426.	34289.	-0.01416	0.00	8.14E+09	-279.408	1254.	0.00
5.9200	0.9259	-4156.	32971.	-0.01420	0.00	8.14E+09	-314.324	1507.	0.00
6.2900	0.8628	142918.	31493.	-0.01416	0.00	8.14E+09	-351.284	1808.	0.00
6.6600	0.8001	283046.	29847.	-0.01404	0.00	7.73E+09	-390.291	2166.	0.00
7.0300	0.7381	415437.	28023.	-0.01384	0.00	7.51E+09	-431.347	2595.	0.00

7.4000	0.6772	539259.	26012.	-0.01355	0.00	7.39E+09	-474.456	3111.	0.00
7.7700	0.6178	653642.	23805.	-0.01319	0.00	7.31E+09	-519.620	3735.	0.00
8.1400	0.5601	757675.	21393.	-0.01276	0.00	7.26E+09	-566.844	4494.	0.00
8.5100	0.5044	850411.	18767.	-0.01227	0.00	7.23E+09	-616.132	5423.	0.00
8.8800	0.4511	930861.	15917.	-0.01172	0.00	7.20E+09	-667.488	6569.	0.00
9.2500	0.4004	997999.	12839.	-0.01113	0.00	7.18E+09	-719.141	7975.	0.00
9.6200	0.3523	1050796.	9683.	-0.01049	0.00	7.16E+09	-702.197	8849.	0.00
9.9900	0.3072	1089577.	6612.	-0.00983	0.00	7.16E+09	-681.303	9847.	0.00
10.3600	0.2650	1114747.	3641.	-0.00914	0.00	7.15E+09	-657.084	11007.	0.00
10.7300	0.2260	1126779.	782.9315	-0.00845	0.00	7.15E+09	-630.213	12382.	0.00
11.1000	0.1900	1126201.	-1951.	-0.00775	0.00	7.15E+09	-601.399	14052.	0.00
11.4700	0.1572	1113580.	-4552.	-0.00705	0.00	7.15E+09	-570.216	16107.	0.00
11.8400	0.1274	1089534.	-7002.	-0.00637	0.00	7.16E+09	-533.287	18585.	0.00
12.2100	0.1006	1054795.	-9168.	-0.00570	0.00	7.16E+09	-442.321	19516.	0.00
12.5800	0.07675	1011163.	-10921.	-0.00506	0.00	7.18E+09	-347.605	20108.	0.00
12.9500	0.05566	960511.	-12269.	-0.00445	0.00	7.19E+09	-259.479	20699.	0.00
13.3200	0.03720	904586.	-13241.	-0.00388	0.00	7.21E+09	-178.359	21291.	0.00
13.6900	0.02121	844996.	-13869.	-0.00334	0.00	7.23E+09	-104.513	21882.	0.00
14.0600	0.00752	783208.	-14186.	-0.00284	0.00	7.25E+09	-38.070	22474.	0.00
14.4300	-0.00403	720541.	-14224.	-0.00238	0.00	7.28E+09	20.9609	23065.	0.00
14.8000	-0.01364	658171.	-14016.	-0.00196	0.00	7.31E+09	72.6764	23656.	0.00
15.1700	-0.02147	597127.	-13681.	-0.00158	0.00	7.35E+09	78.1747	16165.	0.00
15.5400	-0.02770	537528.	-13278.	-0.00124	0.00	7.39E+09	103.3166	16559.	0.00
15.9100	-0.03250	479879.	-12773.	-9.37E-04	0.00	7.44E+09	124.0924	16954.	0.00
16.2800	-0.03602	424601.	-12185.	-6.69E-04	0.00	7.50E+09	140.7548	17348.	0.00
16.6500	-0.03843	372031.	-11532.	-4.34E-04	0.00	7.57E+09	153.5860	17742.	0.00
17.0200	-0.03988	322430.	-10829.	-2.31E-04	0.00	7.66E+09	162.8901	18137.	0.00
17.3900	-0.04049	275991.	-10092.	-6.25E-05	0.00	8.13E+09	168.9860	18531.	0.00
17.7600	-0.04043	232843.	-9335.	7.63E-05	0.00	8.14E+09	172.3395	18925.	0.00
18.1300	-0.03981	193058.	-8568.	1.92E-04	0.00	8.14E+09	173.2287	19319.	0.00
18.5000	-0.03872	156660.	-7801.	2.88E-04	0.00	8.14E+09	171.9321	19714.	0.00
18.8700	-0.03726	123629.	-7045.	3.64E-04	0.00	8.14E+09	168.7245	20108.	0.00
19.2400	-0.03549	93906.	-6307.	4.24E-04	0.00	8.14E+09	163.8744	20502.	0.00
19.6100	-0.03349	67400.	-5593.	4.68E-04	0.00	8.14E+09	157.6405	20896.	0.00
19.9800	-0.03134	43992.	-4909.	4.98E-04	0.00	8.14E+09	150.2701	21291.	0.00
20.3500	-0.02907	23540.	-4261.	5.16E-04	0.00	8.14E+09	141.9964	21685.	0.00
20.7200	-0.02675	5884.	-3650.	5.24E-04	0.00	8.14E+09	133.0373	22079.	0.00
21.0900	-0.02442	-9150.	-3080.	5.23E-04	0.00	8.14E+09	123.5939	22474.	0.00
21.4600	-0.02211	-21747.	-2553.	5.15E-04	0.00	8.14E+09	113.8498	22868.	0.00
21.8300	-0.01984	-32096.	-2070.	5.00E-04	0.00	8.14E+09	103.9709	23262.	0.00
22.2000	-0.01766	-40391.	-1630.	4.81E-04	0.00	8.14E+09	94.1045	23656.	0.00
22.5700	-0.01558	-46825.	-1234.	4.57E-04	0.00	8.14E+09	84.3801	24051.	0.00
22.9400	-0.01361	-51588.	-879.933	4.30E-04	0.00	8.14E+09	74.9095	24445.	0.00
23.3100	-0.01176	-54868.	-567.585	4.01E-04	0.00	8.14E+09	65.7875	24839.	0.00
23.6800	-0.01005	-56842.	-294.792	3.70E-04	0.00	8.14E+09	57.0923	25233.	0.00
24.0500	-0.00847	-57683.	-59.518	3.39E-04	0.00	8.14E+09	48.8871	25628.	0.00
24.4200	-0.00703	-57551.	140.5208	3.08E-04	0.00	8.14E+09	41.2204	26022.	0.00
24.7900	-0.00574	-56599.	307.7929	2.77E-04	0.00	8.14E+09	34.1274	26416.	0.00
25.1600	-0.00458	-54966.	444.8976	2.46E-04	0.00	8.14E+09	27.6314	26810.	0.00
25.5300	-0.00355	-52780.	554.5126	2.17E-04	0.00	8.14E+09	21.7447	27205.	0.00
25.9000	-0.00265	-50157.	639.3489	1.89E-04	0.00	8.14E+09	16.4698	27599.	0.00
26.2700	-0.00187	-47203.	702.1094	1.62E-04	0.00	8.14E+09	11.8007	27993.	0.00
26.6400	-0.00121	-44009.	745.4543	1.37E-04	0.00	8.14E+09	7.7240	28388.	0.00
27.0100	-6.51E-04	-40656.	771.9704	1.14E-04	0.00	8.14E+09	4.2201	28782.	0.00
27.3800	-1.92E-04	-37215.	784.1452	9.32E-05	0.00	8.14E+09	1.2640	29176.	0.00
27.7500	1.76E-04	-33743.	784.3460	7.38E-05	0.00	8.14E+09	-1.174	29570.	0.00
28.1200	4.63E-04	-30289.	774.8025	5.64E-05	0.00	8.14E+09	-3.125	29965.	0.00
28.4900	6.77E-04	-26893.	757.5931	4.08E-05	0.00	8.14E+09	-4.627	30359.	0.00
28.8600	8.25E-04	-23583.	734.6345	2.70E-05	0.00	8.14E+09	-5.715	30753.	0.00
29.2300	9.16E-04	-20383.	707.6741	1.50E-05	0.00	8.14E+09	-6.429	31147.	0.00
29.6000	9.59E-04	-17307.	678.2846	4.75E-06	0.00	8.14E+09	-6.809	31542.	0.00
29.9700	9.59E-04	-14363.	647.8606	-3.89E-06	0.00	8.14E+09	-6.895	31936.	0.00
30.3400	9.24E-04	-11552.	617.6165	-1.10E-05	0.00	8.14E+09	-6.728	32330.	0.00
30.7100	8.61E-04	-8872.	588.5854	-1.65E-05	0.00	8.14E+09	-6.349	32725.	0.00
31.0800	7.77E-04	-6317.	561.6190	-2.07E-05	0.00	8.14E+09	-5.798	33119.	0.00
31.4500	6.78E-04	-3874.	537.3869	-2.34E-05	0.00	8.14E+09	-5.117	33513.	0.00
31.8200	5.69E-04	-1532.	516.3767	-2.49E-05	0.00	8.14E+09	-4.347	33907.	0.00
32.1900	4.57E-04	724.3959	498.8930	-2.51E-05	0.00	8.14E+09	-3.529	34302.	0.00
32.5600	3.46E-04	2911.	485.0563	-2.41E-05	0.00	8.14E+09	-2.704	34696.	0.00

32.9300	2.42E-04	5045.	474.8004	-2.20E-05	0.00	8.14E+09	-1.916	35090.	0.00
33.3000	1.51E-04	7139.	467.8695	-1.86E-05	0.00	8.14E+09	-1.206	35484.	0.00
33.6700	7.68E-05	9209.	463.8140	-1.42E-05	0.00	8.14E+09	-0.620	35879.	0.00
34.0400	2.49E-05	11266.	-236.043	-8.61E-06	0.00	8.14E+09	-314.630	5.61E+07	0.00
34.4100	3.11E-07	7118.	-943.238	-3.60E-06	0.00	8.14E+09	-3.926	5.61E+07	0.00
34.7800	-7.06E-06	2891.	-753.998	-8.72E-07	0.00	8.14E+09	89.1696	5.61E+07	0.00
35.1500	-7.43E-06	422.6682	-347.661	4.97E-07	0.00	1.62E+09	93.8652	5.61E+07	0.00
35.5200	-2.65E-06	-196.022	-64.958	8.08E-07	0.00	1.62E+09	33.4786	5.61E+07	0.00
35.8900	-2.59E-07	-154.586	16.6361	3.26E-07	0.00	1.62E+09	3.2754	5.61E+07	0.00
36.2600	2.47E-07	-48.468	16.9705	4.76E-08	0.00	1.62E+09	-3.125	5.61E+07	0.00
36.6300	1.63E-07	-3.913	5.4566	-2.43E-08	0.00	1.62E+09	-2.062	5.61E+07	0.00
37.0000	3.14E-08	0.00	0.00	-2.97E-08	0.00	1.62E+09	-0.396	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

Pile-head deflection = 1.61857241 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -2824812. inch-lbs
Maximum shear force = 41800. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 9
Number of zero deflection points = 5

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 5

Pile-head conditions are Displacement and Pile-head Rotation (Loading Type 5)
Displacement of pile head = 1.000000 inches
Rotation of pile head = 0.000E+00 radians
Axial load on pile head = 46000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0000	-2009670.	31941.	0.00	0.00	6.98E+09	0.00	0.00	0.00
0.3700	0.9972	-1867857.	31883.	-0.00123	0.00	6.98E+09	-12.628	56.2269	0.00
0.7400	0.9891	-1726050.	31794.	-0.00237	0.00	7.02E+09	-27.330	122.6905	0.00
1.1100	0.9761	-1584559.	31640.	-0.00342	0.00	7.04E+09	-42.152	191.7386	0.00
1.4800	0.9587	-1443694.	31422.	-0.00437	0.00	7.06E+09	-56.029	259.4886	0.00
1.8500	0.9373	-1303749.	31145.	-0.00524	0.00	7.08E+09	-68.646	325.1903	0.00
2.2200	0.9122	-1164989.	30817.	-0.00601	0.00	7.10E+09	-78.900	384.0382	0.00
2.5900	0.8839	-1027637.	30442.	-0.00669	0.00	7.13E+09	-90.113	452.6598	0.00
2.9600	0.8528	-891930.	30010.	-0.00729	0.00	7.16E+09	-104.590	544.5695	0.00
3.3300	0.8192	-758172.	29512.	-0.00780	0.00	7.21E+09	-119.526	647.8578	0.00
3.7000	0.7835	-626674.	28942.	-0.00823	0.00	7.26E+09	-137.173	777.3551	0.00
4.0700	0.7461	-497803.	28281.	-0.00857	0.00	7.33E+09	-160.693	956.2574	0.00
4.4400	0.7074	-372038.	27512.	-0.00883	0.00	7.45E+09	-185.828	1166.	0.00
4.8100	0.6677	-249891.	26623.	-0.00901	0.00	7.67E+09	-214.444	1426.	0.00
5.1800	0.6274	-131942.	25603.	-0.00912	0.00	8.16E+09	-245.077	1734.	0.00
5.5500	0.5867	-18810.	24442.	-0.00916	0.00	8.16E+09	-277.730	2102.	0.00
5.9200	0.5460	88849.	23132.	-0.00914	0.00	8.16E+09	-312.404	2540.	0.00
6.2900	0.5055	190340.	21664.	-0.00907	0.00	8.15E+09	-349.099	3066.	0.00
6.6600	0.4655	284928.	20028.	-0.00893	0.00	7.58E+09	-387.814	3699.	0.00
7.0300	0.4262	371836.	18216.	-0.00874	0.00	7.45E+09	-428.551	4464.	0.00
7.4000	0.3879	450251.	16240.	-0.00849	0.00	7.37E+09	-461.562	5283.	0.00

7.7700	0.3508	519511.	14176.	-0.00820	0.00	7.32E+09	-468.069	5924.	0.00
8.1400	0.3151	579480.	12090.	-0.00786	0.00	7.28E+09	-471.320	6641.	0.00
8.5100	0.2810	630085.	9997.	-0.00749	0.00	7.26E+09	-471.478	7450.	0.00
8.8800	0.2486	671317.	7910.	-0.00710	0.00	7.24E+09	-468.772	8373.	0.00
9.2500	0.2180	703224.	5840.	-0.00667	0.00	7.23E+09	-463.493	9440.	0.00
9.6200	0.1893	725905.	3799.	-0.00623	0.00	7.22E+09	-455.979	10694.	0.00
9.9900	0.1626	739506.	1796.	-0.00578	0.00	7.21E+09	-446.221	12182.	0.00
10.3600	0.1380	744218.	-154.605	-0.00533	0.00	7.21E+09	-432.518	13919.	0.00
10.7300	0.1153	740309.	-2035.	-0.00487	0.00	7.21E+09	-414.558	15959.	0.00
11.1000	0.09473	728135.	-3796.	-0.00442	0.00	7.22E+09	-378.539	17742.	0.00
11.4700	0.07611	708407.	-5334.	-0.00398	0.00	7.22E+09	-314.277	18334.	0.00
11.8400	0.05943	682394.	-6594.	-0.00355	0.00	7.23E+09	-253.295	18925.	0.00
12.2100	0.04460	651303.	-7591.	-0.00314	0.00	7.25E+09	-196.041	19516.	0.00
12.5800	0.03155	616265.	-8344.	-0.00275	0.00	7.26E+09	-142.861	20108.	0.00
12.9500	0.02016	578335.	-8870.	-0.00239	0.00	7.28E+09	-94.001	20699.	0.00
13.3200	0.01035	538479.	-9188.	-0.00205	0.00	7.31E+09	-49.614	21291.	0.00
13.6900	0.00198	497578.	-9320.	-0.00173	0.00	7.33E+09	-9.771	21882.	0.00
14.0600	-0.00504	456423.	-9285.	-0.00145	0.00	7.37E+09	25.5309	22474.	0.00
14.4300	-0.01085	415715.	-9103.	-0.00118	0.00	7.40E+09	56.3598	23065.	0.00
14.8000	-0.01555	376068.	-8794.	-9.46E-04	0.00	7.45E+09	82.8377	23656.	0.00
15.1700	-0.01925	338007.	-8455.	-7.34E-04	0.00	7.50E+09	70.0870	16165.	0.00
15.5400	-0.02206	301287.	-8117.	-5.45E-04	0.00	7.56E+09	82.2917	16559.	0.00
15.9100	-0.02409	266154.	-7730.	-3.79E-04	0.00	7.62E+09	91.9943	16954.	0.00
16.2800	-0.02543	232802.	-7305.	-2.38E-04	0.00	8.15E+09	99.3681	17348.	0.00
16.6500	-0.02621	201384.	-6852.	-1.20E-04	0.00	8.15E+09	104.7291	17742.	0.00
17.0200	-0.02650	172007.	-6379.	-1.84E-05	0.00	8.15E+09	108.2386	18137.	0.00
17.3900	-0.02637	144745.	-5894.	6.79E-05	0.00	8.16E+09	110.0641	18531.	0.00
17.7600	-0.02590	119637.	-5405.	1.40E-04	0.00	8.16E+09	110.3761	18925.	0.00
18.1300	-0.02513	96692.	-4917.	1.99E-04	0.00	8.16E+09	109.3454	19319.	0.00
18.5000	-0.02413	75891.	-4437.	2.46E-04	0.00	8.16E+09	107.1415	19714.	0.00
18.8700	-0.02295	57194.	-3968.	2.82E-04	0.00	8.16E+09	103.9296	20108.	0.00
19.2400	-0.02163	40539.	-3516.	3.08E-04	0.00	8.16E+09	99.8695	20502.	0.00
19.6100	-0.02021	25849.	-3083.	3.27E-04	0.00	8.16E+09	95.1139	20896.	0.00
19.9800	-0.01873	13031.	-2672.	3.37E-04	0.00	8.16E+09	89.8068	21291.	0.00
20.3500	-0.01722	1982.	-2286.	3.41E-04	0.00	8.16E+09	84.0828	21685.	0.00
20.7200	-0.01570	-7410.	-1926.	3.40E-04	0.00	8.16E+09	78.0665	22079.	0.00
21.0900	-0.01420	-15262.	-1593.	3.34E-04	0.00	8.16E+09	71.8713	22474.	0.00
21.4600	-0.01274	-21695.	-1288.	3.23E-04	0.00	8.16E+09	65.5998	22868.	0.00
21.8300	-0.01133	-26833.	-1011.	3.10E-04	0.00	8.16E+09	59.3431	23262.	0.00
22.2000	-0.00998	-30798.	-761.009	2.95E-04	0.00	8.16E+09	53.1816	23656.	0.00
22.5700	-0.00871	-33711.	-538.197	2.77E-04	0.00	8.16E+09	47.1842	24051.	0.00
22.9400	-0.00752	-35690.	-341.519	2.58E-04	0.00	8.16E+09	41.4096	24445.	0.00
23.3100	-0.00642	-36849.	-169.878	2.38E-04	0.00	8.16E+09	35.9063	24839.	0.00
23.6800	-0.00540	-37296.	-21.983	2.18E-04	0.00	8.16E+09	30.7131	25233.	0.00
24.0500	-0.00448	-37134.	103.6095	1.98E-04	0.00	8.16E+09	25.8600	25628.	0.00
24.4200	-0.00365	-36457.	208.4571	1.78E-04	0.00	8.16E+09	21.3687	26022.	0.00
24.7900	-0.00290	-35355.	294.1980	1.58E-04	0.00	8.16E+09	17.2534	26416.	0.00
25.1600	-0.00224	-33909.	362.5180	1.40E-04	0.00	8.16E+09	13.5214	26810.	0.00
25.5300	-0.00166	-32193.	415.1222	1.22E-04	0.00	8.16E+09	10.1742	27205.	0.00
25.9000	-0.00116	-30273.	453.7100	1.05E-04	0.00	8.16E+09	7.2077	27599.	0.00
26.2700	-7.32E-04	-28207.	479.9532	8.87E-05	0.00	8.16E+09	4.6135	27993.	0.00
26.6400	-3.72E-04	-26047.	495.4767	7.39E-05	0.00	8.16E+09	2.3791	28388.	0.00
27.0100	-7.54E-05	-23837.	501.8435	6.03E-05	0.00	8.16E+09	0.4888	28782.	0.00
27.3800	1.64E-04	-21615.	500.5406	4.80E-05	0.00	8.16E+09	-1.076	29176.	0.00
27.7500	3.51E-04	-19412.	492.9695	3.68E-05	0.00	8.16E+09	-2.335	29570.	0.00
28.1200	4.91E-04	-17253.	480.4372	2.68E-05	0.00	8.16E+09	-3.310	29965.	0.00
28.4900	5.89E-04	-15157.	464.1503	1.80E-05	0.00	8.16E+09	-4.026	30359.	0.00
28.8600	6.50E-04	-13138.	445.2110	1.03E-05	0.00	8.16E+09	-4.505	30753.	0.00
29.2300	6.80E-04	-11207.	424.6138	3.69E-06	0.00	8.16E+09	-4.773	31147.	0.00
29.6000	6.83E-04	-9369.	403.2441	-1.91E-06	0.00	8.16E+09	-4.853	31542.	0.00
29.9700	6.63E-04	-7626.	381.8775	-6.54E-06	0.00	8.16E+09	-4.771	31936.	0.00
30.3400	6.25E-04	-5976.	361.1802	-1.02E-05	0.00	8.16E+09	-4.552	32330.	0.00
30.7100	5.72E-04	-4414.	341.7091	-1.31E-05	0.00	8.16E+09	-4.219	32725.	0.00
31.0800	5.09E-04	-2936.	323.9130	-1.51E-05	0.00	8.16E+09	-3.797	33119.	0.00
31.4500	4.39E-04	-1532.	308.1331	-1.63E-05	0.00	8.16E+09	-3.311	33513.	0.00
31.8200	3.64E-04	-192.960	294.6038	-1.68E-05	0.00	8.16E+09	-2.783	33907.	0.00
32.1900	2.90E-04	1091.	283.4530	-1.65E-05	0.00	8.16E+09	-2.239	34302.	0.00
32.5600	2.18E-04	2331.	274.7013	-1.56E-05	0.00	8.16E+09	-1.703	34696.	0.00
32.9300	1.52E-04	3537.	268.2622	-1.40E-05	0.00	8.16E+09	-1.198	35090.	0.00

33.3000	9.38E-05	4719.	263.9397	-1.17E-05	0.00	8.16E+09	-0.749	35484.	0.00
33.6700	4.74E-05	5885.	261.4266	-8.85E-06	0.00	8.16E+09	-0.383	35879.	0.00
34.0400	1.52E-05	7044.	-165.265	-5.33E-06	0.00	8.16E+09	-191.821	5.61E+07	0.00
34.4100	3.36E-08	4420.	-592.050	-2.21E-06	0.00	8.16E+09	-0.425	5.61E+07	0.00
34.7800	-4.44E-06	1787.	-468.491	-5.21E-07	0.00	8.16E+09	56.0819	5.61E+07	0.00
35.1500	-4.60E-06	260.0017	-215.133	3.15E-07	0.00	1.65E+09	58.0432	5.61E+07	0.00
35.5200	-1.64E-06	-123.206	-40.214	4.99E-07	0.00	1.65E+09	20.7494	5.61E+07	0.00
35.8900	-1.63E-07	-97.299	10.4172	2.02E-07	0.00	1.65E+09	2.0572	5.61E+07	0.00
36.2600	1.54E-07	-30.784	10.6669	2.99E-08	0.00	1.65E+09	-1.945	5.61E+07	0.00
36.6300	1.03E-07	-2.589	3.4660	-1.50E-08	0.00	1.65E+09	-1.299	5.61E+07	0.00
37.0000	2.08E-08	0.00	0.00	-1.85E-08	0.00	1.65E+09	-0.262	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 5:

Pile-head deflection = 1.00000000 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -2009670. inch-lbs
Maximum shear force = 31941. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 6

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 46000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 28000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.1144	-3088562.	46000.	0.00	0.00	3.65E+09	0.00	0.00	0.00
0.3700	2.1061	-2884088.	45972.	-0.00364	0.00	3.65E+09	-12.683	26.7383	0.00
0.7400	2.0821	-2679428.	45883.	-0.00633	0.00	6.32E+09	-27.445	58.5259	0.00
1.1100	2.0498	-2475075.	45728.	-0.00808	0.00	6.80E+09	-42.323	91.6740	0.00
1.4800	2.0104	-2271356.	45509.	-0.00962	0.00	6.93E+09	-56.250	124.2317	0.00
1.8500	1.9644	-2068564.	45231.	-0.01100	0.00	6.95E+09	-68.909	155.7466	0.00
2.2200	1.9127	-1866967.	44902.	-0.01226	0.00	6.98E+09	-79.195	183.8403	0.00
2.5900	1.8556	-1666783.	44526.	-0.01338	0.00	7.00E+09	-90.441	216.4037	0.00
2.9600	1.7938	-1468251.	44092.	-0.01437	0.00	7.02E+09	-104.963	259.7959	0.00
3.3300	1.7280	-1271672.	43593.	-0.01524	0.00	7.04E+09	-119.942	308.1906	0.00
3.7000	1.6585	-1077359.	43021.	-0.01598	0.00	7.07E+09	-137.640	368.4729	0.00
4.0700	1.5861	-885674.	42357.	-0.01659	0.00	7.10E+09	-161.230	451.3389	0.00
4.4400	1.5112	-697099.	41586.	-0.01709	0.00	7.15E+09	-186.438	547.7713	0.00
4.8100	1.4344	-512146.	40694.	-0.01746	0.00	7.21E+09	-215.134	665.9393	0.00
5.1800	1.3561	-331395.	39671.	-0.01772	0.00	7.33E+09	-245.856	804.9354	0.00
5.5500	1.2770	-155465.	38506.	-0.01786	0.00	8.17E+09	-278.603	968.6610	0.00
5.9200	1.1975	14983.	37192.	-0.01790	0.00	8.18E+09	-313.376	1162.	0.00
6.2900	1.1181	179252.	35719.	-0.01785	0.00	8.17E+09	-350.173	1391.	0.00
6.6600	1.0390	336606.	34078.	-0.01770	0.00	7.33E+09	-388.997	1662.	0.00

7.0300	0.9609	486266.	32260.	-0.01744	0.00	7.22E+09	-429.847	1986.	0.00
7.4000	0.8841	627415.	30257.	-0.01710	0.00	7.17E+09	-472.724	2374.	0.00
7.7700	0.8091	759197.	28058.	-0.01667	0.00	7.13E+09	-517.628	2841.	0.00
8.1400	0.7361	880715.	25656.	-0.01616	0.00	7.11E+09	-564.560	3405.	0.00
8.5100	0.6656	991036.	23040.	-0.01557	0.00	7.09E+09	-613.521	4093.	0.00
8.8800	0.5978	1089184.	20203.	-0.01492	0.00	7.07E+09	-664.510	4935.	0.00
9.2500	0.5331	1174148.	17135.	-0.01421	0.00	7.06E+09	-717.528	5976.	0.00
9.6200	0.4716	1244875.	13827.	-0.01345	0.00	7.05E+09	-772.577	7273.	0.00
9.9900	0.4137	1300274.	10270.	-0.01265	0.00	7.04E+09	-829.656	8905.	0.00
10.3600	0.3593	1339216.	6610.	-0.01181	0.00	7.04E+09	-818.919	10118.	0.00
10.7300	0.3088	1361909.	3056.	-0.01096	0.00	7.03E+09	-781.834	11242.	0.00
11.1000	0.2620	1369082.	-325.911	-0.01010	0.00	7.03E+09	-741.719	12569.	0.00
11.4700	0.2191	1361526.	-3525.	-0.00924	0.00	7.03E+09	-699.473	14175.	0.00
11.8400	0.1800	1340073.	-6535.	-0.00838	0.00	7.04E+09	-655.999	16182.	0.00
12.2100	0.1446	1305584.	-9330.	-0.00755	0.00	7.04E+09	-603.101	18512.	0.00
12.5800	0.1130	1259102.	-11804.	-0.00674	0.00	7.05E+09	-511.570	20108.	0.00
12.9500	0.08479	1202438.	-13818.	-0.00597	0.00	7.05E+09	-395.299	20699.	0.00
13.3200	0.05998	1137886.	-15334.	-0.00523	0.00	7.06E+09	-287.639	21291.	0.00
13.6900	0.03835	1067575.	-16392.	-0.00454	0.00	7.07E+09	-189.023	21882.	0.00
14.0600	0.01970	993455.	-17033.	-0.00389	0.00	7.09E+09	-99.705	22474.	0.00
14.4300	0.00381	917291.	-17298.	-0.00329	0.00	7.10E+09	-19.776	23065.	0.00
14.8000	-0.00954	840666.	-17229.	-0.00274	0.00	7.11E+09	50.8155	23656.	0.00
15.1700	-0.02055	764978.	-16950.	-0.00224	0.00	7.13E+09	74.8264	16165.	0.00
15.5400	-0.02945	690706.	-16540.	-0.00179	0.00	7.15E+09	109.8446	16559.	0.00
15.9100	-0.03645	618546.	-15987.	-0.00138	0.00	7.17E+09	139.1717	16954.	0.00
16.2800	-0.04174	549082.	-15316.	-0.00102	0.00	7.20E+09	163.0977	17348.	0.00
16.6500	-0.04553	482791.	-14550.	-7.06E-04	0.00	7.23E+09	181.9536	17742.	0.00
17.0200	-0.04801	420050.	-13711.	-4.29E-04	0.00	7.26E+09	196.1023	18137.	0.00
17.3900	-0.04934	361143.	-12819.	-1.91E-04	0.00	7.30E+09	205.9302	18531.	0.00
17.7600	-0.04970	306268.	-11891.	1.17E-05	0.00	7.36E+09	211.8397	18925.	0.00
18.1300	-0.04924	255546.	-10945.	1.81E-04	0.00	7.42E+09	214.2413	19319.	0.00
18.5000	-0.04810	209029.	-9996.	3.14E-04	0.00	8.16E+09	213.5476	19714.	0.00
18.8700	-0.04645	166708.	-9054.	4.16E-04	0.00	8.17E+09	210.3647	20108.	0.00
19.2400	-0.04440	128522.	-8132.	4.96E-04	0.00	8.17E+09	205.0315	20502.	0.00
19.6100	-0.04204	94370.	-7238.	5.57E-04	0.00	8.18E+09	197.8755	20896.	0.00
19.9800	-0.03946	64112.	-6379.	6.00E-04	0.00	8.18E+09	189.2095	21291.	0.00
20.3500	-0.03672	37580.	-5560.	6.27E-04	0.00	8.18E+09	179.3294	21685.	0.00
20.7200	-0.03389	14580.	-4788.	6.42E-04	0.00	8.18E+09	168.5121	22079.	0.00
21.0900	-0.03102	-5099.	-4065.	6.44E-04	0.00	8.18E+09	157.0140	22474.	0.00
21.4600	-0.02817	-21682.	-3395.	6.37E-04	0.00	8.18E+09	145.0703	22868.	0.00
21.8300	-0.02537	-35403.	-2778.	6.21E-04	0.00	8.18E+09	132.8936	23262.	0.00
22.2000	-0.02265	-46503.	-2215.	5.99E-04	0.00	8.18E+09	120.6741	23656.	0.00
22.5700	-0.02004	-55220.	-1706.	5.72E-04	0.00	8.18E+09	108.5794	24051.	0.00
22.9400	-0.01757	-61793.	-1250.	5.40E-04	0.00	8.18E+09	96.7553	24445.	0.00
23.3100	-0.01525	-66455.	-845.840	5.05E-04	0.00	8.18E+09	85.3257	24839.	0.00
23.6800	-0.01309	-69430.	-491.262	4.68E-04	0.00	8.18E+09	74.3942	25233.	0.00
24.0500	-0.01110	-70934.	-183.927	4.30E-04	0.00	8.18E+09	64.0451	25628.	0.00
24.4200	-0.00927	-71170.	78.8966	3.91E-04	0.00	8.18E+09	54.3440	26022.	0.00
24.7900	-0.00762	-70330.	300.1948	3.53E-04	0.00	8.18E+09	45.3399	26416.	0.00
25.1600	-0.00614	-68592.	483.1366	3.15E-04	0.00	8.18E+09	37.0663	26810.	0.00
25.5300	-0.00482	-66118.	631.0088	2.79E-04	0.00	8.18E+09	29.5428	27205.	0.00
25.9000	-0.00366	-63058.	747.1569	2.44E-04	0.00	8.18E+09	22.7762	27599.	0.00
26.2700	-0.00266	-59544.	834.9330	2.10E-04	0.00	8.18E+09	16.7626	27993.	0.00
26.6400	-0.00180	-55696.	897.6497	1.79E-04	0.00	8.18E+09	11.4882	28388.	0.00
27.0100	-0.00107	-51618.	938.5408	1.50E-04	0.00	8.18E+09	6.9312	28782.	0.00
27.3800	-4.66E-04	-47399.	960.7272	1.23E-04	0.00	8.18E+09	3.0627	29176.	0.00
27.7500	2.28E-05	-43117.	967.1893	9.84E-05	0.00	8.18E+09	-0.152	29570.	0.00
28.1200	4.08E-04	-38835.	960.7434	7.62E-05	0.00	8.18E+09	-2.752	29965.	0.00
28.4900	6.99E-04	-34604.	944.0236	5.62E-05	0.00	8.18E+09	-4.780	30359.	0.00
28.8600	9.07E-04	-30466.	919.4673	3.85E-05	0.00	8.18E+09	-6.282	30753.	0.00
29.2300	0.00104	-26449.	889.3044	2.31E-05	0.00	8.18E+09	-7.305	31147.	0.00
29.6000	0.00111	-22575.	855.5494	9.79E-06	0.00	8.18E+09	-7.900	31542.	0.00
29.9700	0.00113	-18854.	819.9961	-1.46E-06	0.00	8.18E+09	-8.115	31936.	0.00
30.3400	0.00110	-15293.	784.2141	-1.07E-05	0.00	8.18E+09	-8.003	32330.	0.00
30.7100	0.00103	-11888.	749.5465	-1.81E-05	0.00	8.18E+09	-7.613	32725.	0.00
31.0800	9.38E-04	-8632.	717.1087	-2.37E-05	0.00	8.18E+09	-6.998	33119.	0.00
31.4500	8.23E-04	-5514.	687.7875	-2.75E-05	0.00	8.18E+09	-6.209	33513.	0.00
31.8200	6.94E-04	-2518.	662.2398	-2.97E-05	0.00	8.18E+09	-5.299	33907.	0.00
32.1900	5.59E-04	374.0464	640.8914	-3.03E-05	0.00	8.18E+09	-4.318	34302.	0.00

32.5600	4.25E-04	3181.	623.9349	-2.93E-05	0.00	8.18E+09	-3.320	34696.	0.00
32.9300	2.99E-04	5922.	611.3260	-2.68E-05	0.00	8.18E+09	-2.359	35090.	0.00
33.3000	1.86E-04	8616.	602.7796	-2.29E-05	0.00	8.18E+09	-1.490	35484.	0.00
33.6700	9.52E-05	11280.	597.7638	-1.75E-05	0.00	8.18E+09	-0.769	35879.	0.00
34.0400	3.11E-05	13929.	-275.188	-1.07E-05	0.00	8.18E+09	-392.453	5.61E+07	0.00
34.4100	5.49E-07	8839.	-1162.	-4.47E-06	0.00	8.18E+09	-6.940	5.61E+07	0.00
34.7800	-8.66E-06	3613.	-934.307	-1.09E-06	0.00	8.18E+09	109.4324	5.61E+07	0.00
35.1500	-9.17E-06	542.8631	-434.270	6.00E-07	0.00	1.69E+09	115.8095	5.61E+07	0.00
35.5200	-3.34E-06	-243.946	-83.505	9.92E-07	0.00	1.69E+09	42.1924	5.61E+07	0.00
35.8900	-3.58E-07	-198.911	20.2014	4.10E-07	0.00	1.69E+09	4.5223	5.61E+07	0.00
36.2600	3.04E-07	-64.660	21.7227	6.41E-08	0.00	1.69E+09	-3.837	5.61E+07	0.00
36.6300	2.11E-07	-6.029	7.2807	-2.88E-08	0.00	1.69E+09	-2.668	5.61E+07	0.00
37.0000	4.84E-08	0.00	0.00	-3.67E-08	0.00	1.69E+09	-0.611	2.80E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 6:

Pile-head deflection = 2.11440190 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -3088562. inch-lbs
Maximum shear force = 46000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 16
Number of zero deflection points = 5

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	12000.	S, rad	0.00	60000.	0.2541	0.00	12000.	-652961.
2	V, lb	10000.	S, rad	0.00	46000.	0.2001	0.00	10000.	-530787.
3	V, lb	7000.	S, rad	0.00	28000.	0.1250	0.00	7000.	-353808.
4	V, lb	41800.	S, rad	0.00	60000.	1.6186	0.00	41800.	-2824812.
5	y, in	1.0000	S, rad	0.00	46000.	1.0000	0.00	31941.	-2009670.
6	V, lb	46000.	S, rad	0.00	28000.	2.1144	0.00	46000.	-3088562.

Maximum pile-head deflection = 2.1144018986 inches
Maximum pile-head rotation = 0.0000000000 radians = 0.000000 deg.

Summary of Warning Messages

The following warning was reported 1062 times

**** Warning ****

This warning is for an input value for uniaxial compressive strength that
has been specified for a soil defined using the vuggy limestone criteria.
The input value is outside of the range of 1,000 to 2,500 psi
(6,895 to 17,237 kPa) which were used in actual field tests
on which this theory is based. Higher or lower values may be applicable
but the user is warned about the theoretical and testing limitations.

The analysis ended normally.

APPENDIX 3

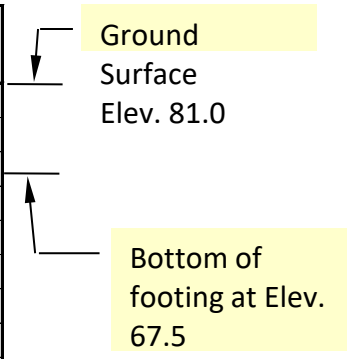
Seismic Design Information

(7 Sheets)

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-011, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:		Prepared by: JJL		Date: 7/2025
Detail:	Site Class	Checked by: JG		Date: 7/2025

BB-1

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	7	2	0.29
5.00	8	3	0.38
10.00	8	5	0.63
15.00	11	5	0.45
20.00	2	5	2.50
25.00	7	5	0.71
30.00	6	5	0.83
35.00	2	5	2.50
40.00	100	5	0.05
45.00	100	5	0.05
50.00	100	5	0.05
55.00	100	5	0.05
60.00	100	5	0.05
105.00	100	45	0.45
	Sum	100	8.33



Assume N value = 100 blows/ft for bedrock

Below bottom of footing:

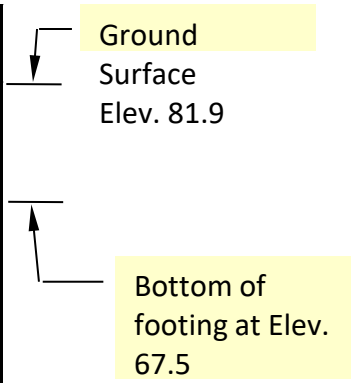
$\bar{N}$ = 12 < 15

The site class is E per Table 3.4.2.1-1 of AASHTO Guide Specification.

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-011, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:		Prepared by: JJL		Date: 7/2025
Detail:	Site Class	Checked by: JG		Date: 7/2025

BB-2

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
5.00	5	5	1.00
10.00	100	5	0.05
15.00	16	5	0.31
20.00	4	5	1.25
25.00	6	5	0.83
30.00	5	5	1.00
35.00	42	5	0.12
40.00	82	5	0.06
45.00	61	5	0.08
50.00	100	5	0.05
55.00	100	5	0.05
60.00	100	5	0.05
65.00	100	5	0.05
115.00	100	50	0.50
	Sum	100	4.05



Assume N value = 100 blows/ft for bedrock

Below bottom of footing:

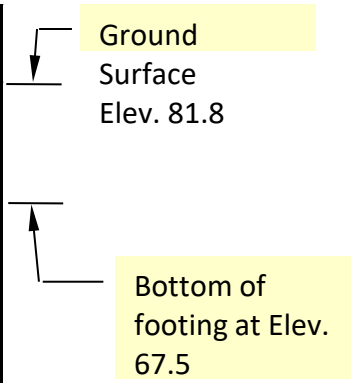
50 > $\bar{N}$ = 25 > 15

The site class is D per Table 3.4.2.1-1 of AASHTO Guide Specification.

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-011, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:		Prepared by: JJL		Date: 7/2025
Detail:	Site Class	Checked by: JG		Date: 7/2025

BB-3

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	37	5	0.14
5.00	8	5	0.63
10.00	21	5	0.24
15.00	8	5	0.63
20.00	6	5	0.83
25.00	7	5	0.71
30.00	5	5	1.00
35.00	45	5	0.11
40.00	49	5	0.10
45.00	100	5	0.05
50.00	100	5	0.05
55.00	100	5	0.05
60.00	100	5	0.05
110.00	100	50	0.50
	Sum	100	4.09



Assume N value = 100 blows/ft for bedrock

Below bottom of footing:

50 > $\bar{N}$ = 24 > 15

The site class is D per Table 3.4.2.1-1 of AASHTO Guide Specification.

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Bridge No. W-38-011, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:		Prepared by: JJL		Date: 7/2025
Detail:	Site Class	Checked by: JG		Date: 7/2025

BB-4

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	79	2	0.03
5.00	3	3	1.00
10.00	21	5	0.24
15.00	11	5	0.45
20.00	8	5	0.63
25.00	6	3	0.50
27.00	8	3	0.38
30.00	44	4	0.09
35.00	100	5	0.05
40.00	100	5	0.05
45.00	100	5	0.05
50.00	100	5	0.05
55.00	100	5	0.05
105.00	100	50	0.50
	Sum	100	3.03

Ground Surface Elev. 82.6

79

3

Bottom of footing at Elev. 67.5

Assume N value = 100 blows/ft for bedrock

Below bottom of footing:

50 > $\bar{N}$ = 33 > 15

The site class is D per Table 3.4.2.1-1 of AASHTO Guide Specification.

Based on Borings BB-1 to BB-4 with consideration of 10' to15' thick loose sand and inorganic silt layer, the controlling site class is E.

From Seismic Design Maps:

PGA = 0.08 g

S_s = 0.16 g

S_1 = 0.04 g

Per Tables 3.4.2.3-1 & 3.4.2.3-2 of AASHTO Guide Specification

F_{pga} = 2.5

F_a = 2.5

F_v = 3.5

Therefore,

A_s = 0.200 g

S_{DS} = 0.400 g

S_{D1} = 0.140 g < 0.15g

Seismic Design Category (SDC) = A



Figure 3.4.1-2b—Horizontal Peak Ground Acceleration Coefficient for the Conterminous United States (*PGA*) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period)

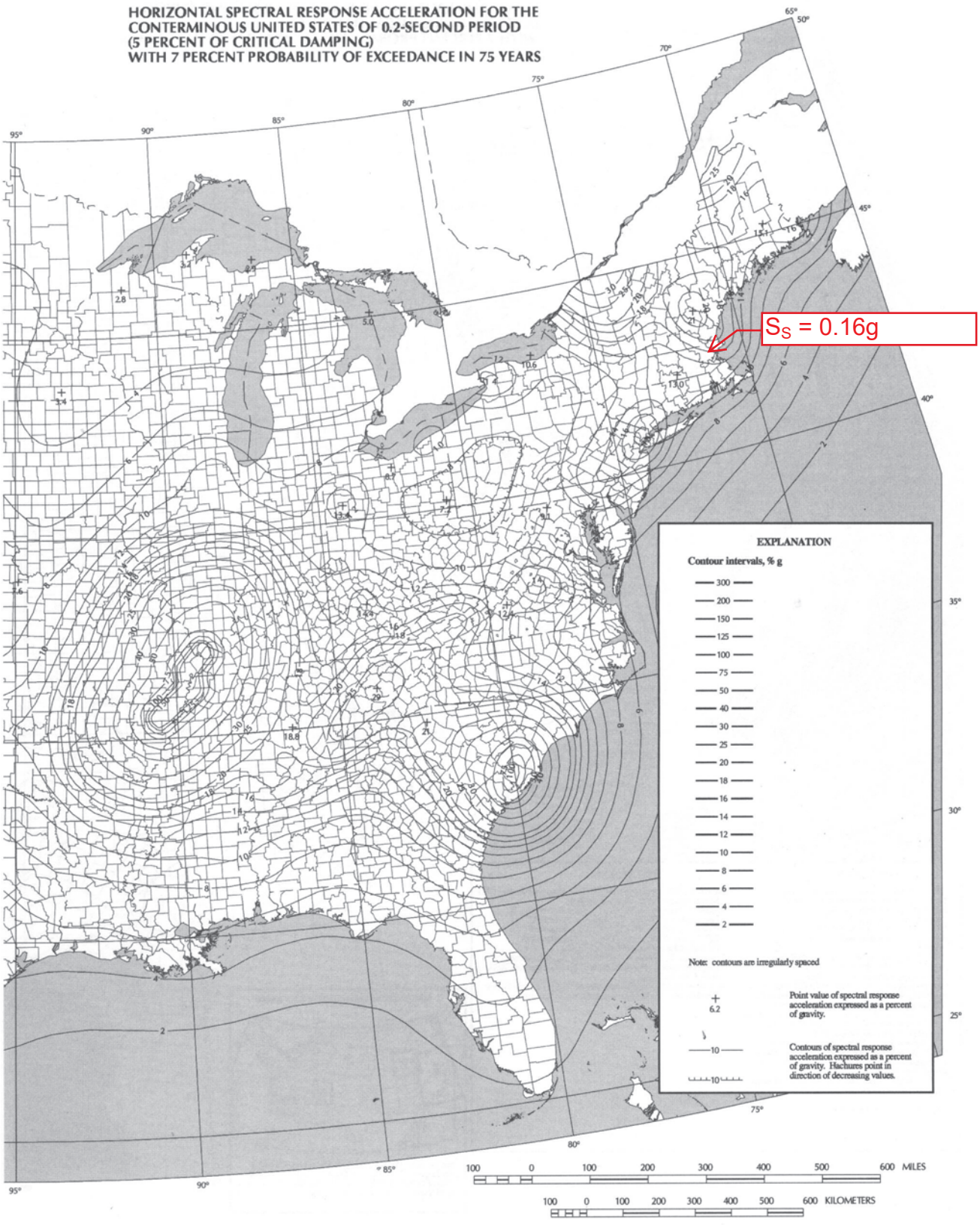


Figure 3.4.1-3b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 0.2-sec (S_s) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

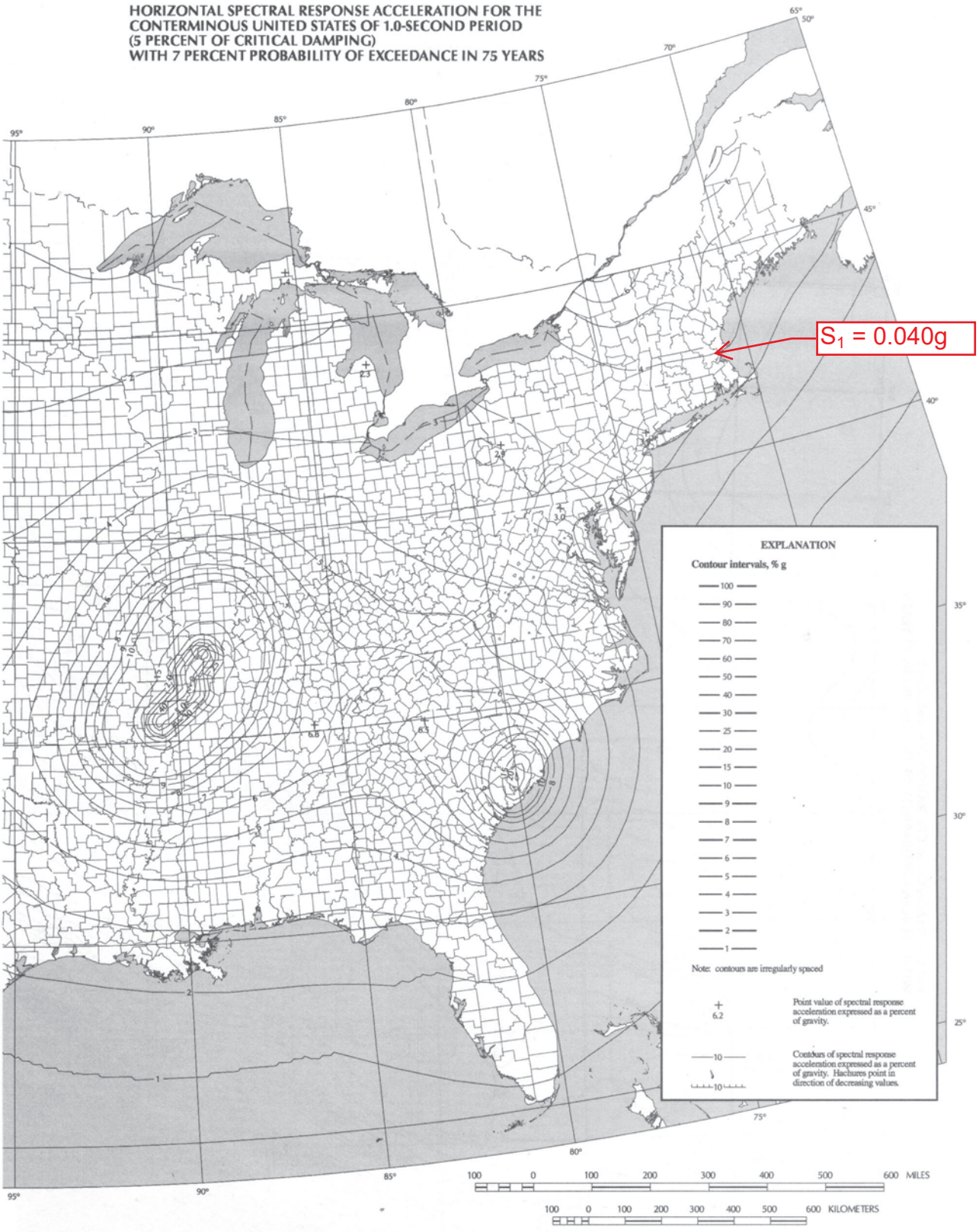


Figure 3.4.1-4b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 1.0-sec (S_1) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

APPENDIX 4

Information from Green

(28 Sheets)

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JOB NO.: 21058.1663 SHEET NO.: OF

JOB NAME: Route 38 (Main Street) over Maple Meadow Brook, Wilmington

CALCULATED BY: AD DATE: 6/16/2025 CHECKED BY: TC DATE:

DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

7.0 SUBSTRUCTURE LOADS

REFERENCES

Dead loads and wearing surface loads are obtained from Section 3 of the calculations.

7.1 Non-Composite Dead Loads from Superstructure (DC1)

Pile Cap	DL Reaction (kips)
North	80.84
South	80.84

7.2 Composite Dead Loads from Superstructure (DC2)

Pile Cap	DL Reaction (kips)
North	16.73
South	16.73

7.3 Wearing Surface Loads from Superstructure (DW)

Pile Cap	DW Reaction (kips)
North	19.81
South	19.81

7.4 Tremie Seal Selfweight (DC)

Tremie Seal Plan Area A_{ts} = 403.33 ft^2

Tremie Seal Thickness t_{ts} = 2.00 ft

Weight of Tremie Seal

DC(seal) = 121.00 k

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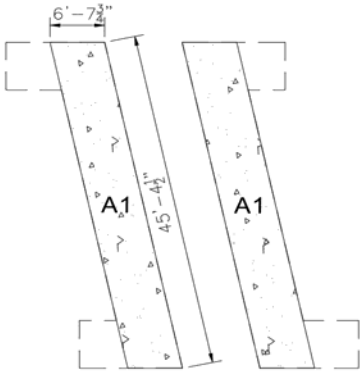
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DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

7.0 SUBSTRUCTURE LOADS

REFERENCES

7.5 Pile Cap Selfweight (DC)



Sectional Area 1:	A_1	=	22.75	ft^2
Pile Cap Length:	L_{pcap}	=	45.38	ft

Weight of Pile Cap

DC(cap)	**=**	**154.84**	**k**

7.6 Pedestal Wall Selfweight (DC)

Pedestal Wall Thickness	t_{pw}	=	2.00	ft
Pedestal Wall Height	h_{pw}	=	6.68	ft
Pedestal Wall Length	L_{pw}	=	45.38	ft

Weight of Pedestal Wall

DC(wall)	**=**	**90.89**	**k**

7.7 Approach Slab Selfweight

The approach slab shall be included as a permanent load on the abutment. For the distribution of the approach slab, it is assumed that the approach slab is simply supported between the approach slab shelf and the end on grade.

Width of Approach Slab	W_{app}	=	32.00	ft
Length of Approach Slab	L_{app}	=	15.00	ft
Thickness of Approach Slab	t_{app}	=	0.83	ft

Weight of Approach Slab = $(W_{app} * L_{app} * t_{app})/2$

DC (App)	**=**	**30.00**	**k**

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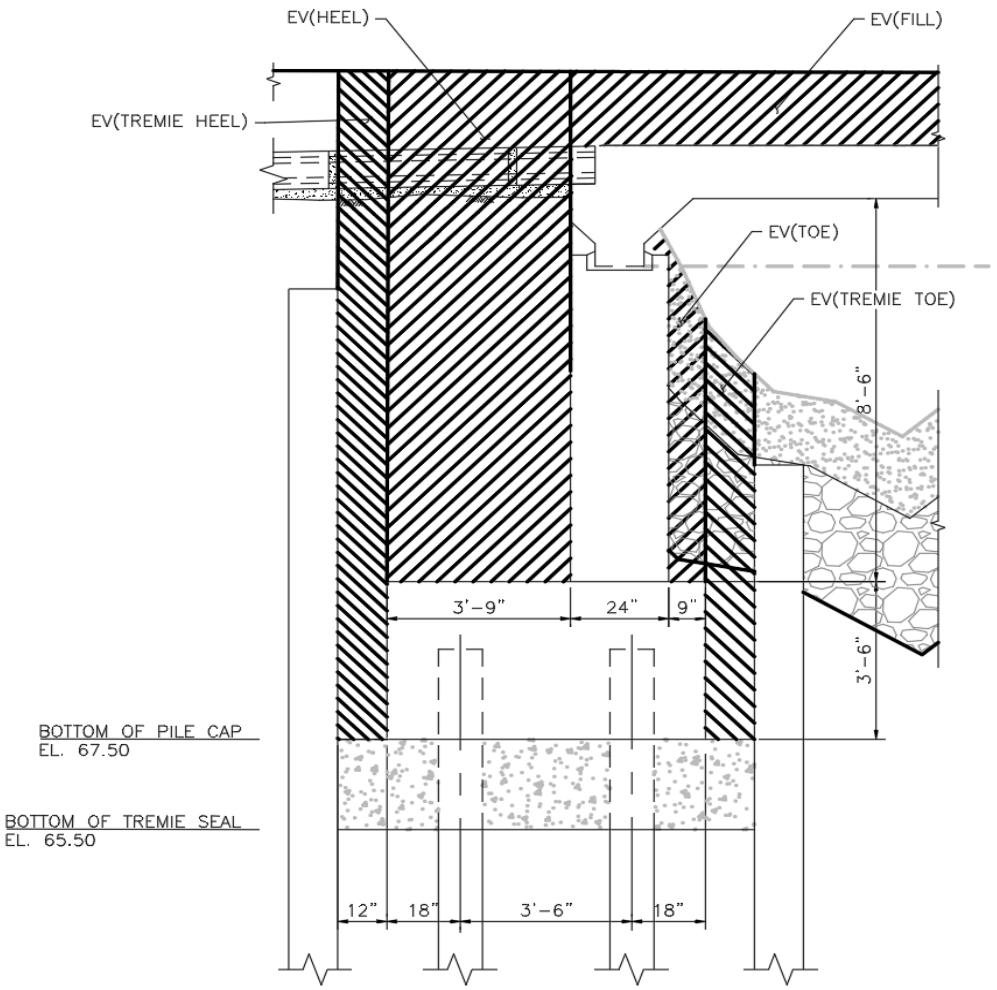
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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.8 Weight of Fill on Substructure



7.8.1 Weight of Fill over Frame

Unit Weight of Roadway Subbase and Controlled Density γ_{fill} = 140 pcf *AASHTO Tab. 3.5.1.1*

Fill over Frame:

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7.0 SUBSTRUCTURE LOADS

REFERENCES

Average Fill Thickness (Avg.), t_{fill}:			1.63	ft
Roadway Width, R_W:			32.00	ft
Length of Frame, L_F:			14.00	ft
Frame Leg Thickness, $t_{F\text{-}leg}$:			1.00	ft
Fill Length Past Frame Leg, D_{oh}:			0.50	ft
Weight of Fill, W_{fill}:				
$W_{fill} = (\gamma_{fill} * t_{fill} * R_W * (L_F + 1) / 2$ Footings	**EV(Fill)**	=	**61.88**	**k**

7.8.2 Weight of Fill on Pile Cap

Length of Frame Cap Heel:	L_{heel}	=	3.75	ft	
Width of Frame Pile Cap:	W_{heel}	=	45.38	ft	
P.G. Elevation at Middle of Heel:	PG_{heel}	=	82.39	ft	
Height of Soil above Frame Heel:	h_{heel}	=	11.39	ft	
Unit Weight Compacted Gravel Borrow:	γ_{grav}	=	140	pcf	*AASHTO Tab. 3.5.1.1*
Weight of Fill on Heel	**EV(Heel)**	=	**271.30**	**k**	
Length of Frame Cap Toe:	L_{toe}	=	0.75	ft	
Width of Frame Pile Cap:	W_{toe}	=	45.38	ft	
Height of Soil above Frame Toe:	h_{toe}	=	8.00	ft	
Unit Weight Soil:	γ_{soil}	=	120	pcf	*Lamson Geotech 4.2*
Weight of Fill on Toe	**EV(Toe)**	=	**32.67**	**k**	

7.8.3 Weight of Fill on Tremie Seal

Length of Tremie Seal:	L_{tseal}	=	47.38	ft
Width of Soil on Tremie Seal, per side of pile cap:	W_{tseal}	=	1.00	ft
Height of Soil on Tremie Seal (Heel Side):	$H_{tsealheel}$	=	14.89	ft
Height of Soil on Tremie Seal (Toe Side):	$H_{tsealtoe}$	=	11.50	ft
Unit Weight Soil:	γ_{soil}	=	120	pcf
Weight of Fill on Tremie Seal	**EV(Tremie Heel)**	=	**84.64**	**k**
	EV(Tremie Toe)	=	**65.38**	**k**

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7.0 SUBSTRUCTURE LOADS

REFERENCES

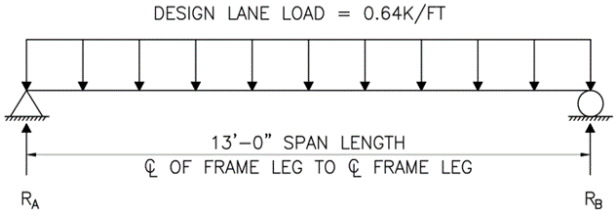
7.9 Vehicular Live Loads (LL)

Per AASHTO LRFD 3.6.1.3.1 the extreme force effect shall be taken as the largest of

a) The effect of the design tandem combined with the design lane load

b) The effect of the design truck with variable axle spacing combined with the effect of the design lane load

7.9.1 Reaction due to Design Lane Load

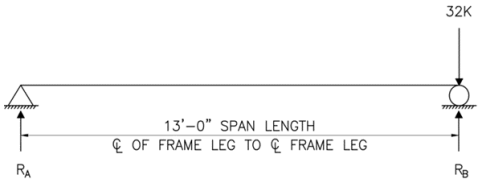


AASHTO LRFD 3.6.1.2.4

L_s' = 13.00 ft

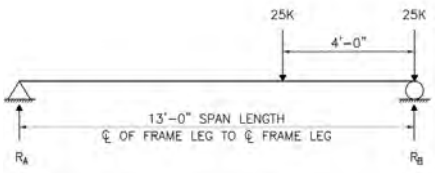
R_A = 5.83 k *BRASS-CULVERT*

7.9.2 Reaction due to Design Truck Load



R_{B1} = 33.50 k *BRASS-CULVERT*

7.9.3 Reaction due to Design Tandem Load



R_{B2} = 42.76 k *BRASS-CULVERT*

CONTROLS

Design Vehicular Live Load, LL_{veh} $=R_A + R_{B2}$	48.59	k
Number of Lanes, N_L	2.00	
Multiple Presence Factor, m	1.00	
$R_{LL} = (LL_{veh} * N_L) * m$	97.18	k
Number of Lanes, N_L	3.00	*MassDOT 3.10.2.2*
Multiple Presence Factor, m	0.85	
$R_{LL} = (LL_{veh} * N_L) * m$	123.90	k
	CONTROLS	

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7.0 SUBSTRUCTURE LOADS

REFERENCES

Option	Description	CL Frame Leg
a	Lane + Tandem	123.90
b	Lane + Truck	100.28

7.10 Braking Force (BR)

Braking force will not be considered, as the force will not transfer through the soil.

7.11 Wind Load on Structure (WS)

Wind Pressure: $P_z = 2.56x10^{-6}V^2K_zGC_D$ *AASHTO Eq. 3.8.1.2.1-1*

where:	Structure Height	Z	=	33.0	ft	
	Ground Surface Roughness			B	-	*AASHTO 3.8.1.1.4*
	Wind Exposure Category			B	-	*AASHTO 3.8.1.1.5*
	Gust Effect Factor	G	=	1.0	-	*AASHTO Tbl. 3.8.1.2.1-1*
	Drag Coefficient (Wind on Superstructure)	C_D	=	1.3	-	*AASHTO Tbl. 3.8.1.2.1-2*
	Drag Coefficient (Wind on Substructure)	C_D	=	1.6		*AASHTO Tbl. 3.8.1.2.1-2*

	STR III	STR V	SER I	
Gust Wind Speed, V (mph)	125.0	80.0	70.0	*AASHTO Tbl. 3.8.1.1.2-1*
Exposure Coefficient, K_z	0.71	1.00	1.00	*AASHTO Tbl. C3.8.1.2.1-1*
Super Wind Pressure, P_z (ksf)	0.0361	0.021	0.016	
Sub Wind Pressure, P_z (ksf)	0.044	0.026	0.020	

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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.11.1 Wind Load on Superstructure (WS_{super})

For usual girder and slab bridges having an individual span length of not more than 150 ft and a maximum height of 33.0 ft above low ground or water level, the following wind load components may be used.

Transverse Wind Load Component				100%	
Longitudinal Wind Load Component				25%	
Projected Superstructure Area	$A_{super} = L_F D_{super}$	A_{super}	=	62.63	ft^2
where: Depth of Superstructure		D_{super}	=	4.47	ft

Due to skew of the bridge, the force will resolved in the parallel and perpendicular forces on the abutments:

	STR III	STR V	SER I
$WS_{super\text{-}trans}$ (k)	2.26	1.30	1.00
$WS_{super\text{-}long}$ (k)	0.56	0.33	0.25
$WS_{super\perp}$(cap)	**0.51**	**0.30**	**0.23**
$WS_{super\parallel}$(cap)	**1.16**	**0.67**	**0.51**

7.11.2 Wind Load on Substructure (WS_{sub})

AASHTO 3.8.1.2.3b

Frame Length = W	W	=	41.88	ft
Frame Leg Thickness	t_{leg}	=	1.00	ft
Frame Leg Exposed Height	H_{expleg}	=	2.00	ft
Wingwall Length	L_{WW}	=	10.00	ft
Wingwall Exposed Height	H_{expWW}	=	8.50	ft

The component perpendicular to the end elevation shall act on the exposed substructure area as seen in end elevation, and the component perpendicular to the front elevation shall act on the exposed substructure area as seen in front elevation.

	STR III	STR V	SER I
$WS_{sub\perp}$(cap)	**0.93**	**0.54**	**0.41**
$WS_{sub\parallel}$(cap)	**3.86**	**2.23**	**1.71**

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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.12 Wind Load on Live Load (WL)

For usual girder and slab bridges having an individual span length of not more than 150 ft and a maximum height of 33.0 ft above low ground or water level, the following wind load components may be used.

AASHTO 3.8.1.3

Transverse Wind Load Component	0.10	klf
Longitudinal Wind Load Component	0.04	klf
$WL_{\perp}$(abut)	**0.39**	k
$WL_{\parallel}$(abut)	**0.69**	k

Vertical Force from Wind Load on Live Load

WL_V(abut)	**1.74**	k

7.13 Seismic Forces (EQ)

Substructures and foundations for bridges classified as SDC A need not be designed for any seismic forces, including those that were specified for the design of superstructure/substructure connections. Additionally, for abutments designed for conventional bridges classified as SDC A, one need not consider the inertial mass of the abutment itself, nor seismic soil forces.

MassDOT 3.4.4

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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.14 Horizontal Earth Pressure (EH)

For the design of cantilever abutments of any height which are founded on rock or piles, the at-rest earth pressure coefficient, K_o, shall be used. *MassDOT BM 3.1.6*

At-rest Laterial Earth Pressure Coefficient: K_o = 0.470 - *Lamson Geotech 4.2*

$$K_o = 1 - \sin(\varphi'_f)$$

Effective Friction Angle of Soil: ϕ'_f = 32.00 ° *Lamson Geotech 4.2*

Horizontal Earth Pressure:

$$EH = 0.5 K \gamma_s H^2$$

EH = 4.89 k/ft

where: γ_s = moist unit weight of soil γ_s = 120.0 pcf *Lamson Geotech 4.2*

H = height of frame and footing H = 13.17 ft

Total Earth Horizontal Pressure on Abutment: **EH_{TOT} = 204.75 k**

Frame Length W = 41.88 ft

7.15 Frame Thrust Force

Frame Thrust Force per Abutment: LL_{thrust} = 3.40 k/ft *BRASS-CULVERT*

LL (Thrust) = 108.80 k

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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.16 Summary of Forces

7.16.1 Summary of Vertical Loads (in Kips)

UNFACTORED VERTICAL LOADS	
LOAD DESCRIPTION	**ABUTMENT**
DC1 - Non-Composite DL	80.84
DC1 - Substructure (Seal, Cap & Wall)	366.73
DC1 - Approach Slab	30.00
DC2 - Composite DL	16.73
DW - Wearing Surface DL	19.81
LL - Vehicular and Pedestrian	123.90
IM - Impact Factor[1]	N/A
BR - Braking Force	N/A
WS - Wind Load on Structure	N/A
WL - Wind Load on LL	1.74
EV(Fill) - Vertical Earth Pressure	61.88
EV(Heel) - Vertical Earth Pressure	271.30
EV(Toe) - Vertical Earth Pressure	32.67
EV(Tremie H.) - Vertical Earth Pressure	84.64
EV(Tremie T.) - Vertical Earth Pressure	65.38

7.16.2 Summary of Horizontal Loads (in Kips)

UNFACTORED HORIZONTAL LOADS		
LOAD DESCRIPTION	**ABUTMENT**	
	X-DIR	**Z-DIR**
BR - Braking Force	N/A	N/A
WS1 - Wind Load on Super	0.51	0.23
WS2 - Wind Load on Sub	1.71	0.41
WL - Wind Load on LL	0.69	0.39
TU - Thermal Force	0.00	0.00
EH - Earth Horizontal	N/A	204.75
LL - Thrust Force	N/A	108.80

Notes:

[1] Dynamic Load Allowance (IM) shall not be used for substructure design.

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7.0 SUBSTRUCTURE LOADS

REFERENCES

7.17 Load Combinations and Load Factors

LOAD	STRENGTH I		STRENGTH III		STRENGTH V		SERVICE I		EXTREME I	
	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}
DC	1.25	0.90	1.25	0.90	1.25	0.90	1.00	1.00	1.00	1.00
DW	1.50	0.65	1.50	0.65	1.50	0.65	1.00	1.00	1.00	1.00
LL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
IM	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
PL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
EH	1.35	0.90	1.35	0.90	1.35	0.90	1.00	1.00	1.00	1.00
EV	1.35	1.00	1.35	1.00	1.35	1.00	1.00	1.00	1.00	1.00
BR	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
WS	0.00	0.00	1.40	1.40	0.40	0.40	0.30	0.30	0.00	0.00
WL	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
TU	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
EQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00

AASHTO Tbl. 3.4.1-1 and Tbl. 3.4.1-2

For At-Rest Cond.

7.18 Load Modifier for Critical or Essential Bridges

Importance Load Modifier, η_I: η_I = 1.00 -

MassDOT BM 3.1.4.4

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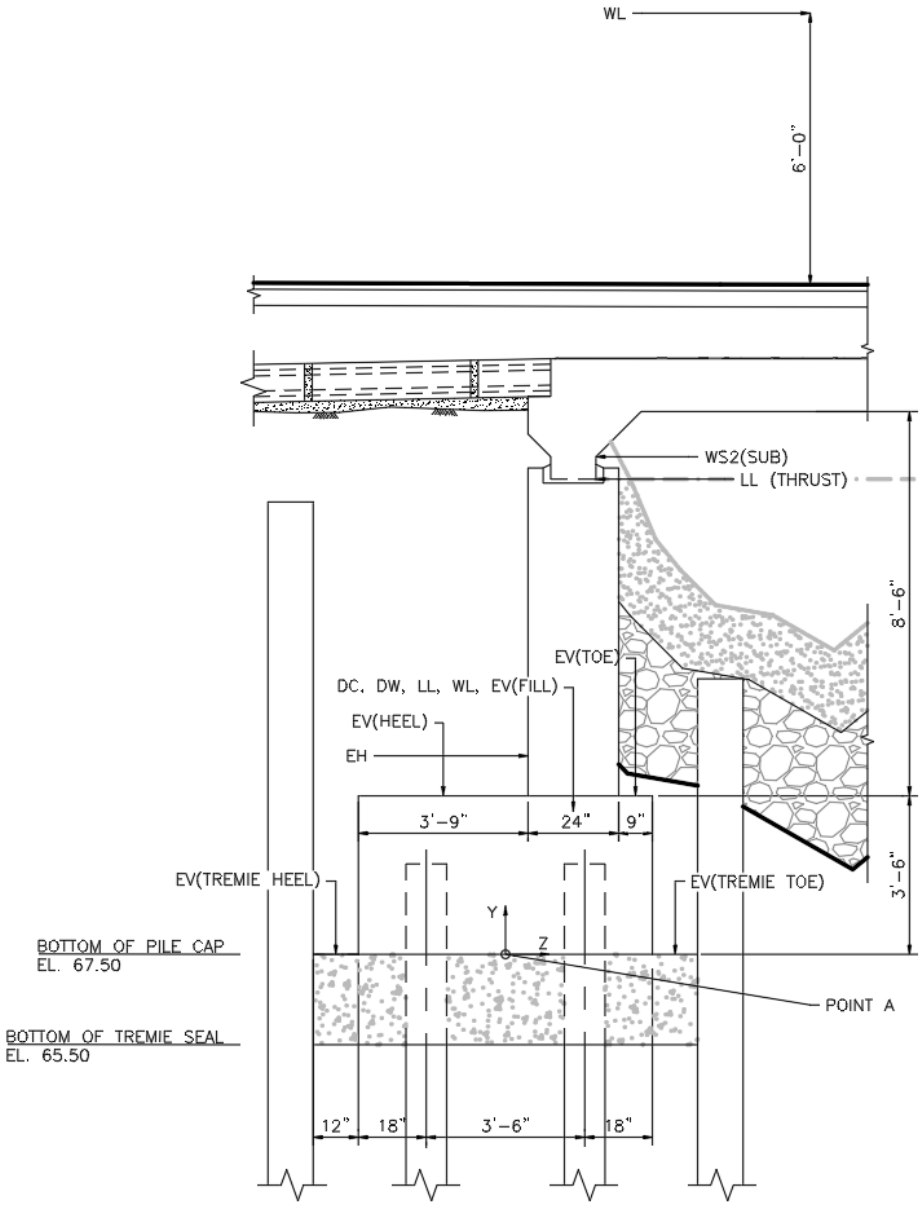
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7.0 SUBSTRUCTURE LOADS ***REFERENCES***

7.19 Factored Forces at Bottom of Pile Cap at Abutment

7.19.1 Location of Forces on Abutment



Forces are located from the bottom of pile cap along the centerline of the pile cap at Point A.

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7.19.2 Abutment - Total Factored Vertical Loads

LOAD (K)	Z (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
DC	18.00	617.88	617.88	617.88	494.31	494.31
DW	18.00	29.71	29.71	29.71	19.81	19.81
LL	18.00	216.83	0.00	167.27	123.90	0.00
BR	18.00	N/A	N/A	N/A	N/A	N/A
WL	18.00	0.00	0.00	1.74	1.74	0.00
EV(Fill)	18.00	83.54	83.54	83.54	61.88	61.88
EV(Heel)	-16.50	366.26	366.26	366.26	271.30	271.30
EV(Toe)	34.50	44.10	44.10	44.10	32.67	32.67
EV(Trem. H.)	-45.00	114.27	114.27	114.27	84.64	84.64
EV(Trem. T.)	15.00	88.26	88.26	88.26	65.38	65.38
TOTAL		**1560.86**	**1344.03**	**1513.04**	**1155.63**	**1029.99**

7.19.3 Total Factored Horizontal Loads - X-Direction (Along Plane of Abutment)

LOAD (K)	Y (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
BR	255.50	N/A	N/A	N/A	N/A	N/A
WS1	170.84	0.00	0.72	0.21	0.15	0.00
WS2	132.00	0.00	2.39	0.68	0.51	0.00
WL	255.50	0.00	0.00	0.69	0.69	0.00
EQ	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL		**0.00**	**3.11**	**1.58**	**1.36**	**0.00**

7.19.4 Total Factored Horizontal Loads - Z-Direction (Perp. to Plane of Abutment)

LOAD (K)	Y (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
BR	255.50	N/A	N/A	N/A	N/A	N/A
WS1	170.84	0.00	0.32	0.09	0.07	0.00
WS2	132.00	0.00	-0.57	-0.16	-0.12	0.00
WL	255.50	0.00	0.00	0.39	0.39	0.00
EH	52.67	276.42	276.42	276.42	204.75	204.75
EQ	N/A	N/A	N/A	N/A	N/A	N/A
LL (Thrust)	119.13	-190.40	0.00	-146.88	-108.80	0.00
TOTAL		**86.02**	**276.16**	**129.85**	**96.29**	**204.75**

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CALCULATED BY: AD DATE: 6/16/2025 CHECKED BY: TC DATE:

DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

7.0 SUBSTRUCTURE LOADS

REFERENCES

7.20 Summary of Factored Moments

7.20.1 Total Factored Moment - Z-Direction (Perp. to Plane of Abutment)

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
DC	926.82	926.82	926.82	741.46	741.46
DW	44.57	44.57	44.57	29.71	29.71
LL	325.25	0.00	250.90	185.85	0.00
WL	0.00	0.00	2.61	2.61	0.00
EV(Fill)	125.31	125.31	125.31	92.82	92.82
EV(Heel)	-503.61	-503.61	-503.61	-373.04	-373.04
EV(Toe)	126.80	126.80	126.80	93.93	93.93
EV(Trem. H.)	-428.51	-428.51	-428.51	-317.41	-317.41
EV(Trem. T.)	110.32	110.32	110.32	81.72	81.72
WS1	0.00	4.51	1.29	0.97	0.00
WS2	0.00	-6.32	-1.81	-1.35	0.00
WL	0.00	0.00	8.31	8.31	0.00
EH	1213.16	1213.16	1213.16	898.64	898.64
LL (Thrust)	-1890.12	0.00	-1458.09	-1080.07	0.00
TOTAL	**50.00**	**1613.07**	**418.09**	**364.15**	**1247.83**

7.20.2 Total Factored Moment - X-Direction (Along Plane of Abutment)

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
WS1	0.00	10.24	2.93	2.19	0.00
WS2	0.00	26.26	7.50	5.63	0.00
WL	0.00	0.00	14.69	14.69	0.00
TOTAL	**0.00**	**36.50**	**25.12**	**22.51**	**0.00**

7.21 Summary of Factored Forces

7.21.1 Factored Forces on Abutment (Kips)

LOAD (K)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. I
VERT.	1560.86	1344.03	1513.04	1155.63	1029.99
HOR. X	0.00	3.11	1.58	1.36	0.00
HOR. Z	86.02	276.16	129.85	96.29	0.00

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7.0 SUBSTRUCTURE LOADS ***REFERENCES***

7.22 Summary of Conservative Factored Moments

Thrust force is ignored in the following tables to produce the highest resultant pile loads in Section 8.

7.22.1 Total Factored Moment - Z-Direction (Perp. to Plane of Abutment)

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
DC	926.82	926.82	926.82	741.46	741.46
DW	44.57	44.57	44.57	29.71	29.71
LL	325.25	0.00	250.90	185.85	0.00
WL	0.00	0.00	2.61	2.61	0.00
EV(Fill)	125.31	125.31	125.31	92.82	92.82
EV(Heel)	-503.61	-503.61	-503.61	-373.04	-373.04
EV(Toe)	126.80	126.80	126.80	93.93	93.93
EV(Trem. H.)	-428.51	-428.51	-428.51	-317.41	-317.41
EV(Trem. T.)	110.32	110.32	110.32	81.72	81.72
WS1	0.00	4.51	1.29	0.97	0.00
WS2	0.00	-6.32	-1.81	-1.35	0.00
WL	0.00	0.00	8.31	8.31	0.00
EH	1213.16	1213.16	1213.16	898.64	898.64
TOTAL	**1940.12**	**1613.07**	**1876.18**	**1444.21**	**1247.83**

7.22.2 Total Factored Moment - X-Direction (Along Plane of Abutment)

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
WS1	0.00	10.24	2.93	2.19	0.00
WS2	0.00	26.26	7.50	5.63	0.00
WL	0.00	0.00	14.69	14.69	0.00
TOTAL	**0.00**	**36.50**	**25.12**	**22.51**	**0.00**

7.23 Summary of Factored Forces

7.23.1 Factored Forces on Abutment (Kips)

LOAD (K)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. I
VERT.	1560.86	1344.03	1513.04	1155.63	1029.99
HOR. X	0.00	3.11	1.58	1.36	0.00
HOR. Z	276.42	276.16	276.73	205.09	204.75

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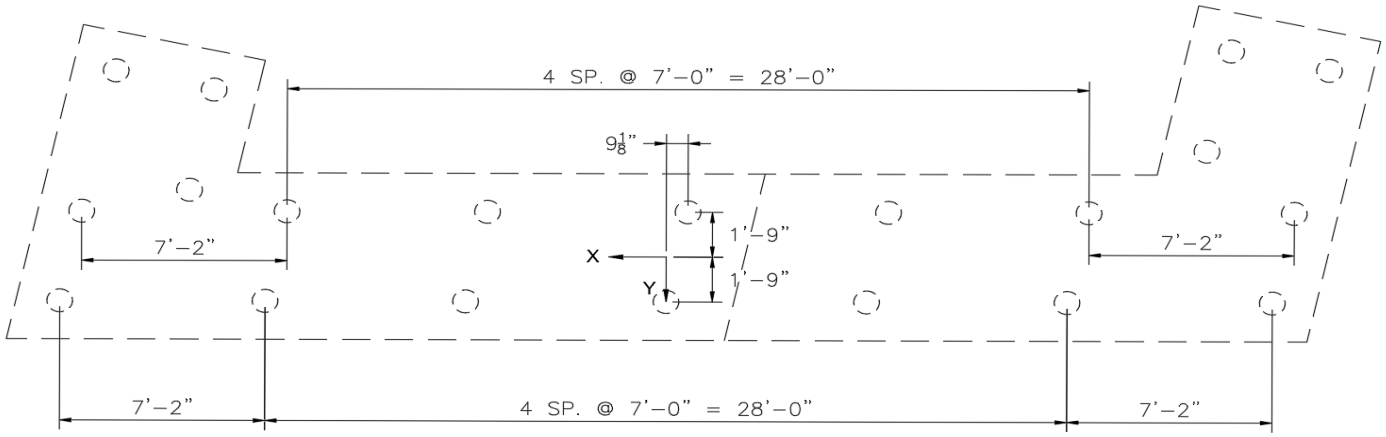
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DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

8.0 GROUP PILE ANALYSIS

REFERENCES



8.1 Calculate Pile Group Centroid and Moment of Inertia - Front Row Piles

Input Pile Location			Calculated Values			
Pile Number	x (ft)	y (ft)	$x' = x - x_c$ (ft)	$y' = y - y_c$ (ft)	x'^2 (ft^2)	y'^2 (ft^2)
1F	21.17	1.75	21.55	1.75	464.22	3.06
2F	14.00	1.75	14.38	1.75	206.76	3.06
3F	7.00	1.75	7.38	1.75	54.45	3.06
4F	0.00	1.75	0.38	1.75	0.14	3.06
5F	-7.00	1.75	-6.62	1.75	43.84	3.06
6F	-14.00	1.75	-13.62	1.75	185.53	3.06
7F	-21.17	1.75	-20.79	1.75	432.12	3.06

8.2 Calculate Pile Group Centroid and Moment of Inertia - Back Row Piles

Input Pile Location			Calculated Values			
Pile Number	x (ft)	y (ft)	$x' = x - x_c$ (ft)	$y' = y - y_c$ (ft)	x'^2 (ft^2)	y'^2 (ft^2)
1B	20.41	-1.75	20.79	-1.75	432.12	3.06
2B	13.24	-1.75	13.62	-1.75	185.53	3.06
3B	6.24	-1.75	6.62	-1.75	43.84	3.06
4B	-0.76	-1.75	-0.38	-1.75	0.14	3.06
5B	-7.76	-1.75	-7.38	-1.75	54.45	3.06
6B	-14.76	-1.75	-14.38	-1.75	206.76	3.06
7B	-21.93	-1.75	-21.55	-1.75	464.22	3.06

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Area of a Pile= 0.63 ft^2

No. of piles on front, n_f : 7

No. of piles on middle, n_m : 7

Centroid of all piles		Moment of Inertias	
x_c (ft)	y_c (ft)	I_{xx} (ft^4)	I_{yy} (ft^4)
-0.38	0.00	2774.13	42.88

$$P = \frac{F'_z}{N} + M'_x \frac{y'}{I_{yy}} + M'_y \frac{x'}{I_{xx}}$$

Where, $F'_z = F_{VERT}$ $M'_x = -F'_z \cdot y_c + M_x$ $M'_y = -F'_z \cdot x_c + M_y$

Load Case	STR-I MAX	STR-I MIN	SER-I MAX	SER-I MIN	STR-III MAX	EXTR. I MAX	STR-V MAX
F'z= (k)	1560.9	1190.5	1155.6	1155.6	1344.0	1030.0	1513.0
My= (k-ft)	0.0	0.0	22.5	22.5	36.5	0.0	25.1
M'y= (k-ft)	591.8	451.4	460.7	460.7	546.1	390.5	598.8
Mx= (k-ft)	1940.1	1398.7	1444.2	1444.2	1613.1	1247.8	1876.2
M'x= (k-ft)	1940.1	1398.7	1444.2	1444.2	1613.1	1247.8	1876.2

8.3 Vertical Loads of Back Piles

Pile No.	STR-I MAX	STR-I MIN	SER-I MAX	SER-I MIN	STR-III MAX	EXTR. I MAX	STR-V MAX
	Pile Load (k)						
1B	36.7	31.3	27.0	27.0	34.3	25.6	36.0
2B	35.2	30.2	25.9	25.9	32.8	24.6	34.4
3B	33.7	29.0	24.7	24.7	31.5	23.6	32.9
4B	32.2	27.9	23.5	23.5	30.1	22.6	31.4
5B	30.7	26.7	22.4	22.4	28.7	21.6	29.9
6B	29.2	25.6	21.2	21.2	27.3	20.6	28.4
7B	27.7	24.4	20.0	20.0	25.9	19.6	26.8
MAXIMUM	**36.7**	**31.3**	**27.0**	**27.0**	**34.3**	**25.6**	**36.0**
ALLOW	270.0	270.0	270.0	270.0	270.0	491.0	270.0
	OKAY	**OKAY**	**OKAY**	**OKAY**	**OKAY**	**OKAY**	**OKAY**

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8.3 Vertical Loads of Front Piles

Pile No.	STR-I MAX	STR-I MIN	SER-I MAX	SER-I MIN	STR-III MAX	EXTR. I MAX	STR-V MAX
	Pile Load (k)						
1F	195.3	145.6	145.1	145.1	166.1	127.5	189.3
2F	193.7	144.5	143.9	143.9	164.7	126.5	187.8
3F	192.3	143.3	142.7	142.7	163.3	125.5	186.2
4F	190.8	142.2	141.6	141.6	161.9	124.6	184.7
5F	189.3	141.0	140.4	140.4	160.5	123.6	183.2
6F	187.8	139.9	139.2	139.2	159.2	122.6	181.7
7F	186.2	138.7	138.0	138.0	157.7	121.6	180.2
MAXIMUM	**195.3**	**145.6**	**145.1**	**145.1**	**166.1**	**127.5**	**189.3**
ALLOW	270.0	270.0	270.0	270.0	270.0	491.0	270.0
	OKAY	**OKAY**	**OKAY**	**OKAY**	**OKAY**	**OKAY**	**OKAY**

Since all piles are vertical, they can be assummed to take equal portion of the horizontal load.

PILE LATERAL CAPACITY CHECK					
	STR-I MAX	SER-I MAX	STR-III MAX	EXTR. I MAX	STR-V MAX
Lateral Cap.	37.20	27.50	37.20	37.20	37.20
Lateral Force	19.74	14.65	19.73	14.63	19.77
	OK	**OK**	**OK**	**OK**	**OK**

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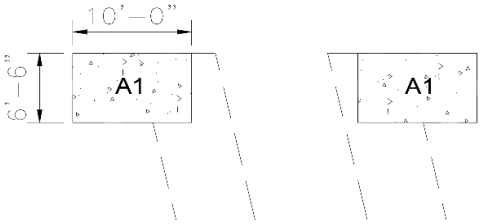
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DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

9.1 Pile Cap Selfweight (DC)

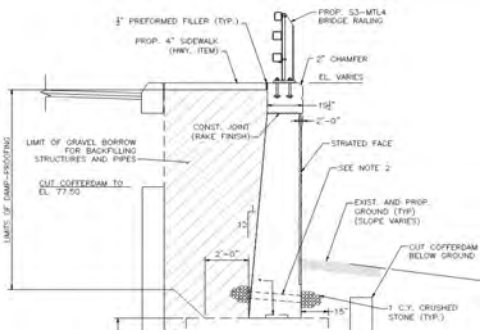


Area 1:	A_1	=	22.75	ft^2
Wingwall Length:	L_{ww}	=	10.00	ft

Weight of Pile Cap

DC(cap)	=	**34.13**	**k**

9.2 Wingwall Stem Selfweight (DC)



Wingwall Length:	L_{ww}	=	10.00	ft
Avg. Stem Height:	H_{ww}	=	11.88	ft
Avg. Wingwall Width:	W_{ww}	=	1.95	ft

Weight of Wingwalls per Pile Cap

DC(WW)	=	**34.81**	**k**

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9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

9.3 Weight of Fill on Substructure

9.3.1 Weight of Fill on Pile Cap

Length of Wingwall Cap Heel:	L_{WWheel}	=	2.83	ft	
Average Width of Wingwall Pile Cap Heel:	W_{WWheel}	=	10.00	ft	
Height of Soil above Wingwall Heel:	h_{WWheel}	=	11.33	ft	
Unit Weight Compacted Gravel Borrow:	γ_{grav}	=	140	pcf	*AASHTO Tab. 3.5.1.1*
Weight of Fill on Heel	**EV(Heel)**	=	**44.94**	**k**	
Length of Wingwall Cap Toe:	L_{WWtoe}	=	1.25	ft	
Average Width of Wingwall Pile Cap Toe:	W_{WWtoe}	=	12.00	ft	
Height of Soil above Wingwall Toe:	h_{WWtoe}	=	1.50	ft	
Unit Weight Soil:	γ_{soil}	=	120	pcf	*Lamson Geotech 4.2*
Weight of Fill on Toe	**EV(Toe)**	=	**2.70**	**k**	

9.4 Horizontal Earth Pressure (EH)

For the design of cantilever abutments of any height which are founded on rock or piles, the at-rest earth pressure coefficient, K_o, shall be used. *MassDOT BM 3.1.6*

At-rest Laterial Earth Pressure Coefficient: $K_o = 1 - \sin(\varphi'_f)$	K_o	=	0.470	-	*Lamson Geotech 4.2*
Effective Friction Angle of Soil:	ϕ'_f	=	32.00	°	*Lamson Geotech 4.2*
Friction Angle Between Fill and Wall:	δ	=	21.00	°	*Lamson Geotech App. 2*
Horizontal Earth Pressure: $EH = 0.5K\gamma_s H^2$	**EH**	=	**6.67**	**k/ft**	
Resultant Vertical Earth Pressure: $EH_v = EH * tan\delta$	**EH_v**	=	**2.56**	**k/ft**	
where: γ_s = moist unit weight of soil	γ_s	=	120.0	pcf	*Lamson Geotech 4.2*
H = height of wingwall and footing	H	=	15.38	ft	
Total Earth Horizontal Pressure on Wingwall:	**EH_{TOT}**	=	**66.72**	**k**	
Total Earth Vertical Pressure on Wingwall:	**EH_{vTOT}**	=	**25.61**	**k**	
Wingwall Length	W	=	10.00	ft	

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9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

9.5 Uniform Surcharge

Dead Load Surcharge: 0.0 psf

Live Load Surcharge: 112.8 psf *AASHTO 3.11.6.4*

$$Uniform\ LL\ Surcharge = k_o \times \gamma_s \times h_{eq} \times \eta_I, \quad where\ h_{eq} = 2ft$$

Total Horizontal Surcharge Pressure on Wingwall:	LS_{TOT} =	**17.35**	**k**
Total Vertical Surcharge Pressure on Wingwall:	LS_{vTOT} =	**6.66**	**k**

9.6 Concentrated Live Loads

Horizontal Load Collision Load: 28.00 k *MassDOT 3.3.2.4*

Note 30.2: MassDOT 3.3.2.4 specifies that the CT load engages an entire section of wall between expansion joints. Therefore, the length over which the load acts is adjusted to the length of the wingwall for stability and stem design checks.

Length of Distribution 5.00 ft

Nominal Collision Load per Foot: 5.60 k/ft

Collision Force Distributed over Wingwall:	CT_{TOT} =	**56.00**	**k**

9.7 Summary of Forces

9.7.1 Summary of Vertical Loads (in Kips)

UNFACTORED VERTICAL LOADS	
LOAD DESCRIPTION	**ABUTMENT**
DC1 - Selfweight Cap	34.13
DC1 - Selfweight Stem	34.81
EV(Heel) - Vertical Earth Pressure	44.94
EV(Toe) - Vertical Earth Pressure	2.70
EH_v - Vertical Component of EH	25.61
LS_v - Vertical Component of LS	6.66

9.7.2 Summary of Horizontal Loads (in Kips)

UNFACTORED HORIZONTAL LOADS		
LOAD DESCRIPTION	**ABUTMENT**	
	X-DIR	**Z-DIR**
LS - Live Load Surcharge	N/A	17.35
EH - Earth Horizontal	N/A	66.72
CT - Collision Force	N/A	56.00

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9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

9.8 Load Combinations and Load Factors

LOAD	STRENGTH I		STRENGTH III		STRENGTH V		SERVICE I		EXTREME II	
	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}	γ_{max}	γ_{min}
DC	1.25	0.90	1.25	0.90	1.25	0.90	1.00	1.00	1.00	1.00
DW	1.50	0.65	1.50	0.65	1.50	0.65	1.00	1.00	1.00	1.00
LL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.50	0.50
IM	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
PL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
EH	1.35	0.90	1.35	0.90	1.35	0.90	1.00	1.00	1.00	1.00
EV	1.35	1.00	1.35	1.00	1.35	1.00	1.00	1.00	1.00	1.00
BR	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
WS	0.00	0.00	1.40	1.40	0.40	0.40	0.30	0.30	0.00	0.00
WL	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
TU	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
EQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00

AASHTO Tbl. 3.4.1-1 and Tbl. 3.4.1-2

For At-Rest Cond.

9.9 Load Modifier for Critical or Essential Bridges

Importance Load Modifier, η_I: η_I = 1.00 -

MassDOT BM 3.1.4.4

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9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

10.0 Wingwall - Total Factored Vertical Loads

LOAD	Z (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. II
DC(Cap)	0.00	42.66	42.66	42.66	34.13	34.13
DC(WW)	12.00	43.51	43.51	43.51	34.81	34.81
EV(Heel)	-22.00	60.67	60.67	60.67	44.94	44.94
EV(Toe)	31.50	3.65	3.65	3.65	2.70	2.70
EH_v	-22.00	34.57	34.57	34.57	25.61	25.61
LS_v	-22.00	11.66	0.00	8.99	6.66	3.33
TOTAL		**196.71**	**185.06**	**194.05**	**148.85**	**145.52**

9.10 Total Factored Horizontal Loads - Z-Direction (Perp. to Plane of Wingwall)

LOAD	Y (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. II
LS	92.28	30.37	0.00	23.42	17.35	8.68
EH	61.52	90.07	90.07	90.07	66.72	66.72
CT	214.56	0.00	0.00	0.00	0.00	56.00
TOTAL		**120.43**	**90.07**	**113.49**	**84.07**	**131.39**

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T: (978) 923-0400 | www.greenintl.com

JOB NO.: 21058.1663 SHEET NO.: OF

JOB NAME: Route 38 (Main Street) over Maple Meadow Brook, Wilmington

CALCULATED BY: AD DATE: 6/16/2025 CHECKED BY: TC DATE:

DESCRIPTION: Bridge W-38-011 Design Calculations (First Set)

9.0 SUBSTRUCTURE LOADS - WINGWALLS

REFERENCES

9.11 Total Factored Moment - Z-Direction (Perp. to Plane of Abutment)

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
DC(Cap)	0.00	0.00	0.00	0.00	0.00
DC(WW)	43.51	43.51	43.51	34.81	34.81
EV(Heel)	-111.23	-111.23	-111.23	-82.39	-82.39
EV(Toe)	9.57	9.57	9.57	7.09	7.09
EH_v	-63.39	-63.39	-63.39	-46.95	-46.95
LS_v	-21.37	0.00	-16.49	-12.21	-6.11
TOTAL	**-142.91**	**-121.54**	**-138.02**	**-99.66**	**-93.56**

LOAD (K-FT)	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
LS	233.51	0.00	180.14	133.44	66.72
EH	461.76	461.76	461.76	342.04	342.04
CT	0.00	0.00	0.00	0.00	1001.29
TOTAL	**695.27**	**461.76**	**641.90**	**475.48**	**1410.05**

SUM	**552.36**	**340.22**	**503.87**	**375.82**	**1316.49**

9.11 Summary of Factored Forces

9.11.1 Factored Forces on Wingwall (Kips)

LOAD	COMBINATION				
	STR. I	STR. III	STR. V	SER. I	EXT. II
VERT.	196.71	185.06	194.05	148.85	145.52
HOR. Z	120.43	90.07	113.49	84.07	131.39

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17. TEMPORARY PEDESTRIAN BRIDGE - PILE CAP DESIGN

REFERENCES

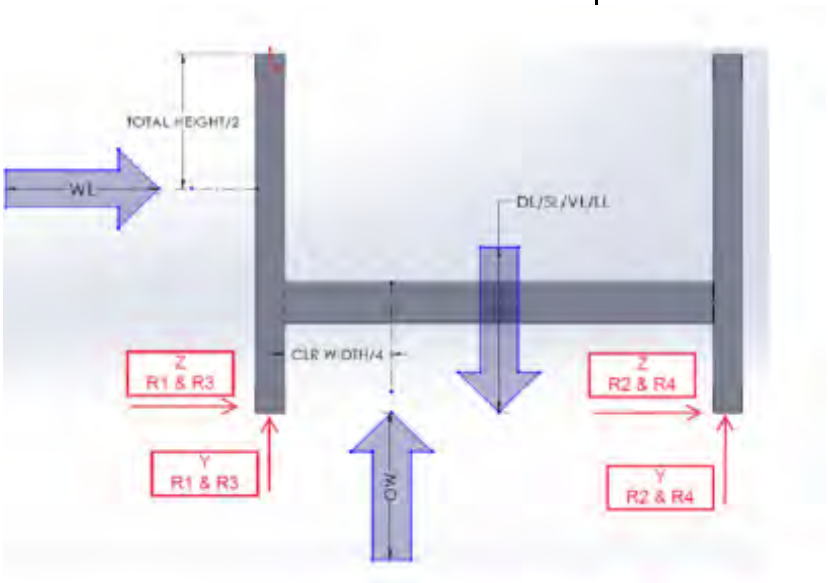
17.1 Loads

17.1.1 Superstructure Loads from Bridge Brothers

Appendix A

	Z	Y	X
DL		-6855	
VL			
LL		-6750	
WL	4589	4656	
OW		2550	
E	4799	4869	
TH		1371	

**Above for 1 pile truss bearing*



17.1.2 Substructure Dead Load

Weight of Concrete, γ_{CONC}:		0.150	k/ft^3
Pile Cap Depth, D		4.50	ft
Pile Cap Width, W		2.50	ft
Pile Cap Length, L		7.83	ft
Volume of Pile Caps		88.13	ft^3
Weight of Pile Cap, Wpc		**-13.22**	**kips per cap**

17.1.3 Lateral Earth Loads

Unit Weight of Soil, γ_s		120.00	pcf
At Rest Earth Pressure Coefficient, K_o		0.47	*Lamson Geotech. 4.3*
Height of Cap		4.50	ft
Length of Cap		7.83	ft
$1/2 * \gamma * H^2 * K_o$	P_A=	0.571	klf
Lateral Earth Pressure Load, $EH_A = P_A * L_{sub}$		4.473	k
Angle of Backslope, $\emptyset_{back}$		90	deg
		4.473	**k**

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17. TEMPORARY PEDESTRIAN BRIDGE - PILE CAP DESIGN

REFERENCES

17.1.4 Seismic Loads

Site Class	E	*Lamson Geotech. 3.9*
1s Acceleration Coeff., S_{D1}	0.140	*Lamson Geotech. 3.9*
Seismic Design Category, SDC	A	*(Ref. AASHTO GS Table 3.5-1)*
Acceleration Coefficent, A_S:	0.200	
Seismic Zone	1	
Assume Percentage of Vertical Load	0.25	*(Ref. AASHTO LRFD 3.10.9.2)*

Note 17-1: *As per the MassDOT BM 2024, Section 3.4.4.3, seismic forces shall only be based on the tributary permanent loads and shall not include the tributary live loads.*

EQ = 0.25 * (DC1 + DC2 + DW) **1.714** **k** *per cap*

Summary of Loads

Vertical Loads		**Weight**		**Say**	
DL from Superstructure	**DC1**	13.71	K	**14.0**	**K**
Live Load + Impact	**LL + IM**	13.50	K	**14.0**	**K**
Wind Load on Superstructure	**W_{superV}**	9.31	K	**10.0**	**K**
Overturning Wind Load	**W_{OW}**	-5.10	K	**-6.0**	**K**
Substructure Load	**W_{abut}**	13.22	K	**14.0**	**K**

Horizontal Loads		**Weight**		**Say**	
Thermal Force	**TH**	2.74	K	**3.0**	**K**
Wind Load on Superstructure (‖ abut)	**$W_{super‖}$**	9.18	K	**10.0**	**K**
Lateral Earth Pressure	**EH**	4.47	K	**5.0**	**K**
Earthquake Load	**EQ**	1.71	K	**2.0**	**K**

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17. TEMPORARY PEDESTRIAN BRIDGE - PILE CAP DESIGN

REFERENCES

Load Combinations and Load Factors AASHTO LRFD Table 3.4.1-1, 3.4.1-2

	Strength I		Strength III		Strength V		Service I		Extreme I	
Load	Ymax	Ymin	Ymax	Ymin	Ymax	Ymin	Ymax	Ymin	Ymax	Ymin
DC	1.25	0.90	1.25	0.90	1.25	0.90	1.00	1.00	1.00	1.00
DW	1.50	0.65	1.50	0.65	1.50	0.65	1.00	1.00	1.00	1.00
LL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
PL	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.50	0.50
EH	1.50	0.90	1.50	0.90	1.50	0.90	1.00	1.00	1.00	1.00
BR	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.00	0.00
CE	1.75	1.75	0.00	0.00	1.35	1.35	1.00	1.00	0.50	0.50
EQ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
TU	1.20	0.50	1.20	0.50	1.20	0.50	1.20	1.00	0.00	0.00
WL	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
WS	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00
EV	1.35	1.00	1.35	1.00	1.35	1.00	1.00	1.00	1.00	1.00

17.2 Factored Loads

17.2.1 Factored Vertical Loads

LOAD (K)	Z (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
DC	0.00	17.50	17.50	17.50	14.00	14.00
LL+I	30.00	24.50	0.00	18.90	14.00	0.00
W_{superv}	0.00	0.00	10.00	10.00	10.00	0.00
W_{OW}	-15.00	0.00	-6.00	-6.00	-6.00	0.00
W_{abut}	0.00	17.50	17.50	17.50	14.00	14.00

17.2.2 Factored Horizontal Loads (Z-Direction, Along Plane of Abutment)

LOAD (K)	Y (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
$W_{superll}$	41.50	0.00	10.00	10.00	10.00	0.00

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17. TEMPORARY PEDESTRIAN BRIDGE - PILE CAP DESIGN

REFERENCES

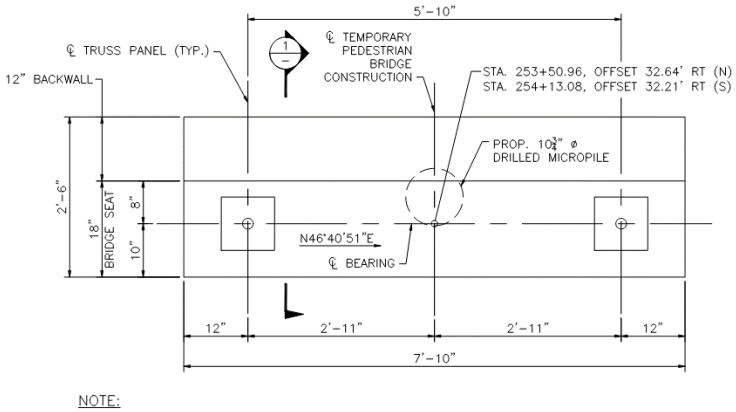
17.2.3 Factored Horizontal Loads (X-Direction, Perpendicular to Abutment)

LOAD (K)	Y (in)	COMBINATION				
		STR. I	STR. III	STR. V	SER. I	EXT. I
TH	42.00	3.60	3.60	3.60	3.60	0.00
EH	18.00	7.50	7.50	7.50	5.00	5.00
EQ	42.00	0.00	0.00	0.00	0.00	2.00

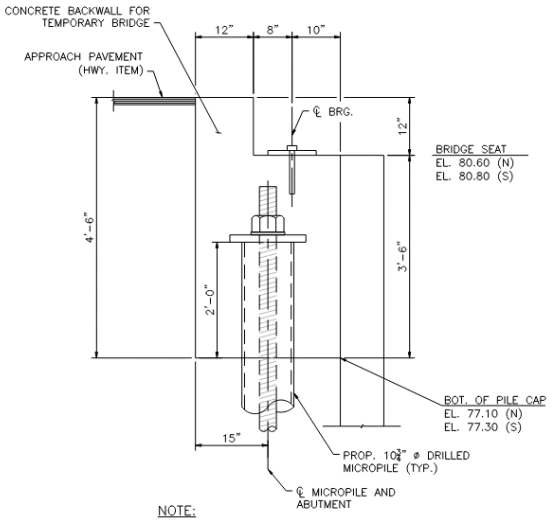
Note 17-2: Temporary abutment caps are to be cast directly against the adjacent support of excavation, supporting the restraint of the pile and cap against lateral deflection in the transverse direction. Therefore, a fixed head condition is assumed and moments are not calculated.

Substructure - Total Loads at Bottom of Pile Cap

Units (kips)										
	Strength I		Strength III		Strength V		Service I		Extreme I	
Load Combination	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Vertical	60.0	50.0	39.0	30.0	58.0	49.0	46.0	46.0	28.0	28.0
Horiz. Z (‖ Abut.)	0.0	0.0	10.0	10.0	10.0	10.0	10.0	10.0	0.0	0.0
Horiz. X (⊥ Abut.)	12.0	6.0	12.0	6.0	12.0	6.0	9.0	8.0	7.0	7.0



TEMPORARY PEDESTRIAN BRIDGE ABUTMENT PLAN
SCALE: 1" = 1'-0"



TEMPORARY PEDESTRIAN BRIDGE ABUTMENT SECTION
SCALE: 1" = 1'-0"

APPENDIX 5

Summary from Hydraulic Report by Green

(1 Sheet)

Table 14 – Hydraulic Data

HYDRAULIC DESIGN DATA			
	CURRENT HYDROLOGY CONDITIONS	**PROJECTED HYDROLOGY CONDITIONS**	
DRAINAGE AREA:	4.1	4.1	SQUARE MILES
DESIGN FLOOD DISCHARGE:	784	784	CFS
DESIGN FLOOD ANNUAL CHANCE (FREQUENCY):	2% (50-YR)	2% (50-YR)	% (YEAR)
DESIGN FLOOD VELOCITY:	9.84	9.84	FT/S
DESIGN FLOOD ELEVATION:	81.70	81.70	FT, NAVD88
BASE (100-YEAR) FLOOD DATA			
BASE FLOOD DISCHARGE:	956	956	CFS
BASE FLOOD ELEVATION:	83.76	83.76	FT, NAVD88
SCOUR DESIGN FLOOD (SDF) EVENT DATA			
SCOUR DESIGN FLOOD ANNUAL CHANCE (RETURN FREQUENCY):	INCIPIENT; Q = 370 CFS		
SCOUR DESIGN FLOOD ELEVATION (IN BRIDGE OPENING IN MAIN CHANNEL):	78.93 FEET		
SCOUR DESIGN FLOOD ABUTMENT SCOUR DEPTH:	8.88 FEET		
SCOUR DESIGN FLOOD PIER SCOUR DEPTH :	N/A		
SCOUR CHECK FLOOD (SCF) EVENT DATA			
SCOUR CHECK FLOOD ANNUAL CHANCE (RETURN FREQUENCY):	INCIPIENT; Q = 370 CFS		
SCOUR CHECK FLOOD ELEVATION (IN BRIDGE OPENING IN MAIN CHANNEL):	78.93 FEET		
SCOUR CHECK FLOOD ABUTMENT SCOUR DEPTH:	8.88 FEET		
SCOUR CHECK FLOOD PIER SCOUR DEPTH :	N/A		
FLOOD OF RECORD			
DISCHARGE:	UNKNOWN		
FREQUENCY (IF KNOWN):	UNKNOWN		
MAXIMUM ELEVATION:	UNKNOWN		
DATE:	UNKNOWN		
HISTORY OF ICE FLOES:	UNKNOWN		
EVIDENCE OF SCOUR AND EROSION:	SCOUR HOLE OBSERVED		



GEI Consultants

Geotechnical Report

Wilmington Route 38 Improvements Rock Slope Evaluation

Wilmington, Massachusetts

Submitted to:
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October 2025
Project No. 2408225





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Appendices

Appendix A Rock Discontinuity Data
Appendix B Photographic Log
Appendix C Schmidt Hammer Field Results
Appendix D Stereonet Plots
Appendix E SWedge Analysis Results
Appendix F CRSP Rockfall Simulation Results

JGA/HKW/RT/MSS:jam
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Executive Summary

Green International Affiliates, Inc. has been contracted by the Massachusetts Department of Transportation (MassDOT) for the design of the reconstruction and rehabilitation of Route 38 (Main Street) in Wilmington, Massachusetts, as part of the *Wilmington – Improvements to Route 38 (Main Street) from Woburn Town Line to Route 62 (Burlington Avenue/Church Street)* project. As part of the project, there are proposed cuts into the existing rock slopes approximately between Station 306+65 and Station 309+20 on the northbound side and between approximately Station 307+90 and Station 309+30 on the southbound side of the proposed roadway reconstruction alignment.

GEI Consultants, Inc. was retained by Green International Affiliates, Inc. to perform additional geotechnical analyses, including rockfall analyses using the Colorado Rockfall Simulation Program (CRSP) and wedge analyses, to support the design of rockfall catchment areas and barrier systems in compliance with MassDOT requirements.

GEI personnel visited the site in December 2024 and conducted rockfall site assessment and rock discontinuities mapping of the exposed rock slopes. The collected field data were utilized to perform kinematic analyses, block size analyses and rockfall analysis to evaluate the potential for various types of rock slope failures and the likelihood of potential rockfall reaching past the proposed roadside catchment / barrier.

The results of the block size analyses determined that the maximum block sizes are potentially up to 18.9 cubic feet (ft^3) along the northbound cut and 23.5 ft^3 along the southbound cut. For rockfall analyses, CRSP simulations demonstrated less than 85 percent rockfall retention at critical sections of Station 308+50 for the northbound rock slope, which did not satisfy the current requirements by MassDOT.

The proposed cuts and catchment design provided by Green satisfy MassDOT retention requirements for both northbound and southbound arrangements for all zones except between northbound Station 308+30 to Station 309+20. A rigid concrete barrier is recommended in this zone to provide adequate retention. Additionally, a rigid concrete barrier is recommended along the southbound cut due to the proximity of the pedestrian walkway.

Construction of the rock cut slopes should prioritize safety measures, including the use of temporary barriers, careful excavation methods to avoid over-fracturing, and the removal of hazardous boulders near the crest. Additional measures, such as clearing vegetation to prevent root expansion and addressing over-excavations with dental grouting, are important measures to maintain long term stability of the rock slopes.

1. Introduction

1.1. Background

Green International Affiliates, Inc. (Green) has been contracted by the Massachusetts Department of Transportation (MassDOT) to provide design services for improvements to a portion of Route 38 in Wilmington, Massachusetts, as part of the Wilmington – Improvements to Route 38 (Main Street) from Woburn Town Line to Route 62 (Burlington Avenue/Church Street) project (the Project) under MassDOT Contract No. 115765.

The Project encompasses a 2.06 mile stretch of Route 38 and will include widening, new pavements, markings, and signage, existing utility improvements, drainage upgrades, and other improvements.

Per your request provided in email dated September 28, 2023, MassDOT has requested additional geotechnical analyses including rockfall analyses using the Colorado Rockfall Simulation Program (CRSP) for the rock cuts identified by Green approximately between Station 308+00 to 310+00 to verify the design of catchment areas and barriers to mitigate potential rockfall hazards.

1.2. Authorization

GEI was authorized to complete the scope of work listed below under Task Order Number 10 of the Standard Task Order Based Subconsultant Agreement Form with Green dated November 6, 2024 and executed on November 7, 2024 and subsequent June and August contract amendments.

1.3. Scope of Work

The scope of work included:

- Review of existing plans, data and published geologic information for the site.
- Rockfall site assessment, including identification of potential rockfall hazards and source areas, evaluation of upper slope surface conditions, and in situ Schmidt hammer readings on exposed rock outcrop.
- Perform rock outcrop mapping, including collecting joint orientation, spacing, persistence, and aperture measurements and recording joint conditions (roughness, waviness, infilling), weathering, and presence of water or seepage.
- Perform CRSP rockfall analyses to aid in the design of roadway catchment area and barrier.
- Perform rock wedge analyses for the proposed rock cut using the collected joint data to understand potential failure modes and develop recommendations for mitigation measures.
- Prepare this report to present the results of our analyses/findings and construction recommendations.

2. Site Description

2.1. Site Location and Description

The rock slopes are located along Route 38 (Main Street) corridor, east of Old Main Street in Wilmington, Massachusetts. The proposed rock cuts extend on the northbound side approximately 255 feet between Station 306+65 and Station 309+20 and approximately 140 feet on the southbound side between approximately Station. 307+90 and Station. 309+30. This section of the roadway follows a smooth, moderate bend along the Route 38 corridor. Based on the available topographic survey data shown in Figure 1, the maximum heights from the toe to the crest of the northbound and southbound rock slopes are approximately 18 and 9 feet, respectively with the crest ranging between approximate El. 101 to 114 and base ranging between approximately El 91 to 94.

At the time of inspection in December 2024, the rock slopes were sparsely covered by vegetation of primarily low shrubs, grasses and weeds concentrated along the base and within fractures of the exposed rock. Small patches of moss or lichen were also evident in areas. A small number of trees and accumulation of soil and organic matter were observed locally in areas. Utility poles and overhead power lines were located in close proximity along the base and at the crest to of the southbound rock slope.

2.1.1. Project Constraints

Roadway widening and rock slope cut is constrained on the southbound portion of the site by the power poles for the paired transmission lines that cross the roadway. The four poles are founded into the outcrop approximately 34 feet from the existing slope. Guy wires, shown on the plans within 5 feet of the rock slope, were not in place during our field investigation. New rock cuts must avoid disturbance to the foundations by maintaining a reasonable distance from top of slope to the poles.

The northbound slope is locally steep in areas where it transitions from ROW to personal property. DOT standard rock slope recommendations would require excessive cuts beyond the ROW resulting in what could be significant impacts to homeowner personal property as well as project scope and budget. Transmission poles mentioned above are also in place behind the northbound slope, albeit farther back. To minimize the impacts and risks, new rock cuts may require steeper slopes that deviate from MassDOT standards and reduce the limits of work. Site Geology

The bedrock of the area (Castle, 2005) is identified as Late Proterozoic to Paleozoic B member (Zwb) of the Waltham Tectonic Melange consisting of interlayered schists, a metamorphic rock that can be foliated and locally sheared. The site's location within the Waltham Tectonic Melange, along with the proximity of the inactive Bloody Bluff Fault Zone approximately 8 miles to the northwest, suggests that the site terrain has experienced shearing and deformation, likely resulting from tectonic processes such as fault movements and terrane accretion, creating a melange-like deformed rock assemblage.

Surficial geology mapping of the overburden soils at the site (Stone, 2006), classifies the overburden as thin glacial till deposits consisting of loose to moderately compact sandy soils that are commonly stony.

3. Field Investigation

3.1. Field Investigation

A GEI engineer and geologist mapped the exposed rock cuts on December 18 and 19, 2024. Observed discontinuity data was collected using a geologic compass with clinometer. Azimuth measurements were corrected for declination from magnetic North of 14 degrees to the west per the NOAA declination calculator. Our team collected data for the accessible joints, bedding, and fractures along the exposed cuts by measuring orientation, spacing, persistence, aperture, shape, roughness, and infilling, as well as the joint roughness coefficient (JRC) and evidence of past or present water or seepage were recorded. Tabulated field data are provided in Appendix A with GEI's General Guidelines for Rock Description. Outcrop photographs with measured joint overlays are presented in Appendix B.

The exposed bedrock consisted of gray to greenish gray fine-grained schist that was generally slightly weathered, foliated, hard to medium hard, and massive with some highly sheared and/or fractured zones. Discontinuities were generally planar, slightly rough to rough with very tight to very open aperture, very close to wide spacing and very low to medium persistence (up to 15 feet), infilled with rock fragments, soil or moss, some iron oxide staining were also evident.

Groundwater seepage was observed at multiple locations during geologic mapping, particularly at the southbound side rock slope where there was minor seepage with drips of groundwater present at the discontinuities. Otherwise, majority of the discontinuities at both the northbound and southbound rock slopes were observed to be dry but with evidence of past water flow.

4. Field Observation and Data Analysis

4.1. Field Observations

4.1.1. Northbound Field Observations

- **Station 307+77 to 308+05**: Evidence of rock raveling involving blocks up to 1 foot wide, and a slightly embedded boulder measuring approximately 2 feet wide by 1 foot high near slope crest
- **Station 308+30 to 308+60**: Loosened rock blocks up to 2 to 3 feet wide were identified from crest to mid-slope.
- **Station 308+05 to 308+30**: Accumulation of multiple spherical to discoidal-shaped surface boulders near slope crest, along with widespread rock fragments up to 1 foot in diameter covering most of the slope surface.
- **Station 308+60 to 309+00**: Rock raveling of up to 1-foot-wide blocks were observed throughout entire slope surface in association with the highly fractured shear zone.
- **Station 309+00 to 309+20**: Sizable detached block measuring approximately 5.5 feet wide by 7 feet high was identified at lower to mid-slope.

Majority of the observed loosened blocks and displaced boulders that would be hazardous to the road user and public appeared to predominantly originate from the crest and mid-portion of the rock slope, with occasional large, detached blocks at lower slope portion (e.g., between Station 309+00 to 309+20).

4.1.2. Southbound Field Observations

- **Station 307+94 to 308+35**: Evidence of multiple wedge blocks measuring up to approximately 3 feet wide by 4 feet high from slope crest to mid-slope.
- **Station 308+35 to 308+67**: Sizable detached rock block measuring approximately 5 feet wide by 4 feet high was identified at lower to mid-slope. Localized shear zones observed between rock blocks with minor rock raveling of rock fragments up to 1 foot wide.
- **Station 308+77 to 308+81**: Rock blocks formed at vertical shearing joints measuring up to 3 feet wide observed at lower to mid-slope and adjacent to large rock slab of approximately 7 feet wide by 6 feet high by 2 feet long.
- **Station 308+89 to 309+27**: Cubic rock blocks up to 0.5 feet wide were observed throughout entire slope surface in association with the highly fractured shear zone.

Observed loosened blocks and displaced boulders appeared to predominantly originate from the crest and mid-portion of the rock slope.

4.1.3. Upper Slope Area

The area above the exposed rock slope face for both cuts features a shallower gradient compared to the main rock face. The upper slope above the northbound lane is predominantly covered with a thin layer of soil and scattered loose boulders, ranging up to 3 feet in diameter, and sparse vegetation. The boulders are angular to subangular and are likely remnants of glacial till deposits (see Photo 1). Factors such as heavy rainfall, freeze-thaw cycles, and ground vibrations induced by construction may destabilize the boulders, especially if they become close to the crest of the rock cut face.

Photo 1. Upper Slope Area at Northbound Side



The area above rock slope on the southbound side was flattened or sloping away towards the quarry to the west. A gravel lined roadway was in place for the power line maintenance around the transmission line.

We did not observe any presence of tension cracks in the areas above either rock slope.

4.2. Schmidt Hammer Rebound Tests

The strength of the bedrock exposed at the rock slopes was estimated using a Schmidt hammer. The Schmidt hammer was used to estimate the Unconfined Compressive Strength (UCS) by measuring the rebound of a spring-loaded mass impacting the surface of the material and using empirical correlations. The field measurements and estimated strength values are shown in Appendix C. However, the surface of the bedrock outcrop may not be a direct representative of the overall bedrock mass as the rock surface tends to be more readily weathered than intact rock. A total of three measurements were taken in two separate locations, depending on which empirical equation used, at Station 309+13 (Southbound), the rock strength has an estimated range of 8,300 to 23,250 psi and at Station 308+25 (Southbound), the exposed bedrock has a strength range of 9,100 to 28,800 psi.

4.3. Kinematic Analysis

Stability of the rock slopes and rockfall potential depends largely on the discontinuities of the rock mass. In addition to visual assessment of the rock slope condition, assessment for potential failure mechanisms controlled by the geometrical conditions, i.e., the orientation of joints in combination with the geometry of the slopes is necessary. These mechanisms can be planar failures on outward dipping joints, wedge failures on intersecting slide planes, toppling failures in conjunction with steeply inward dipping or vertical joint systems, or more complex failure modes involving combinations of these mechanisms.

Kinematic analysis using stereographic projections allows us to evaluate the failure modes that may occur for the joint sets that we measured. Joint sets that were not accessible or measured may have different failure potentials.

We used Dips software (RocScience, 2024) to identify joint sets for each exposure and perform kinematic analysis. The discontinuities are presented in stereonet plots with an equal angle, lower hemisphere projection with each point representing the pole vector that is perpendicular to the plane of the measured joint or bedding. Identified joints sets are provided in Table 4-1 below. A friction angle of 25 degrees is assumed for schist rock. Kinematic analyses were based on the proposed slope cuts provided by Green as shown on Figures 2 through 6. Stereonet plots for all collected data collected kinematic analyses for northbound and southbound sides are presented in Appendix D.

Table 4-1. Joint Sets

Joint Set No.	Dip	Dip Direction	Alignment Direction
J1	78	324	Northbound & Southbound
J2	80	208	Northbound & Southbound
J3	42	015	Northbound & Southbound
J4	74	062	Northbound & Southbound
J5	46	139	Northbound
J6	8	077	Northbound & Southbound
J7	84	029	Northbound
J8	83	129	Southbound

4.3.1. Planar Sliding

Planar sliding slope orientations are represented as great circles on the stereographic projection of joint measurements. The friction cone, corresponding to a joint friction angle of 25 degrees, along with the lateral slope limits, defines the daylight envelope for planar sliding (shaded pink). Planar sliding was evaluated for a slope angle of 76 degrees from horizontal for both exposures.

4.3.2. Wedge Sliding

Wedge sliding is defined by the line of intersection between two, or more, discontinuity planes forming a wedge. As a result, stereographic projections focus on the intersections of these planes rather than their pole vectors. Intersections that fall within the Critical Zone for wedge sliding (shaded pink) indicate potential wedge failures. The Secondary Critical Zone (shaded yellow) lies between the slope plane and

a plane (great circle) inclined at the friction angle. Intersections within these zones represent wedges that can slide on a single joint plane. In this region, while the intersections are inclined at angles less than the friction angle, sliding occurs along a single joint plane where the dip vector exceeds the friction angle. The legend provides the percentage of the data population that falls within these zones.

4.3.3. Flexural Toppling and Direct Toppling

Flexural toppling can occur when the slope angle exceeds the sum of the inclination of a discontinuity set (with a strike direction subparallel to the slope face) and the joint friction angle. This mechanism is commonly observed in rock masses with closely spaced, steeply dipping discontinuities. For kinematic analysis, flexural toppling is assessed by overlaying the lateral slope limits, slope orientation, and the slip limit (derived from the joint friction angle) onto the stereographic projection of pole vectors. The resulting critical area for potential flexural toppling is shaded pink, representing the zone where toppling is kinematically feasible.

Direct toppling can form when there are steeply dipping discontinuities (near vertical) that dip into the slope and intersect with near-horizontal base planes, creating release surfaces. For kinematic analysis, the intersections falling within the Critical Intersection Zone for Direct Toppling (shaded pink) indicate the potential for toppling block formation. As intersections approach vertical, the likelihood of toppling in a direction outside the lateral limits of the slope increases. To account for this, oblique toppling is considered for near-vertical intersections that fall outside the Critical Intersection Zone but within the Oblique Toppling and Base Plane Zone (shaded yellow).

4.3.4. Northbound Kinematics

As the roadway section curves, we analyzed three slope orientations based on the proposed rock cut geometries. The slope locations and orientations are summarized in Table 4-2.

Table 4-2. Slope Geometries

Approximate Location	Dip (Degrees)	Dip Direction (Degrees)
Station 306+65 to 308+00	51	265
Station 308+00 to 308+30	59	265
Station 308+30 to 309+20	76	255

Based on the analysis, the potential for planar sliding failure is considered low.

The kinematic analysis identified one intersection between sets J1 and J2 with an average trend and plunge of 278/70 degrees as observed between Stations 307+60 and 308+30. Flexural, direct, and oblique toppling failure is considered low with less than 10 percent of critical intersections being within the critical zone for each analysis.

4.3.5. Southbound Kinematics

Due to the shorter length of the rock exposure, the southbound slope was analyzed for a single orientation with a dip direction of 81 degrees and dip of 72 degrees. Planar sliding along the southbound rock cut is considered moderate with 33 percent of data falling within the critical zone.

There is a moderate potential for wedge sliding with multiple joint sets falling within the critical zone as summarized in Table 4-3 below:

Table 4-3. Southbound Wedge Sliding

Joint Sets	Trend	Plunge
J1 / J3	047	38
J1 / J8	041	62
J2 / J4	135	44
J3 / J8	035	41

Flexural toppling failure is considered low with no joints within the critical zone. Direct and oblique toppling potential is considered moderate per the analysis and direct observations.

4.4. Block Size Analysis

In addition to visual assessment of the rock slope condition and estimated block sizes, SWedge (Rocscience, 2025), was utilized to further evaluate the potential for wedge failures and determine the size of potential failure blocks to assist with the rock fall analysis. SWedge employs a Combinations Analysis approach, which considers various joint set intersections to calculate block sizes and evaluate their stability under specified conditions.

Maximum block sizes are anticipated to be 18.9 ft^3 along the northbound cut and 23.5 ft^3 along the southbound cut resulting in a maximum block length of 3.3 and 3.6 for spherical blocks, respectively Detailed SWedge results are presented in Appendix E.

4.5. Rockfall Assessment

4.5.1. MassDOT Rock Cut Standards

Standard rock cut design section is provided in Drawing Number 121.0.1 of the MassDOT Construction Standards dated January 2025 with the goal of 90 percent retention for all projects. Draft guidelines for alterations to the standard (2023) recommend that re-alignments and remediation meet a minimum of 85 percent retention. Additionally, where constricted by site logistics, a combined catchment and barrier is recommended to achieve a minimum of 85 percent retention.

4.5.2. Rockfall Assessment

In order to simulate the potential of rockfall reaching past the proposed roadside catchment / rigid concrete barrier, rockfall simulation was performed using Colorado Rockfall Simulation Program (CRSP) Version 4.0.

CRSP evaluates rockfall behavior influenced by factors such as slope geometry, slope material properties, and boulder size and material characteristics.

Key slope geometry parameters affecting rockfall include slope inclination, length, surface roughness, and lateral variability. Slope inclination influences zones of acceleration and deceleration, while slope length determines the distance over which a boulder accelerates or decelerates. Surface roughness, representing irregularities on the slope surface, is defined as the perpendicular variation of the slope within a slope distance equal to the radius of the rock, which significantly impacts boulder behavior by altering the impact angle and subsequent bounce. CRSP incorporates surface roughness by randomly varying slope angles within limits defined by boulder size and roughness characteristics.

CRSP utilizes the normal coefficient of restitution (R_n) and the tangential coefficient of friction (R_t) to determine how kinetic energy is dissipated during impacts, influencing boulder rebound and movement along the slope. R_n measures the degree of elasticity in a collision normal to the slope and R_t accounts for frictional resistance to movement parallel to the slope. The input coefficients utilized in the analysis as discussed by Jones (2000) and are given in Table 4-4.

Table 4-4. CRSP Input Coefficients

Slope Description	Tangential Coefficient (R_t)	Normal Coefficient (R_n)	Remarks
Smooth hard surfaces and paving	0.9-1.0	0.60-1.0	(i) Based on rockfall testing in Colorado, USA. (ii) Rt is not very sensitive compared to Rn but may be important for hard or significantly vegetated slopes. (iii) Use lower Rt as the density of vegetation on the slope increases. (iv) For short slopes try lower Rn values in applicable range. (v) If max velocity/kinetic energy (KE) is design criterion, use lower Rn values in range; if avg. velocity/KE is criterion, use higher Rn values in range.
Most bedrock and boulder fields	0.75-0.95	0.15-0.30	
Talus and firm soil slopes	0.65-0.95	0.12-0.20	
Soft soil slopes	0.50-0.80	0.10-0.20	

A conservative normal coefficient of restitution (R_n) and tangential coefficient of friction (R_t) of 0.95 and 0.15 was used in our rockfall analyses, respectively. Surface roughness of approximately 1 foot was used based on our field observations. For rock shape, spherical rocks were used as they represent a worst-case scenario as they comprise the greatest amount of rock mass for a given radius. The size of the rock was modelled based on our field observations and results of the SWedge analysis.

Simulations were conducted for the existing and proposed rock cut profiles at a number of critical sections including Stations 307+50, 308+00, and 308+50 for the northbound rock slope and Stations 308+50 and 309+00 for the southbound rock slope based on slope geometry, proximity to the roadway, and other site features. CRSP profiles for existing and proposed conditions were developed from cross sections provided by Green as shown on Figures 2 through 6 as discussed in more detail below We modelled the rockfall origin from crest below the overburden bench down to the lower portion of the slope. An analysis point was placed at the proposed position for the end of catchment at the roadway for

a maximum of 100 blocks simulated. Rockfall is conservatively assumed to be spherical. CRSP results are summarized in Table 4-5. Detailed output results are presented in Appendix F.

Table 4-5. Summary of CRSP Rockfall Simulation Results

Location	Station	Rock Size (ft)	Catchment Length (ft)	Rocks Passing (%)	Maximum Bounce Height (ft)	Maximum Velocity (ft/sec)	Maximum Kinetic Energy (kip-ft)
Existing Condition (dashed line)							
Northbound	307+50	3.3	7.1	7	0.32	9.73	6.1
	308+00		7.5	36	0.78	12.74	10.1
	308+50		4.9	60	0.76	15.14	14.8
Southbound	308+50	3.6	6.75	16	0.32	8.92	6.0
	309+00		5.9	9	0.33	9.5	7.0
Initial Rock Cut Treatment (red line)							
Northbound	308+00	3.3	7.15	0	-	-	-
	308+50		7.15	19	0.01	6.75	3.0
Southbound	308+50	3.6	3.48	0	-	-	-
	309+00		3.5	0	-	-	-
Alternative Rock Cut Treatment (green line)							
Northbound	307+50	3.3	7.0	4	0.31	5.86	2.8
	308+00		NA	2	0.06	12	6.4
Southbound	308+50	3.6	3.1	2	0.05	3.47	1.3
	309+00		2.2	9	0.43	6.58	4.2

4.5.2.1. Existing Conditions

Existing conditions shown on Figures 2 through 6 are represented by a dashed line. Existing catchments are generally flat or sloping towards the roadway on both sides of the roadway. CRSP simulation results for existing conditions show that the Northbound Station 307+50 and Southbound Station 309+00 meet MassDOT's rockfall retention requirements with 93 percent and 91 percent, respectively. Analysis for Southbound Station 308+50 is within a margin of error with 84 percent rockfall retention that could be a result of model sensitivity. Northbound Stations 308+00 and 308+50 are not compliant with MassDOT requirements per our analysis and could result in a public hazard.

4.5.2.2. Initial Rock Cut Treatment

Initial rock cuts (shown in red in Figs 2 through 6) were modeled utilizing a 1H:4V cut above a 7H:1V catchment. CRSP simulations demonstrated rockfall retention rates of 100 percent at critical sections of Stations 308+00 for the proposed rock cut and catchment configuration at the northbound rock slope, which meet MassDOT's 85 percent rockfall retention requirement. At the critical section of Station 308+50, the retention rate of 81 percent falls below the MassDOT's rockfall retention requirement.

At the critical sections of Station 308+50 and 309+00 on the southbound rock slope, CRSP simulations demonstrated rockfall retention rates of 100 percent, which meet MassDOT's 85 percent rockfall retention requirement.

4.5.2.3. Alternative Rock Cut Treatment

Alternative analysis (shown in green in Figs 3 through 6) included a 0.8H:1V to 0.6H:1V rock cut at critical sections along the northbound side to minimize the work limits outside the ROW and total rock removal. Southbound analysis utilized the existing slopes with a 3.4H:1V catchment and barrier to mitigate pedestrian hazards. CRSP simulations demonstrated rockfall retention rates of 96 percent and 98 percent at critical sections of Stations 307+50 and 308+00, respectively, for the proposed rock cut and catchment configuration at the northbound rock slope, which meet MassDOT's 85 percent rockfall retention requirement.

At the critical sections of Station 308+50 and 309+00 on the southbound rock slope, CRSP simulations demonstrated rockfall retention rates of 98 percent and 91 percent, which meet MassDOT's 85 percent rockfall retention requirement.

5. Conclusions and Recommendations

Based on our review of the available information, field inspection, geologic mapping, and evaluation of the collected data, we present the following conclusions and recommendations:

5.1. Rockfall Hazard Recommendations

The alternative proposed cuts and catchment ditches shown on Figures 2 through 6 are adequate to retain the required 85 percent of rockfall for all sections except northbound Sta 308+50. Increasing the catchment in this area would require increasing the limits of work and impacts to project constraints discussed previously. As the zone is considered relatively short, a draped mesh or retaining system is not considered economical due to the limited length. A rigid concrete barrier is recommended for the northbound cut from Sta 308+30 to the end of the cut (approx. Station 309+20) to provide additional retention. The barrier should be designed by Green to accommodate the modelled bounce heights and rockfall energies detailed in Table 4-5 of this report and in conformance with current MassDOT Standard Specifications. Alternatively, rock bolting could be considered in this area to prevent rockfall. Rock bolt pattern should be designed to extend beyond the maximum block diameter and to withstand the maximum load.

A rigid concrete barrier is also recommended along the southbound cut due to the proposed pedestrian sidewalk.

5.2. Construction Recommendations

- Excavation should be performed using tools and methods that prevent rock from being sprayed or dropped onto the roadway below. Care should be taken to avoid over-fracturing, loosening, or undercutting the rock face.
- Temporary barriers should be used to intercept or deflect small rocks and fragments ejected during excavation. Heavy rubber mats, such as blasting mats, draped over the rock face may help stabilize and constrain the surface temporarily during excavation.
- Potentially hazardous surface boulders located at or near the crest of the proposed rock cut should be scaled or removed wherever feasible.
- Over-excavations that create overhangs or overbreaks on the rock face should be addressed with dental grouting to restore stability.
- Surface vegetation should be cleared to minimize root expansion within rock discontinuities, which could loosen the rock over time.

6. References

Castle, R.O., Hepburn, C.J. & Kopera, J.P. (2005). Preliminary Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts v 1.0, Massachusetts Geologic Survey (4th), (in review, April 2005)

Stone, B.D., Stone, J.R. and DiGiacomo-Cohen, M.L. (2006). Surficial geologic map of the Salem Depot-Newburyport East-Wilmington-Rockport 16-quadrangle area in northeast Massachusetts, U.S. Geological Survey

Jones, C.L., Higgins, J.D. & Andrew, R.D. (2000). Colorado Rockfall Simulation Program, Version 4.0. Colorado Department of Transport, Colorado Geological Survey, Colorado School of Mines, Denver, Colorado, USA.

Massachusetts Department of Transportation (MassDOT), 2023, *"Working Draft Guide to Modify Construction Drawing E102.1.0,* Version August 8, 2023.

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Figures

Figure 1. Site Contour Plan

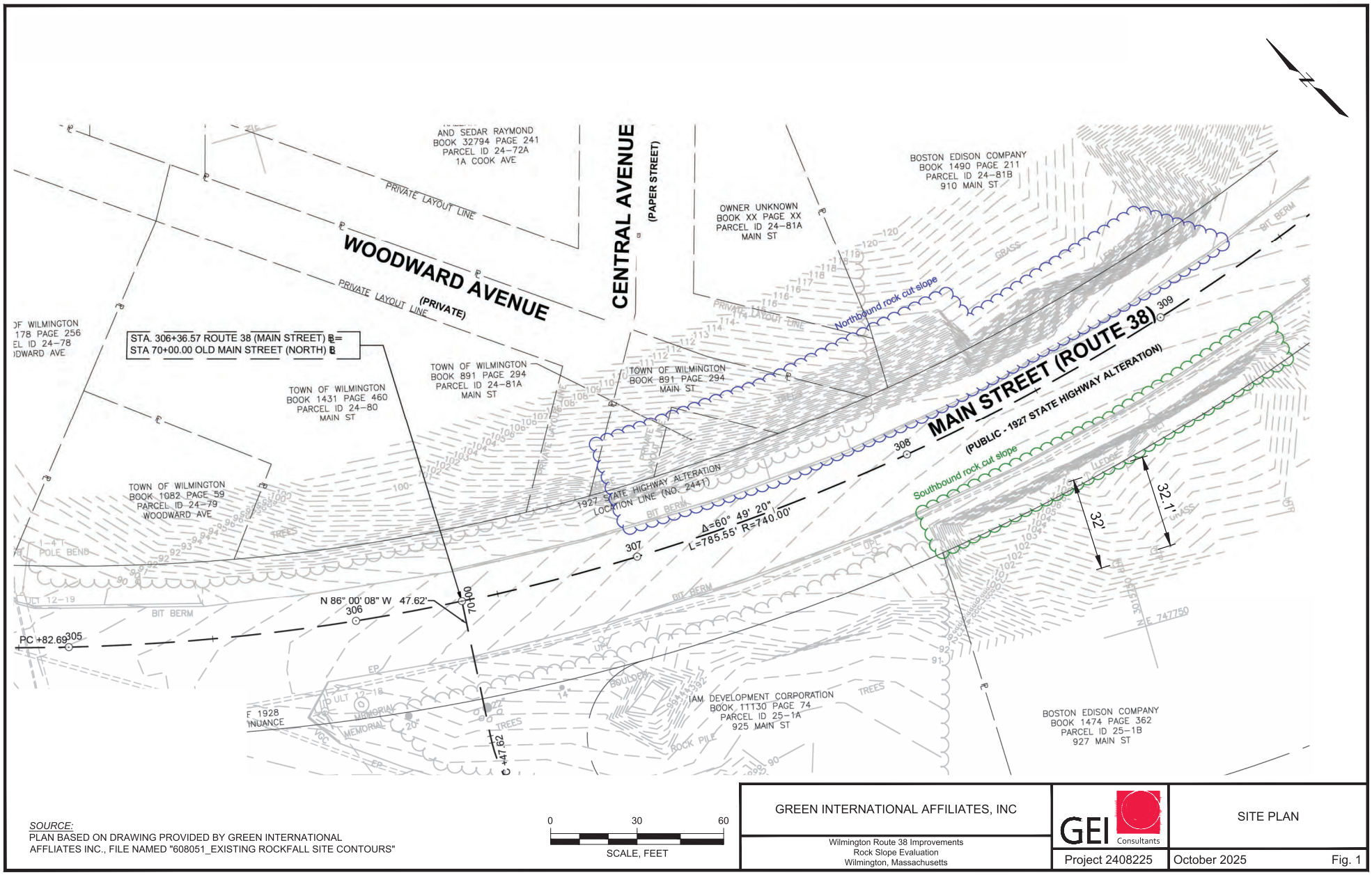
Figure 2. Cross Sections Sta 306+50 & Sta 307+00

Figure 3. Cross Sections Sta 307+50

Figure 4. Cross Sections Sta 308+00

Figure 5. Cross Sections Sta 308+50

Figure 6. Cross Sections Sta 309+00



SOURCE:
PLAN BASED ON DRAWING PROVIDED BY GREEN INTERNATIONAL AFFLIATES INC., FILE NAMED "608051_EXISTING ROCKFALL SITE CONTOURS"

0 30 60
SCALE, FEET

GREEN INTERNATIONAL AFFILIATES, INC

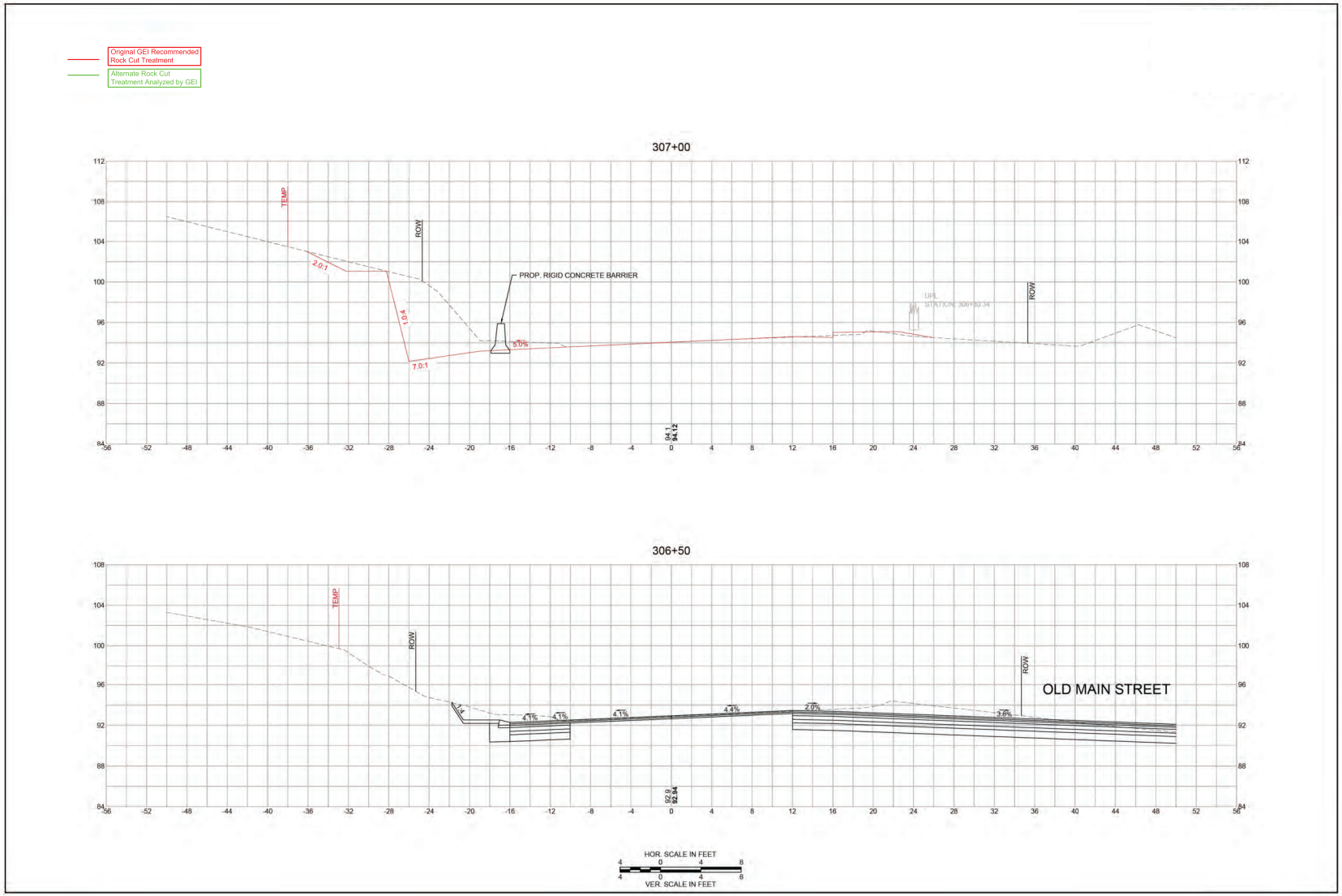
Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

SITE PLAN

Project 2408225 | October 2025 | Fig. 1

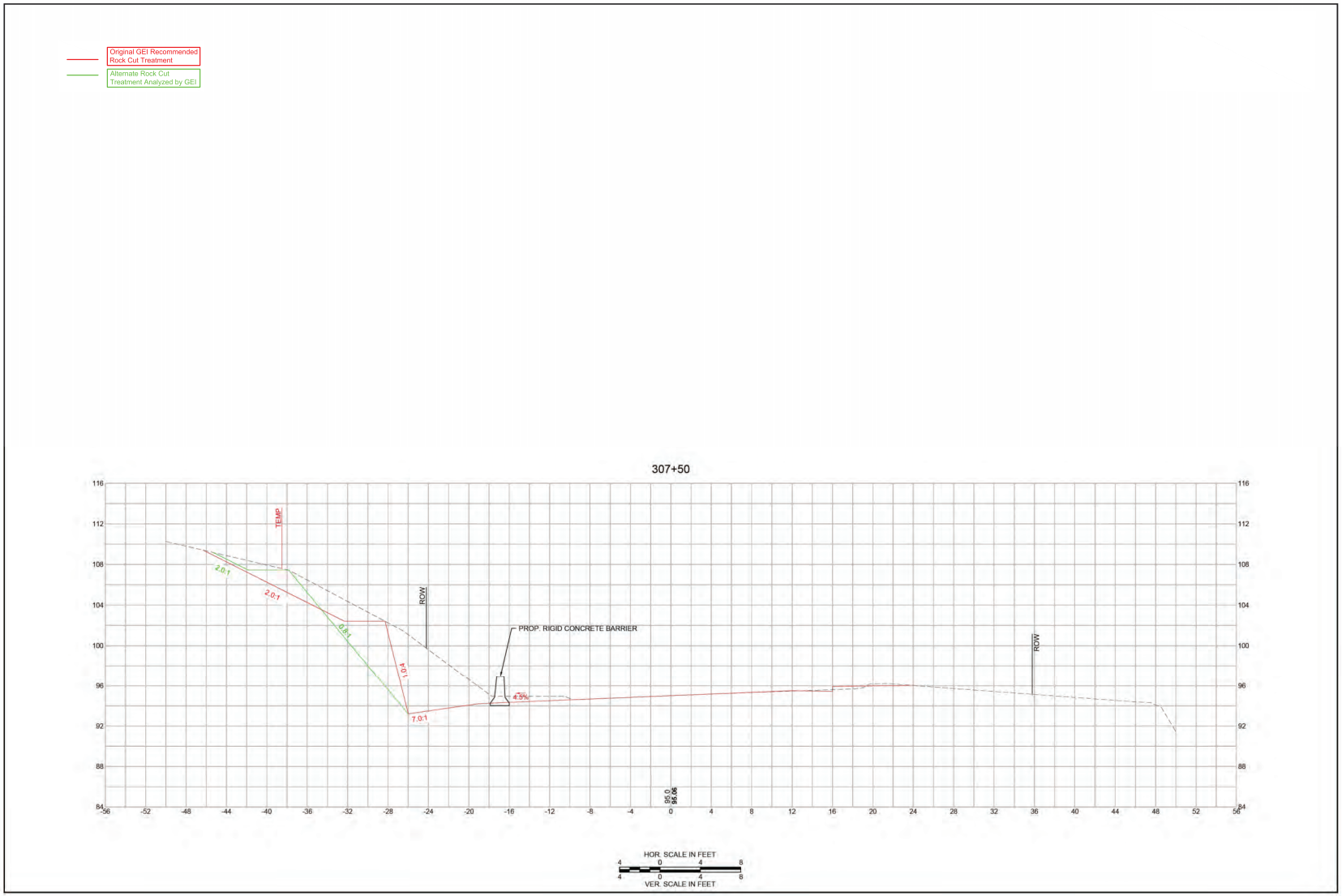
CHECHURIN, DMITRY C:\Users\dchechurin\OneDrive - GEI Consultants, Inc\Desktop\New folder\New folder (3)\2408225 - Fig 1-6.dwg - 8/29/2025



SOURCE:
PLAN BASED ON DRAWING PROVIDED BY GREEN INTERNATIONAL AFFLIATES INC.,
FILE NAMED "608051_(CROSS SECTIONS) - ROCK CUT ADJUSTMENT WITH OVERLAY"

GREEN INTERNATIONAL AFFILIATES, INC	GEI Consultants	CROSS SECTIONS STA 306+50 and STA 307+00
Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	October 2025 Fig. 2

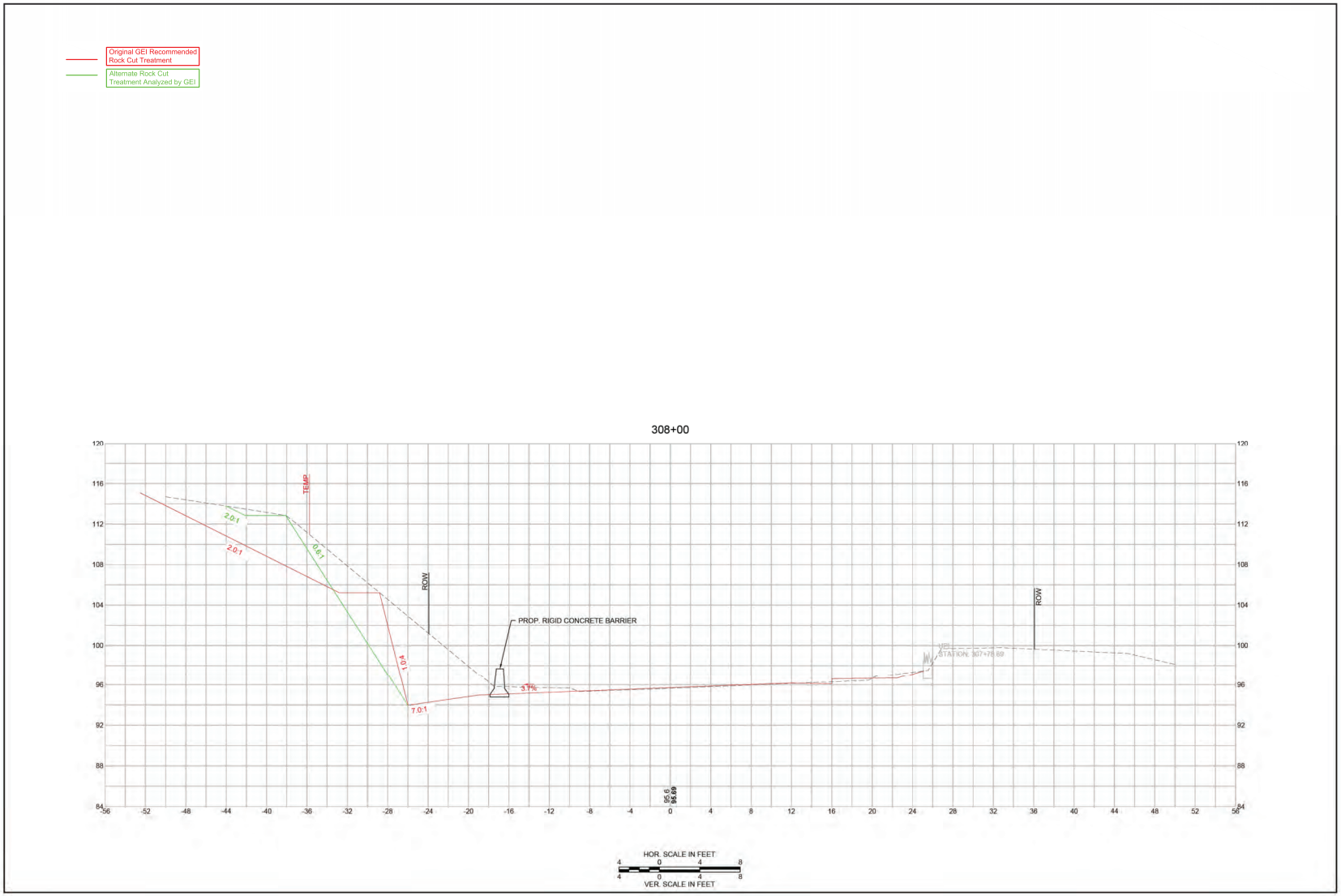
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SOURCE:
PLAN BASED ON DRAWING PROVIDED BY GREEN INTERNATIONAL AFFLIATES INC.,
FILE NAMED "608051_(CROSS SECTIONS) - ROCK CUT ADJUSTMENT WITH OVERLAY"

GREEN INTERNATIONAL AFFILIATES, INC	GEI Consultants	CROSS SECTIONS STA 307+50
Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	October 2025 Fig. 3

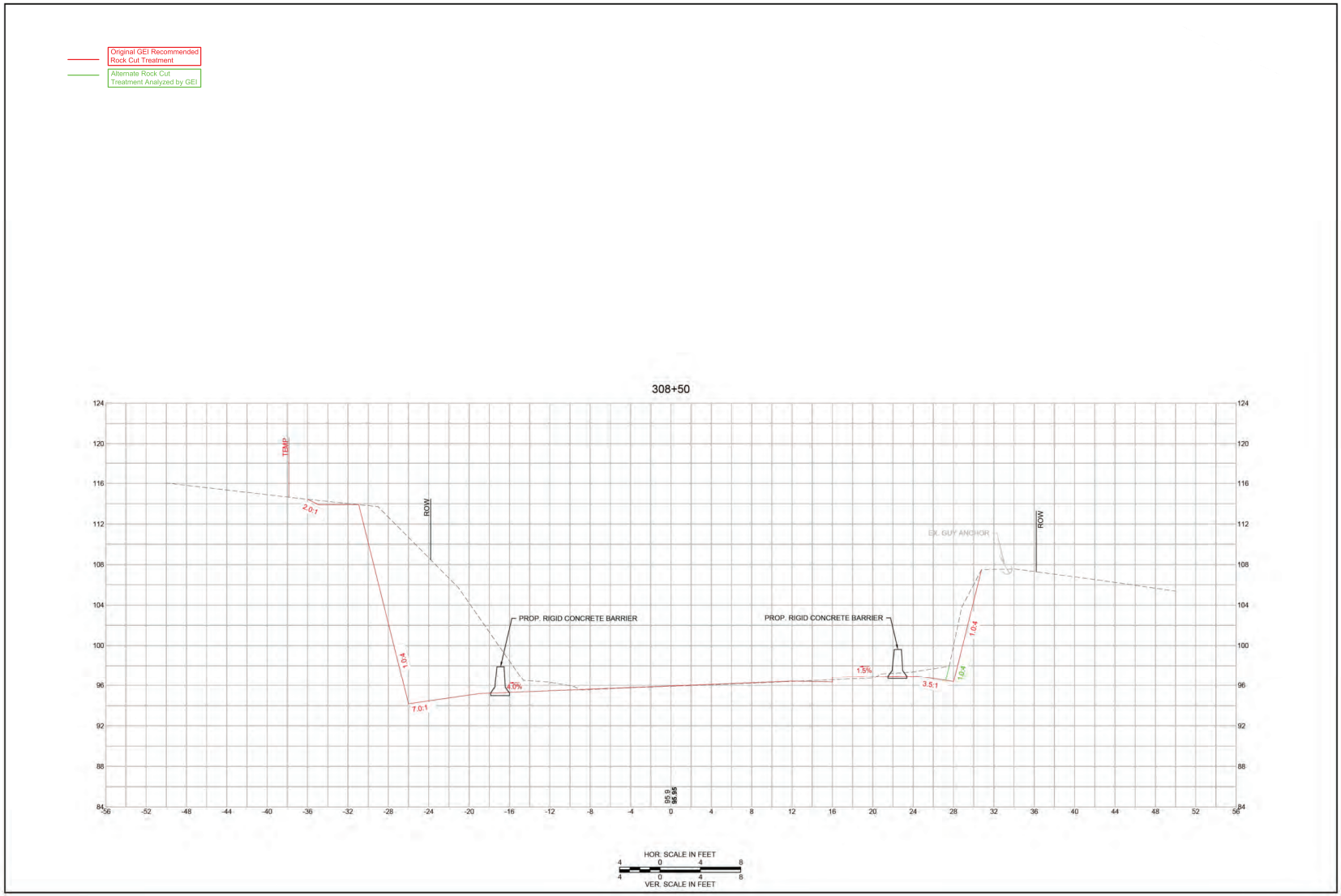
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PLAN BASED ON DRAWING PROVIDED BY GREEN INTERNATIONAL AFFLIATES INC.,
FILE NAMED "608051_(CROSS SECTIONS) - ROCK CUT ADJUSTMENT WITH OVERLAY"

GREEN INTERNATIONAL AFFILIATES, INC	GEI Consultants	CROSS SECTIONS STA 308+00
Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	October 2025 Fig. 4

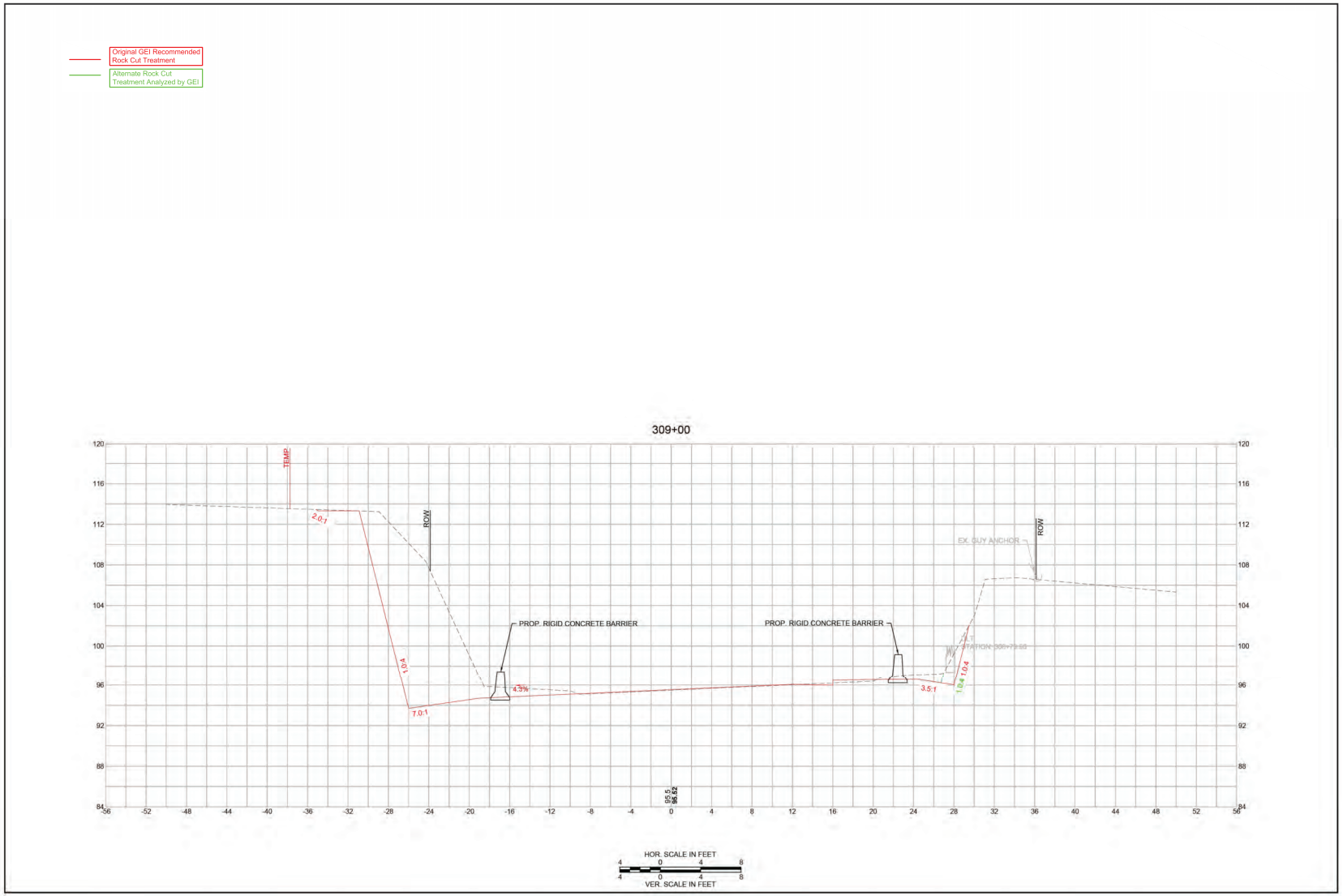
CHECHURIN, DMITRY C:\Users\dchechurin\OneDrive - GEI Consultants, Inc\Desktop\New folder\New folder (3)\2408225 - Fig 1-6.dwg - 8/29/2025



SOURCE:
PLAN BASED ON DRAWING PROVIDED BY GREEN INTERNATIONAL AFFLIATES INC.,
FILE NAMED "608051_(CROSS SECTIONS) - ROCK CUT ADJUSTMENT WITH OVERLAY"

GREEN INTERNATIONAL AFFILIATES, INC	GEI Consultants	CROSS SECTIONS STA 308+50
Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	October 2025 Fig. 5

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FILE NAMED "608051_(CROSS SECTIONS) - ROCK CUT ADJUSTMENT WITH OVERLAY"

GREEN INTERNATIONAL AFFILIATES, INC	GEI Consultants	CROSS SECTIONS STA 309+00
Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	October 2025 Fig. 6

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Appendix A Rock Discontinuity Data

General Guidelines for Rock Descriptions

Characteristic	Descriptive Terms		Standard Definition
1. ROCK TYPE	*Refer to Quarterly of the Colorado School of Mines, Volume 50, Number I*		
2. HARDNESS	VERY HARD		Cannot be scratched with knife or sharp pick; breaking of hand specimens requires several hard blows of geologist's hammer.
	HARD		Can be scratched with knife or pick only with difficulty; hard blow(s) of hammer required to break hand specimen.
	MEDIUM HARD		Can be scratched with knife or pick up to 1/16 in. deep; hard specimens can be broken with moderate blow with hammer.
	SOFT		Readily gouged or grooved with knife or geologist's pick; can be excavated in chips to pieces several inches in size by moderate blows of a pick point; small thin pieces can be broken by finger pressure.
	VERY SOFT		Can be carved with knife, excavated readily with point of pick, or readily scratched by fingernail. Pieces one inch thick or more can be broken by finger pressure.
3. GRAIN SIZE AND RANGE	IGNEOUS, METAMORPHIC, CRYSTALLINE SED.	FINE-GRAINED MEDIUM-GRAINED COARSE-GRAINED	Less than 1 mm (f-med sand range) 1 mm to 5 mm (med-coarse sand range) 5mm and greater (fine gravel and larger)
	SEDIMENTARY		Use soil grain size
5. WEATHERING	FRESH OR UNWEATHERED		Rock fresh, crystals bright, few joints may show staining. Rock rings under hammer if crystalline.
	SLIGHTLY WEATHERED		Rock generally fresh, joints stained, discoloration extends into rock up to 1 in. (in outcrops). Joints may contain clay. In granitic rocks, some occ. feldspar crystals are dull and discolored; crystalline rocks ring if struck with hammer.
	MODERATELY WEATHERED		Except for quartz, most of the rock mass shows discoloration and weathering effects; Rock has a dull sound under hammer and shows significant strength loss compared with fresh rock.
	HIGHLY WEATHERED		All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. Some fragments of stronger rock are usually left.
	COMPLETELY WEATHERED		Rock is decomposed to a soil. Rock fabric may not be discernible except in scattered locations. Quartz may be present as dikes or stringers.
6. DISCONTINUITIES			Describe joint type, openness, spacing, dip angle, weathering. Don't use terms such as very close, close, or wide. Instead give actual joint spacing, such as 2 to 30 inches, or 6 inches to 4 feet.
DEFINITION	Rock Quality Designation (RQD)		RQD is the ratio of the cumulative length of pieces of sound core 4 inches or longer to the total penetration length of the core run. If the core is broken by handling or drilling (fracture surfaces are fresh and sharp), the broken pieces are fitted together and counted as one piece provided they form the required length of 4 inches.

ROCK DISCONTINUITY MAPPING

GEI Consultants

Project Name: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Project Manager: Rich Tobin
GEI Field Staff: Jule Archuleta / Max Wong

Description of Face to be Mapped:
Gray to greenish gray, fine grained schist, hard to very hard, slightly weathered, foliated, generally massive and blocky, with some shear and highly fractured zones.

Date: 12/18/2024
Weather: Sunny
Temp (°F): 39
Declination (°): 14W

Location / Station	Slope/Cut Information			Joint / Feature			Persistence	Spacing	Aperture	Infilling	Joint Surface Shape	Surface Roughness	Lithology / Rock Type	Water	Joint Set ID	Min JRC	Max JRC	Remarks
	Width / Height	Dip	~~Strike~~ / Dip Direction	Type	Dip	~~Strike~~ / Dip Direction												
NB 307+00	7	45	265	J	65	293	VL - L	C	VT	-	P	SR	Schist	Dl	1	8	10	
	7	45	265	J	88	219	VL	W	T	IO/Mo	P	SR	Schist	DW	2	10	12	
	7	45	265	J	40	046	VL	W	O	S	P	R	Schist	DW	3	12	14	
	7	45	265	Fr	80	092	VL	W	VT	-	P	SR	Schist	DW	-	6	8	
NB 307+65	17	85	265	J	78	206	M	C - M	VT - O	RF/Mo	P	SR	Schist	DW	2	6	10	
NB 307+68	17	85	265	J	84	212	M	M	VT	RF/S	P	SR	Schist	DW	2	6	10	
	17	85	265	J	63	325	VL	C	VT - O	RF/Mo	P	SR	Schist	DW	1	8	8	
NB 307+69	17	85	265	J	40	151	VL	VC - C	T - MO	IO/Mo	P	SR	Schist	DL	5	6	8	
	17	85	265	J	17	135	M	W	O	RF/S	P	SR	Schist	DL	6	N/A	N/A	N/A - Obscured / insufficient surface for measurement
NB 307+77 to 308+05	17	85	265	J	85	191	VL - L	VC - C	VT - T	IO/Mo	P	SR	Schist	DW	2	6	8	
	17	85	265	J	73	310	L	M	T - MO	IO/Mo	P	SR	Schist	DW	1	6	8	
	17	85	265	J	5	037	M	M	MO	S	P	SR	Schist	DW	6	8	10	
	17	85	265	Fr	47	356	L	-	MO	FR/S	U	SR	Schist	DW	3	8	10	
	17	85	265	J	87	335	L	-	-	-	P	SR	Schist	DW	1	8	10	
NB 308+05 to 308+30	17	85	265	J	83	206	L	VC - M	MO	RF/S	P	SR	Schist	DW	2	6	8	
	17	85	265	J	74	342	VL	-	-	-	P	SR	Schist	DW	1	6	8	
NB 308+30 to 308+60	17	85	255	J	81	210	L - M	M - W	MO - O	RF/IO	P	SR	Schist	DW	2	8	10	
	17	85	255	J	70	072	VL	VC	VT - T	IO/Mo	P	SR	Schist	DW	4	6	8	
	17	85	255	Fr	4	251	M	W	T	IO/Mo	P	SR	Schist	DW	-	6	8	
	17	85	255	J	40	128	M	W	T - MO	RF/S	P	SR	Schist	DW	5	6	8	
	17	85	255	J	11	030	L	W	MO - O	RF/IO	P	SR	Schist	DW	6	8	10	

Type
Fr=Fracture (random)
J=Joint (joint set)
BJ=Bedding Joint
FJ=Foliation Joint
VJ=Vein Joint
SZ=Shear Zone
Fa=Fault
GC=Geologic Contact

Persistence
VL=Very Low (<3.3')
L=Low (3.3-10')
M=Medium (10-33')
H=High (33-66')
VH=Very High (>66')

NT=No Termination
S=Single Termination
DT = Double Termination

Spacing
EW=Extremely Wide (>20')
VW=Very Wide (6.5-20')
W=Wide (2-6.5')
M=Moderate (8"-2')
C=Close (2.5-8")
VC=Very Close (1-2.5")
EC=Extremely Close (<1")

Aperture
VT=Very Tight (<0.1mm)
T=Tight (0.1-0.5mm)
MO=Moderately Open (0.5-2.5mm)
O=Open (2.5-10mm)
VO=Very Open (10-25mm)

Joint Surface
P=Planar
S=Stepped
Z=Zigzag
U=Undulating

Roughness
VR=Very Rough
R=Rough
SR=Slightly Rough
Sm=Smooth
Sl=Slickensided

Infilling
Ca=Calcite
Ch=Chlorite
Cl=Clay
S = Soil
R=Roots
Q=Quartz
Mo=Moss
IO=Iron Oxide Stains
RF=Rock Fragments
ML=silt

Water
DL=dry w/no signs of past water flow
DW=dry but evidence of past water flow
M=Moist but no free water
MS=Minor seepage, drips but no steady flow
SS= Steady seepage, estimate flow rate

ROCK DISCONTINUITY MAPPING

Project Name: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Project Manager: Rich Tobin
GEI Field Staff: Jule Archuleta / Max Wong

Description of Face to be Mapped:
Gray to greenish gray, fine grained schist, hard to very hard, slightly weathered, foliated, generally massive and blocky, with some shear and highly fractured zones.

Date: 12/18/2024
Weather: Sunny
Temp (°F): 39
Declination (°): 14W

Location / Station	Slope/Cut Information			Joint / Feature			Persistence	Spacing	Aperture	Infilling	Joint Surface Shape	Surface Roughness	Lithology / Rock Type	Water	Joint Set ID	Min JRC	Max JRC	Remarks
	Width / Height	Dip	~~Strike~~ / Dip Direction	Type	Dip	~~Strike~~ / Dip Direction												
NB 308+80	17	85	255	J	82	137	L	M	T	Mo	P	Sm	Schist	DL	5	4	6	Shear zone
	17	85	255	J	83	032	VL	VC	T	Mo	P	SR	Schist	DL	7	6	8	Shear zone
NB 309+00	17	85	255	J	86	026	L	M	-	IO	P	SR	Schist	DL	7	6	8	
	17	85	255	J	84	312	L	W	MO	IO/Mo	P	SR	Schist	DW	1	6	8	
	17	85	255	J	60	138	M	M	MO - O	IO	P	SR	Schist	N/A	5	N/A	N/A	N/A - Obscured / insufficient surface for measurement

Type
Fr=Fracture (random)
J=Joint (joint set)
BJ=Bedding Joint
FJ=Foliation Joint
VJ=Vein Joint
SZ=Shear Zone
Fa=Fault
GC=Geologic Contact

Persistence
VL=Very Low (<3.3')
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M=Medium (10-33')
H=High (33-66')
VH=Very High (>66')

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Spacing
EW=Extremely Wide (>20')
VW=Very Wide (6.5-20')
W=Wide (2-6.5')
M=Moderate (8"-2')
C=Close (2.5-8")
VC=Very Close (1-2.5")
EC=Extremely Close (<1")

Aperture
VT=Very Tight (<0.1mm)
T=Tight (0.1-0.5mm)
MO=Moderately Open (0.5-2.5mm)
O=Open (2.5-10mm)
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Joint Surface
P=Planar
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Roughness
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MS=Minor seepage, drips but no steady flow
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ROCK DISCONTINUITY MAPPING

GEI Consultants

Project Name: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Project Manager: Rich Tobin
GEI Field Staff: Jule Archuleta / Max Wong

Description of Face to be Mapped:
Gray to greenish gray, fine grained schist, hard to very hard, slightly weathered, foliated, generally massive and blocky, with some shear and highly fractured zones.

Date: 12/18/2024
Weather: Sunny
Temp (°F): 39
Declination (°): 14W

Location / Station	Slope/Cut Information			Joint / Feature			Persistence	Spacing	Aperture	Infilling	Joint Surface Shape	Surface Roughness	Lithology / Rock Type	Water	Joint Set ID	Min JRC	Max JRC	Remarks
	Width / Height	Dip	~~Strike~~ / Dip Direction	Type	Dip	~~Strike~~ / Dip Direction												
SB 308+12	6	89	081	J	70	201	L	W	O	ML/Mo	P	Sm	Schist	DW	2	4	6	
SB 308+15	6	89	081	J	66	061	L	M	VO	Mo	P	R	Schist	MS	4	10	12	
SB 308+15	6	89	081	J	85	121	L	C - M	MO	Mo	P	SR	Schist	MS	8	6	10	
SB 308+20	6	89	081	J	12	049	M	C - M	MO	Mo	P	SR	Schist	MS	6	6	8	
SB 308+25	6	89	081	J	75	210	VL	W	T	IO	P	SR	Schist	DW	2	6	8	
SB 308+79	9	89	081	J	85	319	L	W	MO - O	Mo/S	P	SR	Schist	M	1	8	10	
SB 308+79	9	89	081	J	53	008	VL	VC - M	T - MO	RF	P	Sm	Schist	MS	3	6	8	
SB 308+79	9	89	081	J	35	016	VL - L	C - M	MO	Mo	P	SR	Schist	DW	3	6	8	
SB 308+79	9	89	081	J	85	050	L	M - W	MO	IO	P	SR	Schist	M	4	8	10	
SB 309+12	9	89	081	J	76	066	L	VC	O	ML	P	R	Schist	DW	4	10	12	
SB 309+12	8.5	89	081	Fr	83	326	L	C	MO - O	IO/ML	P	SR	Schist	DW	1	8	10	
SB 309+12	8.5	89	081	J	79	220	L	C	T	IO	P	SR	Schist	DW	2	8	10	
SB 309+12	8.5	89	081	J	10	093	L	W	MO	IO/S	P	Sm - SR	Schist	MS	6	6	8	

Type
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M=Moist but no free water
MS=Minor seepage, drips but no steady flow
SS= Steady seepage, estimate flow rate

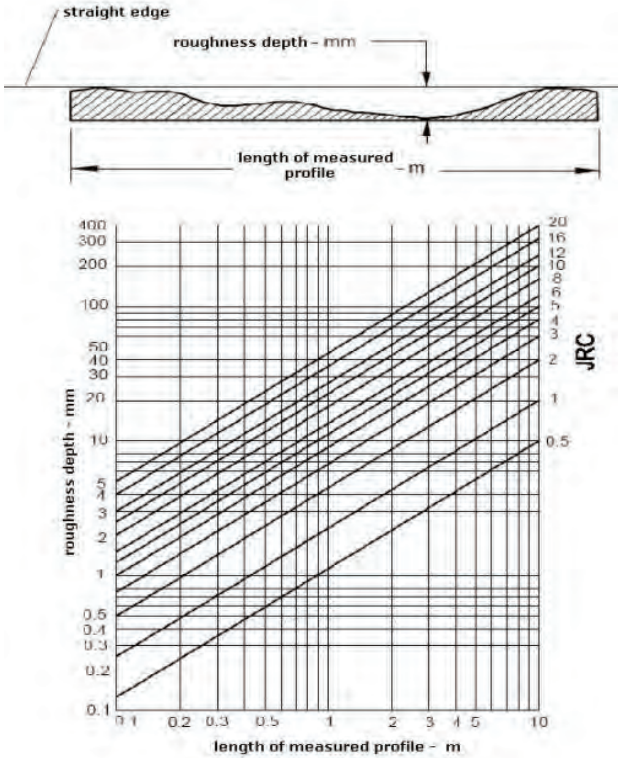
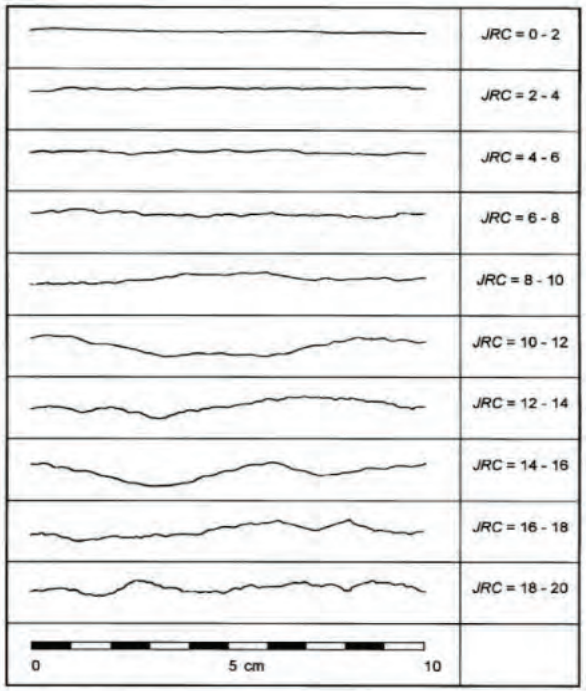
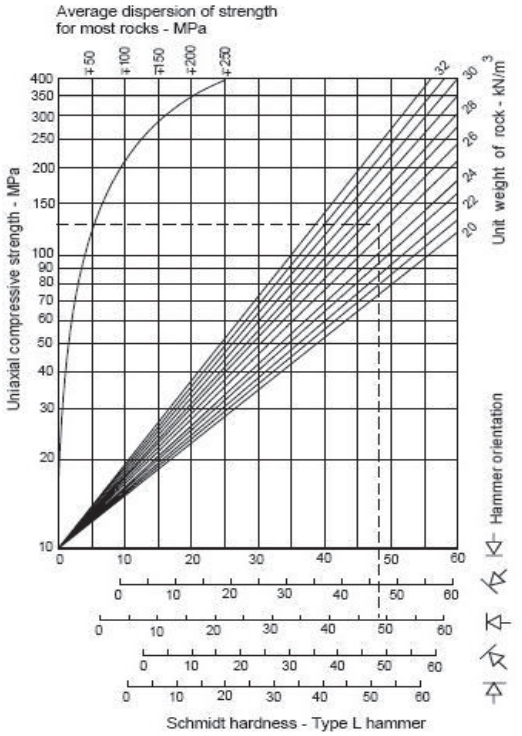


Diagram to determine JRC (after Barton)



Rock joint roughness profiles showing the typical range of JRC (Barton & Chubey 1977)



Grade	*Term*	*Description*
I	Fresh	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.
II	Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
III	Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
IV	Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
V	Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
VI	Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

Table 3.6 Classification of rock material strengths (ISRM, 1981)

Grade	*Description*	*Field identification*	*Approximate range of compressive strength*	
			MPa	(p.s.i)
R6	Extremely strong rock	Specimen can only be chipped with geological hammer	>250	(>36 000)
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it	100–250	(15 000–36 000)
R4	Strong rock	Specimen requires more than one blow with a geological hammer to fracture it.	50–100	(7 000–15 000)
R3	Medium weak rock	Cannot be scraped or peeled with a pocket knife; specimen can be fractured with single firm blow of geological hammer	25–50	(3 500–7 000)
R2	Weak rock	Can be peeled with a pocket knife; shallow indentations made by firm blow with point of geological hammer	5–25	(725–3 500)
R1	Very weak rock	Crumbles under firm blows with point of geological hammer; can be peeled by a pocket knife	1–5	(150–725)
R0	Extremely weak rock	Indented by thumbnail	0.25–1	(35–150)
S6	Hard clay	Indented with difficulty by thumbnail	>0.5	(>70)
S5	Very stiff clay	Readily indented by thumbnail	0.25–0.5	(35–70)
S4	Stiff clay	Readily indented by thumb but penetrated only with great difficulty	0.1–0.25	(15–35)
S3	Firm clay	Can be penetrated several inches by thumb with moderate effort	0.05–0.1	(7–15)
S2	Soft clay	Easily penetrated several inches by thumb	0.025–0.05	(4–7)
S1	Very soft clay	Easily penetrated several inches by fist	<0.025	(<4)

Appendix B Photographic Log



Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 307+00 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

ROCK DISCONTINUITY MAPPING

Project 2408225

December 2024

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 307+60 – 307+77 (NORTHBOUND)

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 307+77 – 308+05 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 308+05 – 308+30 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 308+30 – 308+60 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 308+60 – 309+00 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)
- Detached Block?

STATION 309+00 – 309+20 (NORTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 307+94 – 308+35 (SOUTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

ROCK DISCONTINUITY MAPPING

Project 2408225 | December 2024 | 8 of 11

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)
- Detached Block

STATION 308+35 – 308+67 (SOUTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

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Key
- Joint Set 1
- Joint Set 2
- Joint Set 3
- Joint Set 4
- Joint Set 5
- Joint Set 6
- Joint Set 7
- Joint Set 8
- Fracture (Random)

STATION 308+67 – 308+89 (SOUTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

ROCK DISCONTINUITY MAPPING

Project 2408225

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STATION 308+89 – 309+27 (SOUTHBOUND)

Wilmington Route 38 Improvements Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

ROCK DISCONTINUITY MAPPING

Project 2408225

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Appendix C Schmidt Hammer Field Results

GEI Consultants

Client: Green International Affiliates, Inc
Project: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Subject: Estimation of Rock Strength Parameters based on Schmidt hammer

Prepared By: M. Wong
Date: 1/2/2025
Checked By: J. Archuleta
Date: 1/21/2025

Rock Description: Schist, slightly weathered
Location: Sta. 309+13 South bound
Hammer type: Type N Schmidt Test Hammer

Specimen Width/Height (ft) 0.3/3
Orientation of hammer axis, α (°): -11
(downward being -90° and upward +90°)

References:

1) Basu, A., & Aydin, A. (2004). A method for normalization of Schmidt hammer rebound values. International journal of rock mechanics and mining sciences, 41(7), 1211-1214.
2) Aydin, A. (2014). ISRM suggested method for determination of the Schmidt hammer rebound hardness: revised version. The ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 2007-2014, 25-33.
3) Minaeian, B., & Ahangari, K. (2013). Estimation of uniaxial compressive strength based on P-wave and Schmidt hammer rebound using statistical method. Arabian Journal of Geosciences, 6, 1925-1931.

Equations:

Ref. 1 Eqn.	Equation		
8	$R_h = (V_2^2 / V_1^2) * 100$	where:	V_1 Velocity of the piston when it touches the plunger. V_1^2 = 11.23 (m/s)^2
			V_2 Initial rebound velocity of the piston.
7	$V_2^2 = \frac{V_{(\alpha)}^2(0.5kx_1^2)}{0.5kx_1^2 + Mgx_1\cos(90+\alpha)}$	where:	k Spring constant. k = 764.2 (N/m)
			x_1 Maximum stretch of the spring. x_1 = 0.076 (m)
			M Mass of the piston. M = 0.3895 (kg)
			$V_{(\alpha)}$ Initial rebound velocity of the piston at angle α.
			α Orientation of hammer axis (downward being -90° and upward +90°)
6	$V_{2(\alpha)}^2 = \frac{kx_{2(\alpha)}^2}{M} + 2gx_{2(\alpha)}\cos(90+\alpha)$	where:	$x_{2(\alpha)}$ Stretch at maximum rebound position. $x_{2(\alpha)} = R_\alpha /100 * x_1$
			R_α Measured rebound at angle α

Ref. 3 Table 3.	Equations yields UCS in MPa.
Singh et al. (1983)	UCS = 2 * R_h
Katz et al. (2000)	UCS = 2.208 * $e^{(0.067 * Rh)}$
Gupta (2009)	UCS = 14.1 * R_h - 642

Measured rebound, R_α	Calibrated rebound, R_h	UCS uniaxial compressive strength (psi)		
		Singh et al. (1983)	Katz et al. (2000)	Gupta (2009)
50	51	14,677	`	10,379
57	58	16,682	15,107	24,518
62	62	18,114	21,034	34,617
63	63	18,401	22,473	36,637
70	70	20,406	35,717	50,774
64	64	18,687	24,011	38,656
64	64	18,687	24,011	38,656
66	66	19,260	27,409	42,696
64	64	18,687	24,011	38,656
67	67	19,547	29,285	44,715
Average	**63**	**63**	**18,315**	**24,784**	**36,031**

GEI Consultants

Client: Green International Affiliates, Inc
Project: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Subject: Estimation of Rock Strength Parameters based on Schmidt hammer

Prepared By: M. Wong
Date: 1/2/2025
Checked By: J. Archuleta
Date: 1/21/2025

Rock Description: Schist, slightly weathered
Location: Sta. 309+13 South bound
Hammer type: Type N Schmidt Test Hammer

Specimen Width/Height (ft) 0.3/3
Orientation of hammer axis, α (°): 0
(downward being -90° and upward +90°)

References:

1) Basu, A., & Aydin, A. (2004). A method for normalization of Schmidt hammer rebound values. International journal of rock mechanics and mining sciences, 41(7), 1211-1214.
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6	$V_{2(\alpha)}^2 = \frac{kx_{2(\alpha)}^2}{M} + 2gx_{2(\alpha)}\cos(90+\alpha)$	where:	$x_{2(\alpha)}$ Stretch at maximum rebound position. $x_{2(\alpha)} = R_\alpha /100 * x_1$
			R_α Measured rebound at angle α

Ref. 3 Table 3.	Equations yields UCS in MPa.
Singh et al. (1983)	UCS = 2 * R_h
Katz et al. (2000)	UCS = 2.208 * $e^{(0.067 * Rh)}$
Gupta (2009)	UCS = 14.1 * R_h - 642

	Measured rebound, R_α	Calibrated rebound, R_h	UCS uniaxial compressive strength (psi)		
			Singh et al. (1983)	Katz et al. (2000)	Gupta (2009)
	50	50	14,500	9,125	9,135
	55	55	15,950	12,757	19,358
	58	58	16,820	15,597	25,491
	58	58	16,820	15,597	25,491
	57	57	16,530	14,586	23,447
	58	58	16,820	15,597	25,491
	59	59	17,110	16,678	27,536
	49	49	14,210	8,534	7,091
	49	49	14,210	8,534	7,091
	57	57	16,530	14,586	23,447
Average	**55**	**55**	**15,950**	**13,159**	**19,358**

GEI Consultants

Client: Green International Affiliates, Inc
Project: Wilmington Route 38 Rock Slope Evaluation
Project No.: 2408225
Subject: Estimation of Rock Strength Parameters based on Schmidt hammer

Prepared By: M. Wong
Date: 1/2/2025
Checked By: J. Archuleta
Date: 1/21/2025

Rock Description: Schist, slightly weathered
Location: Sta. 308+25 South bound
Hammer type: Type N Schmidt Test Hammer

Specimen Width/Height (ft) 0.3/3
Orientation of hammer axis, α (°): 5
(downward being -90° and upward +90°)

References:

1) Basu, A., & Aydin, A. (2004). A method for normalization of Schmidt hammer rebound values. International journal of rock mechanics and mining sciences, 41(7), 1211-1214.
2) Aydin, A. (2014). ISRM suggested method for determination of the Schmidt hammer rebound hardness: revised version. The ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 2007-2014, 25-33.
3) Minaeian, B., & Ahangari, K. (2013). Estimation of uniaxial compressive strength based on P-wave and Schmidt hammer rebound using statistical method. Arabian Journal of Geosciences, 6, 1925-1931.

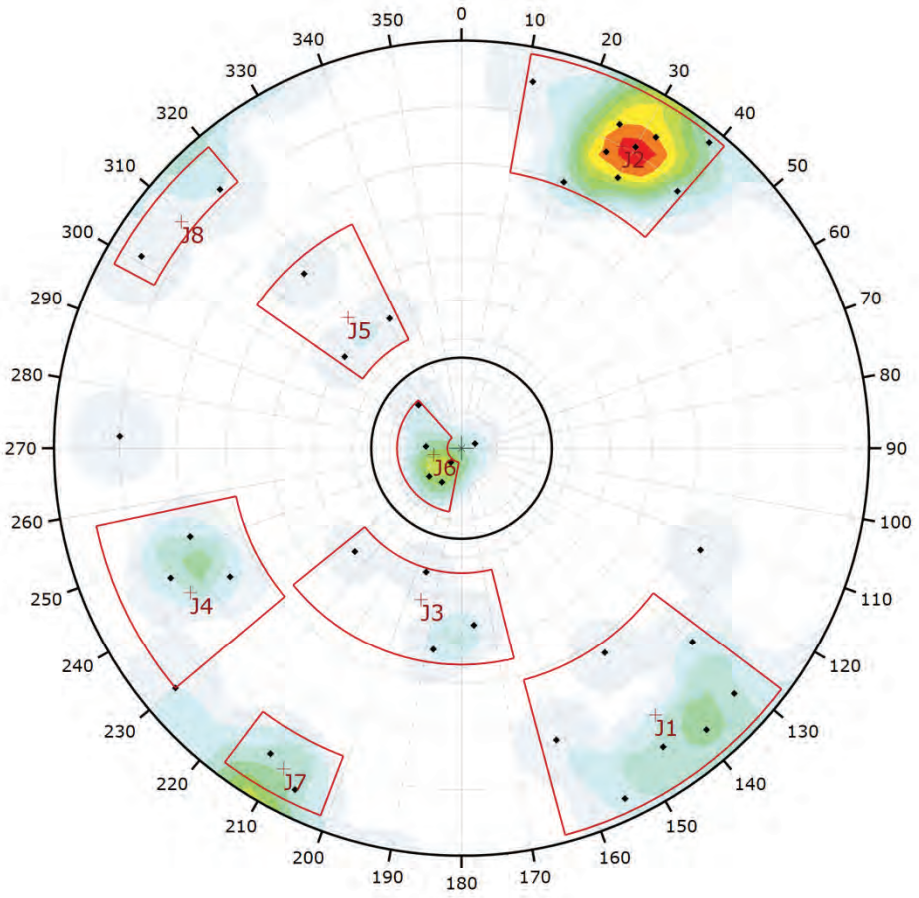
Equations:

Ref. 1 Eqn.	Equation		
8	$R_h = (V_2^2 / V_1^2) * 100$	where:	V_1 Velocity of the piston when it touches the plunger. V_1^2 = 11.23 (m/s)^2
			V_2 Initial rebound velocity of the piston.
7	$V_2^2 = \frac{V_{(\alpha)}^2(0.5kx_1^2)}{0.5kx_1^2 + Mgx_1\cos(90+\alpha)}$	where:	k Spring constant. k = 764.2 (N/m)
			x_1 Maximum stretch of the spring. x_1 = 0.076 (m)
			M Mass of the piston. M = 0.3895 (kg)
			$V_{(\alpha)}$ Initial rebound velocity of the piston at angle α.
			α Orientation of hammer axis (downward being -90° and upward +90°)
6	$V_{2(\alpha)}^2 = \frac{kx_{2(\alpha)}^2}{M} + 2gx_{2(\alpha)}\cos(90+\alpha)$	where:	$x_{2(\alpha)}$ Stretch at maximum rebound position. $x_{2(\alpha)} = R_\alpha /100 * x_1$
			R_α Measured rebound at angle α

Ref. 3 Table 3.	Equations yields UCS in MPa.
Singh et al. (1983)	UCS = 2 * R_h
Katz et al. (2000)	UCS = 2.208 * $e^{(0.067 * Rh)}$
Gupta (2009)	UCS = 14.1 * R_h - 642

Measured rebound, R_α	Calibrated rebound, R_h	UCS uniaxial compressive strength (psi)		
		Singh et al. (1983)	Katz et al. (2000)	Gupta (2009)
65	65	18,791	24,593	39,387
71	71	20,541	36,847	51,725
68	68	19,666	30,103	45,556
64	64	18,499	22,990	37,331
67	67	19,374	28,141	43,500
66	66	19,083	26,307	41,443
69	69	19,958	32,201	47,613
68	68	19,666	30,103	45,556
65	65	18,791	24,593	39,387
69	69	19,958	32,201	47,613
Average	**67**	**67**	**19,433**	**28,808**	**43,911**

Appendix D Stereonet Plots



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.30
	1.30 - 2.60
	2.60 - 3.90
	3.90 - 5.20
	5.20 - 6.50
	6.50 - 7.80
	7.80 - 9.10
	9.10 - 10.40
	10.40 - 11.70
	11.70 - 13.00

Contour Data	Pole Vectors
Maximum Density	12.43%
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		78	324	J1
2m		80	208	J2
3m		42	15	J3
4m		74	62	J4
5m		46	139	J5
6m		8	77	J6
7m		84	29	J7
8m		83	129	J8

Plot Mode	Pole Vectors
Vector Count	39 (39 Entries)
Hemisphere	Lower
Projection	Equal Angle

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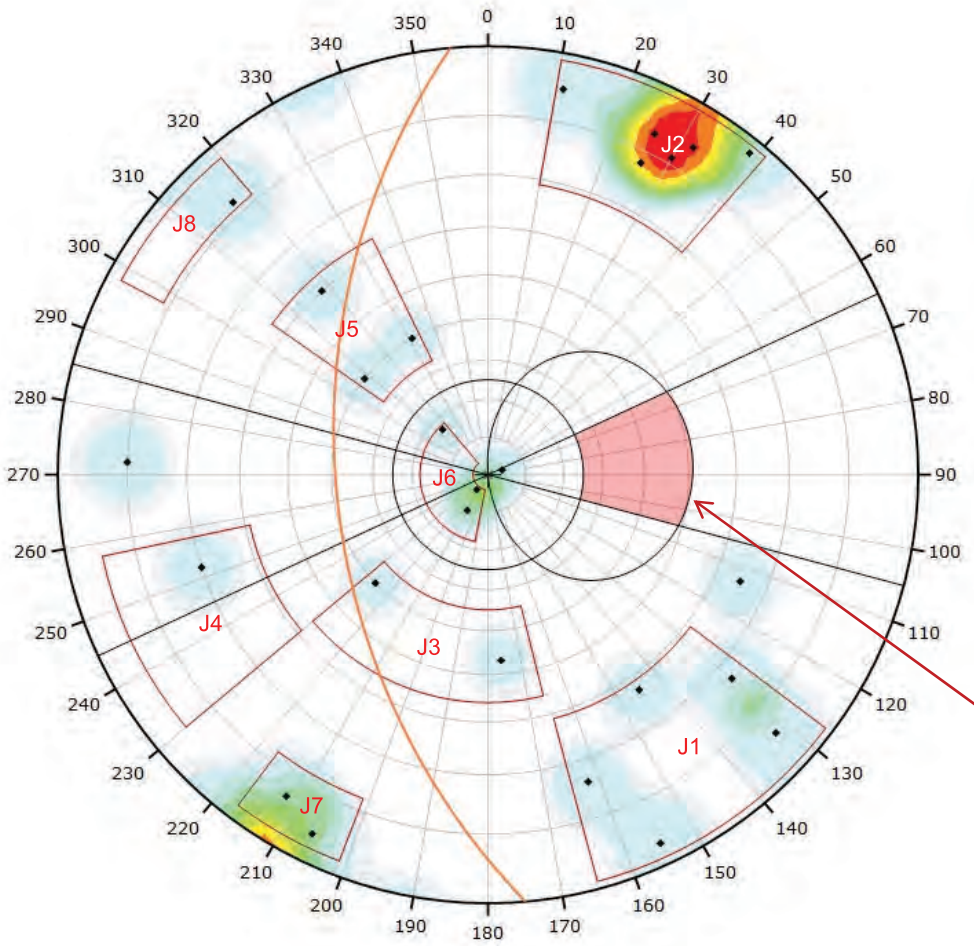
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Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

Project 2408225

KINEMATIC ANALYSIS
ALL FIELD DATA (NORTH AND SOUTHBOUND ROCK SLOPES)

June 2025



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

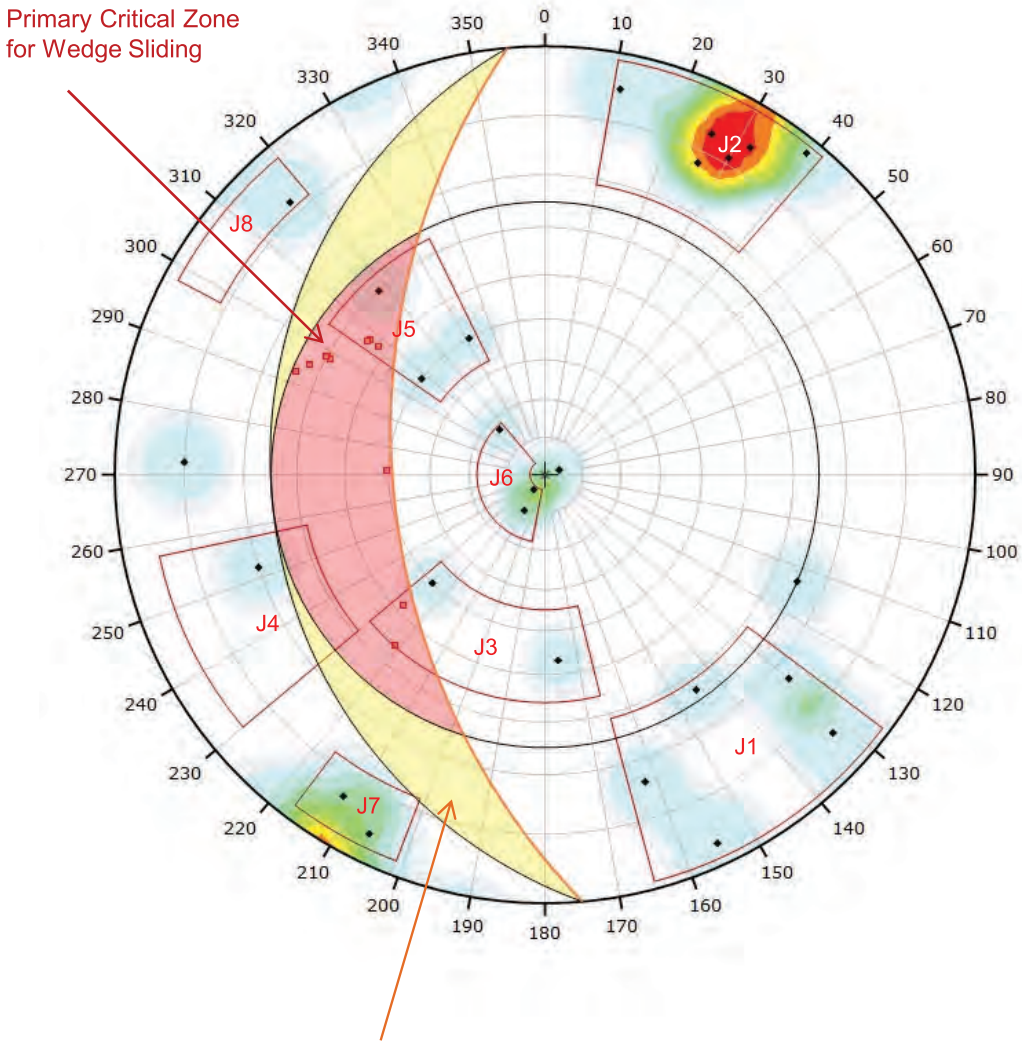
Kinematic Analysis	Planar Sliding
Slope Dip	51
Slope Dip Direction	265
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	26	0.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

Critical Zone for Planar Sliding

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Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	June 2025 2 of 17



Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	51		
Slope Dip Direction	265		
Friction Angle	25°		
	Critical	Total	%
Wedge Sliding	11	325	3.38%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

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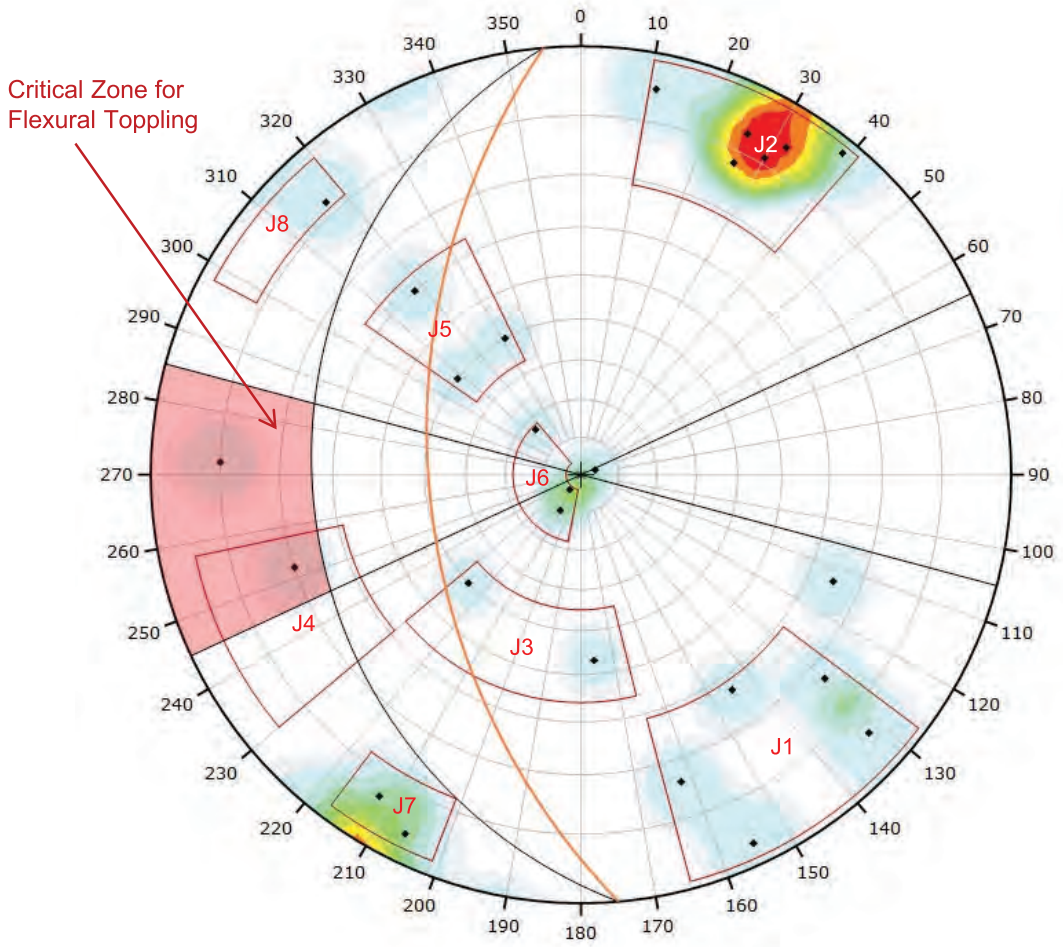
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Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

Project 2408225

KINEMATIC ANALYSIS
WEDGE SLIDING OF
NORTHBOUND ROCK SLOPE
(STATION 307+00 TO 308+00)

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Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	51
Slope Dip Direction	265
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	2	26	7.69%
Flexural Toppling (Set 13: J4)	1	1	100.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

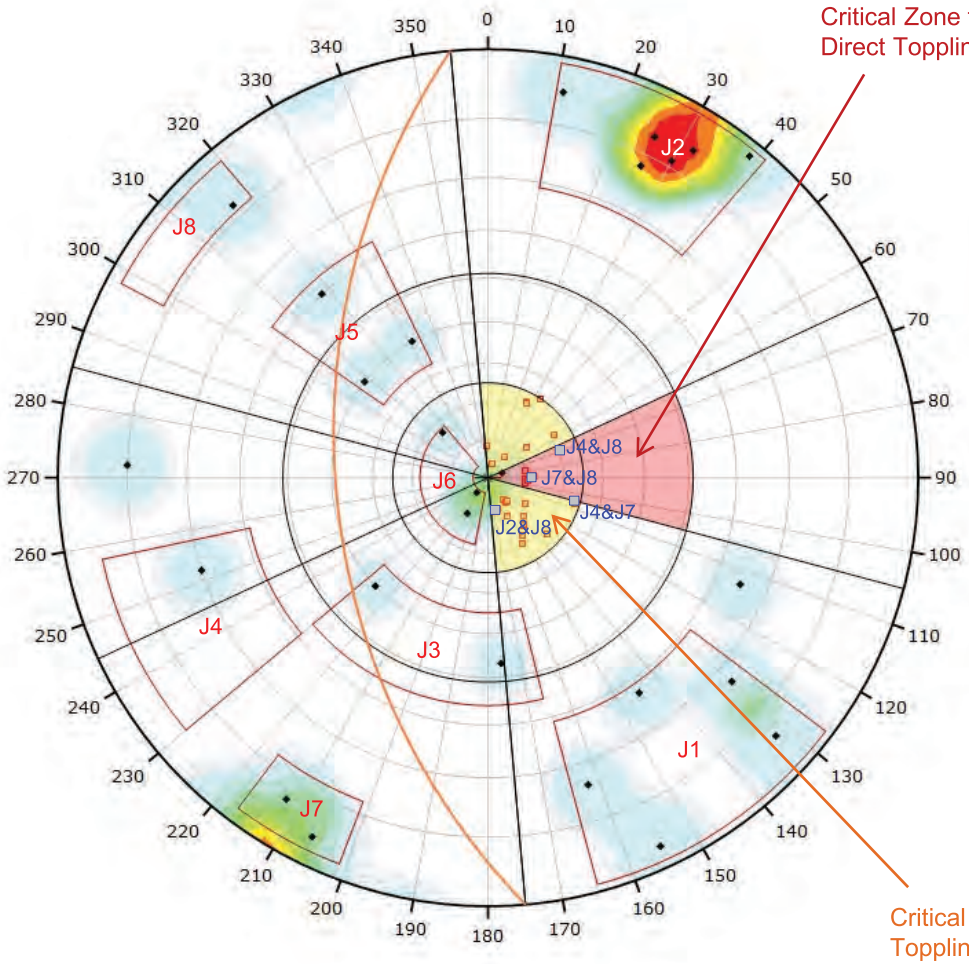
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KINEMATIC ANALYSIS
FLEXURAL TOPPLING OF
NORTHBOUND ROCK SLOPE
(STATION 307+00 TO 308+00)

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Critical Zone for Direct Toppling

Critical Zone for Oblique Toppling and Base Plane Toppling

Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	51
Slope Dip Direction	285
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	6	325	1.85%
Oblique Toppling (Intersection)	24	325	7.38%
Base Plane (All)	1	26	3.85%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

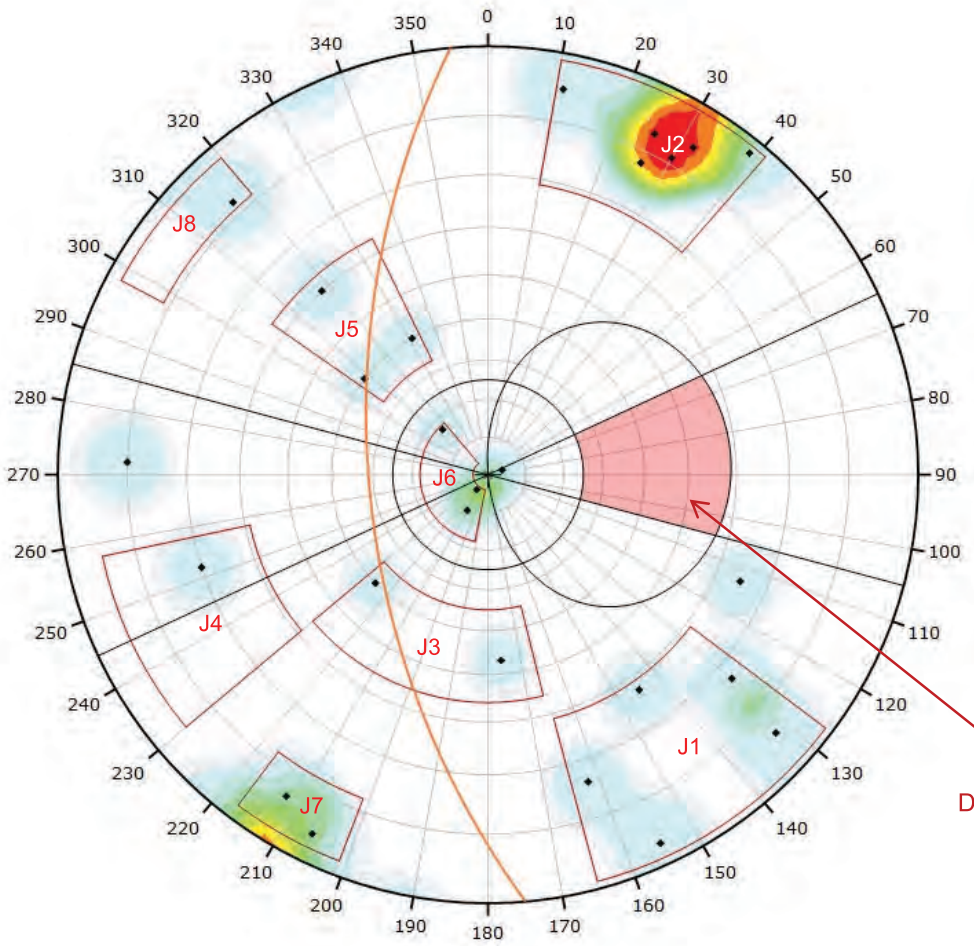
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KINEMATIC ANALYSIS
DIRECT TOPPLING OF
NORTHBOUND ROCK SLOPE
(STATION 307+00 TO 308+00)

Project 2408225 | June 2025 | 5 of 17



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

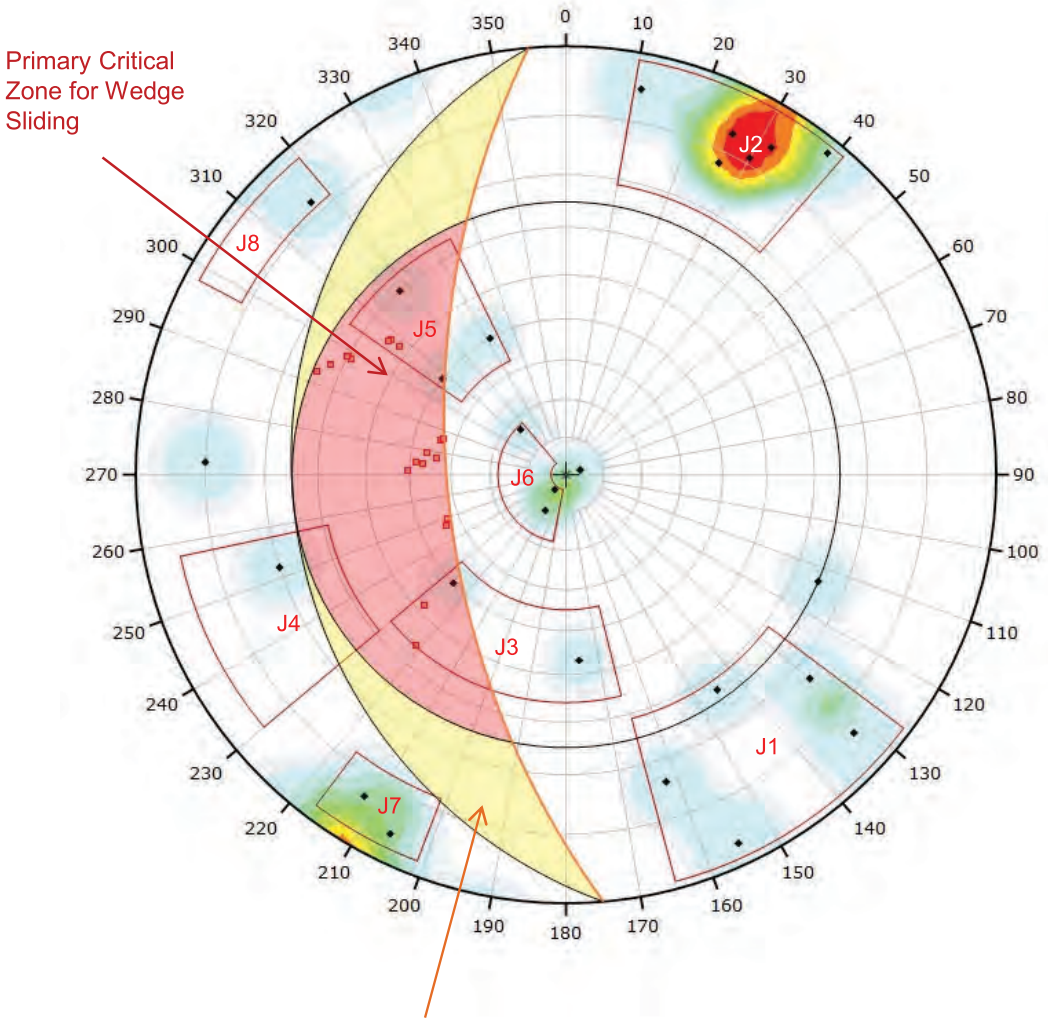
Kinematic Analysis	Planar Sliding
Slope Dip	59
Slope Dip Direction	265
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	26	0.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

Daylight Envelope

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Wilmington Route 38 Improvements Rock Slope Evaluation Wilmington, Massachusetts	Project 2408225	June 2025 6 of 17



Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	59		
Slope Dip Direction	265		
Friction Angle	25°		
	Critical	Total	%
Wedge Sliding	19	325	5.85%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

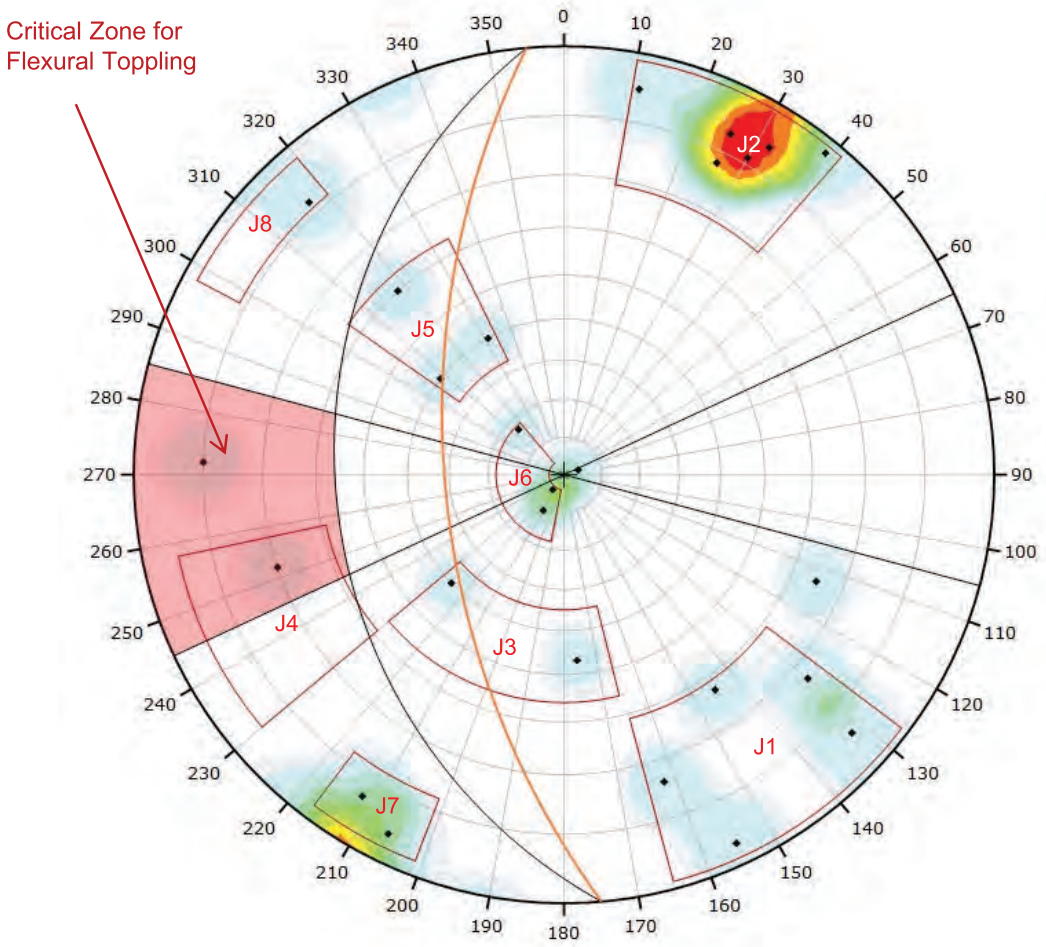
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Rock Slope Evaluation
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KINEMATIC ANALYSIS
WEDGE SLIDING OF
NORTHBOUND ROCK SLOPE
(STATION 308+00 TO 308+30)

Project 2408225 | June 2025 | 7 of 17



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	59
Slope Dip Direction	265
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	2	26	7.69%
Flexural Toppling (Set 13: J4)	1	1	100.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

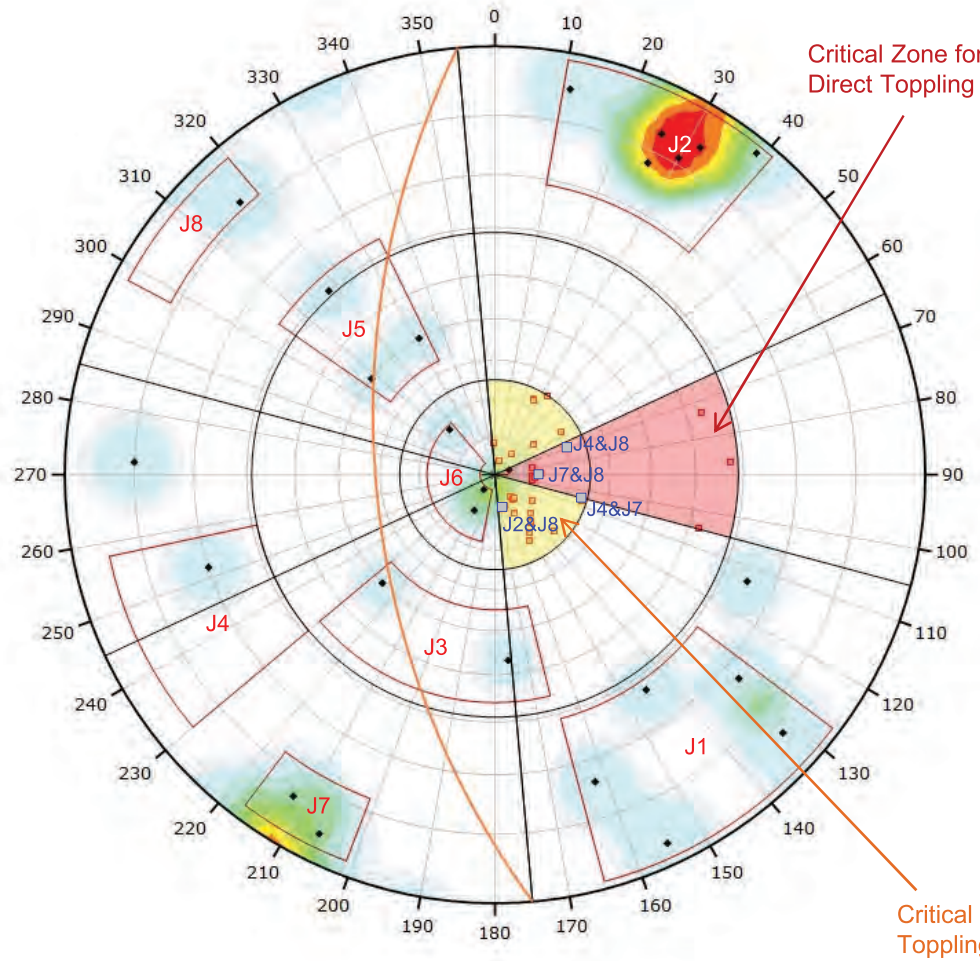
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Rock Slope Evaluation
Wilmington, Massachusetts

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KINEMATIC ANALYSIS
FLEXURAL TOPPLING OF
NORTHBOUND ROCK SLOPE
(STATION 308+00 TO 308+30)

Project 2408225 | June 2025 | 8 of 17



Critical Zone for Direct Toppling

Critical Zone for Oblique Toppling and Base Plane Toppling

Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	59
Slope Dip Direction	285
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	9	325	2.77%
Oblique Toppling (Intersection)	24	325	7.38%
Base Plane (All)	1	26	3.85%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

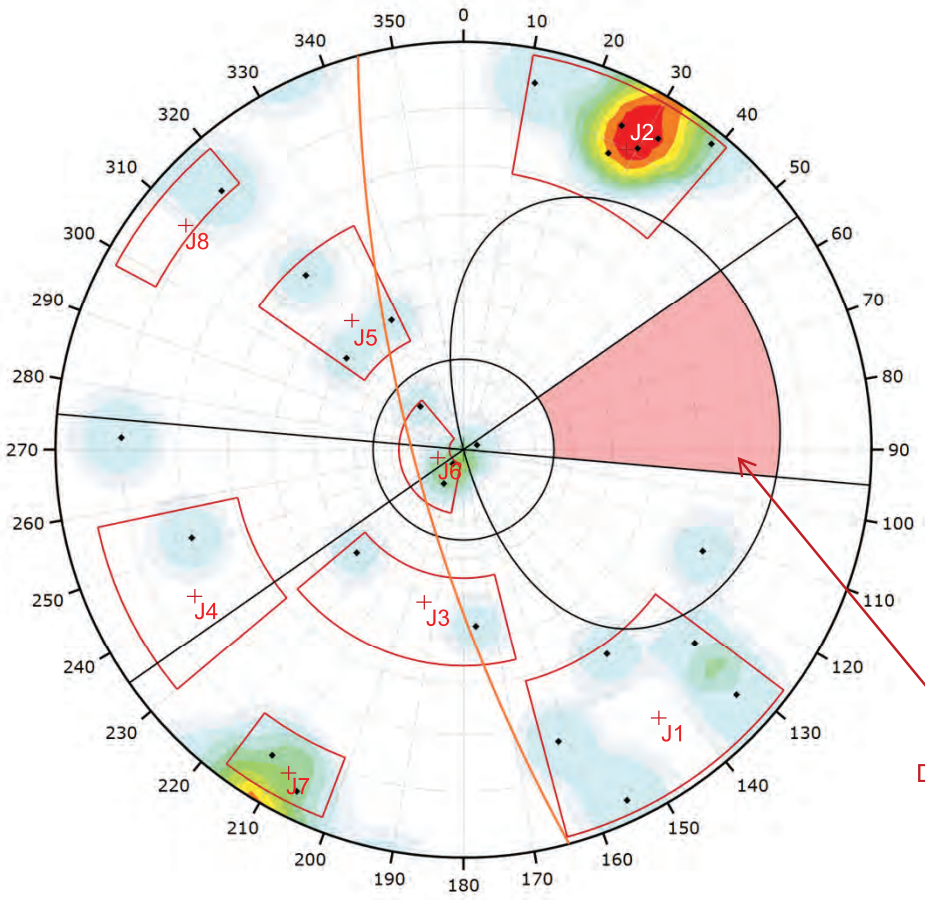
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Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

KINEMATIC ANALYSIS
DIRECT TOPPLING OF
NORTHBOUND ROCK SLOPE
(STATION 308+00 TO 308+30)

Project 2408225 | June 2025 | 9 of 17



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	76
Slope Dip Direction	255
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	26	0.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

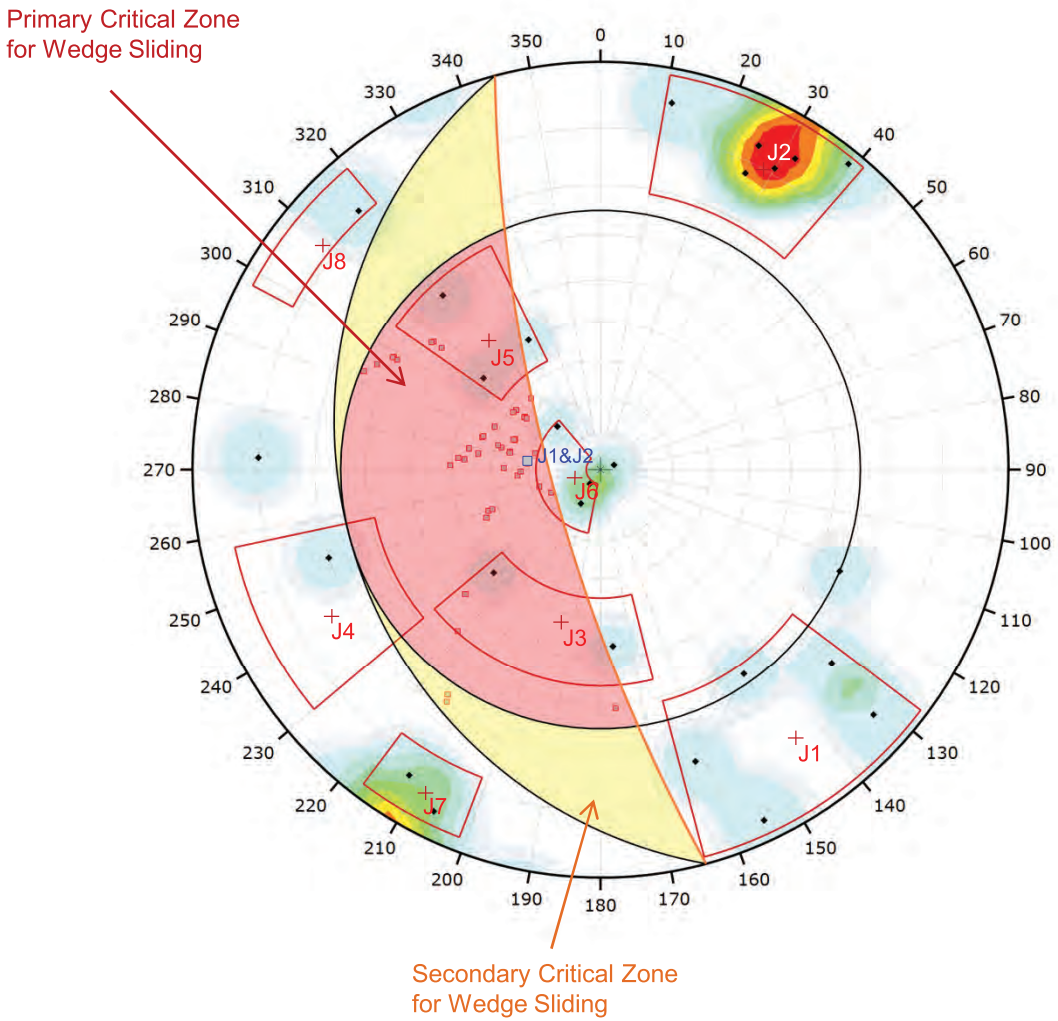
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Rock Slope Evaluation
Wilmington, Massachusetts

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KINEMATIC ANALYSIS
PLANAR SLIDING OF
NORTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 10 of 17



Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	76
Slope Dip Direction	255
Friction Angle	25°

	Critical	Total	%
Wedge Sliding	48	325	14.77%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

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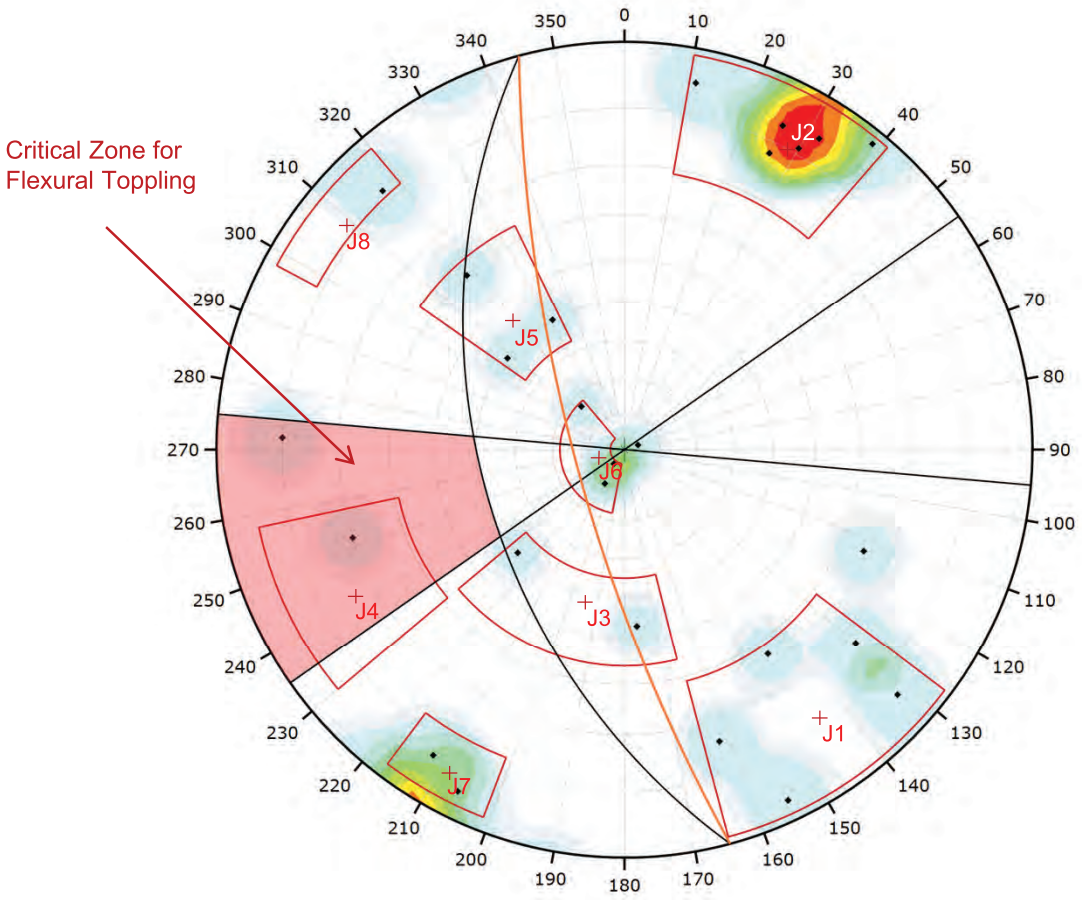
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Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

Project 2408225

KINEMATIC ANALYSIS
WEDGE SLIDING OF
NORTHBOUND ROCK SLOPE

June 2025



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	76
Slope Dip Direction	255
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	2	26	7.69%
Flexural Toppling (Set 13: J4)	1	1	100.00%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Hemisphere	Lower
Projection	Equal Angle

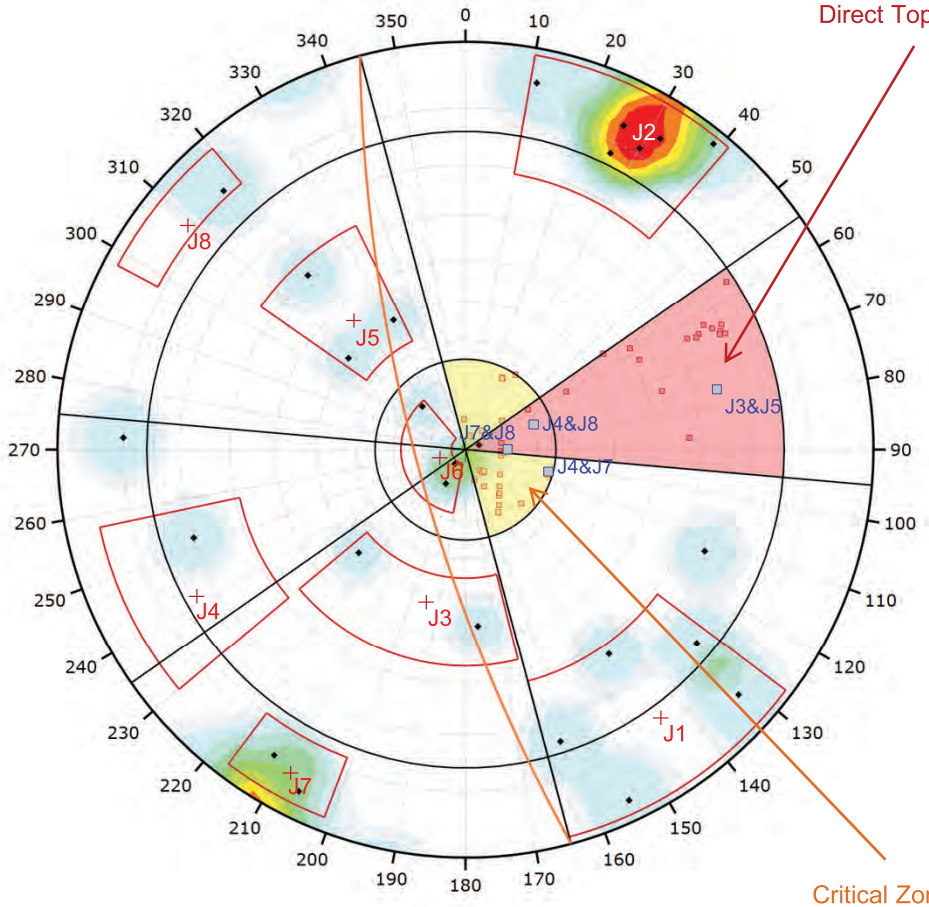
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Rock Slope Evaluation
Wilmington, Massachusetts

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KINEMATIC ANALYSIS
FLEXURAL TOPPLING OF
NORTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 12 of 17



Critical Zone for Direct Toppling

Critical Zone for Oblique Toppling and Base Plane Toppling

Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.80%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	76
Slope Dip Direction	255
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	22	325	6.77%
Oblique Toppling (Intersection)	23	325	7.08%
Base Plane (All)	1	26	3.85%

Plot Mode	Pole Vectors
Vector Count	26 (26 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	325
Hemisphere	Lower
Projection	Equal Angle

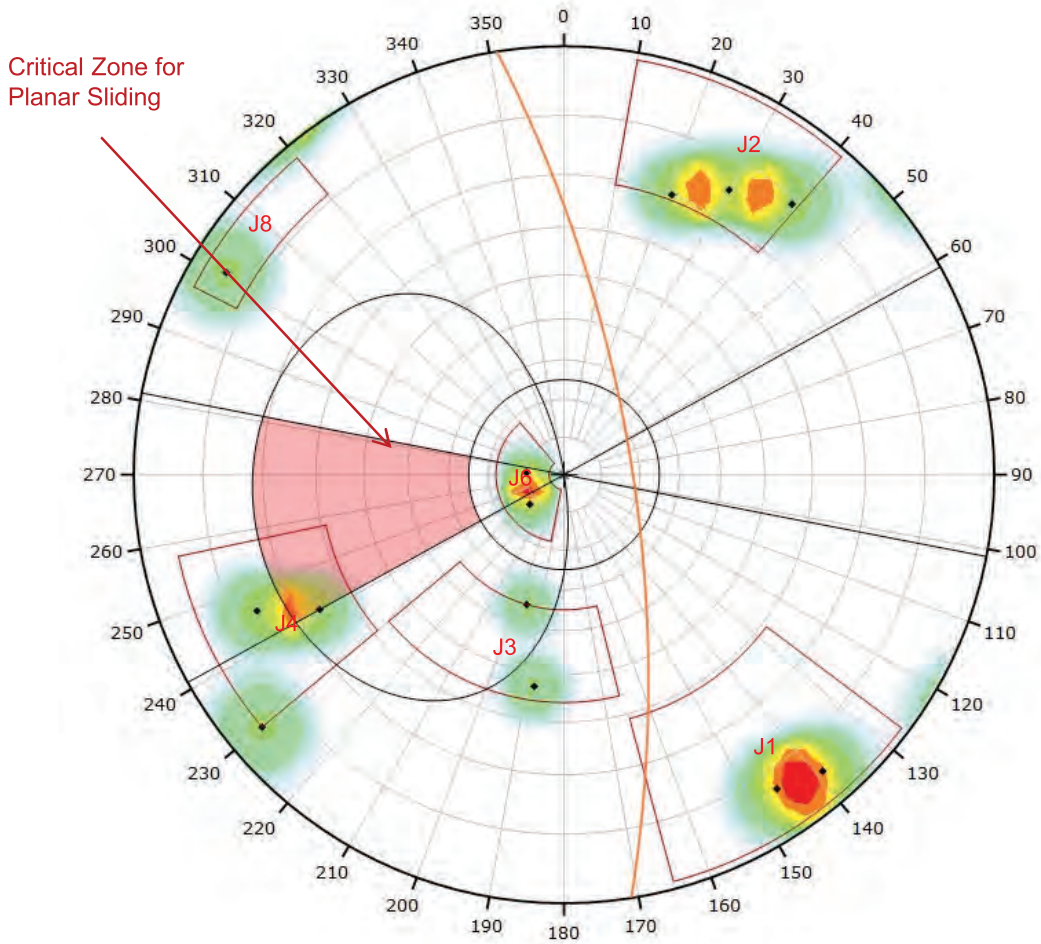
GREEN INTERNATIONAL AFFILIATES, INC.

Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

KINEMATIC ANALYSIS
DIRECT TOPPLING OF
NORTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 13 of 17



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.53%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	72
Slope Dip Direction	81
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	13	7.69%
Planar Sliding (Set 13: J4)	1	3	33.33%

Plot Mode	Pole Vectors
Vector Count	13 (13 Entries)
Hemisphere	Lower
Projection	Equal Angle

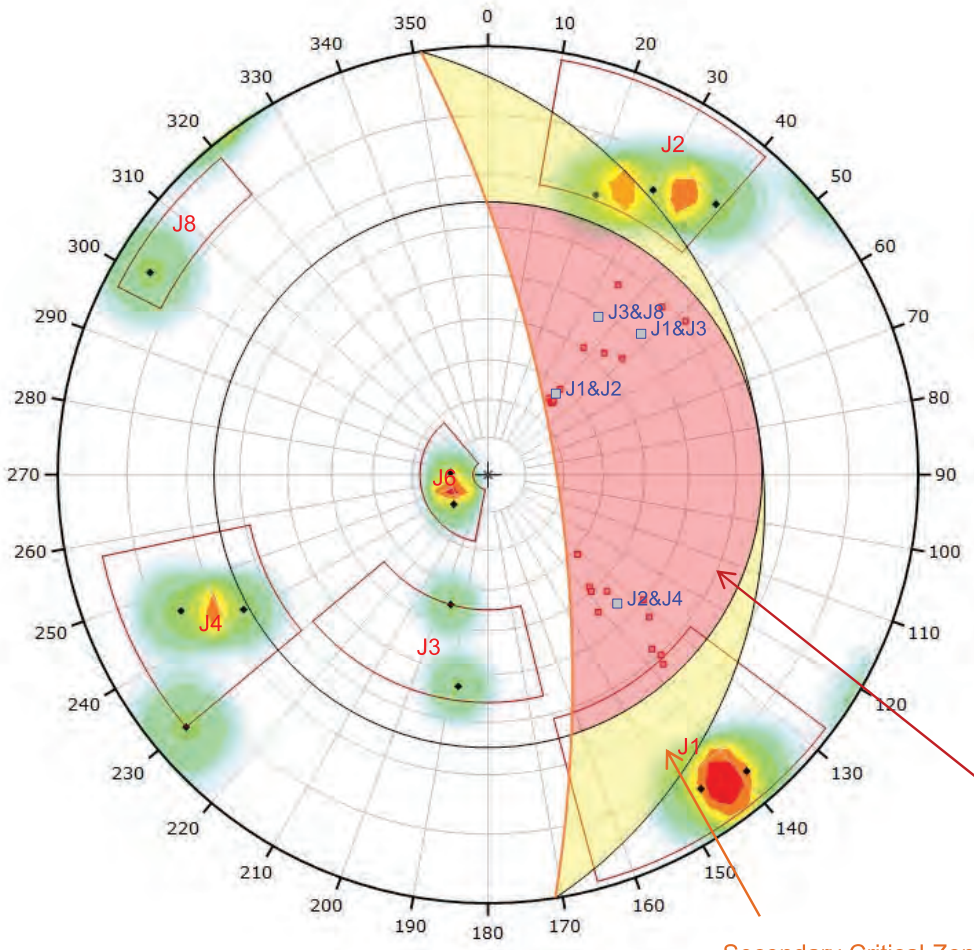
GREEN INTERNATIONAL AFFILIATES, INC.

Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

KINEMATIC ANALYSIS
PLANAR SLIDING OF
SOUTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 14 of 17



Symbol	Feature
◆	Pole Vectors
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.53%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	72
Slope Dip Direction	81
Friction Angle	25°

	Critical	Total	%
Wedge Sliding	22	78	28.21%

Plot Mode	Pole Vectors
Vector Count	13 (13 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	78
Hemisphere	Lower
Projection	Equal Angle

Primary Critical Zone for Wedge Sliding

Secondary Critical Zone for Wedge Sliding

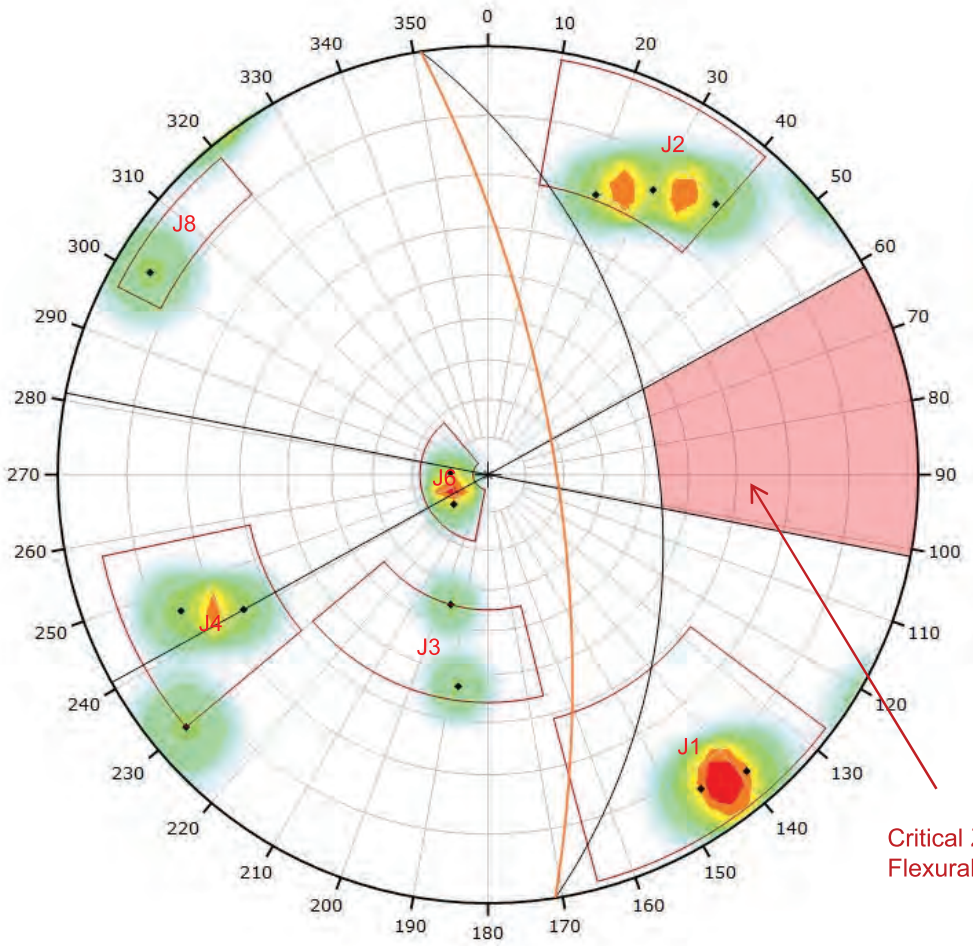
GREEN INTERNATIONAL AFFILIATES, INC.

Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

KINEMATIC ANALYSIS
WEDGE SLIDING OF
SOUTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 15 of 17



Symbol	Feature
◆	Pole Vectors

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.53%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Flexural Toppling
Slope Dip	72
Slope Dip Direction	81
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Flexural Toppling (All)	0	13	0.00%

Plot Mode	Pole Vectors
Vector Count	13 (13 Entries)
Hemisphere	Lower
Projection	Equal Angle

Critical Zone for
Flexural Toppling

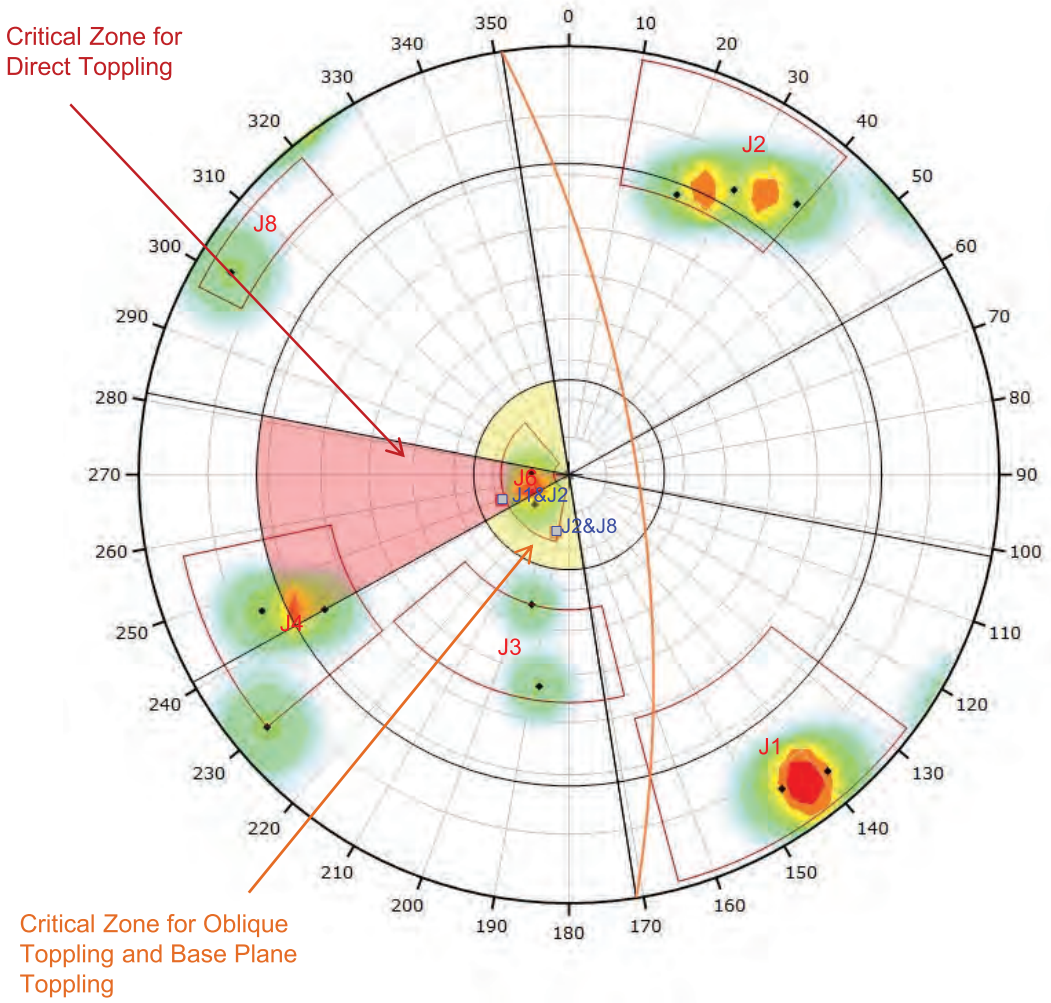
GREEN INTERNATIONAL AFFILIATES, INC.

Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

KINEMATIC ANALYSIS
FLEXURAL TOPPLING OF
SOUTHBOUND ROCK SLOPE

Project 2408225 | June 2025 | 16 of 17



Symbol	Feature
◆	Pole Vectors
▢	Critical Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Pole Vectors
Maximum Density	14.53%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	72
Slope Dip Direction	81
Friction Angle	25°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	1	15	6.67%
Oblique Toppling (Intersection)	1	15	6.67%
Base Plane (All)	3	13	23.08%
Base Plane (Set 8: J8)	2	2	100.00%
Base Plane (Set 13: J4)	1	3	33.33%

Plot Mode	Pole Vectors
Vector Count	13 (13 Entries)
Intersection Mode	Mean Set Planes
Intersections Count	15
Hemisphere	Lower
Projection	Equal Angle

GREEN INTERNATIONAL AFFILIATES, INC.

Wilmington Route 38 Improvements
Rock Slope Evaluation
Wilmington, Massachusetts

GEI Consultants

Project 2408225

KINEMATIC ANALYSIS
DIRECT TOPPLING OF
SOUTHBOUND ROCK SLOPE

June 2025

17 of 17

Appendix E SWedge Analysis Results

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	NB_255
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	46
Number of Invalid Wedges	4904
Number of Failed Wedges	22
Number of Stable Wedges	24

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.8447

Safety Factor	0.5693
Wedge Height (On Slope) [ft]	8.069
Bench Width (On Upper Face) [ft]	3.379
Wedge Volume [ft3]	18.935
Wedge Weight [lbs]	3256.809
Wedge Area (Joint1) [ft2]	18.467
Wedge Area (Joint2) [ft2]	16.282
Wedge Area (Slope) [ft2]	17.327
Wedge Area (Upper Face) [ft2]	7.040

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	1302.555	1905.979
Effective Normal Stress [psf]	70.536	117.061
Shear Strength [psf]	32.891	54.586
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	2628.060
Resisting Force [lbs]	1496.164

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
53.798	279.118	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	8.333	4.477
Joint 2	9.079	3.596

Persistence

Joint 1 [ft]	10.000
Joint 2 [ft]	10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	27.260	61.000
Joint 1 & Crest	86.397	49.000
Joint 2 & Crest	66.343	70.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	78.000	206.000
Joint Set 2	63.000	325.000
Slope	76.000	255.000
Upper Face	0.000	255.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	17
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	NO
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

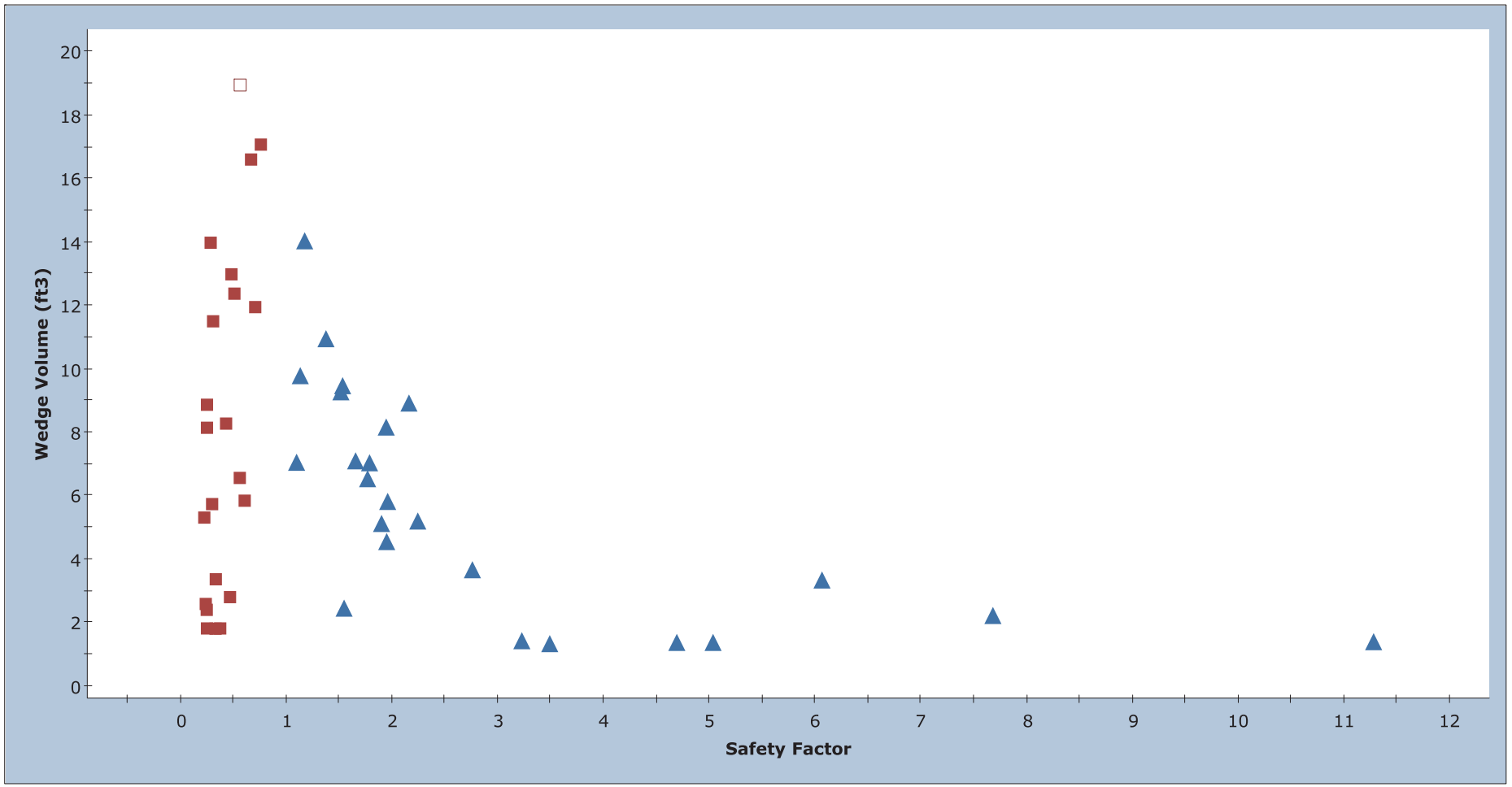
Point	East	North	Up
124	0.000	0.000	0.000
134	1.808	1.027	8.069
234	2.886	-2.998	8.069
123	5.832	-0.936	8.069

Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	15 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg



rocscience	Project	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	Company: GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	File Name: NB_255.swd7

SWEDGE 7.021



Top - Scaled

Factor of Safety: 0.5693



Perspective - Scaled



Front - Scaled



Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
SWEDGE 7.021	*Date*	1/6/2025, 5:55:48 PM	*File Name* NB_255.swd7

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	NB_265
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	62
Number of Invalid Wedges	4888
Number of Failed Wedges	25
Number of Stable Wedges	37

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.9290

Safety Factor	0.5693
Wedge Height (On Slope) [ft]	8.069
Bench Width (On Upper Face) [ft]	3.716
Wedge Volume [ft3]	21.880
Wedge Weight [lbs]	3763.442
Wedge Area (Joint1) [ft2]	17.882
Wedge Area (Joint2) [ft2]	19.430
Wedge Area (Slope) [ft2]	18.206
Wedge Area (Upper Face) [ft2]	8.135

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	1505.182	2202.476
Effective Normal Stress [psf]	84.173	113.354
Shear Strength [psf]	39.251	52.858
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	3036.884
Resisting Force [lbs]	1728.909

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
53.798	279.118	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	8.354	4.335
Joint 2	9.057	4.291

Persistence

Joint 1 [ft]	10.000
Joint 2 [ft]	10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	28.767	61.000
Joint 1 & Crest	84.559	59.000
Joint 2 & Crest	66.674	60.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	78.000	206.000
Joint Set 2	63.000	325.000
Slope	76.000	265.000
Upper Face	0.000	265.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	17
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	NO
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

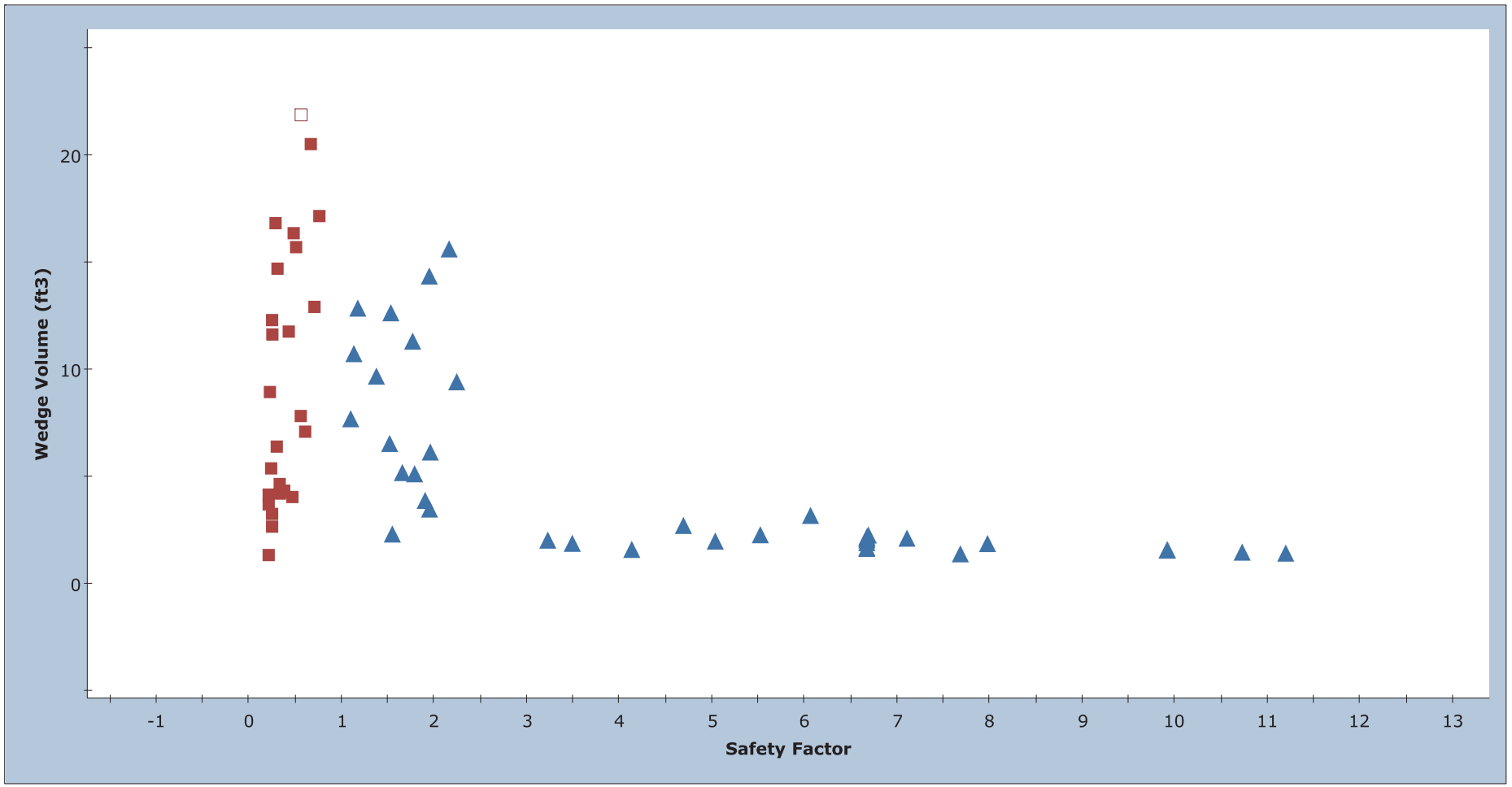
Point	East	North	Up
124	0.000	0.000	0.000
134	1.935	0.964	8.069
234	2.317	-3.397	8.069
123	5.832	-0.936	8.069

Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	15 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg



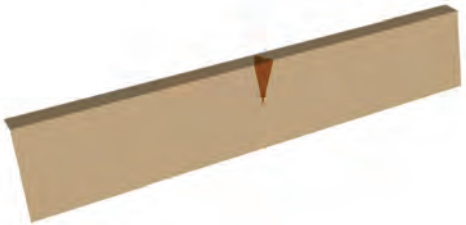
rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	*File Name* NB_265.swd7

SWEDGE 7.021



Top - Scaled

Factor of Safety: 0.5693



Perspective - Scaled



Front - Scaled



Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
SWEDGE 7.021	*Date*	1/6/2025, 5:55:48 PM	*File Name* NB_265.swd7

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	SB
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	30
Number of Invalid Wedges	4920
Number of Failed Wedges	9
Number of Stable Wedges	21

Current Wedge Data - Picked Wedge

Safety Factor	0.8267
Wedge Height (On Slope) [ft]	5.108
Bench Width (On Upper Face) [ft]	4.000
Wedge Volume [ft3]	22.583
Wedge Weight [lbs]	3884.350
Wedge Area (Joint1) [ft2]	15.953
Wedge Area (Joint2) [ft2]	19.651
Wedge Area (Slope) [ft2]	17.456
Wedge Area (Upper Face) [ft2]	13.264

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	585.362	3226.650
Effective Normal Stress [psf]	36.693	164.198
Shear Strength [psf]	17.110	76.567
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	2150.166
Resisting Force [lbs]	1777.570

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
33.611	34.334	9.227

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	5.328	6.223
Joint 2	9.126	4.414

Persistence

Joint 1 [ft]	9.227
Joint 2 [ft]	9.227

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	45.892	75.000
Joint 1 & Crest	98.880	40.000
Joint 2 & Crest	35.227	65.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	85.000	121.000
Joint Set 2	35.000	16.000
Slope	76.000	81.000
Upper Face	0.000	81.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	11.5
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	NO
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

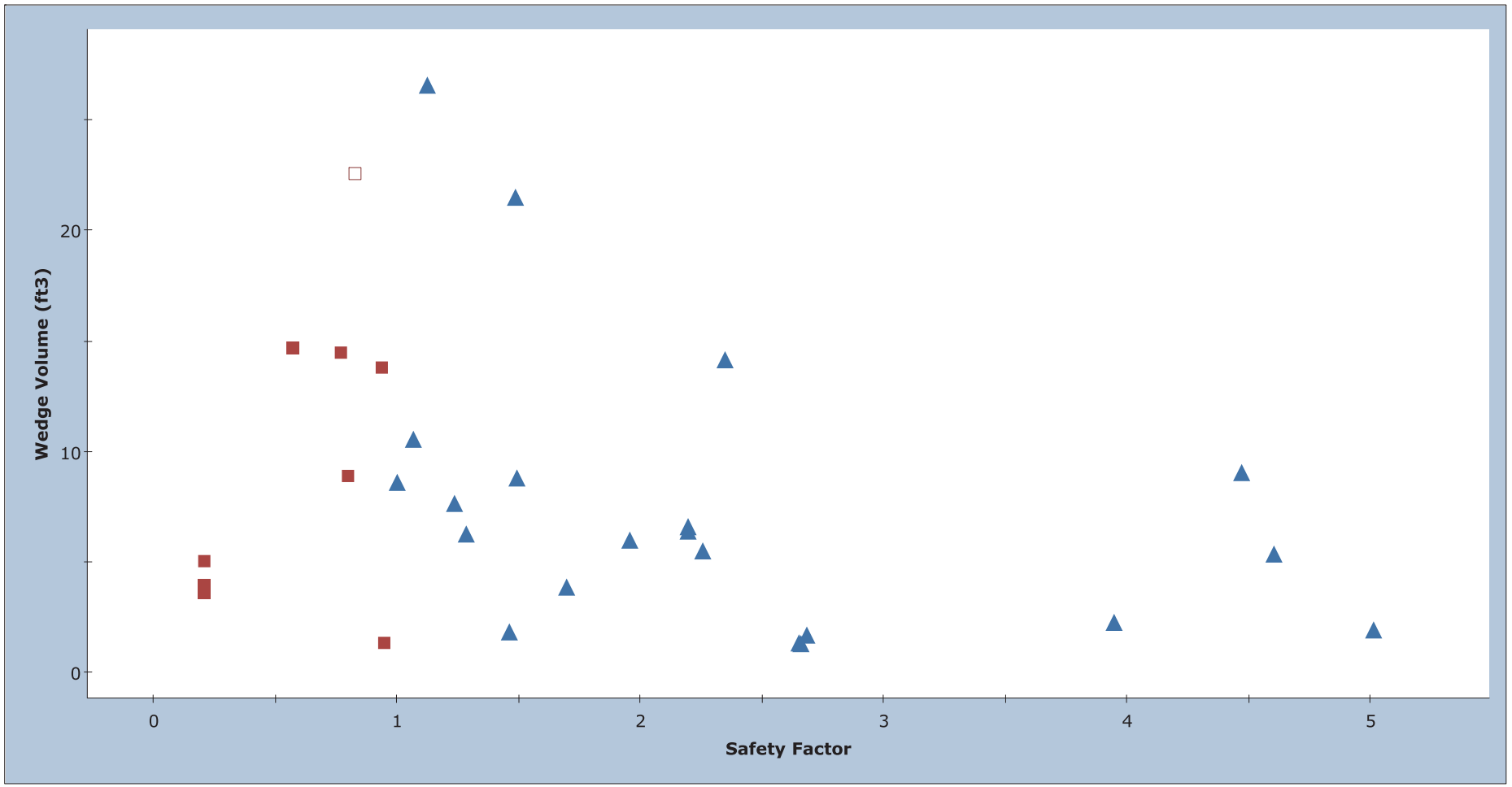
Point	East	North	Up
124	0.000	0.000	0.000
134	-1.129	-1.012	5.108
234	-0.092	-7.562	5.108
123	-4.334	-6.346	5.108

Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	10 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg



rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	*File Name* SB.swd7

SWEDGE 7.021



Top



Perspective



Front



Side

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
SWEDGE 7.021	*Date*	1/6/2025, 5:55:48 PM	*File Name* SB.swd7

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	NB_255 (308+50)
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	46
Number of Invalid Wedges	4904
Number of Failed Wedges	36
Number of Stable Wedges	10

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.8447

Safety Factor	0.0697
Wedge Height (On Slope) [ft]	8.069
Bench Width (On Upper Face) [ft]	3.379
Wedge Volume [ft3]	18.935
Wedge Weight [lbs]	3256.809
Wedge Area (Joint1) [ft2]	18.467
Wedge Area (Joint2) [ft2]	16.282
Wedge Area (Slope) [ft2]	17.327
Wedge Area (Upper Face) [ft2]	7.040

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	0.000	403.166
Effective Normal Stress [psf]	0.000	24.762
Shear Strength [psf]	0.000	11.547
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	2696.734
Resisting Force [lbs]	187.999

Water Pressures/Forces

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	NB_265 (307+50)
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	65
Number of Invalid Wedges	4885
Number of Failed Wedges	8
Number of Stable Wedges	57

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.9738

Safety Factor	0.8162
Wedge Height (On Slope) [ft]	4.640
Bench Width (On Upper Face) [ft]	3.895
Wedge Volume [ft3]	8.011
Wedge Weight [lbs]	1377.954
Wedge Area (Joint1) [ft2]	12.359
Wedge Area (Joint2) [ft2]	11.170
Wedge Area (Slope) [ft2]	7.940
Wedge Area (Upper Face) [ft2]	5.179

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	773.031	346.096
Effective Normal Stress [psf]	62.549	30.984
Shear Strength [psf]	29.167	14.448
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	639.403
Resisting Force [lbs]	521.858

Water Pressures/Forces

	Average Pressure [psf]	Force [lbs]
Joint 1	49.126	607.139
Joint 2	49.126	548.738
Slope	0.000	0.000

Joint 1

Wetted Area [ft2] 41385.288

Line of Thrust	East	North	Up
Direction	-30.974	442.951	414.068
Point of Application	12.109	10.050	11.004

Polygon #	East	North	Up	Water Pressure [psf]
1	11.631	-3.339	18.462	21.110
1	11.845	-3.400	18.800	0.000
1	11.649	-3.537	18.800	0.000
2	11.631	-3.339	18.462	21.110
2	11.649	-3.537	18.800	0.000
2	0.000	0.000	0.000	0.000
3	11.631	-3.339	18.462	21.110
3	11.845	-3.400	18.800	0.000
3	11.649	-3.537	18.800	0.000
4	11.631	-3.339	18.462	21.110
4	11.649	-3.537	18.800	0.000
4	0.000	0.000	0.000	0.000
5	11.631	-3.339	18.462	21.110
5	11.845	-3.400	18.800	0.000
5	11.649	-3.537	18.800	0.000
6	11.631	-3.339	18.462	21.110
6	11.649	-3.537	18.800	0.000
6	0.000	0.000	0.000	0.000
7	5.174	-1.485	8.213	9.391
7	5.269	-1.513	8.363	0.000
7	5.182	-1.574	8.363	0.000
8	5.174	-1.485	8.213	9.391
8	5.182	-1.574	8.363	0.000
8	0.000	0.000	0.000	0.000
9	10.012	15.166	7.057	732.761
9	26.673	40.402	18.800	0.000
9	11.029	3.546	18.800	0.000
10	10.012	15.166	7.057	732.761
10	11.029	3.546	18.800	0.000
10	0.000	0.000	0.000	0.000
11	10.012	15.166	7.057	732.761
11	26.673	40.402	18.800	0.000
11	11.029	3.546	18.800	0.000
12	10.012	15.166	7.057	732.761
12	11.029	3.546	18.800	0.000
12	0.000	0.000	0.000	0.000
13	2.131	3.227	1.502	155.932
13	5.676	8.598	4.001	0.000
13	2.347	0.755	4.001	0.000
14	2.131	3.227	1.502	155.932
14	2.347	0.755	4.001	0.000

14	0.000	0.000	0.000	0.000
15	1.928	2.920	1.359	141.092
15	5.136	7.779	3.620	0.000
15	2.124	0.683	3.620	0.000
16	1.928	2.920	1.359	141.092
16	2.124	0.683	3.620	0.000
16	0.000	0.000	0.000	0.000
17	5.922	-1.700	9.400	10.749
17	11.845	-3.400	18.800	0.000
17	11.649	-3.537	18.800	0.000
18	5.922	-1.700	9.400	10.749
18	11.649	-3.537	18.800	0.000
18	0.000	0.000	0.000	0.000
19	5.922	-1.700	9.400	10.749
19	11.845	-3.400	18.800	0.000
19	11.649	-3.537	18.800	0.000
20	5.922	-1.700	9.400	10.749
20	11.649	-3.537	18.800	0.000
20	0.000	0.000	0.000	0.000
21	5.922	-1.700	9.400	10.749
21	11.845	-3.400	18.800	0.000
21	11.649	-3.537	18.800	0.000
22	5.922	-1.700	9.400	10.749
22	11.649	-3.537	18.800	0.000
22	0.000	0.000	0.000	0.000
23	2.635	-0.756	4.182	4.782
23	5.269	-1.513	8.363	0.000
23	5.182	-1.574	8.363	0.000
24	2.635	-0.756	4.182	4.782
24	5.182	-1.574	8.363	0.000
24	0.000	0.000	0.000	0.000
25	14.324	-7.785	9.400	586.560
25	28.647	-15.571	18.800	0.000
25	11.779	-5.031	18.800	0.000
26	14.324	-7.785	9.400	586.560
26	11.779	-5.031	18.800	0.000
26	0.000	0.000	0.000	0.000
27	14.324	-7.785	9.400	586.560
27	28.647	-15.571	18.800	0.000
27	11.779	-5.031	18.800	0.000
28	14.324	-7.785	9.400	586.560
28	11.779	-5.031	18.800	0.000
28	0.000	0.000	0.000	0.000
29	3.607	-1.960	2.367	147.701
29	7.214	-3.921	4.734	0.000
29	2.966	-1.267	4.734	0.000
30	3.607	-1.960	2.367	147.701
30	2.966	-1.267	4.734	0.000
30	0.000	0.000	0.000	0.000
31	11.631	-3.339	18.462	21.110
31	11.845	-3.400	18.800	0.000
31	11.649	-3.537	18.800	0.000
32	11.631	-3.339	18.462	21.110
32	11.649	-3.537	18.800	0.000

32	0.000	0.000	0.000	0.000
33	11.631	-3.339	18.462	21.110
33	11.845	-3.400	18.800	0.000
33	11.649	-3.537	18.800	0.000
34	11.631	-3.339	18.462	21.110
34	11.649	-3.537	18.800	0.000
34	0.000	0.000	0.000	0.000
35	11.631	-3.339	18.462	21.110
35	11.845	-3.400	18.800	0.000
35	11.649	-3.537	18.800	0.000
36	11.631	-3.339	18.462	21.110
36	11.649	-3.537	18.800	0.000
36	0.000	0.000	0.000	0.000
37	5.174	-1.485	8.213	9.391
37	5.269	-1.513	8.363	0.000
37	5.182	-1.574	8.363	0.000
38	5.174	-1.485	8.213	9.391
38	5.182	-1.574	8.363	0.000
38	0.000	0.000	0.000	0.000
39	10.012	15.166	7.057	732.761
39	26.673	40.402	18.800	0.000
39	11.029	3.546	18.800	0.000
40	10.012	15.166	7.057	732.761
40	11.029	3.546	18.800	0.000
40	0.000	0.000	0.000	0.000
41	10.012	15.166	7.057	732.761
41	26.673	40.402	18.800	0.000
41	11.029	3.546	18.800	0.000
42	10.012	15.166	7.057	732.761
42	11.029	3.546	18.800	0.000
42	0.000	0.000	0.000	0.000
43	2.131	3.227	1.502	155.932
43	5.676	8.598	4.001	0.000
43	2.347	0.755	4.001	0.000
44	2.131	3.227	1.502	155.932
44	2.347	0.755	4.001	0.000
44	0.000	0.000	0.000	0.000
45	1.928	2.920	1.359	141.092
45	5.136	7.779	3.620	0.000
45	2.124	0.683	3.620	0.000
46	1.928	2.920	1.359	141.092
46	2.124	0.683	3.620	0.000
46	0.000	0.000	0.000	0.000
47	11.571	-0.325	13.549	40.636
47	12.127	-0.341	14.200	0.000
47	11.605	-0.707	14.200	0.000
48	11.571	-0.325	13.549	40.636
48	11.605	-0.707	14.200	0.000
48	0.000	0.000	0.000	0.000
49	11.571	-0.325	13.549	40.636
49	12.127	-0.341	14.200	0.000
49	11.605	-0.707	14.200	0.000
50	11.571	-0.325	13.549	40.636
50	11.605	-0.707	14.200	0.000

50	0.000	0.000	0.000	0.000
51	11.571	-0.325	13.549	40.636
51	12.127	-0.341	14.200	0.000
51	11.605	-0.707	14.200	0.000
52	11.571	-0.325	13.549	40.636
52	11.605	-0.707	14.200	0.000
52	0.000	0.000	0.000	0.000
53	6.195	-0.174	7.254	21.757
53	6.493	-0.183	7.603	0.000
53	6.213	-0.378	7.603	0.000
54	6.195	-0.174	7.254	21.757
54	6.213	-0.378	7.603	0.000
54	0.000	0.000	0.000	0.000
55	12.039	-5.676	6.972	451.006
55	24.520	-11.559	14.200	0.000
55	12.627	-12.391	14.200	0.000
56	12.039	-5.676	6.972	451.006
56	12.627	-12.391	14.200	0.000
56	0.000	0.000	0.000	0.000
57	12.039	-5.676	6.972	451.006
57	24.520	-11.559	14.200	0.000
57	12.627	-12.391	14.200	0.000
58	12.039	-5.676	6.972	451.006
58	12.627	-12.391	14.200	0.000
58	0.000	0.000	0.000	0.000
59	4.040	-1.905	2.340	151.344
59	8.228	-3.879	4.765	0.000
59	4.237	-4.158	4.765	0.000
60	4.040	-1.905	2.340	151.344
60	4.237	-4.158	4.765	0.000
60	0.000	0.000	0.000	0.000
61	3.934	-1.855	2.278	147.378
61	8.012	-3.777	4.640	0.000
61	4.126	-4.049	4.640	0.000
62	3.934	-1.855	2.278	147.378
62	4.126	-4.049	4.640	0.000
62	0.000	0.000	0.000	0.000

Joint 2

Wetted Area [ft2] 32862.096

Line of Thrust	East	North	Up
Direction	-270.991	-469.370	85.841
Point of Application	11.818	13.075	11.011

Polygon #	East	North	Up	Water Pressure [psf]
1	11.631	-3.339	18.462	21.110
1	11.845	-3.400	18.800	0.000
1	11.626	-3.274	18.800	0.000
2	11.631	-3.339	18.462	21.110
2	11.626	-3.274	18.800	0.000
2	0.000	0.000	0.000	0.000
3	11.631	-3.339	18.462	21.110
3	11.845	-3.400	18.800	0.000

3	11.626	-3.274	18.800	0.000
4	11.631	-3.339	18.462	21.110
4	11.626	-3.274	18.800	0.000
4	0.000	0.000	0.000	0.000
5	11.631	-3.339	18.462	21.110
5	11.845	-3.400	18.800	0.000
5	11.626	-3.274	18.800	0.000
6	11.631	-3.339	18.462	21.110
6	11.626	-3.274	18.800	0.000
6	0.000	0.000	0.000	0.000
7	5.174	-1.485	8.213	9.391
7	5.269	-1.513	8.363	0.000
7	5.172	-1.456	8.363	0.000
8	5.174	-1.485	8.213	9.391
8	5.172	-1.456	8.363	0.000
8	0.000	0.000	0.000	0.000
9	10.012	15.166	7.057	732.761
9	26.673	40.402	18.800	0.000
9	8.677	30.427	18.800	0.000
10	10.012	15.166	7.057	732.761
10	8.677	30.427	18.800	0.000
10	0.000	0.000	0.000	0.000
11	10.012	15.166	7.057	732.761
11	26.673	40.402	18.800	0.000
11	8.677	30.427	18.800	0.000
12	10.012	15.166	7.057	732.761
12	8.677	30.427	18.800	0.000
12	0.000	0.000	0.000	0.000
13	2.131	3.227	1.502	155.932
13	5.676	8.598	4.001	0.000
13	1.847	6.475	4.001	0.000
14	2.131	3.227	1.502	155.932
14	1.847	6.475	4.001	0.000
14	0.000	0.000	0.000	0.000
15	1.928	2.920	1.359	141.092
15	5.136	7.779	3.620	0.000
15	1.671	5.859	3.620	0.000
16	1.928	2.920	1.359	141.092
16	1.671	5.859	3.620	0.000
16	0.000	0.000	0.000	0.000
17	5.922	-1.700	9.400	10.749
17	11.845	-3.400	18.800	0.000
17	11.626	-3.274	18.800	0.000
18	5.922	-1.700	9.400	10.749
18	11.626	-3.274	18.800	0.000
18	0.000	0.000	0.000	0.000
19	5.922	-1.700	9.400	10.749
19	11.845	-3.400	18.800	0.000
19	11.626	-3.274	18.800	0.000
20	5.922	-1.700	9.400	10.749
20	11.626	-3.274	18.800	0.000
20	0.000	0.000	0.000	0.000
21	5.922	-1.700	9.400	10.749
21	11.845	-3.400	18.800	0.000

21	11.626	-3.274	18.800	0.000
22	5.922	-1.700	9.400	10.749
22	11.626	-3.274	18.800	0.000
22	0.000	0.000	0.000	0.000
23	2.635	-0.756	4.182	4.782
23	5.269	-1.513	8.363	0.000
23	5.172	-1.456	8.363	0.000
24	2.635	-0.756	4.182	4.782
24	5.172	-1.456	8.363	0.000
24	0.000	0.000	0.000	0.000
25	14.324	-7.785	9.400	586.560
25	28.647	-15.571	18.800	0.000
25	12.799	-16.679	18.800	0.000
26	14.324	-7.785	9.400	586.560
26	12.799	-16.679	18.800	0.000
26	0.000	0.000	0.000	0.000
27	14.324	-7.785	9.400	586.560
27	28.647	-15.571	18.800	0.000
27	12.799	-16.679	18.800	0.000
28	14.324	-7.785	9.400	586.560
28	12.799	-16.679	18.800	0.000
28	0.000	0.000	0.000	0.000
29	3.607	-1.960	2.367	147.701
29	7.214	-3.921	4.734	0.000
29	3.223	-4.200	4.734	0.000
30	3.607	-1.960	2.367	147.701
30	3.223	-4.200	4.734	0.000
30	0.000	0.000	0.000	0.000
31	11.631	-3.339	18.462	21.110
31	11.845	-3.400	18.800	0.000
31	11.626	-3.274	18.800	0.000
32	11.631	-3.339	18.462	21.110
32	11.626	-3.274	18.800	0.000
32	0.000	0.000	0.000	0.000
33	11.631	-3.339	18.462	21.110
33	11.845	-3.400	18.800	0.000
33	11.626	-3.274	18.800	0.000
34	11.631	-3.339	18.462	21.110
34	11.626	-3.274	18.800	0.000
34	0.000	0.000	0.000	0.000
35	11.631	-3.339	18.462	21.110
35	11.845	-3.400	18.800	0.000
35	11.626	-3.274	18.800	0.000
36	11.631	-3.339	18.462	21.110
36	11.626	-3.274	18.800	0.000
36	0.000	0.000	0.000	0.000
37	5.174	-1.485	8.213	9.391
37	5.269	-1.513	8.363	0.000
37	5.172	-1.456	8.363	0.000
38	5.174	-1.485	8.213	9.391
38	5.172	-1.456	8.363	0.000
38	0.000	0.000	0.000	0.000
39	10.012	15.166	7.057	732.761
39	26.673	40.402	18.800	0.000

39	8.677	30.427	18.800	0.000
40	10.012	15.166	7.057	732.761
40	8.677	30.427	18.800	0.000
40	0.000	0.000	0.000	0.000
41	10.012	15.166	7.057	732.761
41	26.673	40.402	18.800	0.000
41	8.677	30.427	18.800	0.000
42	10.012	15.166	7.057	732.761
42	8.677	30.427	18.800	0.000
42	0.000	0.000	0.000	0.000
43	2.131	3.227	1.502	155.932
43	5.676	8.598	4.001	0.000
43	1.847	6.475	4.001	0.000
44	2.131	3.227	1.502	155.932
44	1.847	6.475	4.001	0.000
44	0.000	0.000	0.000	0.000
45	1.928	2.920	1.359	141.092
45	5.136	7.779	3.620	0.000
45	1.671	5.859	3.620	0.000
46	1.928	2.920	1.359	141.092
46	1.671	5.859	3.620	0.000
46	0.000	0.000	0.000	0.000
47	11.571	-0.325	13.549	40.636
47	12.127	-0.341	14.200	0.000
47	11.588	-0.516	14.200	0.000
48	11.571	-0.325	13.549	40.636
48	11.588	-0.516	14.200	0.000
48	0.000	0.000	0.000	0.000
49	11.571	-0.325	13.549	40.636
49	12.127	-0.341	14.200	0.000
49	11.588	-0.516	14.200	0.000
50	11.571	-0.325	13.549	40.636
50	11.588	-0.516	14.200	0.000
50	0.000	0.000	0.000	0.000
51	11.571	-0.325	13.549	40.636
51	12.127	-0.341	14.200	0.000
51	11.588	-0.516	14.200	0.000
52	11.571	-0.325	13.549	40.636
52	11.588	-0.516	14.200	0.000
52	0.000	0.000	0.000	0.000
53	6.195	-0.174	7.254	21.757
53	6.493	-0.183	7.603	0.000
53	6.204	-0.276	7.603	0.000
54	6.195	-0.174	7.254	21.757
54	6.204	-0.276	7.603	0.000
54	0.000	0.000	0.000	0.000
55	12.039	-5.676	6.972	451.006
55	24.520	-11.559	14.200	0.000
55	11.918	-4.284	14.200	0.000
56	12.039	-5.676	6.972	451.006
56	11.918	-4.284	14.200	0.000
56	0.000	0.000	0.000	0.000
57	12.039	-5.676	6.972	451.006
57	24.520	-11.559	14.200	0.000

57	11.918	-4.284	14.200	0.000
58	12.039	-5.676	6.972	451.006
58	11.918	-4.284	14.200	0.000
58	0.000	0.000	0.000	0.000
59	4.040	-1.905	2.340	151.344
59	8.228	-3.879	4.765	0.000
59	3.999	-1.437	4.765	0.000
60	4.040	-1.905	2.340	151.344
60	3.999	-1.437	4.765	0.000
60	0.000	0.000	0.000	0.000
61	3.934	-1.855	2.278	147.378
61	8.012	-3.777	4.640	0.000
61	3.894	-1.400	4.640	0.000
62	3.934	-1.855	2.278	147.378
62	3.894	-1.400	4.640	0.000
62	0.000	0.000	0.000	0.000

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
27.647	295.241	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	7.413	3.896
Joint 2	6.218	4.755

Persistence

Joint 1 [ft]	10.000
Joint 2 [ft]	10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	20.153	34.000
Joint 1 & Crest	53.655	91.000
Joint 2 & Crest	106.193	55.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	47.000	356.000
Joint Set 2	81.000	210.000
Slope	51.000	265.000
Upper Face	0.000	265.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	14.2
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	YES
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Joint Water Pressure Data

Water Unit Weight [lbs/ft3]	62.4
Pore Pressure Distribution Model	Peak Pressure - Beneath Crest
Water Depth Model	Percent Filled
Percent Filled	100
Hu	1

Joint Plane Application

Joint1	YES
Joint2	YES

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	East	North	Up
124	0.000	0.000	0.000
134	4.126	-4.049	4.640
234	3.894	-1.400	4.640
123	8.012	-3.777	4.640

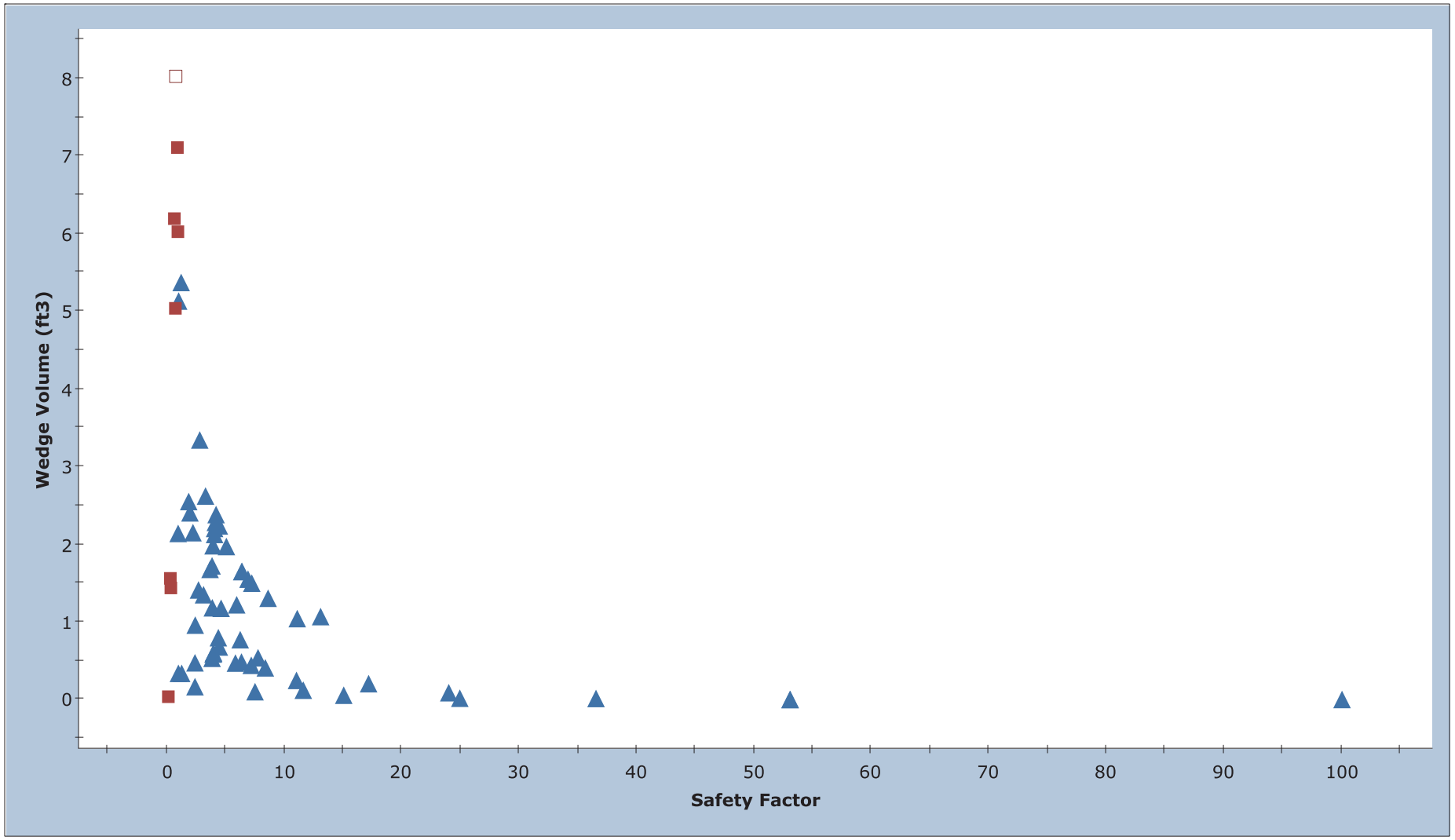
Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	15 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg

Safety Factor vs. Wedge Volume (ft3)



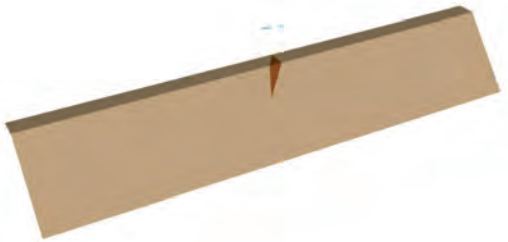
rocscience	Project	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	Company: GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	File Name: NB_265 (307+50).swd7

SWEDGE 7.021



Top - Scaled

Factor of Safety: 0.8162



Perspective - Scaled



Front - Scaled



Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
SWEDGE 7.021	*Date*	1/6/2025, 5:55:48 PM	*File Name* NB_265 (307+50).swd7

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	NB_265 (308+00)
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	73
Number of Invalid Wedges	4877
Number of Failed Wedges	16
Number of Stable Wedges	57

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.9048

Safety Factor	0.9465
Wedge Height (On Slope) [ft]	3.620
Bench Width (On Upper Face) [ft]	3.619
Wedge Volume [ft3]	11.345
Wedge Weight [lbs]	1951.341
Wedge Area (Joint1) [ft2]	15.396
Wedge Area (Joint2) [ft2]	11.156
Wedge Area (Slope) [ft2]	10.971
Wedge Area (Upper Face) [ft2]	9.402

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	322.020	1111.713
Effective Normal Stress [psf]	20.916	99.654
Shear Strength [psf]	9.753	46.469
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	706.369
Resisting Force [lbs]	668.561

Water Pressures/Forces

	Average Pressure [psf]	Force [lbs]
Joint 1	47.031	724.090
Joint 2	47.031	524.662
Slope	0.000	0.000

Joint 1

Wetted Area [ft2] 3015.342

Line of Thrust	East	North	Up
Direction	-604.080	256.417	306.014
Point of Application	11.849	14.676	11.091

Polygon #	East	North	Up	Water Pressure [psf]
1	11.631	-3.339	18.462	21.110
1	11.845	-3.400	18.800	0.000
1	11.649	-3.537	18.800	0.000
2	11.631	-3.339	18.462	21.110
2	11.649	-3.537	18.800	0.000
2	0.000	0.000	0.000	0.000
3	11.631	-3.339	18.462	21.110
3	11.845	-3.400	18.800	0.000
3	11.649	-3.537	18.800	0.000
4	11.631	-3.339	18.462	21.110
4	11.649	-3.537	18.800	0.000
4	0.000	0.000	0.000	0.000
5	11.631	-3.339	18.462	21.110
5	11.845	-3.400	18.800	0.000
5	11.649	-3.537	18.800	0.000
6	11.631	-3.339	18.462	21.110
6	11.649	-3.537	18.800	0.000
6	0.000	0.000	0.000	0.000
7	5.174	-1.485	8.213	9.391
7	5.269	-1.513	8.363	0.000
7	5.182	-1.574	8.363	0.000
8	5.174	-1.485	8.213	9.391
8	5.182	-1.574	8.363	0.000
8	0.000	0.000	0.000	0.000
9	10.012	15.166	7.057	732.761
9	26.673	40.402	18.800	0.000
9	11.029	3.546	18.800	0.000
10	10.012	15.166	7.057	732.761
10	11.029	3.546	18.800	0.000
10	0.000	0.000	0.000	0.000
11	10.012	15.166	7.057	732.761
11	26.673	40.402	18.800	0.000
11	11.029	3.546	18.800	0.000
12	10.012	15.166	7.057	732.761
12	11.029	3.546	18.800	0.000
12	0.000	0.000	0.000	0.000
13	2.131	3.227	1.502	155.932
13	5.676	8.598	4.001	0.000
13	2.347	0.755	4.001	0.000
14	2.131	3.227	1.502	155.932
14	2.347	0.755	4.001	0.000
14	0.000	0.000	0.000	0.000
15	1.928	2.920	1.359	141.092
15	5.136	7.779	3.620	0.000
15	2.124	0.683	3.620	0.000
16	1.928	2.920	1.359	141.092
16	2.124	0.683	3.620	0.000
16	0.000	0.000	0.000	0.000

Joint 2

Wetted Area [ft2] 2197.568

Line of Thrust	East	North	Up
Direction	163.500	-294.962	401.915
Point of Application	11.265	21.348	11.091

Polygon #	East	North	Up	Water Pressure [psf]
1	11.631	-3.339	18.462	21.110
1	11.845	-3.400	18.800	0.000
1	11.626	-3.274	18.800	0.000
2	11.631	-3.339	18.462	21.110
2	11.626	-3.274	18.800	0.000
2	0.000	0.000	0.000	0.000
3	11.631	-3.339	18.462	21.110
3	11.845	-3.400	18.800	0.000
3	11.626	-3.274	18.800	0.000
4	11.631	-3.339	18.462	21.110
4	11.626	-3.274	18.800	0.000
4	0.000	0.000	0.000	0.000
5	11.631	-3.339	18.462	21.110
5	11.845	-3.400	18.800	0.000
5	11.626	-3.274	18.800	0.000
6	11.631	-3.339	18.462	21.110
6	11.626	-3.274	18.800	0.000
6	0.000	0.000	0.000	0.000
7	5.174	-1.485	8.213	9.391
7	5.269	-1.513	8.363	0.000
7	5.172	-1.456	8.363	0.000
8	5.174	-1.485	8.213	9.391
8	5.172	-1.456	8.363	0.000
8	0.000	0.000	0.000	0.000
9	10.012	15.166	7.057	732.761
9	26.673	40.402	18.800	0.000
9	8.677	30.427	18.800	0.000
10	10.012	15.166	7.057	732.761
10	8.677	30.427	18.800	0.000
10	0.000	0.000	0.000	0.000
11	10.012	15.166	7.057	732.761
11	26.673	40.402	18.800	0.000
11	8.677	30.427	18.800	0.000
12	10.012	15.166	7.057	732.761
12	8.677	30.427	18.800	0.000
12	0.000	0.000	0.000	0.000
13	2.131	3.227	1.502	155.932
13	5.676	8.598	4.001	0.000
13	1.847	6.475	4.001	0.000
14	2.131	3.227	1.502	155.932
14	1.847	6.475	4.001	0.000
14	0.000	0.000	0.000	0.000
15	1.928	2.920	1.359	141.092
15	5.136	7.779	3.620	0.000
15	1.671	5.859	3.620	0.000
16	1.928	2.920	1.359	141.092
16	1.671	5.859	3.620	0.000
16	0.000	0.000	0.000	0.000

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
21.223	213.433	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	4.252	7.709
Joint 2	7.087	3.962

Persistence

Joint 1 [ft] 10.000
Joint 2 [ft] 10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	46.733	38.000
Joint 1 & Crest	96.688	28.000
Joint 2 & Crest	36.579	114.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	65.000	293.000
Joint Set 2	40.000	151.000
Slope	59.000	265.000
Upper Face	0.000	265.000

Joint Set 1 Data

Cohesion [psf] 0
Friction Angle [deg] 25
Waviness Angle [deg] 0

Joint Set 2 Data

Cohesion [psf] 0
Friction Angle [deg] 25
Waviness Angle [deg] 0

Slope Data

Slope Height [ft]	18.8
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	YES
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Joint Water Pressure Data

Water Unit Weight [lbs/ft3]	62.4
Pore Pressure Distribution Model	Peak Pressure - Beneath Crest
Water Depth Model	Percent Filled
Percent Filled	100
Hu	1

Joint Plane Application

Joint1	YES
Joint2	YES

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	East	North	Up
124	0.000	0.000	0.000
134	2.124	0.683	3.620
234	1.671	5.859	3.620
123	5.136	7.779	3.620

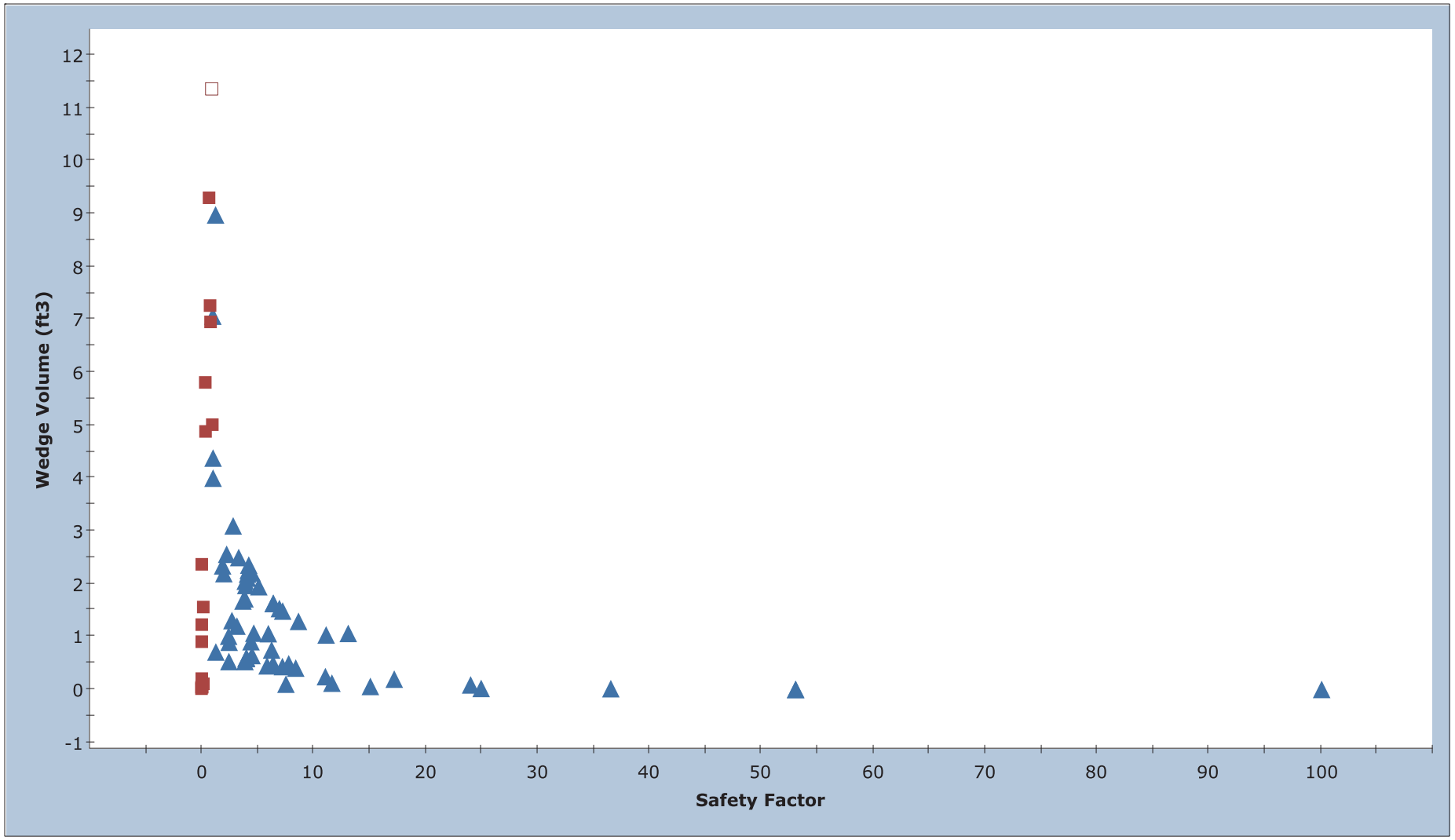
Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	15 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg

Safety Factor vs. Wedge Volume (ft3)



rocscience	Project	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	Company: GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	File Name: NB_265 (308+00).swd7

SWEDGE 7.021



Top - Scaled

Factor of Safety: 0.9465



Perspective - Scaled



Front - Scaled



Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	*File Name* NB_265 (308+00).swd7

SWEDGE 7.021

	Average Pressure [psf]	Force [lbs]
Joint 1	105.201	1942.708
Joint 2	105.201	1712.873
Slope	0.000	0.000

Joint 1

Wetted Area [ft2] 5506.565

Line of Thrust	East	North	Up
Direction	-833.017	-1707.938	403.912
Point of Application	5.677	-0.577	11.496

Polygon #	East	North	Up	Water Pressure [psf]
1	5.187	-0.090	10.314	604.376
1	10.057	-0.175	20.000	0.000
1	7.085	-7.176	20.000	0.000
2	5.187	-0.090	10.314	604.376
2	7.085	-7.176	20.000	0.000
2	0.000	0.000	0.000	0.000
3	5.187	-0.090	10.314	604.376
3	10.057	-0.175	20.000	0.000
3	7.085	-7.176	20.000	0.000
4	5.187	-0.090	10.314	604.376
4	7.085	-7.176	20.000	0.000
4	0.000	0.000	0.000	0.000
5	4.431	-0.077	8.811	516.287
5	8.591	-0.150	17.085	0.000
5	6.053	-6.130	17.085	0.000
6	4.431	-0.077	8.811	516.287
6	6.053	-6.130	17.085	0.000
6	0.000	0.000	0.000	0.000
7	2.316	-0.040	4.605	269.826
7	4.490	-0.078	8.929	0.000
7	3.163	-3.204	8.929	0.000
8	2.316	-0.040	4.605	269.826
8	3.163	-3.204	8.929	0.000
8	0.000	0.000	0.000	0.000
9	5.394	-0.866	7.464	782.218
9	14.454	-2.320	20.000	0.000
9	4.481	2.544	20.000	0.000
10	5.394	-0.866	7.464	782.218
10	4.481	2.544	20.000	0.000
10	0.000	0.000	0.000	0.000
11	5.394	-0.866	7.464	782.218
11	14.454	-2.320	20.000	0.000
11	4.481	2.544	20.000	0.000
12	5.394	-0.866	7.464	782.218
12	4.481	2.544	20.000	0.000
12	0.000	0.000	0.000	0.000
13	2.577	-0.414	3.565	373.630
13	6.904	-1.108	9.553	0.000
13	2.140	1.215	9.553	0.000
14	2.577	-0.414	3.565	373.630
14	2.140	1.215	9.553	0.000

14	0.000	0.000	0.000	0.000
15	2.177	-0.349	3.012	315.603
15	5.832	-0.936	8.069	0.000
15	1.808	1.027	8.069	0.000
16	2.177	-0.349	3.012	315.603
16	1.808	1.027	8.069	0.000
16	0.000	0.000	0.000	0.000
17	5.394	-0.866	7.464	782.218
17	14.454	-2.320	20.000	0.000
17	4.481	2.544	20.000	0.000
18	5.394	-0.866	7.464	782.218
18	4.481	2.544	20.000	0.000
18	0.000	0.000	0.000	0.000
19	5.394	-0.866	7.464	782.218
19	14.454	-2.320	20.000	0.000
19	4.481	2.544	20.000	0.000
20	5.394	-0.866	7.464	782.218
20	4.481	2.544	20.000	0.000
20	0.000	0.000	0.000	0.000
21	2.577	-0.414	3.565	373.630
21	6.904	-1.108	9.553	0.000
21	2.140	1.215	9.553	0.000
22	2.577	-0.414	3.565	373.630
22	2.140	1.215	9.553	0.000
22	0.000	0.000	0.000	0.000
23	2.177	-0.349	3.012	315.603
23	5.832	-0.936	8.069	0.000
23	1.808	1.027	8.069	0.000
24	2.177	-0.349	3.012	315.603
24	1.808	1.027	8.069	0.000
24	0.000	0.000	0.000	0.000

Joint 2

Wetted Area [ft2] 4516.188

Line of Thrust	East	North	Up
Direction	-875.382	1250.174	777.628
Point of Application	6.037	-1.817	11.479

Polygon #	East	North	Up	Water Pressure [psf]
1	5.187	-0.090	10.314	604.376
1	10.057	-0.175	20.000	0.000
1	4.481	2.544	20.000	0.000
2	5.187	-0.090	10.314	604.376
2	4.481	2.544	20.000	0.000
2	0.000	0.000	0.000	0.000
3	5.187	-0.090	10.314	604.376
3	10.057	-0.175	20.000	0.000
3	4.481	2.544	20.000	0.000
4	5.187	-0.090	10.314	604.376
4	4.481	2.544	20.000	0.000
4	0.000	0.000	0.000	0.000
5	4.431	-0.077	8.811	516.287
5	8.591	-0.150	17.085	0.000

5	3.828	2.174	17.085	0.000
6	4.431	-0.077	8.811	516.287
6	3.828	2.174	17.085	0.000
6	0.000	0.000	0.000	0.000
7	2.316	-0.040	4.605	269.826
7	4.490	-0.078	8.929	0.000
7	2.000	1.136	8.929	0.000
8	2.316	-0.040	4.605	269.826
8	2.000	1.136	8.929	0.000
8	0.000	0.000	0.000	0.000
9	5.394	-0.866	7.464	782.218
9	14.454	-2.320	20.000	0.000
9	7.154	-7.431	20.000	0.000
10	5.394	-0.866	7.464	782.218
10	7.154	-7.431	20.000	0.000
10	0.000	0.000	0.000	0.000
11	5.394	-0.866	7.464	782.218
11	14.454	-2.320	20.000	0.000
11	7.154	-7.431	20.000	0.000
12	5.394	-0.866	7.464	782.218
12	7.154	-7.431	20.000	0.000
12	0.000	0.000	0.000	0.000
13	2.577	-0.414	3.565	373.630
13	6.904	-1.108	9.553	0.000
13	3.417	-3.550	9.553	0.000
14	2.577	-0.414	3.565	373.630
14	3.417	-3.550	9.553	0.000
14	0.000	0.000	0.000	0.000
15	2.177	-0.349	3.012	315.603
15	5.832	-0.936	8.069	0.000
15	2.886	-2.998	8.069	0.000
16	2.177	-0.349	3.012	315.603
16	2.886	-2.998	8.069	0.000
16	0.000	0.000	0.000	0.000
17	5.394	-0.866	7.464	782.218
17	14.454	-2.320	20.000	0.000
17	7.154	-7.431	20.000	0.000
18	5.394	-0.866	7.464	782.218
18	7.154	-7.431	20.000	0.000
18	0.000	0.000	0.000	0.000
19	5.394	-0.866	7.464	782.218
19	14.454	-2.320	20.000	0.000
19	7.154	-7.431	20.000	0.000
20	5.394	-0.866	7.464	782.218
20	7.154	-7.431	20.000	0.000
20	0.000	0.000	0.000	0.000
21	2.577	-0.414	3.565	373.630
21	6.904	-1.108	9.553	0.000
21	3.417	-3.550	9.553	0.000
22	2.577	-0.414	3.565	373.630
22	3.417	-3.550	9.553	0.000
22	0.000	0.000	0.000	0.000
23	2.177	-0.349	3.012	315.603
23	5.832	-0.936	8.069	0.000

23	2.886	-2.998	8.069	0.000
24	2.177	-0.349	3.012	315.603
24	2.886	-2.998	8.069	0.000
24	0.000	0.000	0.000	0.000

Failure Mode

Sliding on joint2

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
53.798	279.118	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	8.333	4.477
Joint 2	9.079	3.596

Persistence

Joint 1 [ft]	10.000
Joint 2 [ft]	10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	27.260	61.000
Joint 1 & Crest	86.397	49.000
Joint 2 & Crest	66.343	70.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	78.000	206.000
Joint Set 2	63.000	325.000
Slope	76.000	255.000
Upper Face	0.000	255.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	20
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	YES
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Joint Water Pressure Data

Water Unit Weight [lbs/ft3]	62.4
Pore Pressure Distribution Model	Peak Pressure - Beneath Crest
Water Depth Model	Percent Filled
Percent Filled	100
Hu	1

Joint Plane Application

Joint1	YES
Joint2	YES

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	East	North	Up
124	0.000	0.000	0.000
134	1.808	1.027	8.069
234	2.886	-2.998	8.069
123	5.832	-0.936	8.069

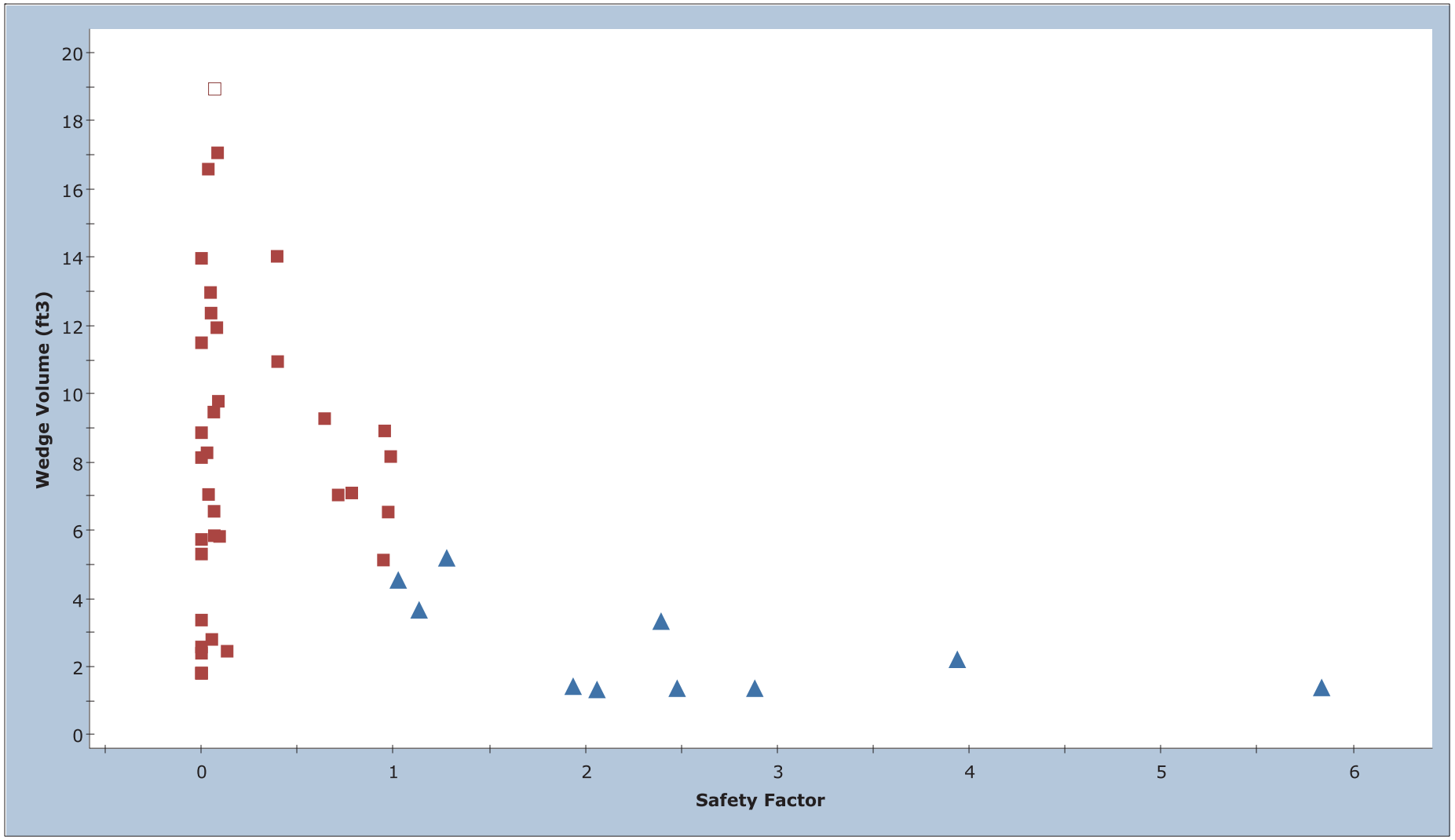
Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	15 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg

Safety Factor vs. Wedge Volume (ft3)



rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	*File Name* NB_255 (308+50).swd7

SWEDGE 7.021



Top - Scaled

Factor of Safety: 0.0697



Perspective - Scaled



Front - Scaled



Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
SWEDGE 7.021	*Date*	1/6/2025, 5:55:48 PM	*File Name* NB_255 (308+50).swd7

SWedge Analysis Information
Wilmington Route 38 Rock Slope Evaluation

Project Summary

File Name	SB
Project Title	Wilmington Route 38 Rock Slope Evaluation
Analysis	SWEDGE - Surface Wedge Stability Analysis
Author	M. Wong
Company	GEI Consultants, Inc
Date Created	1/6/2025, 5:55:48 PM

Analysis Results

Analysis Type - Combinations

Number of Combinations	4950
Number of Valid Wedges	24
Number of Invalid Wedges	4926
Number of Failed Wedges	5
Number of Stable Wedges	19

Current Wedge Data - Picked Wedge

Wedge is Scaled, Scale Factor 0.9792

Safety Factor	0.8267
Wedge Height (On Slope) [ft]	5.535
Bench Width (On Upper Face) [ft]	3.917
Wedge Volume [ft3]	23.465
Wedge Weight [lbs]	4035.997
Wedge Area (Joint1) [ft2]	16.929
Wedge Area (Joint2) [ft2]	20.853
Wedge Area (Slope) [ft2]	18.899
Wedge Area (Upper Face) [ft2]	12.717

Effective Normal and Strength Properties

	Joint 1	Joint 2
Effective Normal Force [lbs]	608.215	3352.620
Effective Normal Stress [psf]	35.928	160.775
Shear Strength [psf]	16.754	74.971
Strength due to Waviness [psf]	0.000	0.000

Driving Force [lbs]	2234.110
Resisting Force [lbs]	1846.968

Failure Mode

Sliding on intersection line (joints 1&2)

Joint Sets 1&2 Line of Intersection

Plunge [deg]	Trend [deg]	Length [ft]
33.611	34.334	10.000

Trace Lengths

	Slope Face [ft]	Upper Face [ft]
Joint 1	5.984	6.093
Joint 2	9.800	4.321

Persistence

Joint 1 [ft]	10.000
Joint 2 [ft]	10.000

Intersection Angles

	Slope Face	Upper Face
Joint 1 & Joint 2	40.132	75.000
Joint 1 & Crest	103.432	40.000
Joint 2 & Crest	36.436	65.000

Dip and Dip Direction

	Dip [deg]	Dip Direction [deg]
Joint Set 1	85.000	121.000
Joint Set 2	35.000	16.000
Slope	72.000	81.000
Upper Face	0.000	81.000

Joint Set 1 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Joint Set 2 Data

Cohesion [psf]	0
Friction Angle [deg]	25
Waviness Angle [deg]	0

Slope Data

Slope Height [ft]	11.5
Bench Width [ft]	4
Rock Unit Weight [lbs/ft3]	172
Water Pressures in the Slope	NO
Overhanging Slope Face	NO
Externally Applied Force	NO
Tension Crack	NO

Wedge Vertices - Picked Wedge

Coordinates in Easting,Northing,Up Format
1=Joint1, 2=Joint2, 3=Upper Face, 4=Slope

Point	East	North	Up
124	0.000	0.000	0.000
134	-1.559	-1.654	5.535
234	-0.543	-8.068	5.535
123	-4.697	-6.877	5.535

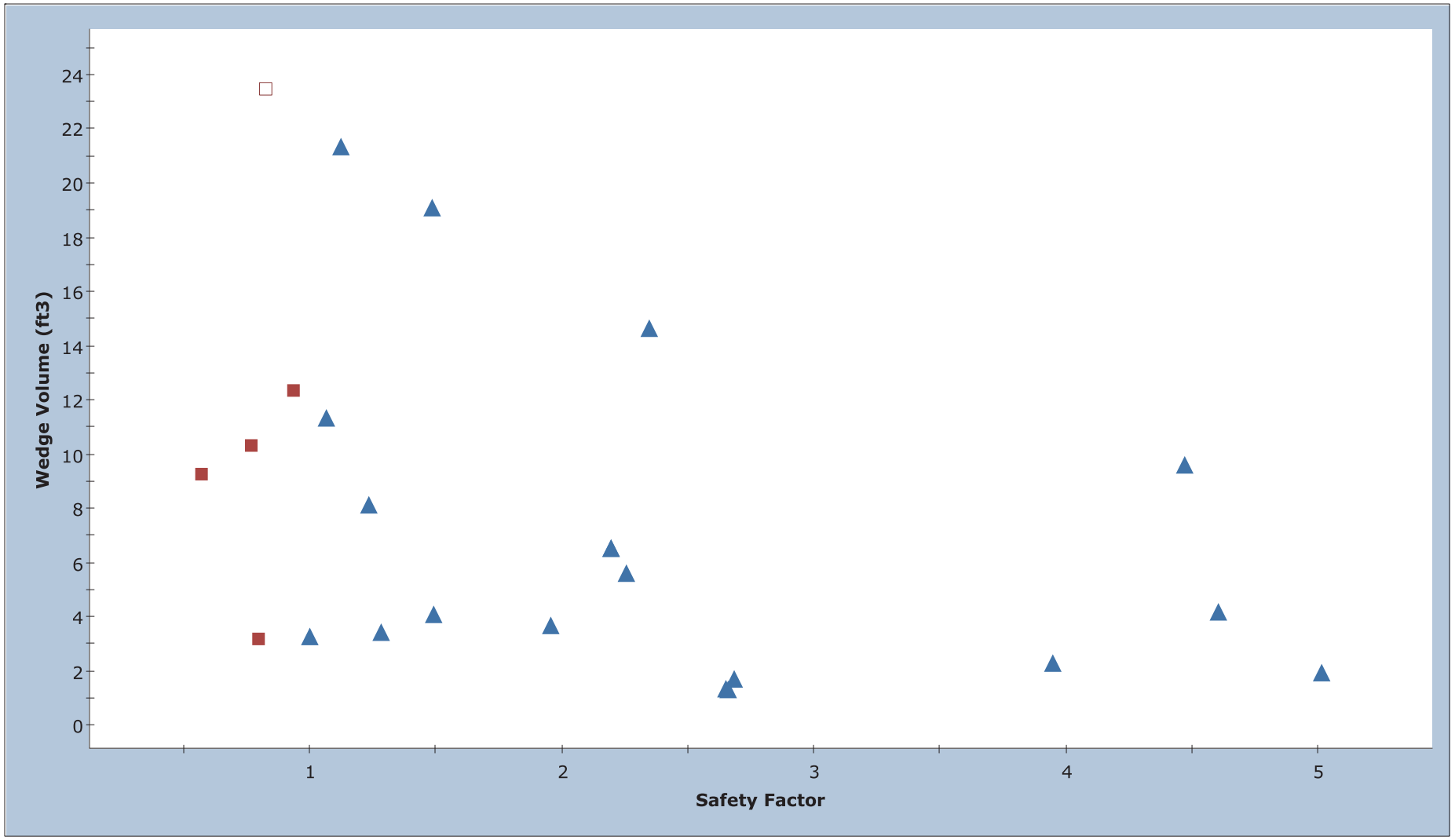
Scaling

Maximum Persistence	
Joint 1 Scaling	10 ft
Joint 2 Scaling	10 ft

Spill Width Parameters

Swelling Factor	1.5
Angle of Repose of Failed Material	38 deg

Safety Factor vs. Wedge Volume (ft3)



rocscience	Project	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	Company: GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	File Name: SB.swd7
SWEDGE 7.021			

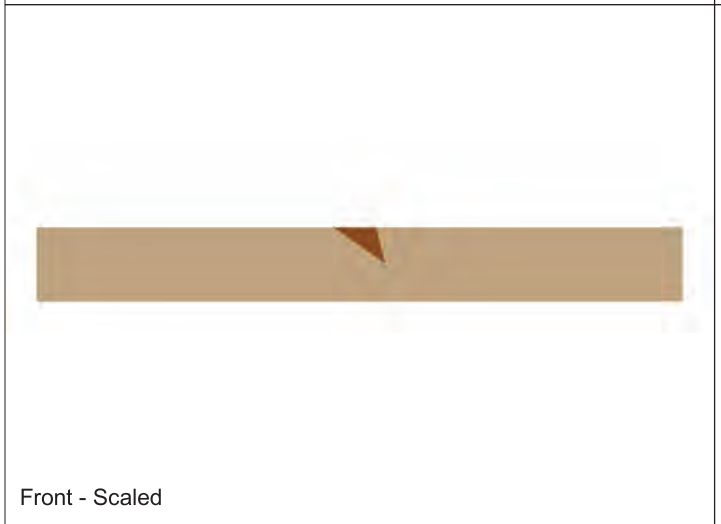


Top - Scaled

Factor of Safety: 0.8267



Perspective - Scaled



Front - Scaled



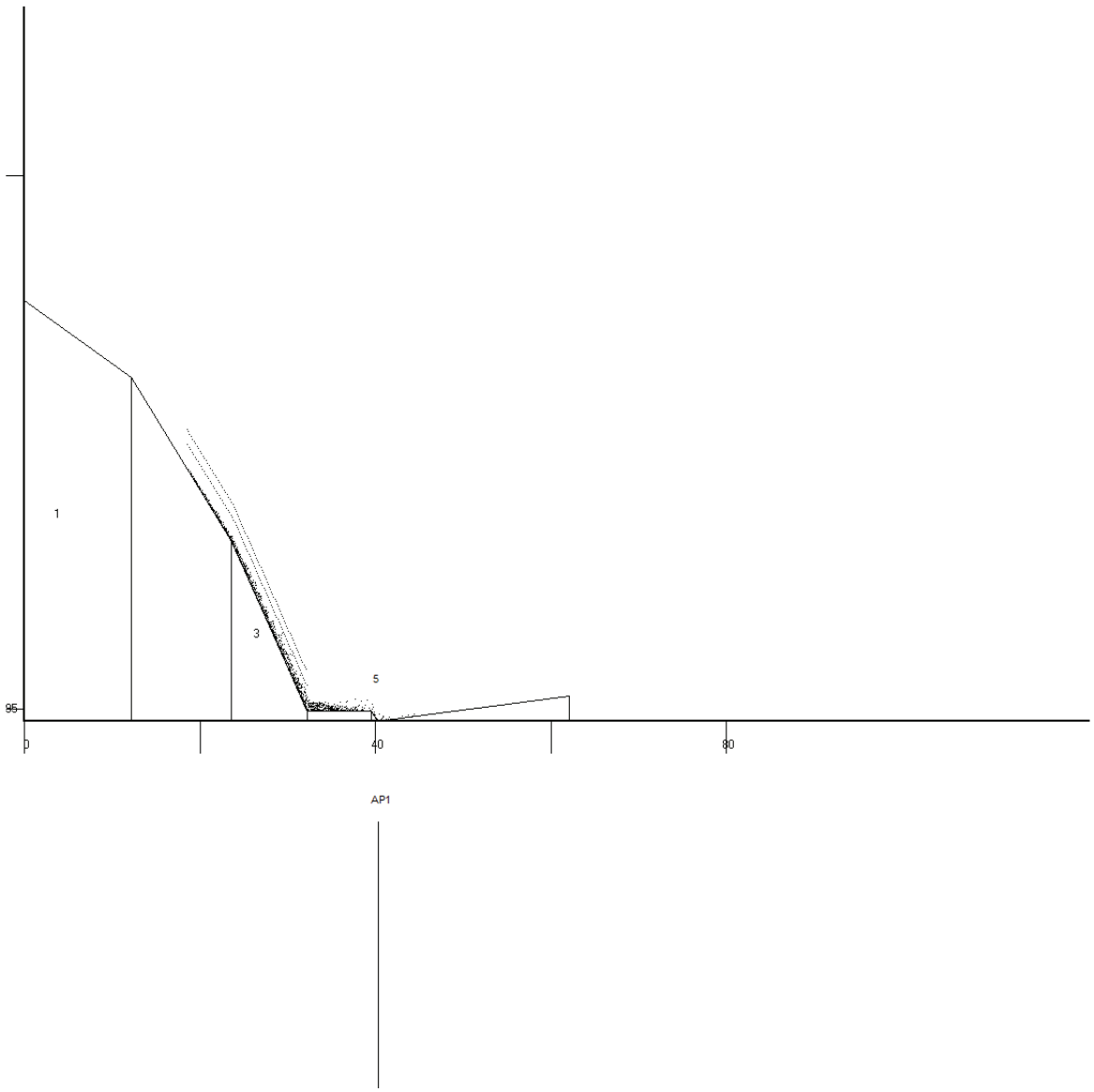
Side - Scaled

rocscience	*Project*	Wilmington Route 38 Rock Slope Evaluation	
	Analysis Description	SWEDGE - Surface Wedge Stability Analysis	
	Drawn By	M. Wong	*Company* GEI Consultants, Inc
	Date	1/6/2025, 5:55:48 PM	*File Name* SB.swd7

SWEDGE 7.021

Appendix F CRSP Rockfall Simulation Results

CRSP Results for Northbound side Rock Slope Station 307+50 (Existing Condition)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\307_50_NB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point 1 X-Coordinate: 40.3
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 104.1
Initial Y-Base Starting Zone Coordinate: 95

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	110.3	12.2	107.43
2	1.0	.95	.15	12.2	107.43	23.63	101.3
3	1.0	.95	.15	23.63	101.3	32.22	94.92
4	1.0	.95	.15	32.22	94.92	39.5	94.92
5	1.0	.95	.15	39.5	94.92	40.29	94.56
6	1.0	.95	.15	40.29	94.56	62.07	95.48

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\307_50_NB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 6
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\307_50_NB.dat

Analysis Point 1: X = 40.3, Y = 95

Total Rocks Passing Analysis Point: 7

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	5.97	2674	0.02
75%	7.75	4190	4.8
90%	9.35	5553	9.1
95%	10.31	6371	11.68
98%	11.39	7289	14.58

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 9.73	Maximum: .32	Maximum: 6064
Average: 5.97	Average: .07	Average: 2674
Minimum: 3.09	G. Mean: .02	Std. Dev.: 2244
Std. Dev.: 2.64	Std. Dev.: 7.08	

Remarks:

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\307_50_NB.dat

Velocity Units: ft/sec Bounce Height Units: ft

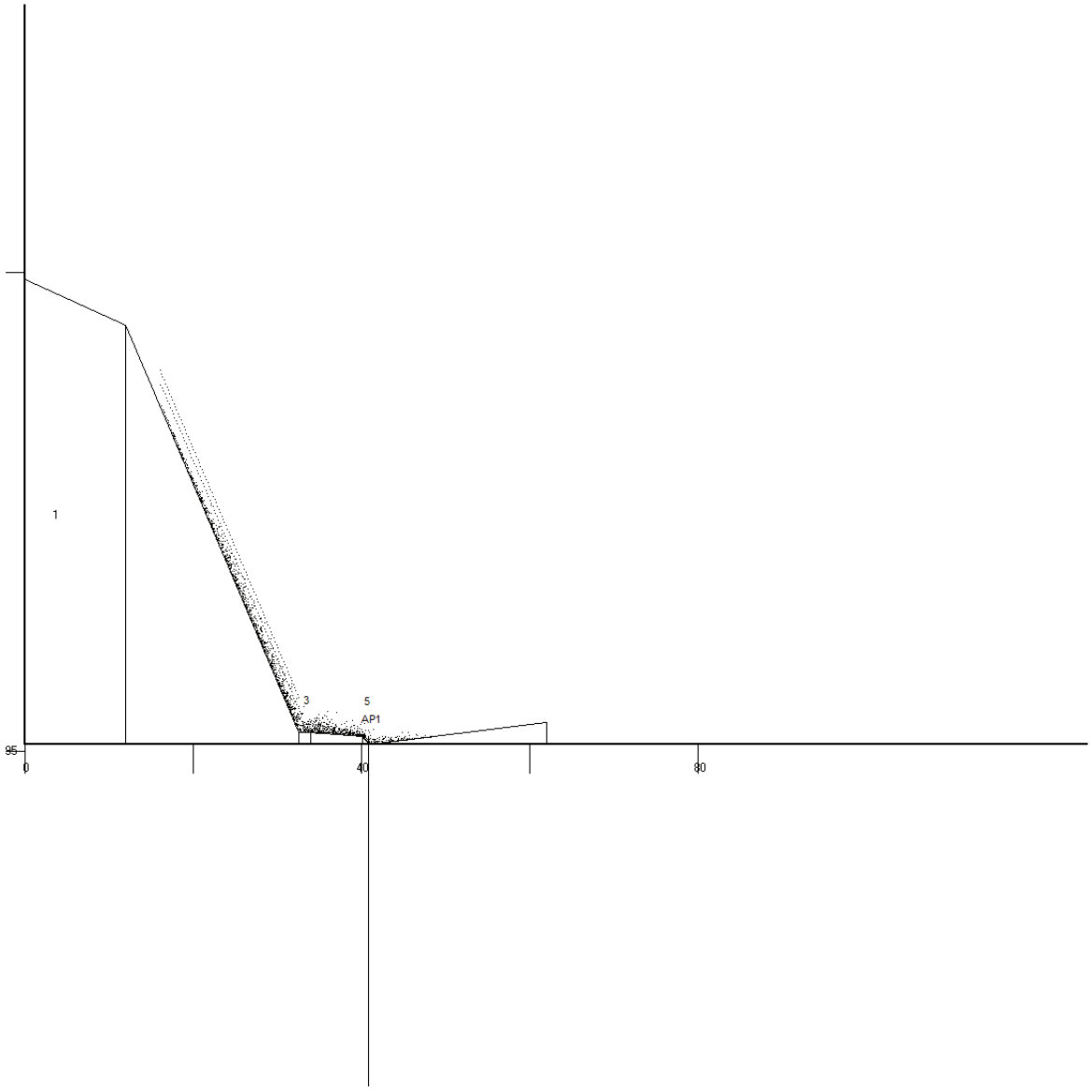
Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	11	7	1.52	1	0
3	17	11	3.07	1	0

4	9	5	2.15	0	0
5	10	6	2.63	0	0
6	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\307_50_NB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	3
20 To 30 ft	7
30 To 40 ft	83
40 To 50 ft	7
50 To 60 ft	0
60 To 62.07 ft	0

CRSP Results for Northbound side Rock Slope Station 308+00 (Existing Condition)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Raw Results\308_00_NB.bmp

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point 1 X-Coordinate: 40.9
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 109.5
Initial Y-Base Starting Zone Coordinate: 95.7

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	114.7	11.99	112.8
2	1.0	.95	.15	11.99	112.8	32.58	95.77
3	1.0	.95	.15	32.58	95.77	33.99	95.77
4	1.0	.95	.15	33.99	95.77	40.12	95.62
5	1.0	.95	.15	40.12	95.62	40.94	95.27
6	1.0	.95	.15	40.94	95.27	61.97	96.18

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Raw Results\308_00_NB.bmp

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 6
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Raw Results\308_00_NB.bmp

Analysis Point 1: X = 40.9, Y = 95

Total Rocks Passing Analysis Point: 36

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	8.34	4940	0.04
75%	10.13	6852	5.99
90%	11.74	8572	11.34
95%	12.7	9604	14.56
98%	13.79	10763	18.16

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 12.74	Maximum: .78	Maximum: 10057
Average: 8.34	Average: .13	Average: 4940
Minimum: 3.62	G. Mean: .04	Std. Dev.: 2831
Std. Dev.: 2.65	Std. Dev.: 8.81	

Remarks:

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Raw Results\308_00_NB.bmp

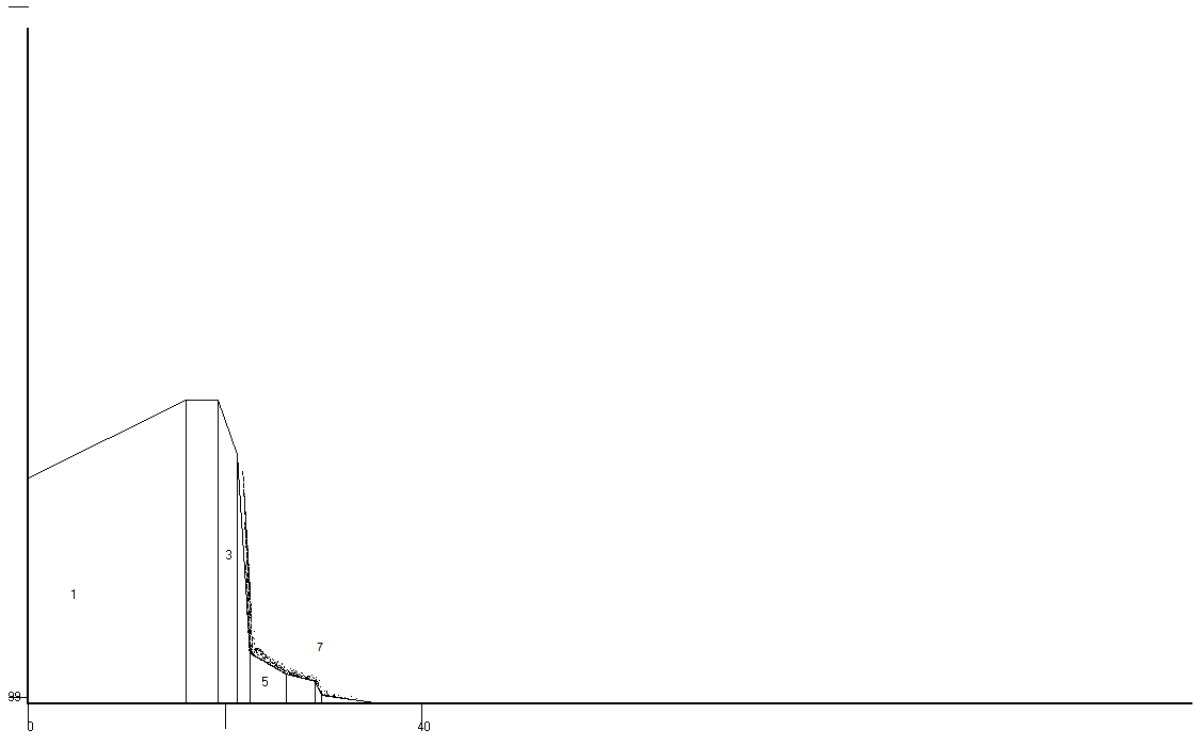
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	22	14	4.38	2	0
3	19	9	3.54	1	0
4	12	7	2.83	1	0
5	13	8	2.68	1	0
6	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Raw Results\308_00_NB.bmp

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	63
40 To 50 ft	37
50 To 60 ft	0
60 To 61.97 ft	0

CRSP Results for Northbound side Rock Slope Station 308+50 (Existing Condition)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_NB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point 1 X-Coordinate: 41.17
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 110.5
Initial Y-Base Starting Zone Coordinate: 96.6

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	116.09	20.95	113.75
2	1.0	.95	.15	20.95	113.75	28.81	105.77
3	1.0	.95	.15	28.81	105.77	35.46	96.49
4	1.0	.95	.15	35.46	96.49	37.97	96.29
5	1.0	.95	.15	37.97	96.29	40.21	95.97
6	1.0	.95	.15	40.21	95.97	41.15	95.64
7	1.0	.95	.15	41.15	95.64	61.96	96.56

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_NB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 7
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_NB.dat

Analysis Point 1: X = 41.17, Y = 96

Total Rocks Passing Analysis Point: 60

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	9.05	5877	0.04
75%	11.05	8326	6.03
90%	12.85	10529	11.41
95%	13.93	11852	14.64
98%	15.14	13336	18.27

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 15.14	Maximum: .76	Maximum: 14816
Average: 9.05	Average: .16	Average: 5877
Minimum: 3.88	G. Mean: .04	Std. Dev.: 3627
Std. Dev.: 2.96	Std. Dev.: 8.87	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_NB.dat

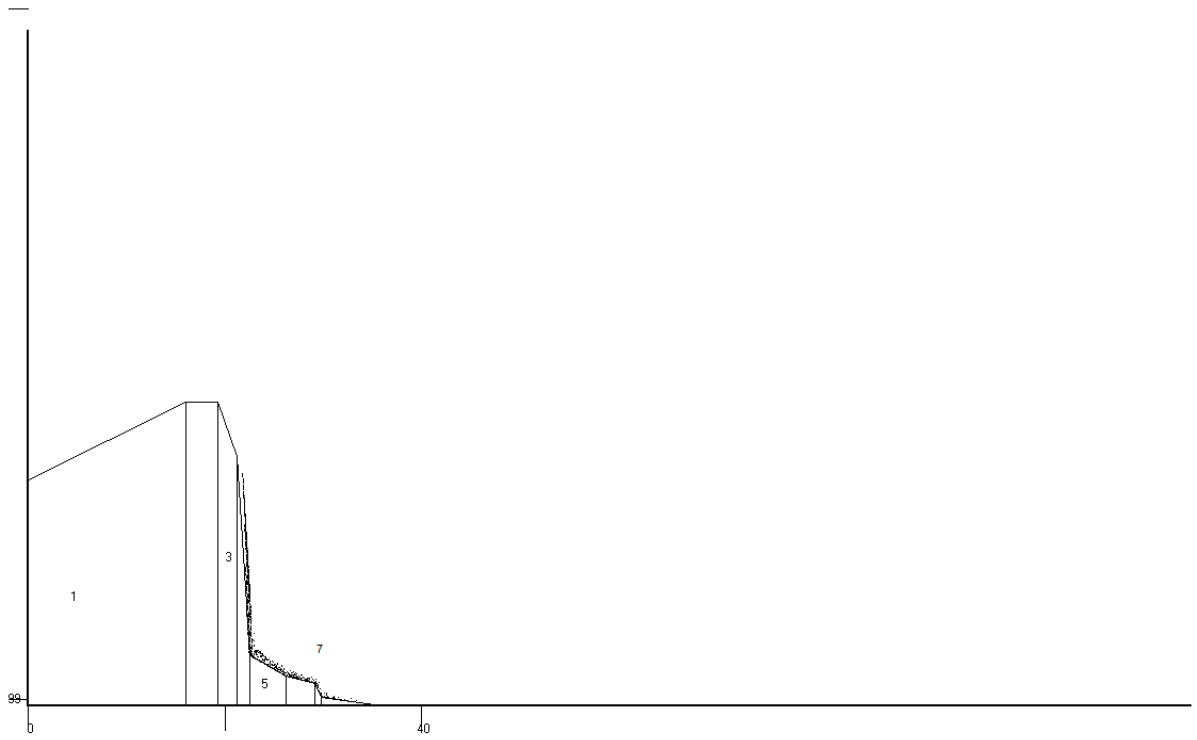
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	15	10	3.05	2	0
3	26	16	4.66	3	0
4	22	9	3.68	1	0
5	15	9	3.16	1	0
6	15	9	3.01	1	0
7	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_NB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	0
30 To 40 ft	39
40 To 50 ft	57
50 To 60 ft	4
60 To 61.96 ft	0

CRSP Results for Southbound side Rock Slope Station 308+50 (Existing Condition)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_SB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point 1 X-Coordinate: 29.83
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 104
Initial Y-Base Starting Zone Coordinate: 100.3

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	105.35	16.03	107.61
2	1.0	.95	.15	16.03	107.61	19.23	107.61
3	1.0	.95	.15	19.23	107.61	21.26	106.01
4	1.0	.95	.15	21.26	106.01	22.48	100.27
5	1.0	.95	.15	22.48	100.27	26.22	99.66
6	1.0	.95	.15	26.22	99.66	29.18	99.46
7	1.0	.95	.15	29.18	99.46	29.84	99.06
8	1.0	.95	.15	29.84	99.06	36.01	98.79

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_SB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 8

Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_SB.dat

Analysis Point 1: X = 29.83, Y = 99

Total Rocks Passing Analysis Point: 16

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	6.15	3154	0.02
75%	7.31	4212	5.58
90%	8.35	5164	10.59
95%	8.97	5736	13.59
98%	9.67	6377	16.97

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 8.92	Maximum: .32	Maximum: 5995
Average: 6.15	Average: .05	Average: 3154
Minimum: 3.64	G. Mean: .02	Std. Dev.: 1567
Std. Dev.: 1.71	Std. Dev.: 8.24	

Remarks:

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_SB.dat

Velocity Units: ft/sec Bounce Height Units: ft

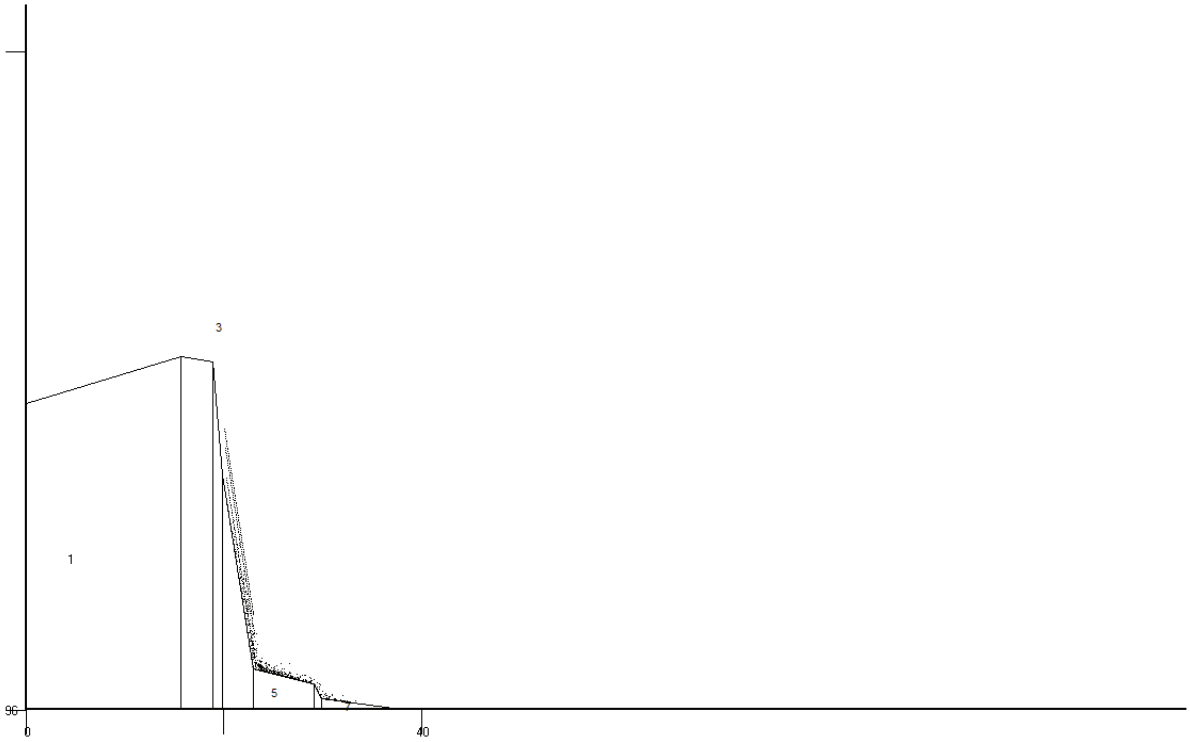
Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			

2	No rocks	past end of cell			
3	No rocks	past end of cell			
4	16	10	3.86	2	1
5	9	6	1.56	0	0
6	8	5	1.51	0	0
7	9	6	1.63	0	0
8	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\308_50_SB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	84
30 To 36.01 ft	16

CRSP Results for Southbound side Rock Slope Station 309+00 (Existing Condition)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\309_00_SB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point 1 X-Coordinate: 30
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 103
Initial Y-Base Starting Zone Coordinate: 97.3

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	105.32	15.66	106.75
2	1.0	.95	.15	15.66	106.75	18.86	106.57
3	1.0	.95	.15	18.86	106.57	19.9	103.14
4	1.0	.95	.15	19.9	103.14	22.96	97.26
5	1.0	.95	.15	22.96	97.26	29.14	96.8
6	1.0	.95	.15	29.14	96.8	29.94	96.37
7	1.0	.95	.15	29.94	96.37	37.95	96.02

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\309_00_SB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 7
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\309_00_SB.dat

Analysis Point 1: X = 30, Y = 96

Total Rocks Passing Analysis Point: 9

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	7.93	5067	0.05
75%	8.53	5767	7.1
90%	9.07	6396	13.43
95%	9.39	6774	17.24
98%	9.76	7198	21.51

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 9.5	Maximum: .33	Maximum: 6996
Average: 7.93	Average: .15	Average: 5067
Minimum: 6.59	G. Mean: .05	Std. Dev.: 1036
Std. Dev.: .89	Std. Dev.: 10.44	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\309_00_SB.dat

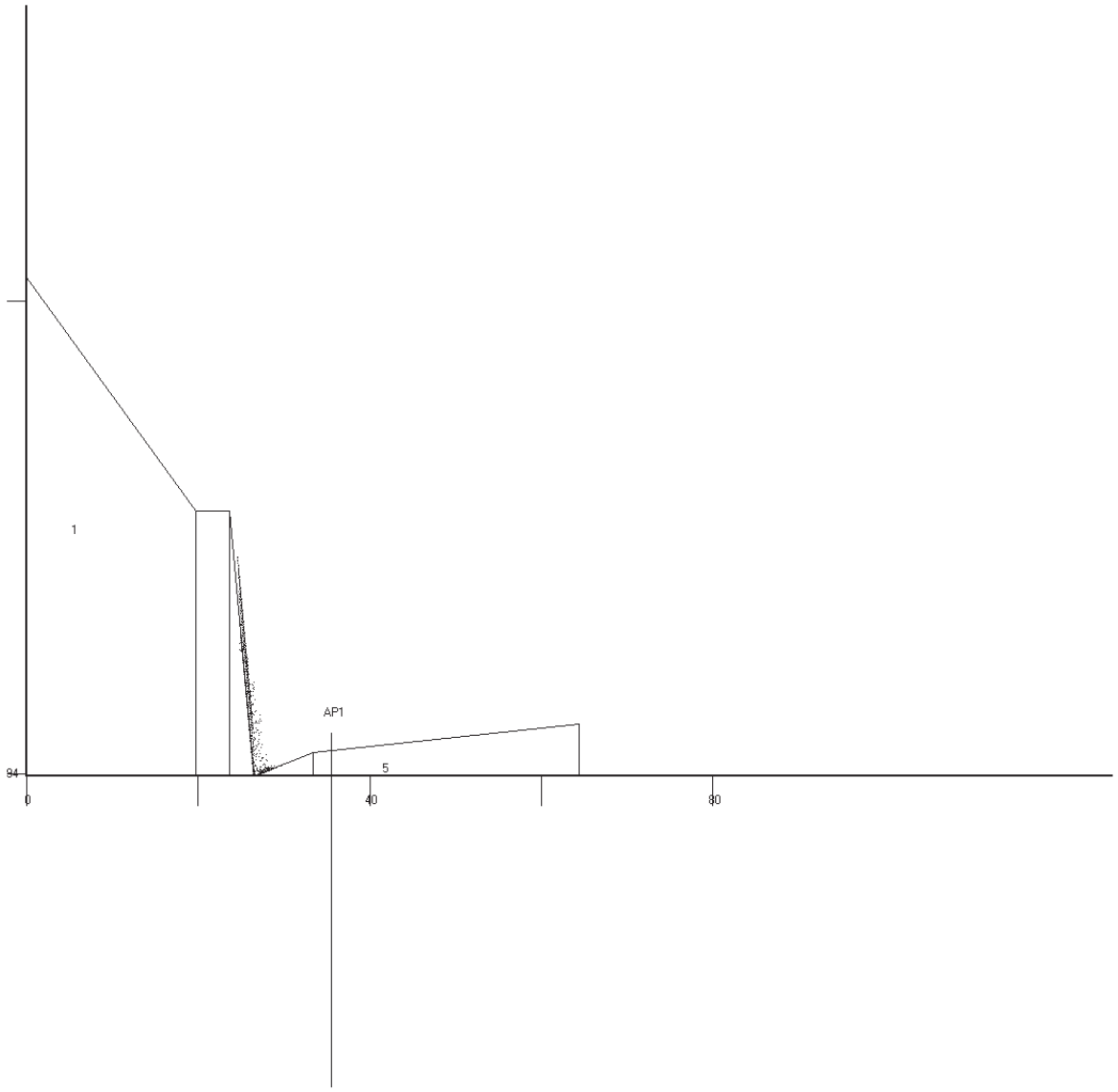
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.	
1	No rocks	past end of cell				
2	No rocks	past end of cell				
3	No rocks	past end of cell				
4	17	13	3.32	2		0
5	8	7	1.45	0		0
6	9	8	.88	0		0
7	No rocks	past end of cell				

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Existing Condition\CRSP Files\309_00_SB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	91
30 To 37.95 ft	9

CRSP Results for Northbound side Rock Slope Station 308+00 (Original Recommended Rock Cut Treatment)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\308_00_NB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 5
Analysis Point 1 X-Coordinate: 35.6
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 101.8
Initial Y-Base Starting Zone Coordinate: 95

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1.0	.95	.15	0	115.01	19.7	105.1
2	1.0	.95	.15	19.7	105.1	23.67	105.1
3	1.0	.95	.15	23.67	105.1	26.46	93.89
4	1.0	.95	.15	26.46	93.89	33.38	94.89
5	1.0	.95	.15	33.38	94.89	64.43	96.09

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\308_00_NB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 5
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\308_00_NB.dat

Analysis Point 1: X = 35.6, Y = 95

NO ROCKS PAST ANALSYSIS POINT 1

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\308_00_NB.dat

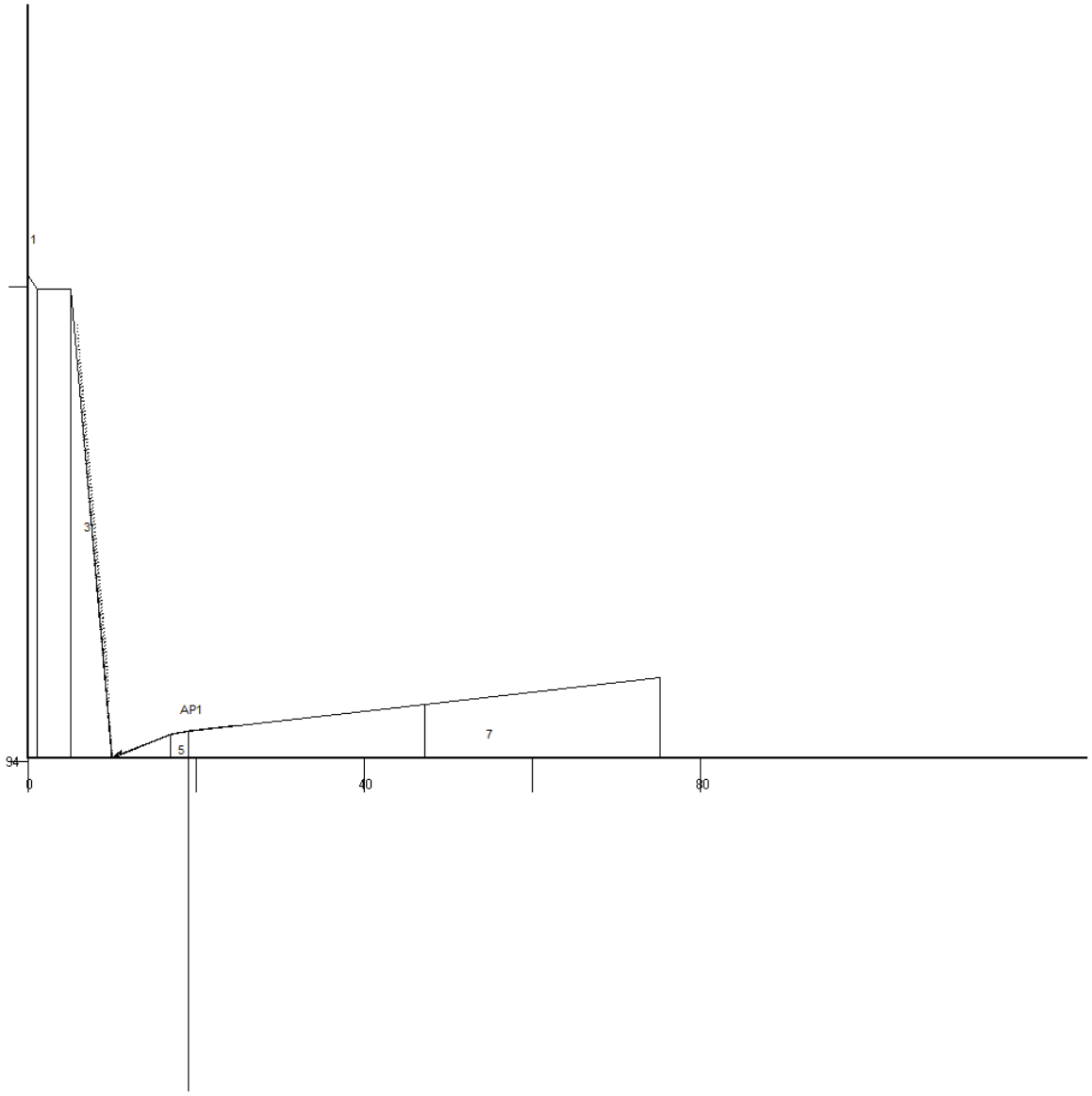
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	21	14	2.56	4	1
4	No rocks	past end of cell			
5	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\308_00_NB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	100
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 64.43 ft	0

CRSP Results for Northbound side Rock Slope Station 308+50 (Original Recommended Rock Cut Treatment)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50NB.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 7
Analysis Point 1 X-Coordinate: 19.13
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 111
Initial Y-Base Starting Zone Coordinate: 96.5

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	.1	.95	.15	0	114.44	1.08	113.9
2	.1	.95	.15	1.08	113.9	5.06	113.9
3	.1	.95	.15	5.06	113.9	10	94.17
4	.1	.95	.15	10	94.17	17	95.15
5	.1	.95	.15	17	95.15	19.17	95.3
6	.1	.95	.15	19.17	95.3	47.17	96.43
7	.1	.95	.15	47.17	96.43	75.17	97.56

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50NB.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 7
Rock Density: 165 lb/ft^3

Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50NB.doc

Analysis Point 1: X = 19.13, Y = 95

Total Rocks Passing Analysis Point: 19

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	4.79	1533	0
75%	5.32	1898	1.15
90%	5.8	2227	2.18
95%	6.09	2425	2.79
98%	6.42	2646	3.49

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 6.75	Maximum: .01	Maximum: 3011
Average: 4.79	Average: -.06	Average: 1533
Minimum: 3.34	G. Mean: 0	Std. Dev.: 541
Std. Dev.: .79	Std. Dev.: 1.7	

Remarks:

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50NB.doc

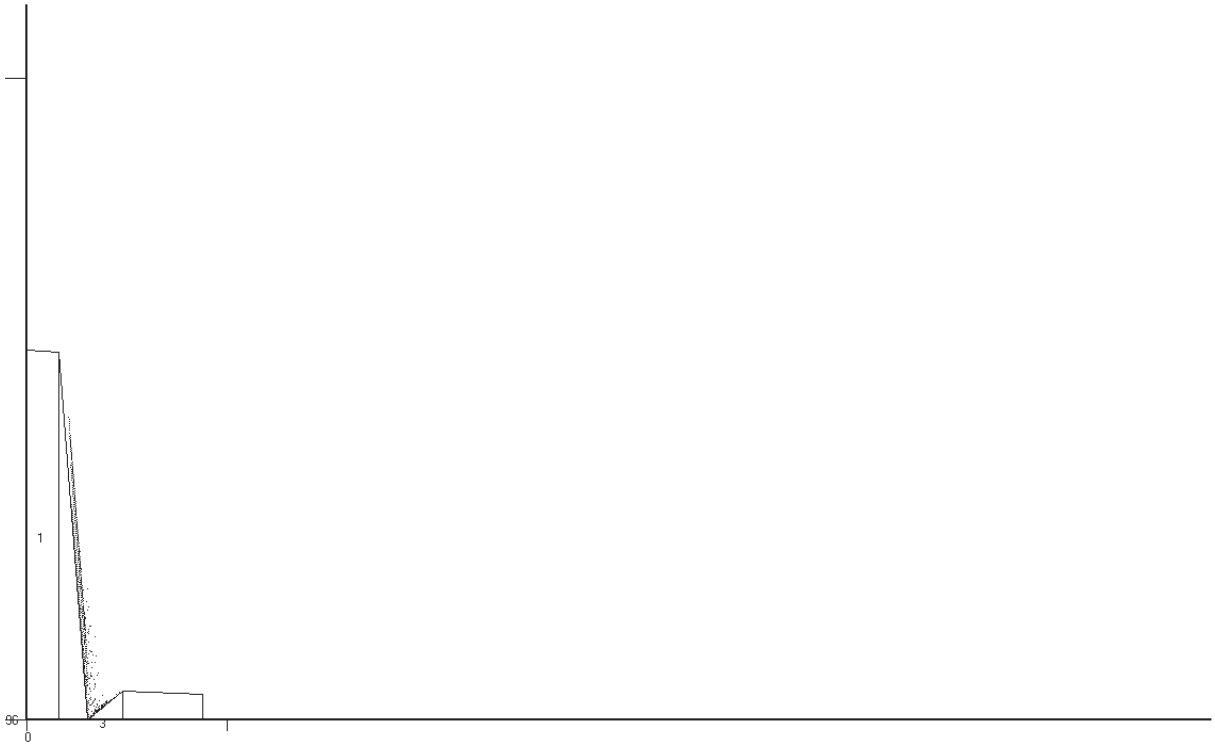
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	31	23	4.4	1	0
4	8	5	1.36	0	-1
5	6	4	.9	0	-1
6	No rocks	past end of cell			
7	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50NB.doc

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	87
20 To 30 ft	13
30 To 40 ft	0
40 To 50 ft	0
50 To 60 ft	0
60 To 70 ft	0
70 To 75.17 ft	0

CRSP Results for Southbound side Rock Slope Station 308+50 (Original Recommended Rock Cut Treatment)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP FIie\308_50_SB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 4
Analysis Point 1 X-Coordinate: 11.7
Analysis Point 2 X-Coordinate:
Analysis Point 3 X-Coordinate:
Initial Y-Top Starting Zone Coordinate: 103.9
Initial Y-Base Starting Zone Coordinate: 97

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	107.54	3.23	107.48
2	1	.95	.15	3.23	107.48	6.1	96
3	1	.95	.15	6.1	96	9.6	96.92
4	1	.95	.15	9.6	96.92	17.6	96.82

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP FIie\308_50_SB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 4
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP FIie\308_50_SB.dat

Analysis Point 1: X = 11.7, Y = 97

NO ROCKS PAST ANALSYSIS POINT 1

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP FIie\308_50_SB.dat

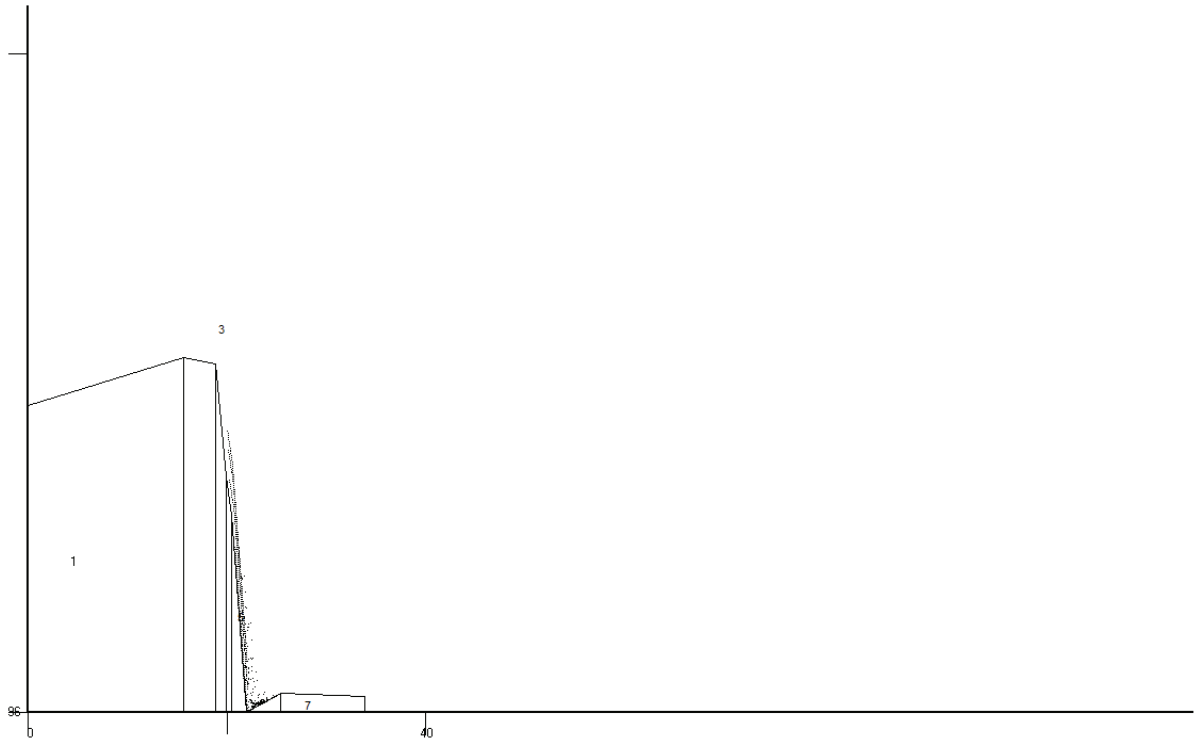
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	22	15	2.7	4	1
3	No rocks	past end of cell			
4	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP FIie\308_50_SB.dat

X Interval	Rocks Stopped
0 To 10 ft	100
10 To 17.6 ft	0

CRSP Results for Southbound side Rock Slope Station 309+00 (Original Recommended Rock Cut Treatment)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\309_00_SB.dat

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 8
Analysis Point 1 X-Coordinate: 27.5
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 103
Initial Y-Base Starting Zone Coordinate: 96.6

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	105.32	15.66	106.75
2	1	.95	.15	15.66	106.75	18.86	106.57
3	1	.95	.15	18.86	106.57	19.9	103.14
4	1	.95	.15	19.9	103.14	20.46	101.98
5	1	.95	.15	20.46	101.98	21.96	96
6	1	.95	.15	21.96	96	25.42	96.56
7	1	.95	.15	25.42	96.56	33.94	96.48
8	1	.95	.15	33.94	96.48	33.95	96.04

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\309_00_SB.dat

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 8

Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\309_00_SB.dat

Analysis Point 1: X = 27.5, Y = 97

NO ROCKS PAST ANALSYSIS POINT 1

CRSP Data Collected at End of Each Cell -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\309_00_SB.dat

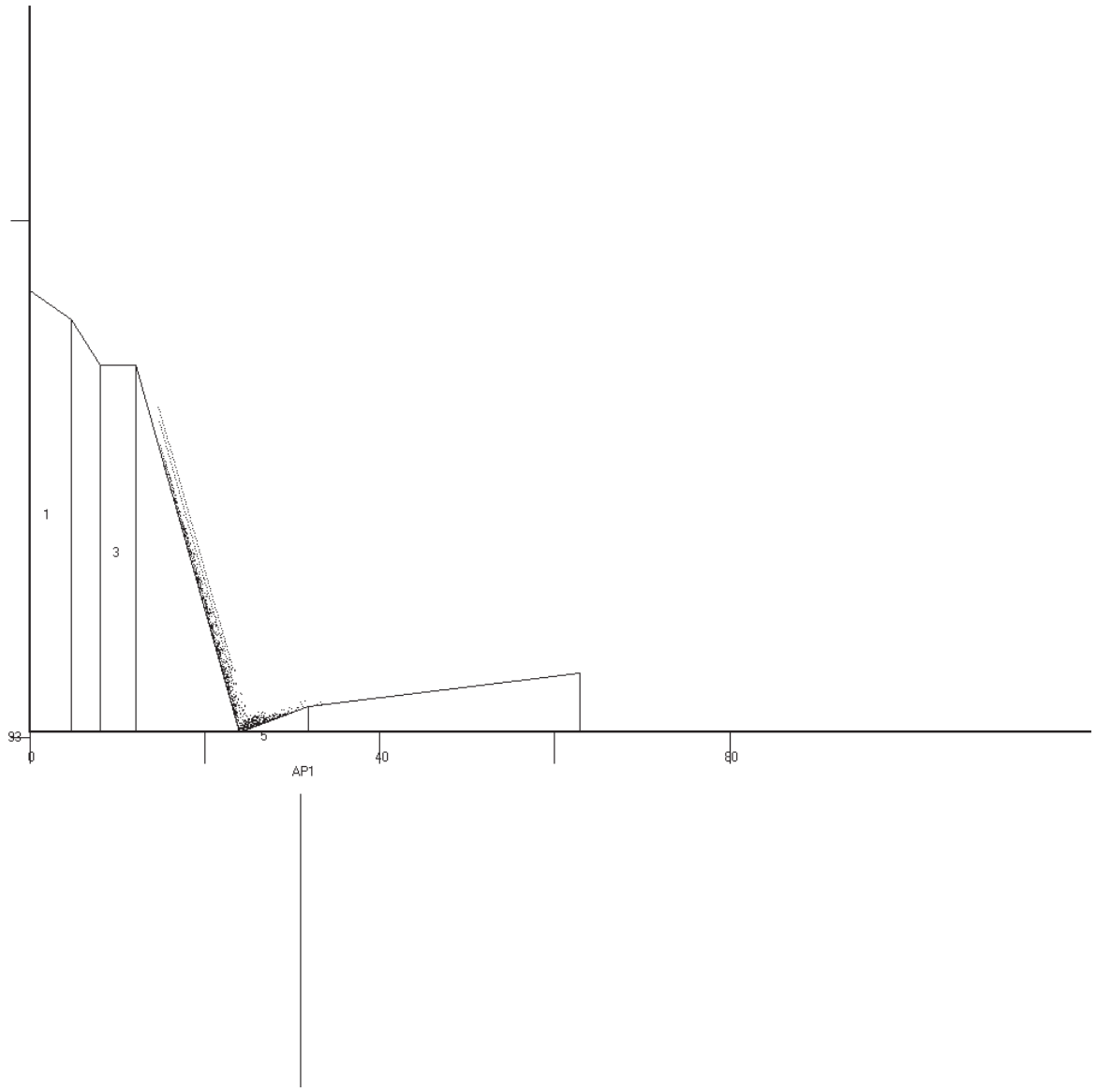
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	No rocks	past end of cell			
4	13	8	3.17	2	0
5	20	14	2.86	4	1
6	No rocks	past end of cell			
7	No rocks	past end of cell			
8	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\09_Evaluation\CRSP\3rd Issue\Original Proposed\CRSP File\309_00_SB.dat

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	100
30 To 33.95 ft	0

CRSP Results for Northbound side Rock Slope Station 307+50 (Alternative Rock Cut Treatment)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\307+50NB.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point 1 X-Coordinate: 31.0
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 104.4
Initial Y-Base Starting Zone Coordinate: 94.2

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	110.3	4.7	109.2
2	1	.95	.15	4.7	109.2	8.1	107.4
3	1	.95	.15	8.1	107.4	12.1	107.4
4	1	.95	.15	12.1	107.4	24.0	93.2
5	1	.95	.15	24.0	93.2	31.9	94.2
6	1	.95	.15	31.9	94.2	62.9	95.5

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\307+50NB.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 6
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\307+50NB.doc

Analysis Point 1: X = 31, Y = 94

Total Rocks Passing Analysis Point: 4

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	4.48	1658	0.02
75%	4.48	1658	0.69
90%	4.48	1658	1.3
95%	4.48	1658	1.66
98%	4.48	1658	2.07

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 5.86	Maximum: .31	Maximum: 2775
Average: 4.48	Average: .1	Average: 1658
Minimum: 2.61	G. Mean: .02	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL

AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\307+50NB.doc

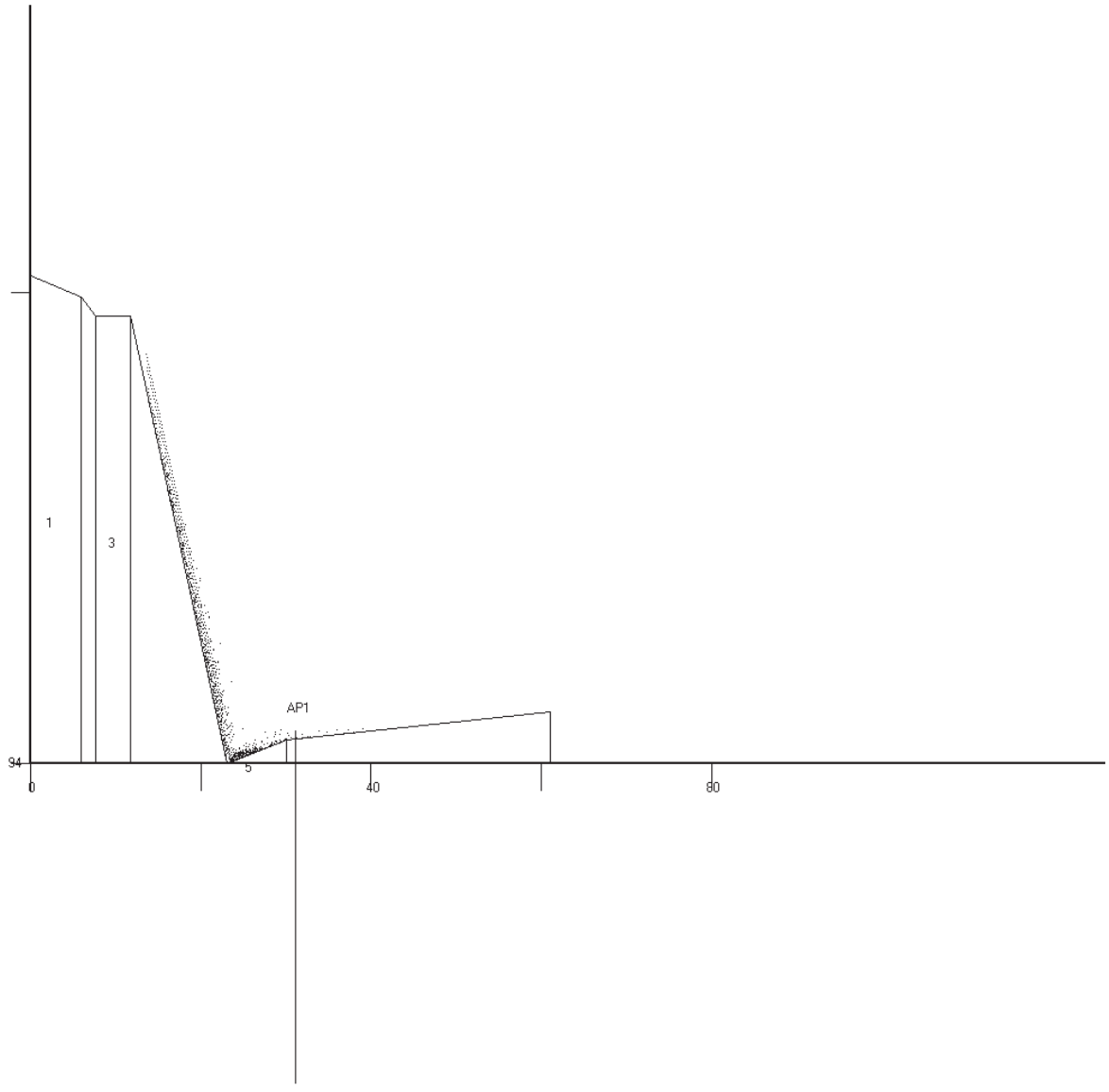
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	No rocks	past end of cell			
4	23	15	3.72	2	0
5	7	5	0	0	-1
6	No rocks	past end of cell			

CRSP Rocks Stopped Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\307+50NB.doc

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	94
30 To 40 ft	6
40 To 50 ft	0
50 To 60 ft	0
60 To 62.9 ft	0

CRSP Results for Northbound side Rock Slope Station 308+00 (Alternative Rock Cut Treatment)



CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+00NB.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point 1 X-Coordinate: 31.1
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 110
Initial Y-Base Starting Zone Coordinate: 95

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	114.7	6	113.8
2	1	.95	.15	6	113.8	7.7	113
3	1	.95	.15	7.7	113	11.7	113
4	1	.95	.15	11.7	113	23.1	94
5	1	.95	.15	23.1	94	30.1	95
6	1	.95	.15	30.1	95	61	96.2

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+00NB.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 6
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.3 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+00NB.doc

Analysis Point 1: X = 31.1, Y = 95

Total Rocks Passing Analysis Point: 2

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	9.34	6407	0.01
75%	9.34	6407	0.68
90%	9.34	6407	1.29
95%	9.34	6407	1.66
98%	9.34	6407	2.06

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 12	Maximum: .06	Maximum: 9717
Average: 9.34	Average: .02	Average: 6407
Minimum: 6.68	G. Mean: .01	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+00NB.doc

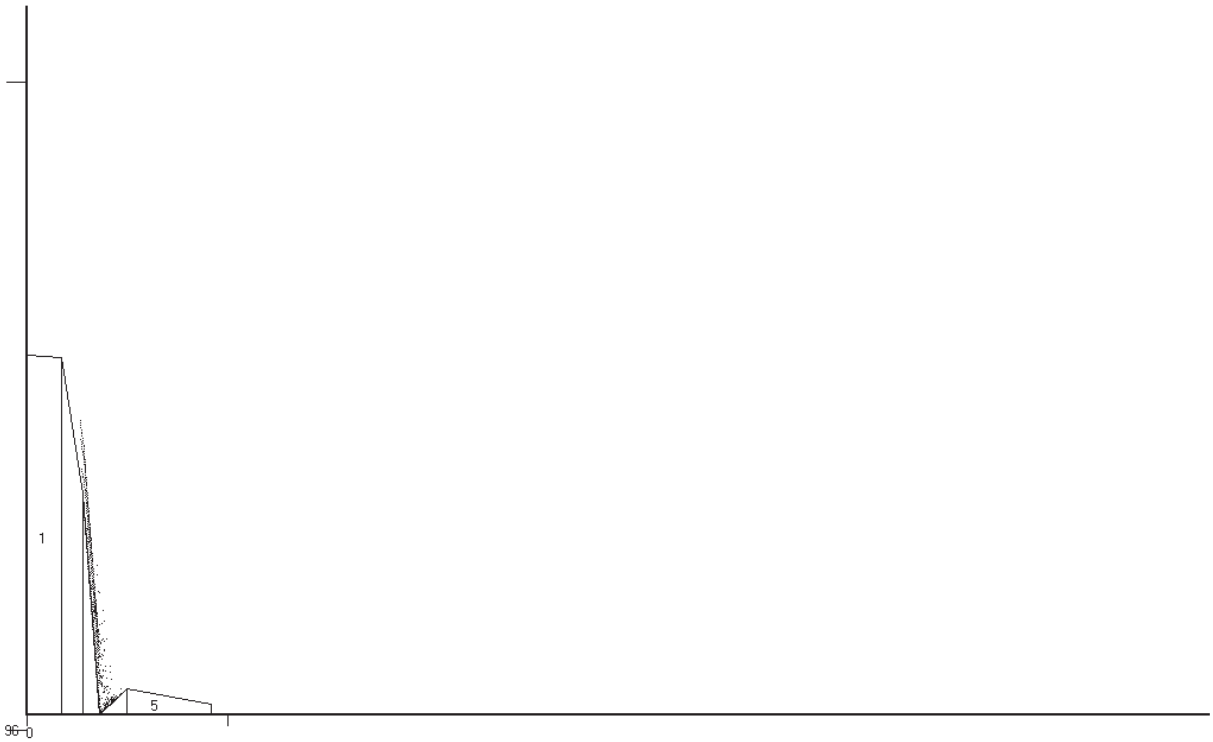
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	No rocks	past end of cell			
4	28	19	5.29	4	0
5	13	7	0	0	0
6	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+00NB.doc

X Interval	Rocks Stopped
0 To 10 ft	0
10 To 20 ft	0
20 To 30 ft	96
30 To 40 ft	4
40 To 50 ft	0
50 To 60 ft	0
60 To 61 ft	0

CRSP Results for Southbound side Rock Slope Station 308+50 (Alternative Rock Cut Treatment)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50SB_catchment.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 5
Analysis Point 1 X-Coordinate: 9.6
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 104
Initial Y-Base Starting Zone Coordinate: 97.3

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	107.55	3.4	107.5
2	1	.95	.15	3.4	107.5	5.5	103.3
3	1	.95	.15	5.5	103.3	7.2	96.5
4	1	.95	.15	7.2	96.5	9.9	97.27
5	1	.95	.15	9.9	97.27	18.4	96.8

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50SB_catchment.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 5
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50SB_catchment.doc

Analysis Point 1: X = 9.6, Y = 97

Total Rocks Passing Analysis Point: 2

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	3.22	1067	0.02
75%	3.22	1067	0.7
90%	3.22	1067	1.31
95%	3.22	1067	1.67
98%	3.22	1067	2.08

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 3.47	Maximum: .05	Maximum: 1349
Average: 3.22	Average: .03	Average: 1067
Minimum: 2.97	G. Mean: .02	Std. Dev.: 0
Std. Dev.: 0	Std. Dev.: 1	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50SB_catchment.doc

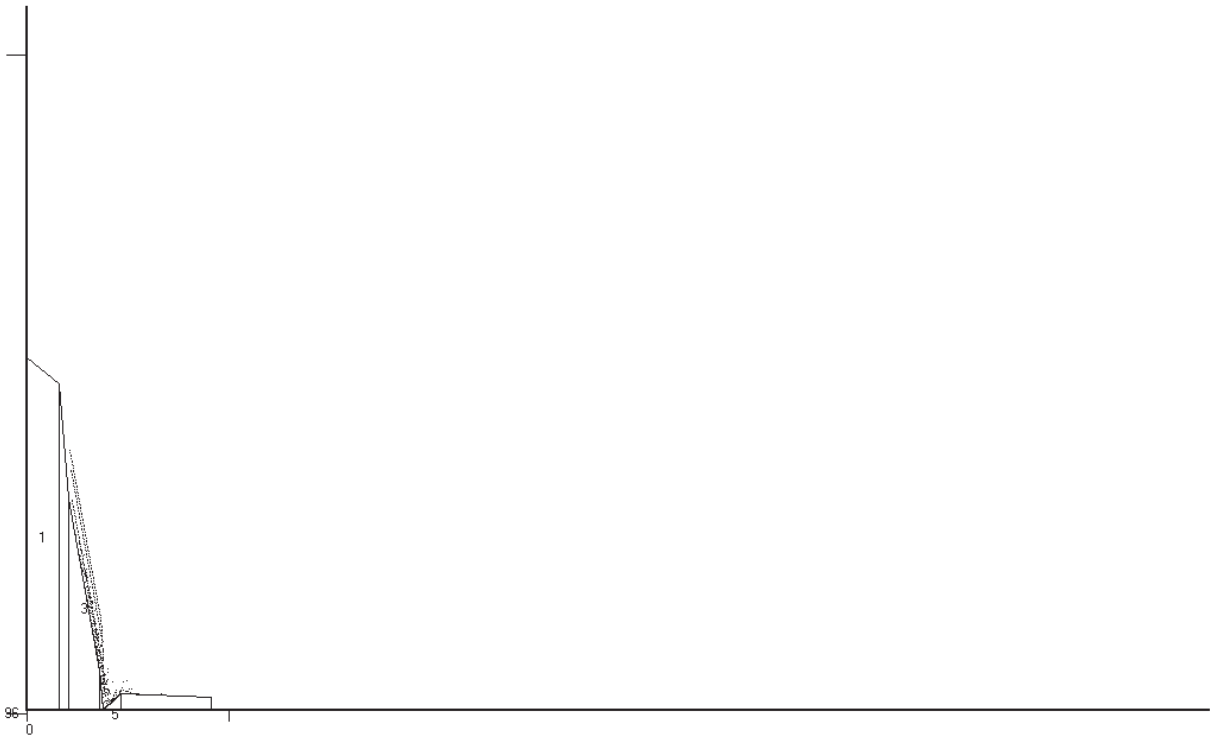
Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.	
1	No rocks	past end of cell				
2	12	7	3.51	2	1	
3	23	14	2.73	4	1	
4	No rocks	past end of cell				
5	No rocks	past end of cell				

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\308+50SB_catchment.doc

X Interval	Rocks Stopped
0 To 10 ft	100
10 To 18.4 ft	0

CRSP Results for Southbound side Rock Slope Station 309+00 (Alternative Rock Cut Treatment)





CRSP Input File -\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\309+00SB_catchment.doc

Input File Specifications

Units of Measure: U.S.
Total Number of Cells: 6
Analysis Point 1 X-Coordinate: 9.8
Analysis Point 2 X-Coordinate: 0
Analysis Point 3 X-Coordinate: 0
Initial Y-Top Starting Zone Coordinate: 102.5
Initial Y-Base Starting Zone Coordinate: 96.6

Remarks:

Cell Data

Cell No.	S.R.	Tang. C.	Norm. C.	Begin X	Begin Y	End X	End Y
1	1	.95	.15	0	106.8	3.1	106
2	1	.95	.15	3.1	106	4.1	102.5
3	1	.95	.15	4.1	102.5	7.2	97.3
4	1	.95	.15	7.2	97.3	7.5	96.1
5	1	.95	.15	7.5	96.1	9.25	96.6
6	1	.95	.15	9.25	96.6	18.25	96.5

CRSP Simulation Specifications: Used with \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\309+00SB_catchment.doc

Total Number of Rocks Simulated: 100
Starting Velocity in X-Direction: 1 ft/sec
Starting Velocity in Y-Direction: -1 ft/sec
Starting Cell Number: 1
Ending Cell Number: 6
Rock Density: 165 lb/ft^3
Rock Shape: Spherical
Diameter: 3.6 ft

CRSP Analysis Point 1 Data - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\309+00SB_catchment.doc

Analysis Point 1: X = 9.8, Y = 97

Total Rocks Passing Analysis Point: 9

Cumulative Probability	Velocity (ft/sec)	Energy (ft-lb)	Bounce Ht. (ft)
50%	4.93	2345	0.01
75%	5.59	2984	8.89
90%	6.18	3559	16.87
95%	6.54	3904	21.66
98%	6.93	4291	27.04

Velocity (ft/sec)	Bounce Height (ft)	Kinetic Energy (ft-lb)
Maximum: 6.58	Maximum: .43	Maximum: 4219
Average: 4.93	Average: .07	Average: 2345
Minimum: 3.8 G. Mean: .01	Std. Dev.: 946	
Std. Dev.: .97	Std. Dev.: 13.14	

Remarks:

CRSP Data Collected at End of Each Cell - \\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\309+00SB_catchment.doc

Velocity Units: ft/sec Bounce Height Units: ft

Cell #	Max. Vel.	Avg. Vel.	S.D. Vel.	Max. Bounce Ht.	Avg. Bounce Ht.
1	No rocks	past end of cell			
2	No rocks	past end of cell			
3	18	12	3.5	2	0
4	20	13	3.3	2	1
5	7	5	1.44	0	0
6	No rocks	past end of cell			

CRSP Rocks Stopped Data -
\\geiconsultants.com\data\Data_Storage\Working\GREEN INTERNATIONAL AFFILIATES\2408225 Wilmington Rock Slope Eval\07_Reports\Geotechnical Report\App F - CRSP Rockfall Simulation Results\2nd Issue\CRSP Raw Results\309+00SB_catchment.doc

X Interval	Rocks Stopped
0 To 10 ft	91
10 To 18.25 ft	9

DOCUMENT A00885

MAST ARM FOUNDATION DESIGN

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Mast Arm Foundation Design

for

Massachusetts Department of Transportation – Highway Division

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Project File No. 608051

Proposed Mast Arms MA-1 to MA-4

for

Route 38 (Main Street)

Wilmington, Massachusetts



3rd Submission: 8/29/2025
2nd Submission: 6/13/2025
1st Submission: 8/18/2020

Prepared for:
Green International Affiliates, Inc.
239 Littleton Road, Suite 3
Westford, Massachusetts 01886
Phone: 978-923-0400

Prepared by:
Lamson Engineering Corporation
437 Cherry Street, Suite # 109
Newton, Massachusetts 02465
Phone: 617-558-0101

TABLE OF CONTENTS

		Page No.
1.0	Introduction	1
2.0	Subsurface Conditions	1
3.0	Foundation Recommendations	2
4.0	Construction Consideration	3

Appendices

1. 2020 Subsurface Exploration Results
2. Calculations
3. Reference Information from Green International Affiliates, Inc.
4. MassDOT Standard Drawings for Overhead Signal Structure and Foundation Mast Arm Cored Pier Foundations

1.0 INTRODUCTION

Based on the 2020 subsurface investigation results, we have performed mast arm design for Mast Arms No. MA-1 to MA-4 for the referenced project along Route 38 (Main Street), Wilmington, Massachusetts.

Mast Arm MA-1 can be supported by 3'-6" diameter drilled shaft embedded 12'-6" into soil.

Mast Arm MA-2 can be supported by 3'-6" diameter drilled shaft embedded 16'-0" into soil.

Mast Arm MA-3 can be supported by 3'-6" diameter drilled shaft embedded 12'-6" into soil.

Mast Arm MA-4 can be supported by 3'-6" diameter drilled shaft embedded 10'-0" into soil.

For detail summary of each mast arm type, see Summary on Page 1 of Appendix 2. Per AASHTO Figure 3.8.1.1.2-1, the design wind speed is 130 mph for Mast Arms MA-1 to MA-4.

2.0 SUBSURFACE CONDITIONS

The 2020 subsurface exploration program, consisting of four (4) test borings were performed at the site from January 9 to January 17, 2020. All borings were performed by Northern Drill Service, Inc. of Northborough, Massachusetts. Lamson Engineering is not involved in monitoring these borings.

Boring B-1 can be used for the 35' Mast Arm No. MA-1.

Boring B-2 can be used for the 25' Mast Arm No. MA-4.

Boring B-3 can be used for the 25' Mast Arm No. MA-2.

Boring B-4 can be used for the 35' Mast Arm No. MA-3.

The soil samples were taken using a 2" outside diameter split spoon sampler driven 24" into the soil by a 140-pound hammer falling 30". Blows per 6" were recorded.

Based on 2020 boring information, the site is comprised of 13.5' to 26.5' thick mostly sand and gravel, some boulders, trace silt materials on top of Granite bedrock.

For detailed information of each boring, refer to the boring logs included in Appendix 1 of this report.

3.0 FOUNDATION RECOMMENDATION

Based on the 2020 boring information and MassDOT Standard Drawings for Overhead Signal Structure and Foundation Mast Arm Cored Pier Foundations, the proposed drilled shaft foundation is suitable to be used to support the proposed mast arms. The proposed drilled shaft foundation are embedded in medium dense to very dense sand and gravel materials. These are competent materials and are capable of supporting loads from the proposed mast arms.

Soil Parameters

Based on the information on the boring logs, the following soil parameters are recommended:

Table 4.2: Recommended Soil Parameters for Drilled Shaft Foundation

Mast Arm No.	Foundation Embedment Materials	Soil Unit Weight, γ (per MassDOT Standard Drawings)	Soil Friction Angle, ϕ_f (per MassDOT Standard Drawings)	Boring #
MA-1	Medium Dense to Very Dense Gravel, some boulders	135 pcf	39°	B-1
MA-2	Medium Dense to Very Dense Sand and Gravel	135 pcf	39°	B-3
MA-3	Medium Dense to Very Dense Sand and Gravel, some boulders	135 pcf	39°	B-4
MA-4	Dense to Very Dense Sand and Gravel, some boulders	135 pcf	39°	B-2

Other applicable parameters are also included in the attached calculations.

For detail recommendations of each mast arm type, see Summary on Page 1 of Appendix 2. Per AASHTO Figure 3.8.1.1.2-1, the design wind speed is 130 mph for Mast Arms MA-1 to MA-4.

4.0 CONSTRUCTION CONSIDERATIONS

4.1 Groundwater Level

Based on the 2020 boring information, groundwater was encountered at a depth from 6’ to 10.4’ from existing ground during the boring operation.

The following factors should be taken into consideration for the recorded water levels:

- Groundwater levels obtained from the washed boring exploration operation are generally unreliable and are provided for reference only.
- Groundwater level fluctuates over time due to seasonal changes and storm events.

4.2 Obstructions

Underground/overhead utilities, boulders, and unknown previous construction materials are potential obstruction materials that may be encountered at the site during construction. Contractors should prepare for these potential obstruction materials during the proposed drilled shaft installation.

APPENDIX 1

2020 Subsurface Exploration Results

Index

- Boring Location Plan
- Boring Logs for Borings B-1, B-2, B-3, and B-4.

Note: Lamson Engineering was not involved in monitoring these borings.

WILMINGTON, MA
ROUTE 38 (MAIN STREET)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	139	260
PROJECT FILE NO.	608051		

TRAFFIC SIGNAL PLANS
CROSS ST - BUTTERS ROW

BORING LOCATIONS AS-BUILT.DWG Plotted on 11-Aug-2020 11:41 AM

MAIN STREET (ROUTE 38)

CROSS STREET

BUTTERS ROW

N
NAD 83

B-1
Approx. Existing Grade Elev.:92.220'
Approx. Grade Elev.:93.077'
Approx. Proposed Footing Elev.:93.410'
N: 3021943.765
E: 746608.422
N42° 32' 23.55"
W71° 09' 51.68"

B-2
Approx. Existing Grade Elev.:95.815'
Approx. Proposed Grade Elev.:95.827'
Approx. Proposed Footing Elev.:96.160'
N: 3021882.079
E: 746713.814
N42° 32' 22.94"
W71° 09' 50.49"

B-3
Approx. Existing Grade Elev.:93.456'
Approx. Proposed Grade Elev.:93.979'
Approx. Proposed Footing Elev.:94.312'
N: 3021885.258
E: 746625.721
N42° 32' 22.98"
W71° 09' 51.66"

B-4
Approx. Existing Grade Elev.:94.464'
Approx. Proposed Grade Elev.:95.786'
Approx. Proposed Footing Elev.:96.119'
N: 3021808.856
E: 746673.484
N42° 32' 22.22"
W71° 09' 51.03"

0 20 50 100
SCALE: 1" = 20'

Northern Drill Service, Inc.	Client: Green International Affiliates, Inc.	Boring # B-1
130 East Main Street, Northborough, MA 01532	Project: MassDOT Route 38 Mast Arms	
TEL 508-393-6900 FAX 508-393-6901	Location: Rt 38 & Cross St., Wilmington, MA	Page 1 OF 1

File #:		CASING	SAMPLER	CORE BARREL
Date Started: 1/14/2020	TYPE	HW	S/S	NX
Date Completed: 1/17/2020	SIZE	4"	2"	1-7/8"
Driller: Justin Stevens	HAMMER		140	
Site Rep.:	FALL		30"	
	Ground Water level:		6'	

SAMPLE					Strata	
No.	**Depth**	**Pen. In.**	**Rec. In.**	**Blows/6"**	**Change**	**SAMPLE DESCRIPTION**
S-1	.5'-2'	24"	11"	2-2-2-2		S-1: Loose dark brown fine sand with little medium to coarse gravel, trace fine gravel.
S-2	4'-6'	24"	5"	3-15-14-11	BOULDER 7.5'-9.5'	S-2: Medium dense dark brown coarse gravel, some medium gravel, trace medium to fine sand.
S-3	9.5-11.5'	4"	0"	100/4"	BOULDER 10'-13'	S-3: NO RECOVERY. CORED BOULDER 10'-13'
S-4	14'-16'	11"	3"	27-100/5"		S-4: Very dense gray medium gravel some medium to coarse sand, little fine gravel.
C-1	17'-22'	60"	55.5"	RQD: 73%		C-1: GRANITE
C-2	22'-27'	60"	43"	RQD: 62%		C-2: GRANITE
						Bottom of Exploration = 27'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Northern Drill Service, Inc.	Client: Green International Affiliates, Inc.	Boring # B-2
130 East Main Street, Northborough, MA 01532	Project: MassDOT Route 38 Mast Arms	
TEL 508-393-6900 FAX 508-393-6901	Location: Rt 38 & Cross St., Wilmington, MA	Page 1 OF 1

File #:		CASING	SAMPLER	CORE BARREL
Date Started: 1/13/2020	TYPE	HW	S/S	NX
Date Completed: 1/14/2020	SIZE	4"	2"	1-7/8"
Driller: Justin Stevens	HAMMER		140	
Site Rep.:	FALL		30"	
	Ground Water level:		7.5'	

SAMPLE					Strata	
No.	**Depth**	**Pen. In.**	**Rec. In.**	**Blows/6"**	**Change**	**SAMPLE DESCRIPTION**
S-1	.5'-2'	24"	18"	18-15-17-29		S-1: Dense tan fine sand some coarse gravel and little fine gravel.
S-2	4'-6'	24"	15"	35-62-67-64	BOULDER 6'-7'	S-2: Very dense tan coarse and medium gravel, some medium to fine sand, trace silt.-glacial till-
S-3	9-11'	24"	13"	26-24-41-85	ROCK AT 13.5'	S-3: Very dense tan fine to medium sand, trace silt, Little medium to fine gravel.
C-1	14.5'-19.5'	60"	55"	RQD:82%		C-1:GRANITE
C-2	19.5'-24.5'	60"	53"	RQD:85%		C-2:GRANITE
						Bottom of Exploration = 24.5'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Northern Drill Service, Inc.	Client: Green International Affiliates, Inc.	Boring # B-3
130 East Main Street, Northborough, MA 01532	Project: MassDOT Route 38 Mast Arms	
TEL 508-393-6900 FAX 508-393-6901	Location: Rt 38 & Cross St., Wilmington, MA	Page 1 OF 1

File #:		CASING	SAMPLER	CORE BARREL
Date Started: 1/17/2020	TYPE	HW	S/S	
Date Completed: 1/17/2020	SIZE	4"	2"	
Driller: CARL BEIRHOLM	HAMMER		140	
Site Rep.:	FALL		30"	

Ground Water level: 9.87'

SAMPLE					Strata	
No.	**Depth**	**Pen. In.**	**Rec. In.**	**Blows/6"**	**Change**	**SAMPLE DESCRIPTION**
						Asphalt = 6"
S-1	.5'-2'	18"	13"	9-21-17		S-1: Dense tan/brown medium sand with some fine sand. Little medium to coarse gravel.
S-2	4'-6'	24"	11"	5-5-7-6		S-2: Medium dense tan fine sand with little medium gravel, trace fine gravel
S-3	9-11'	24"	12"	26-41-45-60		S-3: Very dense gray coarse gravel, some fine sand, trace fine gravel, trace silt. -glacial till-
S-4	14'-16'	24"	9"	27-27-41-53		S-4: Very dense tan coarse gravel, some fine sand, little fine gravel, trace silt.
S-5	19'-20.5'	14"	7"	36-53-100/2"	boulder 16.5'-18' 3"-6" cobbles	S-5: very dense tan medium gravel, some fine gravel, little fine sand, trace silt
S-6	24'-24.7"	7"	5"	65-100/1"		S-6: Very dense medium to coarse gravel, some fine gravel, little fine sand, trace silt Spoon Refusal at 24'-7". Roller bit to 26.5'. Possible boulder or bedrock Bottom of Exploration = 26.5'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Northern Drill Service, Inc.	Client: Green International Affiliates, Inc.	Boring # B-4
130 East Main Street, Northborough, MA 01532	Project: MassDOT Route 38 Mast Arms	
TEL 508-393-6900 FAX 508-393-6901	Location: Rt 38 & Cross St., Wilmington, MA	Page 1 OF 1

File #:		CASING	SAMPLER	CORE BARREL
Date Started: 1/9/2020	TYPE	HW	S/S	NX
Date Completed: 1/13/2020	SIZE	4"	2"	1-7/8
Driller: Justin Stevens	HAMMER		140	
Site Rep.:	FALL		30"	

Ground Water level: 10.4'

SAMPLE						
No.	**Depth**	**Pen. In.**	**Rec. In.**	**Blows/6"**	**Strata Change**	**SAMPLE DESCRIPTION**
S-1	0"-2'	24"	13"	4-6-5-8	Boulder 2.9'-3.7'	S-1: Loose medium and fine sand, some fine gravel, little coarse gravel.
S-2	4'-6'	24"	6"	25-23-15-15	Boulder 6.1'-7.3'	S-2: Dense dark brown coarse gravel, some fine sand and silt, little fine gravel - Glacial Till-
S-3	9-11'	22"	15"	18-29-37-100/4"	Boulder 12'-13.2	S-3: Very dense tan fine sand and medium gravel, little coarse gravel, trace silt - Glacial Till-
S-4	14'-16'	24"	10"	27-54-50-55		S-4: Very dense tan medium sand, some fine gravel, little coarse gravel trace fine sand and silt - Glacial Till-
C-1	19.5'-24.5'	60"	47"	RQD:32%		C-1: GRANITE
						Bottom of Exploration = 24.5'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

APPENDIX 2

Calculations

INDEX OF CALCULATIONS

Description	Page
Summary	1
Mast Arm MA-1 Section	2
Mast Arm MA-2 Section	3
Mast Arm MA-3 Section	4
Mast Arm MA-4 Section	5

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Mast Arm Foundation	Prepared by: JJL	Date:	8/2025
Detail:	Summary	Checked by: JG	Date:	8/2025

Summary of Drilled Shaft Design

Mast Arm Foundation Design (Design Wind Speed, V = 130 mph)							
Mast Arm No.	Foundation Type per MassDOT Standard Drawing	Reference Boring Number	Drilled Shaft Diameter, D (ft)	Factored Vertical Resistance (kips)	Factored Vertical Load (kips)	MassDOT Standard Drawing Embedment Depth (ft)	Recommended Drilled Shaft Soil Embedment Depth (ft)
MA-1 (35' Mast Arm)	Drilled Shaft embeded into Wet Sand (Dense)	B-1	3.5	-	-	12.5	**12.5**
MA-2 (25' Mast Arm)	Drilled Shaft embeded into Wet Sand (Dense)	B-3	3.5	-	-	10.0	**16.0 (Note 3)**
MA-3 (35' Mast Arm)	Drilled Shaft embeded into Wet Sand (Dense)	B-4	3.5	-	-	12.5	**12.5**
MA-4 (25' Mast Arm)	Drilled Shaft embeded into Wet Sand (Dense)	B-2	3.5	-	-	10.0	**10.0**

Notes:

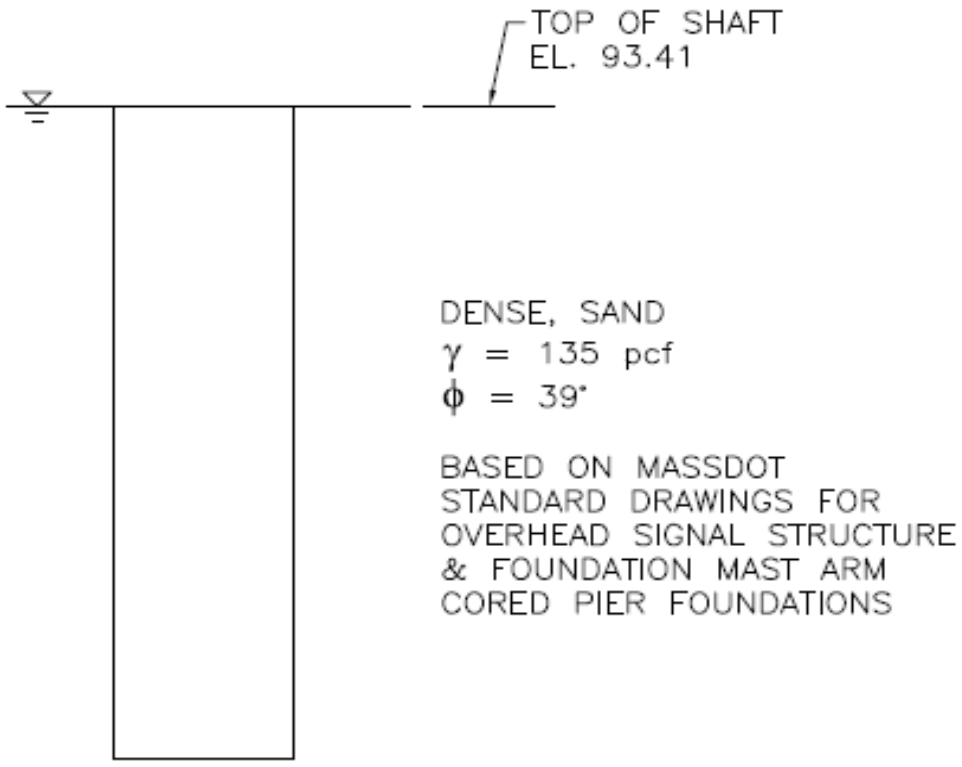
1. Water table is assumed to be at the top of drilled shaft for each mast arm foundation.

2. The soil embedment depth is per MassDOT Standard Drawings for Overhead Signal Structure & Foundation Mast Arm Cored Pier Foundations.

3. The design soil embedment depth considered is from the bottom of the slope, which is approximately 6' below the top of the drilled shaft. Therefore, the actual embedment depth is 16' for MA-2.

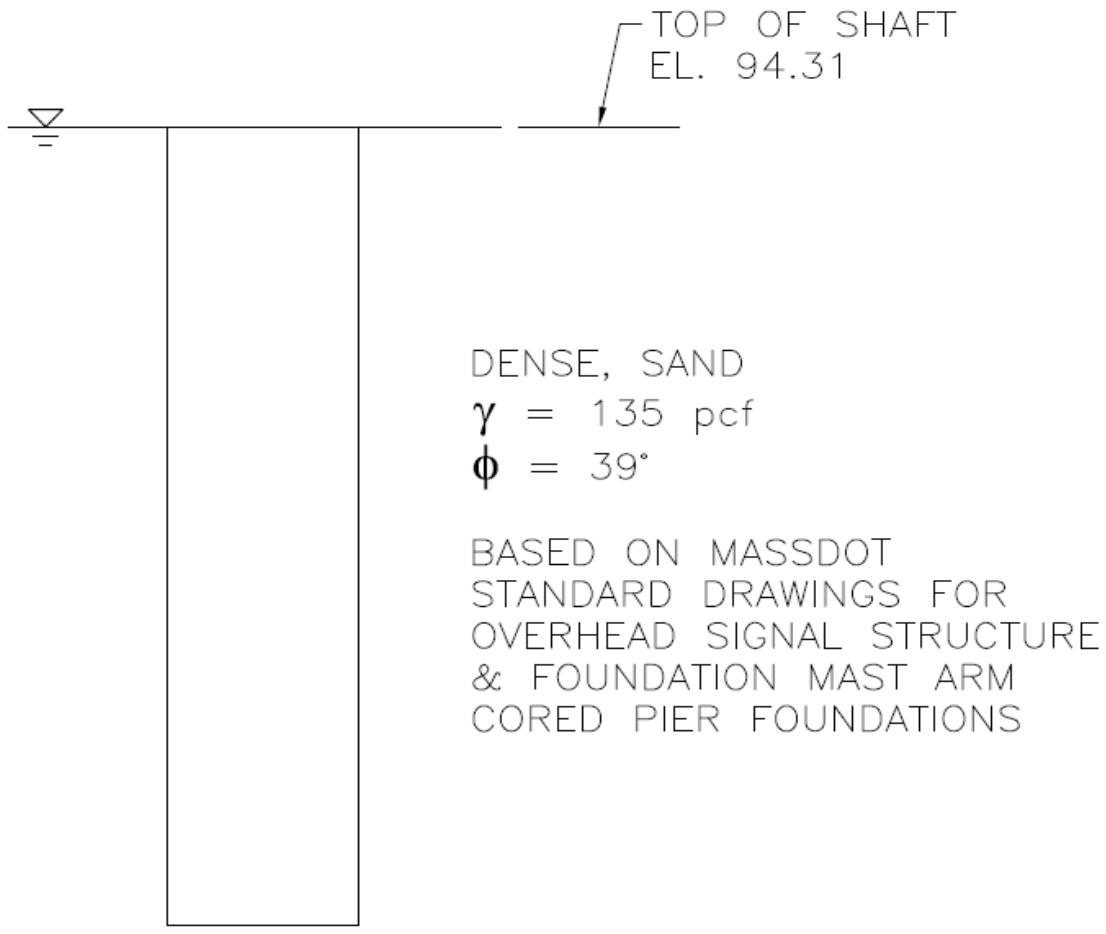
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Project:	Route 38, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Mast Arm Foundation	Prepared by: JJL		Date: 8/2025
Detail:	Mast Arm Section	Checked by: JG		Date: 8/2025

MA-1 Section
(Based on Boring B-1)



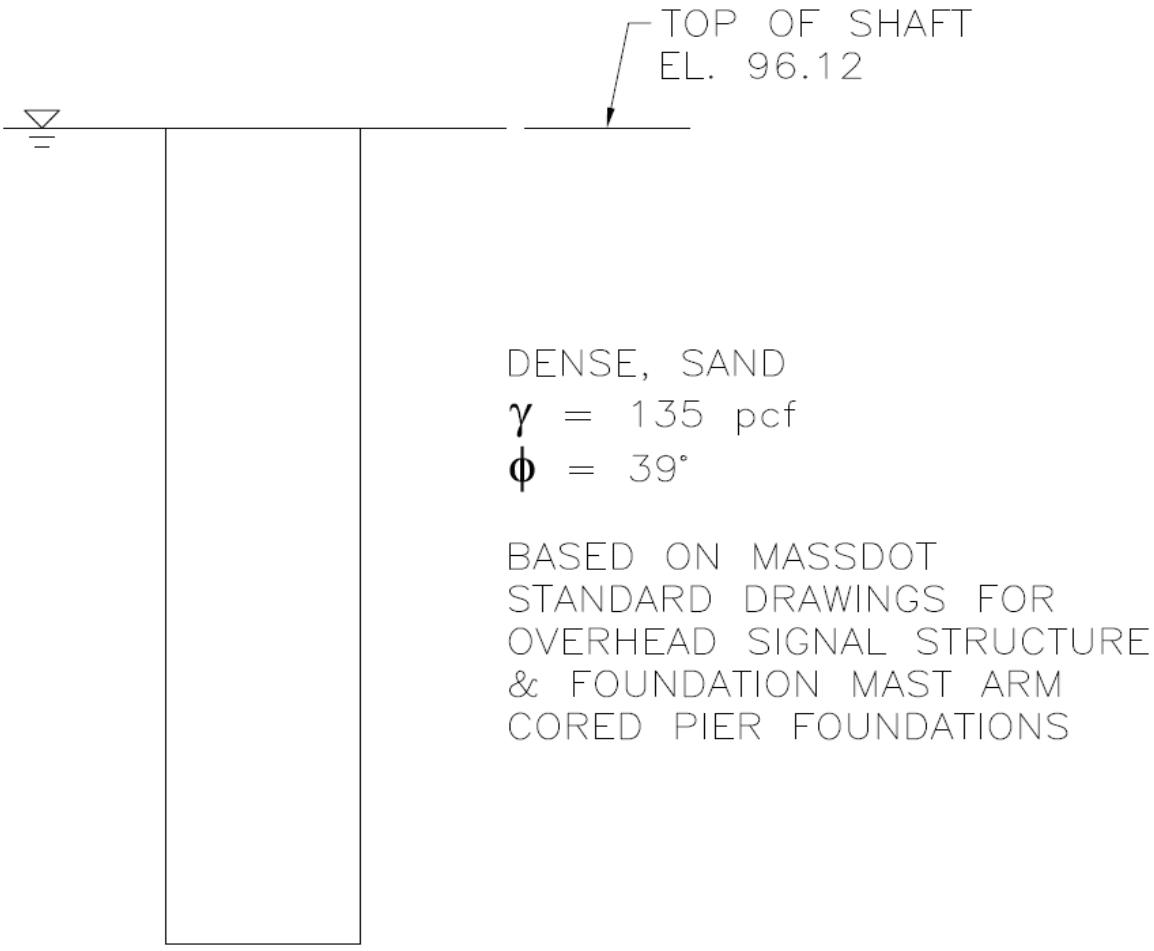
LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Mast Arm Foundation	Prepared by: JJL		Date: 8/2025
Detail:	Mast Arm Section	Checked by: JG		Date: 8/2025

MA-2 Section
(Based on Boring B-3)



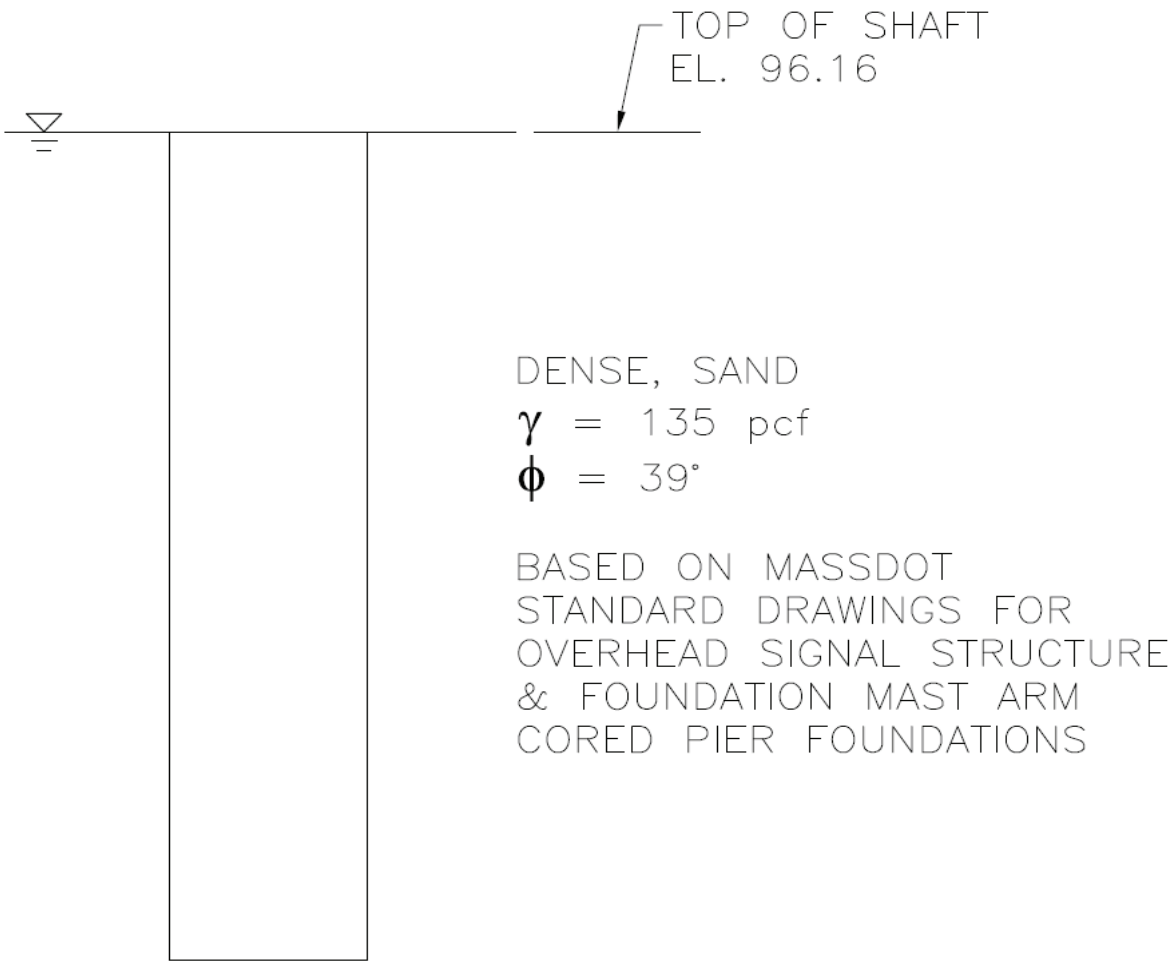
LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Mast Arm Foundation	Prepared by: JJL		Date: 8/2025
Detail:	Mast Arm Section	Checked by: JG		Date: 8/2025

MA-3 Section
(Based on Boring B-4)



LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Mast Arm Foundation	Prepared by: JJL		Date: 8/2025
Detail:	Mast Arm Section	Checked by: JG		Date: 8/2025

MA-4 Section
(Based on Boring B-2)



Appendix 3

Reference Information from Green International Affiliates, Inc

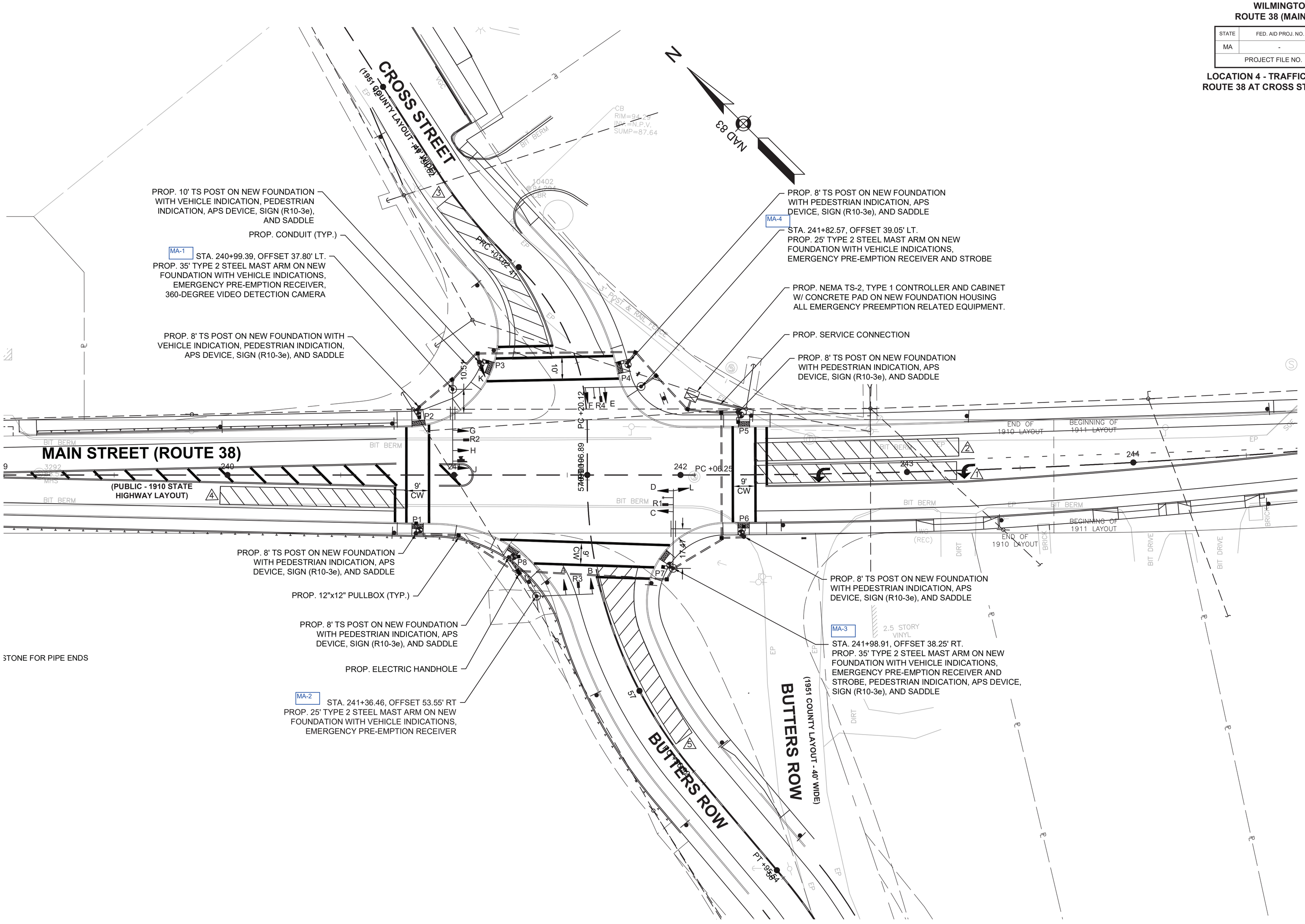
Index

- Mast Arm Location Plan

WILMINGTON, MA
ROUTE 38 (MAIN STREET)

STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
MA	-	177	394
PROJECT FILE NO.	608051		

LOCATION 4 - TRAFFIC SIGNAL PLANS
ROUTE 38 AT CROSS ST/ BUTTERS ROW



0 20 50 100
SCALE: 1" = 20'

NOTE OF CAUTION - DRILLING FOR FOUNDATION AND INSTALLATION OF POLES SHALL NOT DISTURB ADJACENT OVERHEAD POWER AND TELECOMMUNICATION LINES. INSTALLED OVERHEAD TRAFFIC SIGNAL EQUIPMENT SHALL BE SITUATED A MINIMUM OF 10 FEET FROM ELECTRICAL CABLES AND WIRING AND SHALL BE SITUATED A MINIMUM OF 3 FEET FROM TELECOMMUNICATIONS CABLES AND WIRING.

608051_TR02(SIGNAL-PLANS).DWG Plotted on 28-Aug-2025 1:47 PM
Proposal No. 608051 - 123406
A00885 - 22

Appendix 4

MassDOT Standard Drawings for Overhead Signal Structure and Foundation Mast Arm Cored Pier Foundations

PIER FOUNDATIONS FOR 110 MPH WIND SPEED ZONE

SOIL TYPE	15' & 20' MAST ARMS				25' & 30' MAST ARMS				35' & 40' MAST ARMS				45' & 50' MAST ARMS				55' & 60' MAST ARMS			
	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS
DRY SAND (LOOSE)	3'–6"	8'–6"	18–#8	#5 @ 12"	3'–6"	9'–0"	18–#8	#5 @ 12"	3'–6"	11'–6"	18–#8	#5 @ 9"	4'–0"	12'–0"	18–#9	#5 @ 9"	4'–6"	13'–0"	18–#10	#5 @ 6"
DRY SAND (DENSE)	3'–6"	7'–6"	18–#8	#5 @ 12"	3'–6"	7'–6"	18–#8	#5 @ 12"	3'–6"	8'–6"	18–#8	#5 @ 9"	4'–0"	9'–0"	18–#9	#5 @ 9"	4'–6"	9'–6"	18–#10	#5 @ 6"
WET SAND (LOOSE)	3'–6"	9'–6"	18–#8	#5 @ 12"	3'–6"	11'–6"	18–#8	#5 @ 12"	3'–6"	14'–6"	18–#8	#5 @ 9"	4'–0"	15'–6"	18–#9	#5 @ 9"	4'–6"	16'–6"	18–#10	#5 @ 6"
WET SAND (DENSE)	3'–6"	8'–6"	18–#8	#5 @ 12"	3'–6"	9'–0"	18–#8	#5 @ 12"	3'–6"	10'–6"	18–#8	#5 @ 9"	4'–0"	11'–6"	18–#9	#5 @ 9"	4'–6"	12'–0"	18–#10	#5 @ 6"
CLAY (SOFT TO MEDIUM STIFF)	3'–6"	12'–0"	18–#8	#5 @ 12"	3'–6"	12'–0"	18–#8	#5 @ 12"	3'–6"	13'–0"	18–#8	#5 @ 9"	4'–0"	14'–0"	18–#9	#5 @ 9"	4'–6"	15'–6"	18–#10	#5 @ 6"
CLAY (STIFF)	3'–6"	10'–6"	18–#8	#5 @ 12"	3'–6"	10'–6"	18–#8	#5 @ 12"	3'–6"	11'–0"	18–#8	#5 @ 9"	4'–0"	12'–0"	18–#9	#5 @ 9"	4'–6"	13'–0"	18–#10	#5 @ 6"

PIER FOUNDATIONS FOR 130 MPH WIND SPEED ZONE

SOIL TYPE	15' & 20' MAST ARMS				25' & 30' MAST ARMS				35' & 40' MAST ARMS				45' & 50' MAST ARMS				55' & 60' MAST ARMS			
	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS	DIAMETER	DEPTH	VERT. BARS	TIE BARS
DRY SAND (LOOSE)	3'–6"	10'–0"	18–#8	#5 @ 12"	3'–6"	10'–6"	18–#8	#5 @ 12"	3'–6"	13'–6"	18–#8	#5 @ 8"	4'–0"	14'–6"	18–#9	#5 @ 6"	4'–6"	15'–6"	18–#10	#5 @ 5"
DRY SAND (DENSE)	3'–6"	8'–6"	18–#8	#5 @ 12"	3'–6"	9'–0"	18–#8	#5 @ 12"	3'–6"	10'–0"	18–#8	#5 @ 8"	4'–0"	11'–0"	18–#9	#5 @ 6"	4'–6"	11'–6"	18–#10	#5 @ 5"
WET SAND (LOOSE)	3'–6"	11'–6"	18–#8	#5 @ 12"	3'–6"	13'–6"	18–#8	#5 @ 12"	3'–6"	17'–0"	18–#8	#5 @ 8"	4'–0"	18'–6"	18–#9	#5 @ 6"	4'–6"	19'–6"	18–#10	#5 @ 5"
WET SAND (DENSE)	3'–6"	10'–0"	18–#8	#5 @ 12"	3'–6"	10'–0"	18–#8	#5 @ 12"	3'–6"	12'–6"	18–#8	#5 @ 8"	4'–0"	13'–6"	18–#9	#5 @ 6"	4'–6"	14'–6"	18–#10	#5 @ 5"
CLAY (SOFT TO MEDIUM STIFF)	3'–6"	12'–6"	18–#8	#5 @ 12"	3'–6"	13'–0"	18–#8	#5 @ 12"	3'–6"	14'–0"	18–#8	#5 @ 8"	4'–0"	16'–0"	18–#9	#5 @ 6"	4'–6"	17'–6"	18–#10	#5 @ 5"
CLAY (STIFF)	3'–6"	11'–0"	18–#8	#5 @ 12"	3'–6"	11'–0"	18–#8	#5 @ 12"	3'–6"	12'–0"	18–#8	#5 @ 8"	4'–0"	13'–0"	18–#9	#5 @ 6"	4'–6"	14'–0"	18–#10	#5 @ 5"

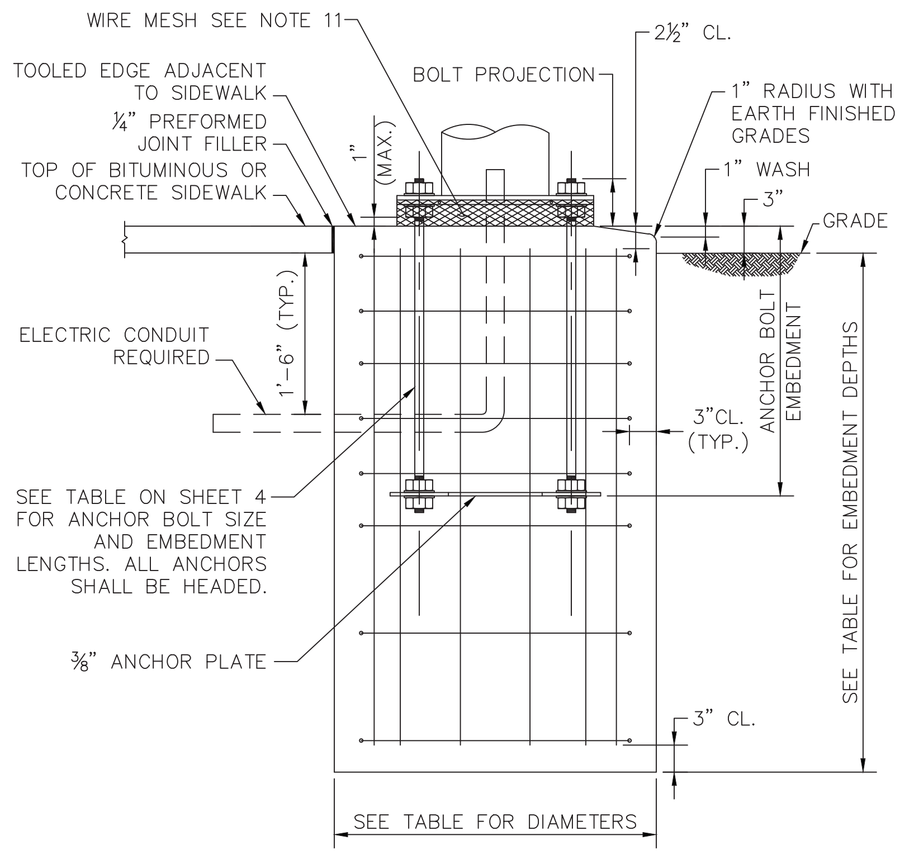
Mast Arm Nos. MA-2 and MA-4

Mast Arm Nos. MA-1 and MA-3

BASIS OF DESIGN

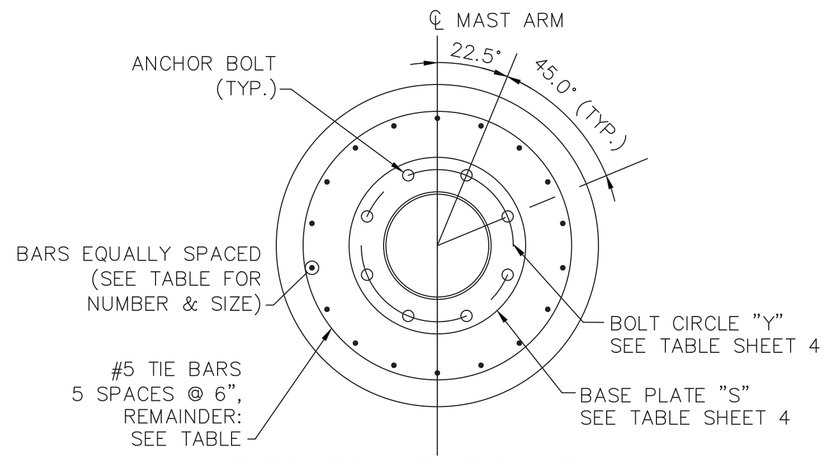
ALL MAST ARM STRUCTURES AND FOUNDATIONS ARE DESIGNED IN ACCORDANCE WITH AASHTO STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES, AND TRAFFIC SIGNALS, SIXTH EDITION 2013, AND THE FOLLOWING PARAMETERS:

OVERTURNING DESIGN	FOUNDATIONS ARE SIZED TO RESIST OVERTURNING ACCORDING TO BROMS' DESIGN METHOD WITH A SAFETY FACTOR THAT INCLUDES AN OVERLOAD FACTOR OF 2.0 AND A SOIL UNDERSTRENGTH FACTOR OF 0.7.		
SOIL PARAMETERS		UNIT WEIGHT	FRICTION ANGLE
	LOOSE DRY SAND:	γ = 102 PCF	Φ = 33°
	DENSE DRY SAND:	γ = 116 PCF	Φ = 39°
	LOOSE WET SAND:	γ = 125 PCF	Φ = 33°
	DENSE WET SAND:	γ = 135 PCF	Φ = 39°
		UNIT WEIGHT	SHEAR STRENGTH
	SOFT TO MEDIUM STIFF CLAY:	γ = 113 PCF	S_U = 1.0 KSF
	STIFF CLAY:	γ = 120 PCF	S_U = 1.9 KSF
DEFLECTION LIMITS	MAXIMUM LATERAL DEFLECTION AT TOP OF MAST ARM FOUNDATION SHAFTS: $\frac{1}{2}$"		



PIER FOUNDATION DETAIL

NO SCALE



PIER FOUNDATION PLAN

NO SCALE

NOTES:

1. FOUNDATIONS SHALL BE 4000 PSI, 565 MASSDOT APPROVED MIX DESIGN.
2. FOUNDATIONS SHALL BE INSTALLED IN ACCORDANCE WITH MASSDOT STANDARD SPECIFICATIONS ITEM 945 – DRILLED SHAFTS
3. REINFORCEMENT SHALL BE ASTM A615 GRADE 60.
4. ANCHOR BOLTS SHALL BE SET BY TEMPLATE.
5. PROVIDE FOR ELECTRICAL CONDUIT.
6. EXCAVATION SHALL BE BY THE AUGER METHOD TO THE NEAT LINES OF THE OUTSIDE DIMENSION OF THE FOUNDATIONS WITHOUT DISTURBING THE SOIL AROUND AND BELOW THE PROPOSED FOUNDATION BOTTOM. ALTERNATE METHODS OF EXCAVATION MAY BE SUBMITTED TO MASSDOT FOR APPROVAL IF THEY MEET THE REQUIREMENTS LISTED IN NOTES 6, 7, AND 8.
7. THE EARTH WALLS OF THE FOUNDATION SHALL BE ADEQUATELY AND SECURELY PROTECTED AT ALL TIMES AGAINST CAVE–INS, DISPLACEMENT OF THE SURROUNDING EARTH AND FOR THE EXCLUSION OF GROUND WATER. THIS MAY BE DONE BY THE USE OF STEEL CYLINDER LINERS OR CASINGS THAT ARE APPROVED BY MASSDOT. IF LINERS ARE USED THEY MAY BE RECLAIMED PROVIDED THAT THEY ARE WITHDRAWN AS THE CONCRETE IS BEING PLACED, MAINTAINING A SUFFICIENT HEAD OF CONCRETE WITHIN THE LINER TO PREVENT REDUCTION IN THE FOUNDATION DIAMETER AND TO PREVENT EXTRANEOUS MATERIAL FROM FALLING IN FROM THE SIDES AND MIXING WITH THE CONCRETE.
8. IF THE SOIL IS DISTURBED OR REMOVED BEYOND THE NEAT LINES OF THE OUTSIDE DIMENSION OF THE FOUNDATION, IT SHALL BE REPLACED WITH CONCRETE. ANY ADDITIONAL COST FOR THE CONCRETE SHALL BE PAID FOR BY THE CONTRACTOR.
9. SPECIAL CARE SHOULD BE GIVEN TO AREAS WHERE WET SOIL IS ENCOUNTERED, TO INSURE THAT THE PREAUGERED HOLE DOES NOT COLLAPSE. THIS MAY REQUIRE THE USE OF STEEL CYLINDER LINERS OR CASINGS TO HOLD THE SOIL IN PLACE UNTIL READY FOR CONCRETE PLACEMENT, UPON APPROVAL FROM THE MASSDOT. THE STEEL CYLINDERS OR CASINGS SHALL BE WITHDRAWN AS THE FOUNDATION CONCRETE IS PLACED.
10. IF LEDGE OR UNSUITABLE SOIL IS ENCOUNTERED (i.e. ONE WHICH DOES NOT APPLY TO THE DESIGN TABLES SHOWN ON THIS SHEET), AN ALTERNATIVE DESIGN SHALL BE PROVIDED BY THE DESIGN ENGINEER. IF UTILITIES OR OTHER UNDERGROUND OBSTRUCTIONS ARE ENCOUNTERED, THE CONTRACTOR SHALL BACKFILL THE AREA TO ITS ORIGINAL CONDITION UNTIL AN ALTERNATE DESIGN HAS BEEN PROVIDED BY THE DESIGN ENGINEER AND APPROVED BY MASSDOT. SPECIAL FOUNDATIONS SHALL BE DESIGNED IN ACCORDANCE WITH BASIS OF DESIGN TABLE ABOVE.
11. A GALVANIZED WIRE MESH SCREEN SHALL BE INSTALLED AT BASE OF POLE. SCREEN SHALL BE PRESS–FORMED OF 3 OR 4 MESH, 21 GAGE OR HEAVIER, STAINLESS STEEL OR HOT DIPPED GALVANIZED WIRE SCREEN OR APPROVED EQUIVALENT. SCREEN SHALL BE SCREWED INTO POLE BASE PLATE, AND SHALL BE FLUSH WITH THE TOP OF THE PIER FOUNDATION.
12. SANDY SOILS WITH STANDARD PENETRATION VALUES GREATER THAN 20 BLOWS PER FOOT SHALL BE CLASSIFIED AS DENSE DRY SAND AND DENSE WET SAND. SANDY SOILS WITH STANDARD PENETRATION VALUES RANGING FROM 6 TO 20 BLOWS PER FOOT SHALL BE CLASSIFIED LOOSE DRY SAND AND LOOSE WET SAND. SANDY SOILS WITH FEWER THAN 6 BLOWS PER FOOT SHALL REQUIRE SPECIAL FOUNDATION DESIGNS BY THE DESIGN ENGINEER AND APPROVED BY MASSDOT. SPECIAL FOUNDATIONS SHALL BE DESIGNED IN ACCORDANCE WITH BASIS OF DESIGN TABLE ABOVE.
13. CLAYS WITH STANDARD PENETRATION VALUES GREATER THAN 6 BLOWS PER FOOT SHALL BE CLASSIFIED AS STIFF CLAY. CLAYS WITH STANDARD PENETRATION VALUES RANGING FROM 2 TO 6 BLOWS PER FOOT SHALL BE CLASSIFIED AS SOFT TO MEDIUM STIFF CLAY. CLAYS WITH FEWER THAN 2 BLOWS PER FOOT SHALL REQUIRE SPECIAL FOUNDATION DESIGNS BY THE DESIGN ENGINEER AND APPROVED BY MASSDOT. SPECIAL FOUNDATIONS SHALL BE DESIGNED IN ACCORDANCE WITH BASIS OF DESIGN TABLE ABOVE.
14. A SANDY SOIL SHALL ONLY BE CLASSIFIED AS 'DRY' IF THE ENTIRE DRY SAND SHAFT LENGTH SITS ABOVE WET SOILS ACCORDING TO THE BORING LOGS. IF ANY PART OF THE SHAFT LENGTH IS CAST AT OR BELOW THE GROUNDWATER LEVEL, THE SOIL SHALL BE CLASSIFIED AS 'WET'.
15. WHERE THE PREDOMINATING SOIL TYPE IS INORGANIC SILT, THE SOIL SHOULD BE TREATED AS CLAY OR WET LOOSE SAND, WHICHEVER LEADS TO A MORE CONSERVATIVE FOUNDATION. INORGANIC SILTS WITH STANDARD PENETRATION N–VALUES LESS THAN 2 BLOWS PER FOOT, ORGANIC SILTS, AND PEAT SHALL REQUIRE SPECIAL FOUNDATION DESIGNS BY THE DESIGN ENGINEER AND APPROVED BY MASSDOT. SPECIAL FOUNDATIONS SHALL BE DESIGNED IN ACCORDANCE WITH BASIS OF DESIGN TABLE ABOVE.
16. WHERE FILL CONTAINS CLAY OR SILT, IT SHOULD BE TREATED AS SOFT CLAY.
17. MAST ARM FOUNDATIONS ARE DESIGNED TO SUPPORT MAST ARMS WITH OR WITHOUT OPTIONAL LUMINAIRE.
18. CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT FOUNDATION DIAMETER IS AT LEAST 17.5" GREATER THAN BOLT CIRCLE DIAMETER FOR ALL STRUCTURES
19. IN ORDER TO CREATE A FLUSH SURFACE, CONTRACTOR SHALL REFER TO THE FINAL ELEVATIONS SHOWN ON THE DESIGN PLANS WHEN INSTALLING FOUNDATIONS IMMEDIATELY ADJACENT TO OR WITHIN A SIDEWALK AREA.

MassDOT Massachusetts Department of Transportation Highway Division

STANDARD DRAWINGS

OVERHEAD SIGNAL STRUCTURE & FOUNDATION
MAST ARM CORED PIER FOUNDATIONS

MASSACHUSETTS DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
10 PARK PLAZA BOSTON, MASS

DECEMBER, 2015

A00885 - 24
Proposal No. 608051 - 132406

DOCUMENT A00886

SOILS AND FOUNDATIONS REPORT

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Soils and Foundations Report

for

Massachusetts Department of Transportation – Highway Division

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Project File No. 608051

Proposed Retaining Wall

for

State Route 38 (Main Street)

Wilmington, Massachusetts



Date: 8/13/2025

Prepared for:
Green International Affiliates, Inc.
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1A. Soil Classification Guidelines

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1.0 EXECUTIVE SUMMARY

This report is prepared for new Retaining Walls Type I, Type II, and Type III along Route 38 (Main Street) in Wilmington, Massachusetts. Based on the 2020 boring exploration results, the proposed walls can be supported by shallow spread footings with bearing resistance values recommended in Section 6.0 'Summary' of this report. The proposed Retaining Walls Type I to III are concrete gravity wall type, and the sections are shown on Figures 5 to 7.

2.0 INTRODUCTION

2.1 Scope of Report

The purpose of this report is to evaluate the substructure foundation types for the proposed retaining wall system based on the 2020 boring exploration results, make recommendations for the proposed foundation system, develop engineering design values, and identify anticipated construction issues. The design values are prepared in AASHTO LRFD format to be compatible with the current MassDOT retaining wall design approach.

2.2 Proposed Retaining Wall

The design concept of the proposed retaining wall can be found on the submission plans prepared by Green International Affiliates, Inc. (Green), who is the Prime Design Engineer for the project. Lamson Engineering Corporation (LEC) is a sub-consultant to Green, responsible for the geotechnical design of the project.

The proposed retaining wall is located along State Route 38 (Main Street) in the Town of Wilmington, as illustrated in Figure 1, 'Project Location Plan'.

Based on the maximum wall height (between the top of wall and the bottom of footing), there are three (3) retaining wall sections in this project.

Retaining Wall Type III located from approximately Station 207+20 to Station 207+70 has a maximum wall height of 12.5 feet with footing width of 6.5 feet.

Retaining Wall Type II located from approximately Station 207+70 to Station 208+45 has a maximum wall height of 14.0 feet with footing width of 7.5 feet.

Retaining Wall type I located from approximately Station 208+45 to Station 209+00 has a maximum wall height of 11.5 feet with footing width of 6.5 feet.

The proposed concrete gravity retaining walls are to be designed according to the AASHTO LRFD and MassDOT LRFD Bridge manual requirements.

2.3 References

The following references were used in the preparation of this report:

- MassDOT LRFD Bridge Manual, Hundredth Anniversary Edition, 2024.
- AASHTO LRFD Bridge Design Specifications, 2020, 9th Edition
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2011, 2nd Edition with 2012, 2014, 2015, and 2022 Interim Revisions.
- Surficial geology of the Wilmington quadrangle, Massachusetts by Robert O. Castle, 1959.
- Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts by Robert O. Castle, J. Christopher Hepburn, and Joseph P. Kopera, 2005.

3.0 SUBSURFACE CONDITIONS

3.1 Local Geology

According to the Surficial Geology Map of the Wilmington Quadrangle, Massachusetts, surficial geologic deposits above the bedrock at the site consist of ground moraine deposits of till with minor amounts of sand and gravel.

Based on the Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts, the bedrock consists of Binary Granite Facies. The Binary Granite Facies can be described as "Chiefly medium-grained, massive to faintly foliated, pearly-white to light-gray monzogranite. Composed mainly of microcline, plagioclase, quartz, muscovite and biotite with accessory garnet. Pegmatite prominent locally."

3.2 2020 Subsurface Exploration Program

A subsurface exploration program consisting of test borings WB-1, WB-2, and WB-3 were completed in January 2020 for the proposed retaining wall, as indicated on Figure 2, 'As-Drilled 2020 Boring Location Plan'.

Borings WB-1, WB-2, and WB-3 were conducted along Route 38 (Main Street) for the beginning, middle, and end of the proposed retaining wall.

The exploration was performed between January 6, 2020 and January 9, 2020 by Northern Drill Services, Inc. on 130 East Main Street, Northborough, Massachusetts. The monitoring of boring explorations was performed by Lamson Engineering Corporation. Materials recorded on the boring logs were visually inspected on site by the engineer from Lamson Engineering, who is also involved in the preparation of this report.

The soil samples were taken using a 2" outside diameter split spoon sampler driven into the soil by a 140-pound hammer falling 30". Blows per 6" were recorded. The materials at the site were included on the boring logs, and are also included on the soil profile in Figures 3 & 4 of this report.

3.3 Subsurface Profiles

The soil profiles of the site, as reflected in the 2020 boring exploration results, are included in Figures 3 & 4 of the report. Based on the 2020 boring information, the soil profile at the site can be separated into three (3) stratums: Stratum 1: Sand and Gravel materials; Stratum 2: Cobbles; Stratum 3: Glacial Till materials.

Figures 3 & 4 depict the retaining wall site soil profiles.

Stratum 1 – Loose to Very Dense Sand and Gravel (Fill)

Stratum 1 consists of fine to coarse, brown sand, that is dry to wet with some fine to coarse gravel, and contain a trace of inorganic silt. The Standard Penetration Test (SPT) blow counts per foot (N) range from 5 to 64, with an average of about 26. Stratum 1 is approximately 11.2' and 16.5' thick, extending from the roadway surface to about Elev. 87.3 and Elev. 81.1 from North to South, respectively.

Loose materials were encountered from Elev. 93.6 to Elev. 85.6 and Elev. 88.3 to Elev. 83.8 at Borings WB-2 and WB-3, respectively.

Stratum 2 – Cobbles

Stratum 2 consists of pockets of cobbles. Stratum 2 is approximately 1.7' and 3.7' thick, extending from the bottom of Stratum 1 to about Elev. 83.6 and Elev. 78.8 from North to South, respectively.

Stratum 3 – Very Dense Sand and Gravel (Glacial Till)

Stratum 3 consists of fine to coarse, grey or brown sand and gravel, that is wet with some inorganic silt. The SPT blow counts (N) range from 19 to 70, with an average of about 39. Stratum 3 is approximately 51.9' thick, extending from bottom of Stratum 1 to about Elev. 149.4 for East Abutment. Stratum 3 is approximately 7.3' and 8.5' thick, extending from bottom of Stratum 2 to about Elev. 76.3 and Elev. 70.3 from North to South, respectively.

For detailed information on each boring, refer to the boring logs included in Appendix 1B of this report.

3.4 Bedrock Information

Based on the obtained bedrock cores, the bedrock consists of medium to coarse grained light to dark gray Granite and Granite Gneiss. The top of bedrock was encountered ranging from Elev. 70.3 to Elev. 70.9 as shown in the table below, with its average top at approximately Elev. 74.5.

Bedrock core recovery ratios are included in the Appendix 1B, Boring Logs; and the Rock Quality Designation (RQD) of each bedrock core run is included in the Appendix 1, Photos.

Table 3.4: Bedrock Information

Boring No.	Ground Elev. (Feet)	Depth from Existing Ground	Top of Bedrock Elev. (Feet)	Recovery Ratio % (RQD %)	Bedrock Type
WB-1	Elev. 103.8	27’-6”	Elev. 76.3	Core 1: 80% (73%) Core 2: 89% (61%)*	Granite
WB-2	Elev. 97.6	20’-9”	Elev. 76.9	Core 1: 42% (42%) Core 2: 97% (97%) Core 3: 95% (95%)	Granite/Quartz
WB-3	Elev. 92.3	22’-0”	Elev. 70.3	Core 1: 87% (50%) Core 2: 100% (53%)	Granite Gneiss

*Core barrel is jammed with incomplete 5-foot core run. RQD values recorded are not representative.

3.5 2020 Groundwater Information

Based on the boring logs, groundwater information can be obtained. However, the obtained groundwater information from the washed boring operation is presented for preliminary reference only.

Table 3.5: 2020 Groundwater Information Measured after Washed Boring Operation

Boring No.	Ground Elev. (Feet)	Groundwater Depth (Feet)	Estimated Groundwater Elev. (Feet)	Remark
WB-1	Elev. 103.8	14’-0”	Elev. 89.8	For Beginning of Wall
WB-2	Elev. 97.6	13’-0”	Elev. 84.6	For Middle of Wall
WB-3	Elev. 92.3	12’-5”	Elev. 79.9	For End of Wall

3.6 Boulder / Cobble Materials Information

Pockets of Cobble materials were encountered during the 2020 boring exploration.

Table 3.6: Boulder / Cobble Materials Information

Boring No.	Ground Elev. (Feet)	Top of Cobble Depth/ (Elev.)	Bottom of Cobble Depth/ (Elev.)	Layer Thickness (Feet)	Remark
WB-1	Elev. 103.8	16.5’ (87.3)	20.2’ (83.6)	3.7	For Beginning of Wall
WB-2	Elev. 97.6	12.0’ (85.6)	13.7’ (83.9)	1.7	For Middle of Wall
WB-3	Elev. 92.3	11.2’ (81.1)	13.5’ (78.8)	2.3	For End of Wall

3.7 Seismic Design Category Evaluation

Based on the 2024 M*assDOT* Bridge Manual 3.4.1, all seismic analysis and design of bridges shall be performed in accordance with the 'AASHTO Guide Specifications for LRFD Seismic Bridge Design'. Based on the 2011 Guide Specifications, Table 3.4.2.1-1 (same as AASHTO Table 3.10.3.1-1) for site soil type and profile, the site class is C (F_{pga} = 1.2, F_a = 1.2, F_v = 1.7).

This structure is considered as a non-critical/non-essential bridge, and a 1,000-year return period is used. With these results and Appendix 3, 'AASHTO Guide Specifications for LRFD Seismic Bridge Design, Figure 3.4.1-2b to Figure 3.4.1-4b for the 1,000-year return period', the following can be obtained:

Acceleration Coefficient (A_s) = 0.096g
Design Spectral Acceleration Coefficient at 0.2-sec Period (S_{DS}) = 0.192g
Design Spectral Acceleration Coefficient at 1.0-sec Period (S_{D1}) = 0.068g

Since S_{D1} is less than 0.15g, the Seismic Design Category (SDC) is A. This is based on Guide Specifications Table 3.5-1 (same as AASHTO Table 4.7.4.3.1-1).

3.8 Liquefaction Potential

A liquefaction assessment is not required for structure in Seismic Design Category (SDC) A. The proposed spread footing is supported by medium dense or dense sand materials which are not susceptible to seismic soil liquefaction effect.

4.0 FOUNDATION RECOMMENDATIONS

4.1 New Retaining Walls

Three types of retaining walls are considered for this project. They are MSE walls, soldier pile lagging walls and conventional concrete retaining walls. Soldier pile lagging wall may not be feasible due to shallow bedrock. Furthermore, conventional concrete retaining wall works better when supporting roadway live load. Therefore, conventional concrete retaining wall is recommended for this project.

Based on the 2020 boring information, shallow spread footings can be used for support of proposed concrete retaining walls. Based on Bridge Manual Section 3.3.2 and the proposed wall is less than 14' high, gravity retaining wall is recommended. The concept of this type of wall and the foundation with varying wall height is shown on Figures 5 to 7.

The proposed bottom of footings is recommended to be at Elev. 93.0, Elev. 88.0, and Elev. 85.0 for Type III, Type II, and Type I, respectively. Unsuitable soil materials range from 2' to 3' below the proposed footing for Type I to Type III wall is recommended to be replaced with compacted 'Gravel Borrow for Bridge Foundation'. The nominal design resistance and the factored design resistance values are included in Section 6 and Appendix 2 of the report.

Settlement: The foundation bearing materials are fine sand materials. The maximum elastic settlement is likely to be approximately 0.6" for sand materials. The estimated settlement is small and is considered

instantaneous and completed upon application of all loads. There is no long term consolidation settlement involved.

Slope Stability: Based on the results of the slope stability analysis in the attached calculations, there is no anticipated slope stability problem.

4.2 Proposed Retaining Wall Design Parameters

The following parameters are recommended to be used for design of the retaining walls:

Wall Type III
Moist Unit Weight of Soil = 120 pcf (behind wall)
Soil Friction Angle = 37° (below footing)
Soil Friction Angle = 32° (behind wall)
Active Lateral Earth Pressure Coefficient = 0.428
At-Rest Lateral Soil Pressure Coefficient = 0.470
Resistance Factor for Sliding for Concrete on soil = 0.8
Angle of back of wall to the horizontal, θ = 72.5°

Wall Type II
Moist Unit Weight of Soil = 120 pcf (behind wall)
Soil Friction Angle = 32° (below footing)
Soil Friction Angle = 32° (behind wall)
Active Lateral Earth Pressure Coefficient = 0.458
At-Rest Lateral Soil Pressure Coefficient = 0.470
Resistance Factor for Sliding for Concrete on soil = 0.8
Angle of back of wall to the horizontal, θ = 69.9°

Wall Type I
Moist Unit Weight of Soil = 120 pcf (behind wall)
Soil Friction Angle = 37° (below footing)
Soil Friction Angle = 32° (behind wall)
Active Lateral Earth Pressure Coefficient = 0.451
At-Rest Lateral Soil Pressure Coefficient = 0.470
Resistance Factor for Sliding for Concrete on soil = 0.8
Angle of back of wall to the horizontal, θ = 70.5°

Unreinforced embankment slope should in general be no steeper than 1:2 (V:H).

Lateral earth pressure values used for design shall be in conformance with *MassDOT* BM 3.1.6.

4" diameter weep holes should be used behind the proposed retaining walls at 10' maximum on center to minimize hydrostatic pressure on the back of the walls.

4.3 Soil Parameters

Based on the information of the boring logs, the following soil parameters are recommended:

Table 4.3: Recommended Soil Parameters

Wall	Soil below Footing (considered)	Soil Unit Weight, γ (below footing)	Soil Friction Angle, ϕ_{f1} (behind wall)	Soil Friction Angle, ϕ_{f2} (below footing)	Boring #
Type III	"Gravel Borrow for Bridge Foundation" on Very Dense, Fine to Coarse Sand	125 pcf	32°	37°	WB-1
Type II	Medium Dense, Fine Sand	120 pcf	32°	32°	WB-2
Type I	"Gravel Borrow for Bridge Foundation" on Very Dense, Fine to Coarse Sand	125 pcf	32°	37°	WB-3

Other relevant parameters are also included in the attached calculations.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Water Control

Water levels encountered during boring operation were generally below the bottom of proposed spread footings. Water control is expected to be minimal.

Water levels recorded on the logs were not accurate due to the washed boring operation.

The following factors should be taken into consideration for the recorded water levels:

- Groundwater levels obtained from the boring exploration operation are generally unreliable and are provided for reference only.
- Groundwater levels fluctuate over time due to seasonal changes.

5.2 Temporary Earth Support

Temporary earth support will be needed for the proposed retaining walls construction. The system shall be designed in accordance with MassDOT Standard Specifications Section 950, 'Sheeting'. Since its use is temporary, the earth support system is to be designed by Contractor. Depending on their excavation scheme, it may be a combination of steel sheeting, soldier pile & lagging system or another retaining system. In selecting steel sheeting, consideration should be given to the presence of cobble

layer at the site potentially making the driving difficult. The Contractor shall design a system that is suitable for the site conditions based on his/her operation.

5.3 Utilities

There are existing underground and overhead utility lines running parallel to the roadway. The contractor should ensure that all existing utilities that are in conflict with the proposed construction are relocated prior to the proposed foundation construction.

5.4 Obstructions

Underground/overhead utilities, boulders, cobbles, and unknown previous roadway construction materials are potential obstruction materials that may be encountered at the site during construction. Contractor should prepare for these potential obstruction materials during the proposed foundation excavation.

5.5 Unsuitable soil Excavations

Organic materials were not encountered in the 2020 boring program. If encountered, it should be removed and replaced by 'Gravel Borrow for Bridge Foundation' materials. The unsuitable soil materials 24" to 36" below Type I to Type III walls footing are replaced with compacted 'Gravel Borrow for Bridge Foundation'.

6.0 SUMMARY

This report is prepared for the proposed concrete gravity Retaining Walls, Type I to Type III, of this Project. Based on the 2020 boring exploration results, the proposed retaining walls can be supported by shallow spread footings.

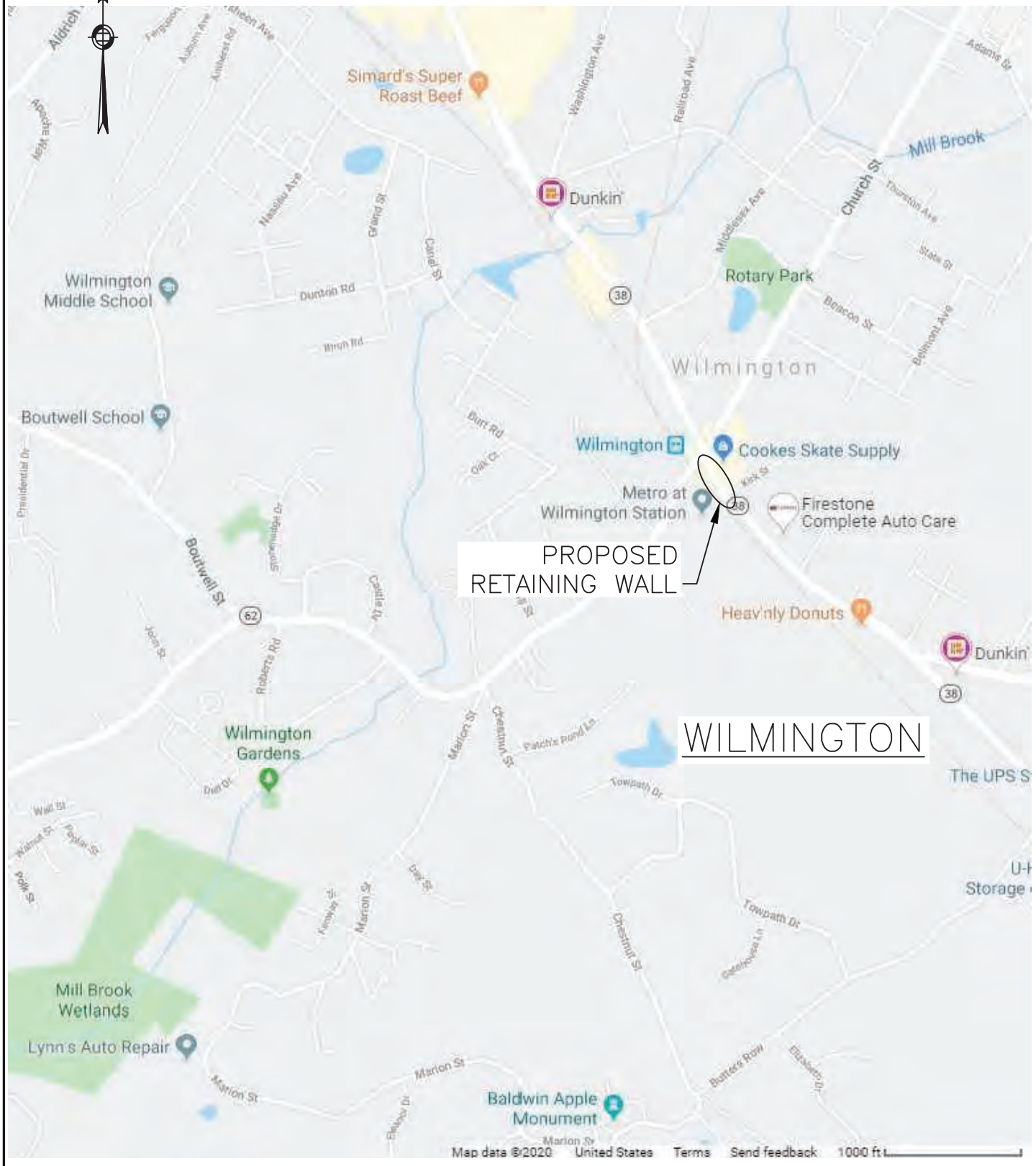
Table 6.1: Summary of Proposed Footing Factored Bearing Resistance

Wall	Station	Max. Design Wall Height, H (ft)	Design Footing Width, B (ft)	Design Bottom of Footing Elevation (ft)	Factored Bearing Pressure (ksf)	Factored Bearing Resistance (ksf)	Remark
Type III	207+20 to 207+70	12.5 Max.	6.5	Elev. 93.0±	3.4	5.1	Based on WB-1 ϕ_{f1} = 32° ϕ_{f2} = 37°
Type II	207+70 to 208+45	14.0 Max.	7.5	Elev. 88.0±	3.7	4.8	Based on WB-2 ϕ_{f1} = 32° ϕ_{f2} = 32°
Type I	208+45 to 209+00	11.5 Max.	6.5	Elev. 85.0±	3.2	6.4	Based on WB-3 ϕ_{f1} = 32° ϕ_{f2} = 37°

Note:
1. Water tables are assumed to be at the bottom of footings for conservative purpose.
2. The bearing resistance factor = 0.55
3. The design wall height is at the high end of the wall. The design wall height is between the top of wall and the bottom of footing.

ϕ_{f1} = Angle of internal friction above footing
ϕ_{f2} = Angle of internal friction below footing

FIGURES



massDOT Highway

GREEN INTERNATIONAL AFFILIATES, INC.
PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS



PROJECT LOCATION PLAN
AS NOTED

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 1

GREEN INTERNATIONAL AFFILIATES, INC.

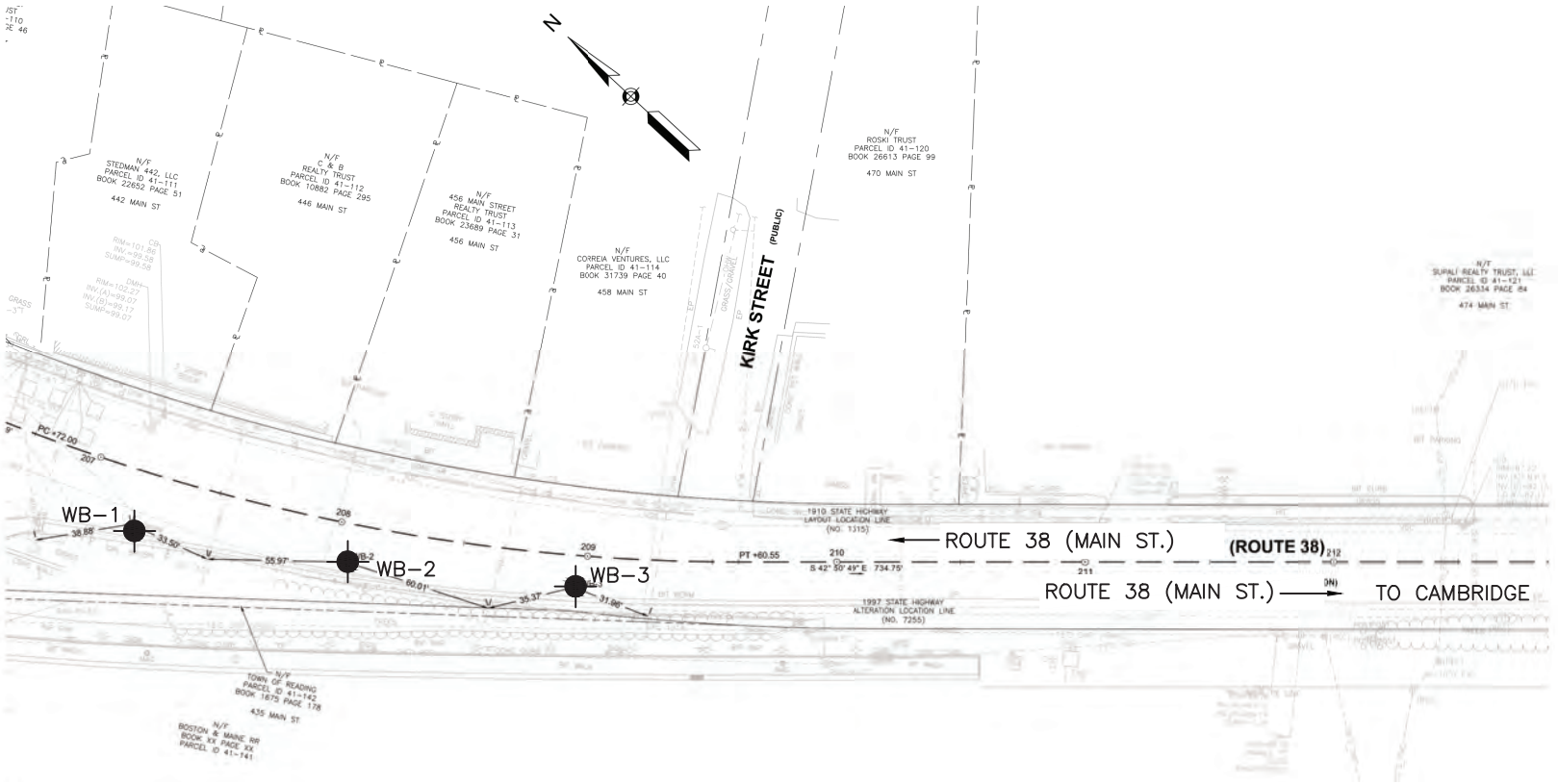
PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

2020 AS-DRILLED BORING LOCATION PLAN

NOT TO SCALE

Fig. 2



AS-DRILLED 2020 BORING LOCATIONS (FEET)			
BORING NO.	NORTHING	EASTING	SURFACE ELEVATION
WB-1	3,024,208	744,149	103.8
WB-2	3,024,137	744,200	97.6
WB-3	3,024,063	744,254	92.3

LEGEND:

WB-X — AS-DRILLED 2020 RETAINING WALL BORING

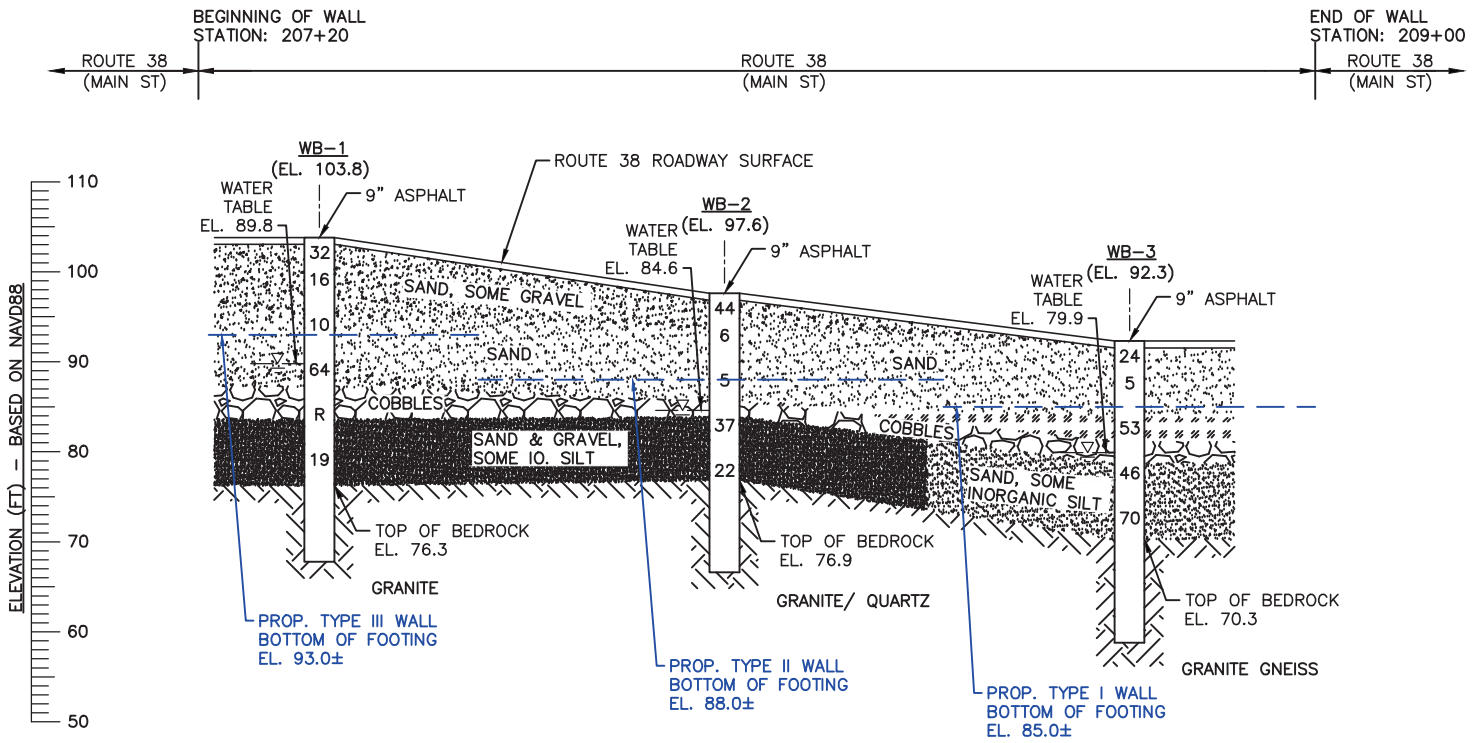
GREEN INTERNATIONAL AFFILIATES, INC.
PROPOSE RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

SOIL PROFILE – PICTORIAL VIEW

SCALE: 3/64" = 1'-0"

Fig. 3



LEGEND

WB-1 (EL. 103.8) BORING LOCATION AND IDENTIFICATION GROUND SURFACE ELEVATION

32 N VALUE (BLOWS/12")

WATER TABLE

R REFUSAL (N>120)

BEDROCK

- SAND
- SAND & GRAVEL
- SAND, SOME GRAVEL
- COBBLES
- SAND & GRAVEL, SOME IO. SILT
- BEDROCK
- SAND, SOME INORGANIC SILT

GENERAL NOTE:

SOIL MATERIALS AND TOP OF BEDROCK ELEVATION SHOWN BETWEEN BORINGS ARE PRELIMINARY BASED ON CONDUCTED BORINGS INFORMATION, AND THEY ARE NOT GUARANTEED TO BE THE MATERIALS OR TOP OF BEDROCK TO BE ENCOUNTERED AT OTHER LOCATIONS OF THE SITE.

NOTES:

1. NUMBER IN COLUMNS INDICATE NUMBER OF BLOWS PER 12" ON A 2" O.D. SPLIT SPOON SAMPLER PRODUCED BY A 30 INCH FALL OF A 140 LB HAMMER.
2. THE ELEVATIONS SHOWN ARE BASED ON THE 1988 NAVD DATUM.

GREEN INTERNATIONAL AFFILIATES, INC.

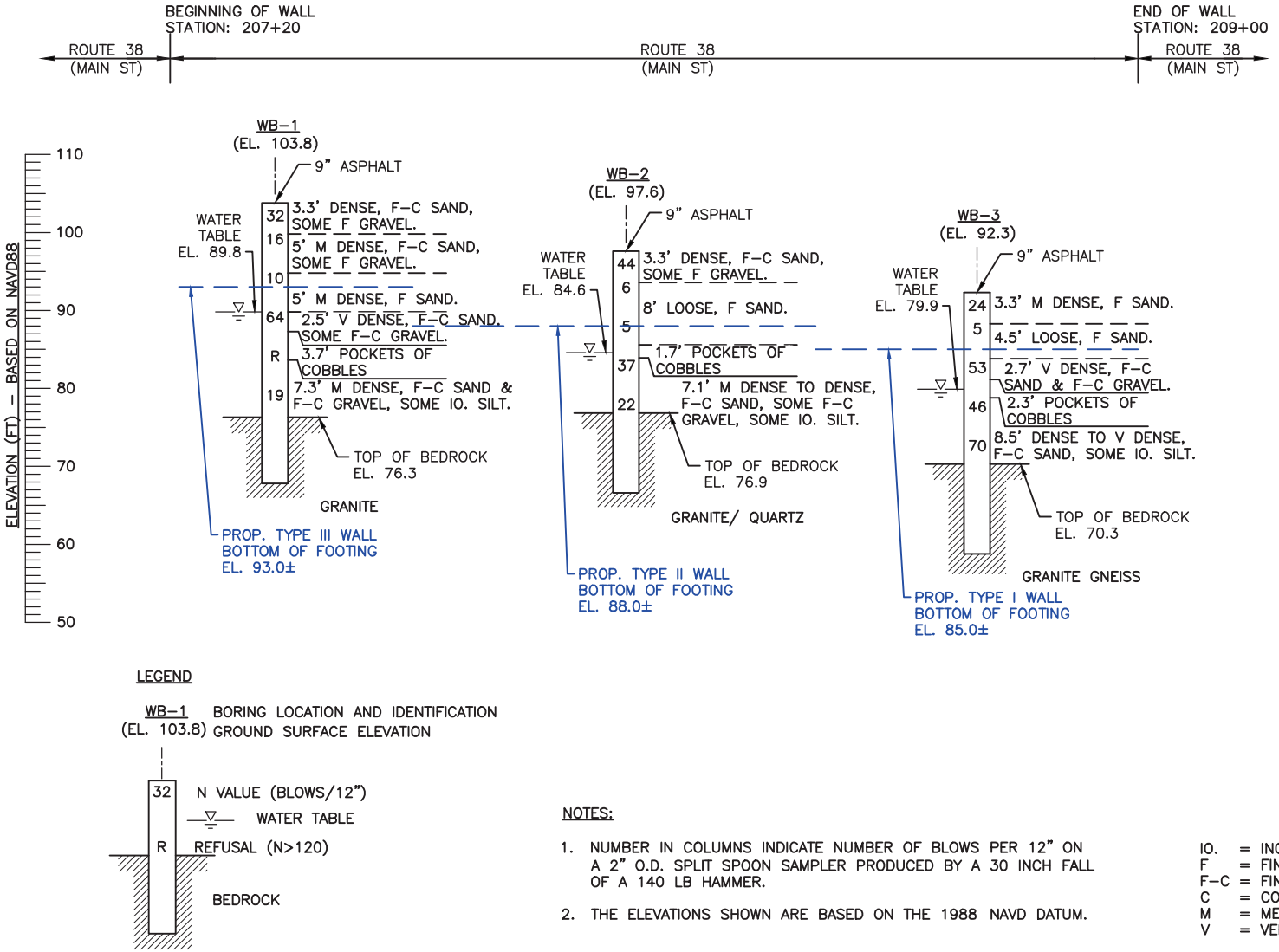
PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

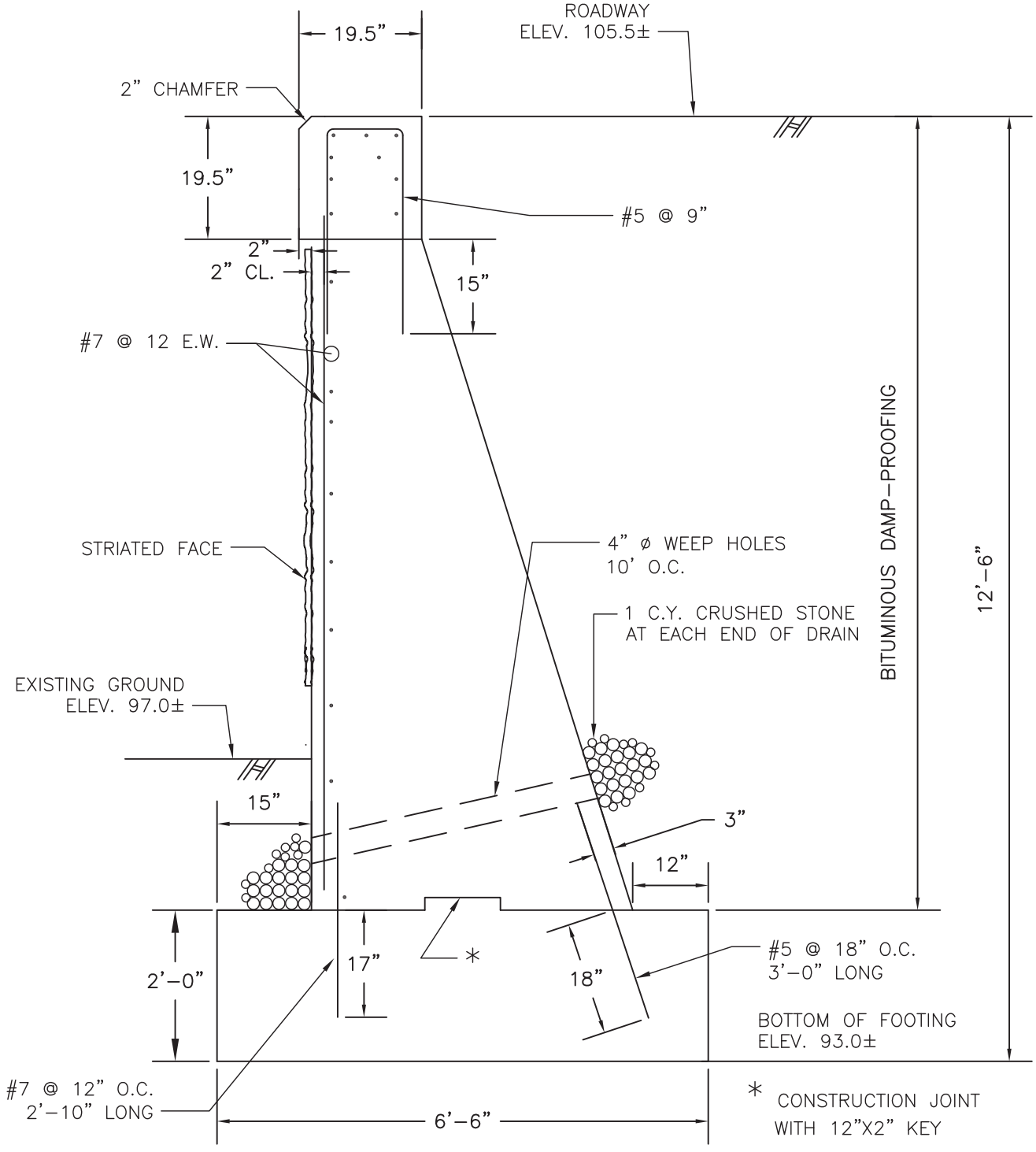
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SOIL PROFILE – DESCRIPTIVE VIEW

SCALE: 3/64" = 1'-0"

Fig. 4

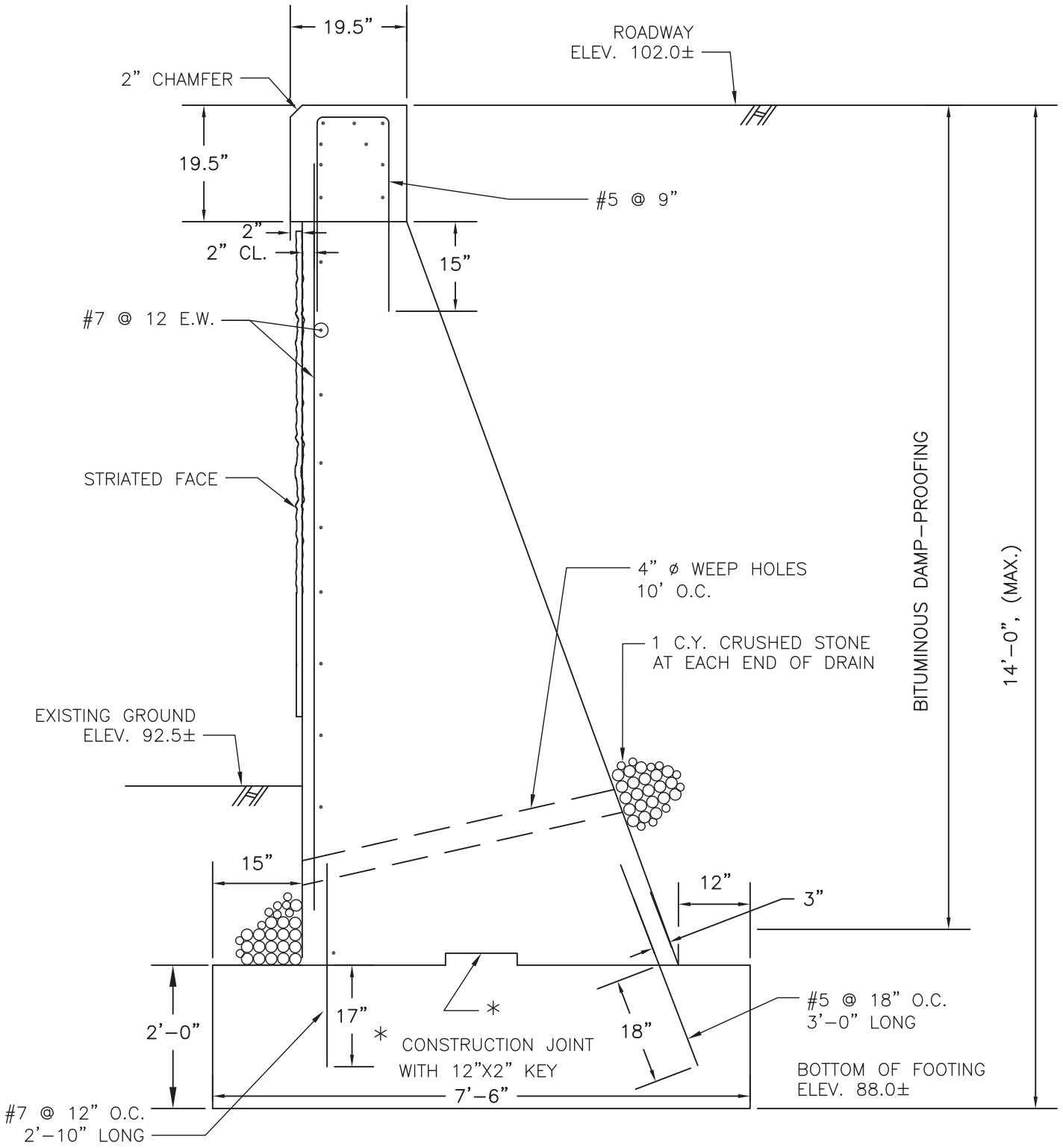




WALL TYPE III – CONCRETE GRAVITY RETAINING WALL

SCALE: 1/2" = 1'-0"

massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. PROPOSED RETAINING WALL STATE ROUTE 38 (MAIN STREET) WILMINGTON, MASSACHUSETTS	SECTION: RETAINING WALL TYPE III CONCRETE GRAVITY WALL SCALE: 1/2" = 1'-0" PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 5



WALL TYPE II – CONCRETE GRAVITY RETAINING WALL

SCALE: 1/2" = 1'-0"

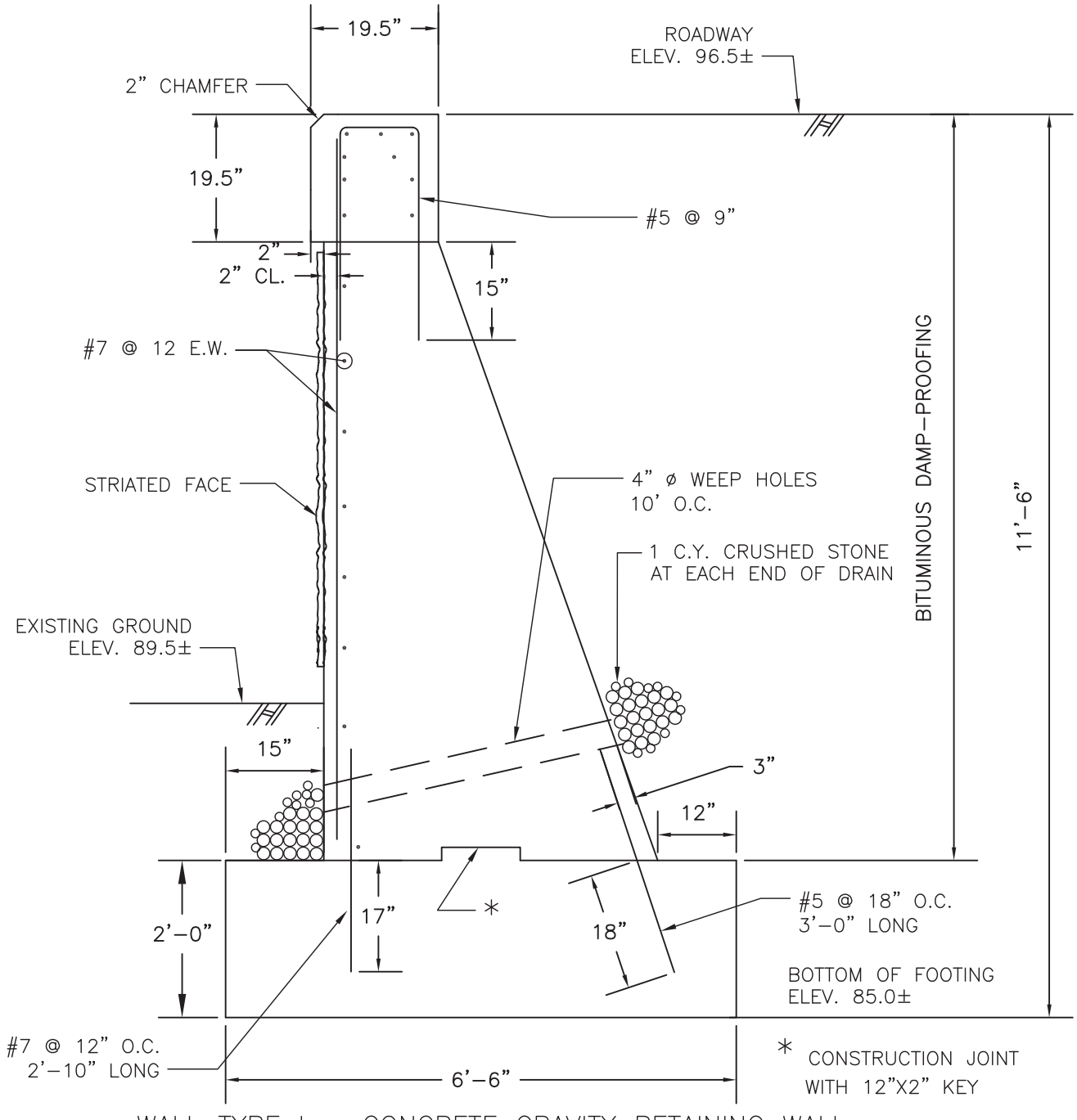
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GREEN INTERNATIONAL AFFILIATES, INC.
PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

SECTION: RETAINING WALL TYPE II
CONCRETE GRAVITY WALL
SCALE: 1/2" = 1'-0"

PREPARED BY
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NEWTON, MASS.

Fig. 6



WALL TYPE I – CONCRETE GRAVITY RETAINING WALL

SCALE: 1/2" = 1'-0"

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GREEN INTERNATIONAL AFFILIATES, INC.
PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

SECTION: RETAINING WALL TYPE I
CONCRETE GRAVITY WALL
SCALE: 1/2" = 1'-0"

PREPARED BY
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NEWTON, MASS.

Fig. 7

Proposal No. 608051 - 132406

A00886 - 22



massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. PROPOSED RETAINING WALL STATE ROUTE 38 (MAIN STREET) WILMINGTON, MASSACHUSETTS	SURFICIAL GEOLOGICAL MAP SCALE: NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 8

GREEN INTERNATIONAL AFFILIATES, INC.

PROPOSED RETAINING WALL
STATE ROUTE 38 (MAIN STREET)
WILMINGTON, MASSACHUSETTS

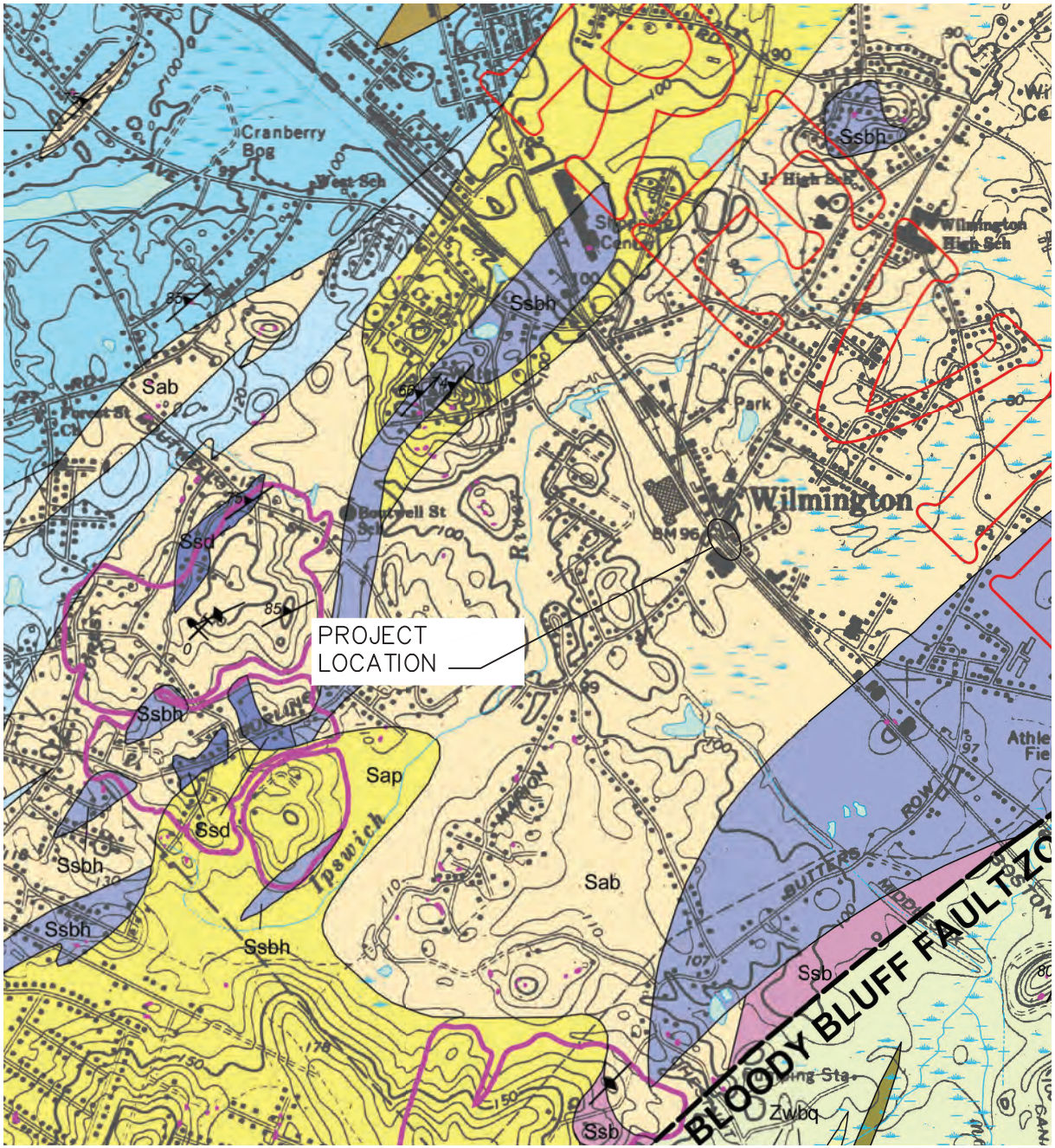
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BEDROCK GEOLOGICAL MAP

SCALE: NOT TO SCALE

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Fig. 9



APPENDIX 1A

Soil Classification Guidelines

(7 Sheets)

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VISUAL IDENTIFICATION OF SOILS

Grain Size: According to AASHTO Designation M146-91 (2000) - On the basis of grain size, soils are divided into the following classes:

SOIL TYPE	GRAIN SIZES (Millimeters / Inches)	
	PASSING	RETAINED
Boulders	Above 305 mm (12")	
Cobbles	305 mm (12")	75 mm (3")
Gravel - Coarse	75 mm (3")	25.0 mm (1")
Gravel - Medium	25 mm (1")	9.5 mm (3/8")
Gravel - Fine	9.5 mm (3/8")	2.00 mm (#10)
Sand - Coarse	2.00 mm (#10)	0.425 mm (#40)
Sand - Fine	0.425 mm (#40)	0.075 mm (#200)
Silt and Clay	Below 0.075 mm (#200)	

Moisture Content is the relative moisture content of the soil at the time of sampling. It shall be designated as: "dry", "moist" and "wet".

Color is the predominant color of the soil sample in the natural state. It shall be designated as: "brown", "yellow", "gray", "white", "red", "blue" or "black".

Coarse grained soils are those having a predominance of Gravel and/or Sand.

Fine grained soils are those having a predominance of Silt and/or Clay.

Density: Coarse grained soils: "loose" or "dense" and a designation as to whether or not the soil is "cemented".

Consistency: Fine grained soils: "hard", "stiff" or "soft", as well as a designation as to whether or not the soil is "plastic" or "non-plastic".

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Several entries are made to describe a soil according to grain size:

The first entry represents the predominating type of soil contained in the sample. This should be capitalized in each case, such as COARSE SAND, FINE GRAVEL, INORGANIC SILT, etc.

The second entry indicates the second and/or third component material. The amount of this material should be indicated by the consistent use of the following words:

"and" ..... 50% to 40% of the secondary component
"some" ..... 40% to 10% of the secondary component
"trace" ..... 10% or less of the secondary component

Hardpan: Some soil mixtures have been subjected to extremely heavy pressures and together with cementation and induration have formed so-called Hardpan. This term does not indicate the composition of the soil but amplifies the description of the consistency of extremely compact soil.

Grain characteristics: In coarse grained soils or when marked grain characteristics are evident, the shape of the grain shall be indicated as: "flat", "sharp" and/or "round". The overall grading of the material shall be designated as "well graded", "poorly graded", or if the material is noticeably of one size, it should be designated as "uniform".

Vegetable Muck and Peat: Vegetable mucks and peats are soil mixtures with varying percentages of organic and vegetable matter formed by decomposition of leaves, grasses and other fibrous materials. The color ranges from light brown to black. When mixture contains high percentage of vegetable material it is called peat. The soil content of the mixture should be identified and an estimate made of the amount of vegetable matter in the mixture.

Other Designations: Certain materials may be incorporated which do not fall under the foregoing classifications and which require further qualification for proper identification. Additional terms may be specifically designated as "rock fragments", "stones", "rock flour", or other qualifying descriptions.

A typical sample description entry would read:

Moist, medium dense, brown, INORGANIC SILT, some fine sand, trace of clay.

[for a sample which is largely inorganic silt with about 30% of fine sand an about 5% of clay]

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FIELD OBSERVATION TO IDENTIFY SILT AND CLAY CHARACTERISTICS

The field tests listed in the table below may be used to distinguish between the structural characteristics of a silt or clay soil.

Characteristics	Silt	Clay
Plasticity in the moist state.	Very little or no plasticity.	Plastic and sticky and can be rolled.
Cohesiveness in dry state.	Little or no cohesive strength in dry state and will crumble and slake readily.	Has a high dried strength. It crumbles with difficulty and slakes slowly in water.
Visual inspection and feel.	Coarse silt grains can be seen. Silt feels gritty when rubbed between fingers.	Clay grains cannot be observed by visual inspection. They feel smooth and greasy when rubbed between fingers.
Settlement in water.	Will settle out of suspension within one hour.	Will stay in suspension in water for several days unless it flocculates.
Movement of water in the voids.	When a small quantity of silt is shaken in the palm of the hand, water will appear on the surface of the soil. When shaking is stopped, water will gradually disappear.	When a small quantity is shaken in the palm of the hand, it will show no signs of water movement out of the voids.

If the fine grain soil is a mixture of silt and clay, the tests indicate whether or not the predominating characteristic of the mixture is silt or clay.

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ORDER OF SAMPLE DESCRIPTION

① **MOISTURE CONTENT:** "Dry", "Moist" or "Wet"

② **SOIL RELATIVE DENSITY OR CONSISTENCY:** See the Penetration Resistance (N) Guide.

③ **COLOR:** "Brown", "Gray", "Black", etc.

④ **MAJOR COMPONENT:** Composes more than 50% of the sample. This should be capitalized (COARSE SAND, INORGANIC SILT, FINE GRAVEL, etc.)

⑤ **MINOR COMPONENT:** Composes samples consistent with the following terms:

"and"	-	40% to 50% of the minor grain sizes
"some"	-	10% to 40% of the minor grain sizes
"trace"	-	less than 10% of the minor grain sizes

Example:

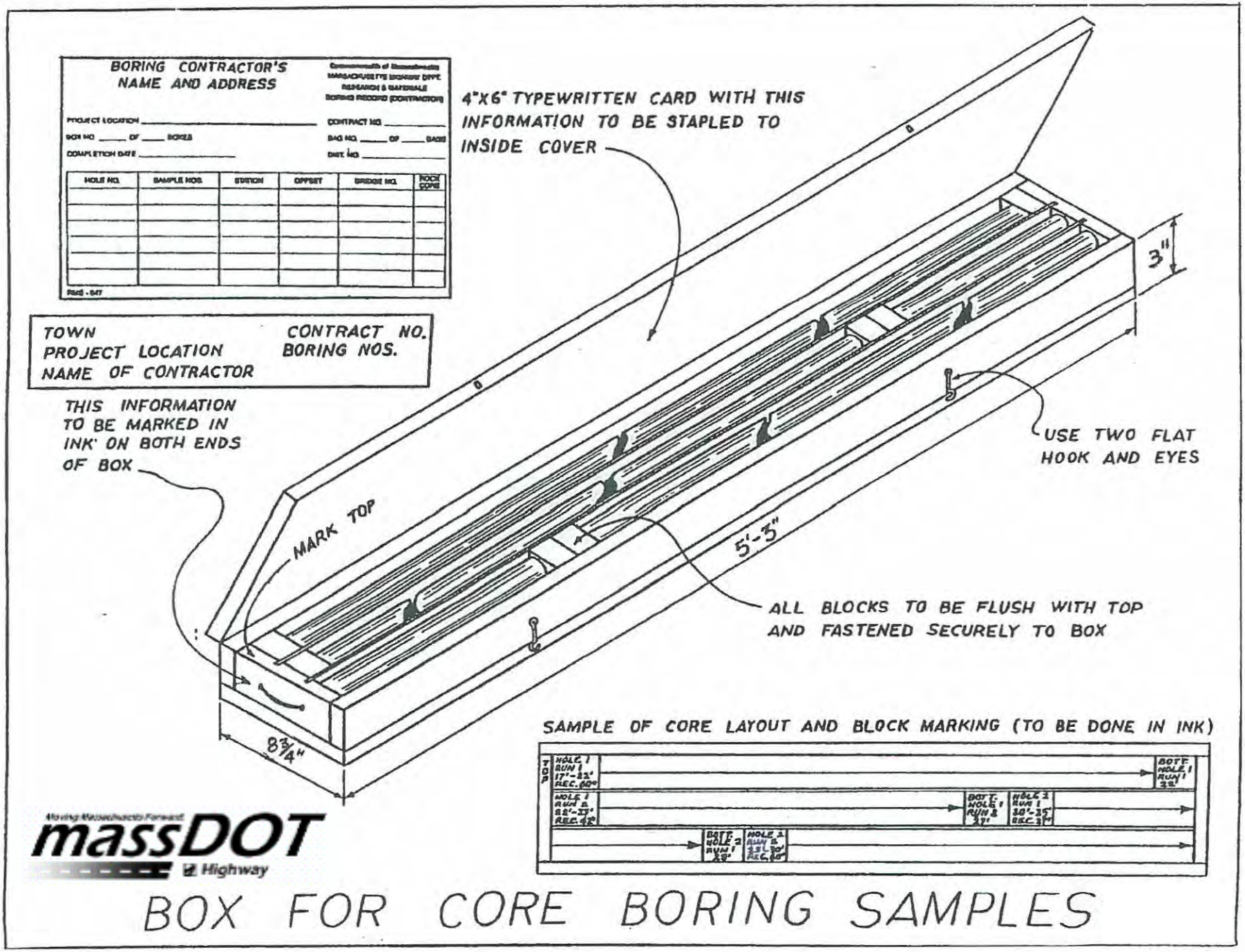
Wet, very dense, brown, COARSE SAND, some inorganic silt, trace of clay

PENETRATION RESISTANCE (N) GUIDE

COHESIONLESS SOILS (SANDS)		COHESIVE SOILS (CLAYS)	
RELATIVE DENSITY	NUMBER OF BLOWS PER FOOT (0.3 Meters)	CONSISTENCY	NUMBER OF BLOWS PER FOOT (0.3 Meters)
VERY LOOSE	0 - 4	VERY SOFT	BELOW 2
LOOSE	4 - 10	SOFT	2 - 4
MEDIUM DENSE	10 - 30	MEDIUM STIFF	4 - 8
DENSE	30 - 50	STIFF	8 - 15
VERY DENSE	OVER 50	VERY STIFF	15 - 30
		HARD	OVER 30

The Standard Penetration Test consists of counting the numbers of blows required to drive a 2-inch (51 mm) O. D. by 1-3/8 inch (35 mm) I. D. split spoon sampler a distance of 12 inches (300 mm) with a 140 pound (63.5 kilogram) hammer free falling 30 inches (760 mm). The sampler is driven a total of 18 inches (450 mm) and the blows are recorded per 6 inches (150 mm) of penetration or fraction there of. The penetration resistance (N) is determined by adding the second and third 6-inch (150 mm) penetration resistance blow counts. A driving rate of 120 blows per foot (300 mm) is considered "Practical Refusal".

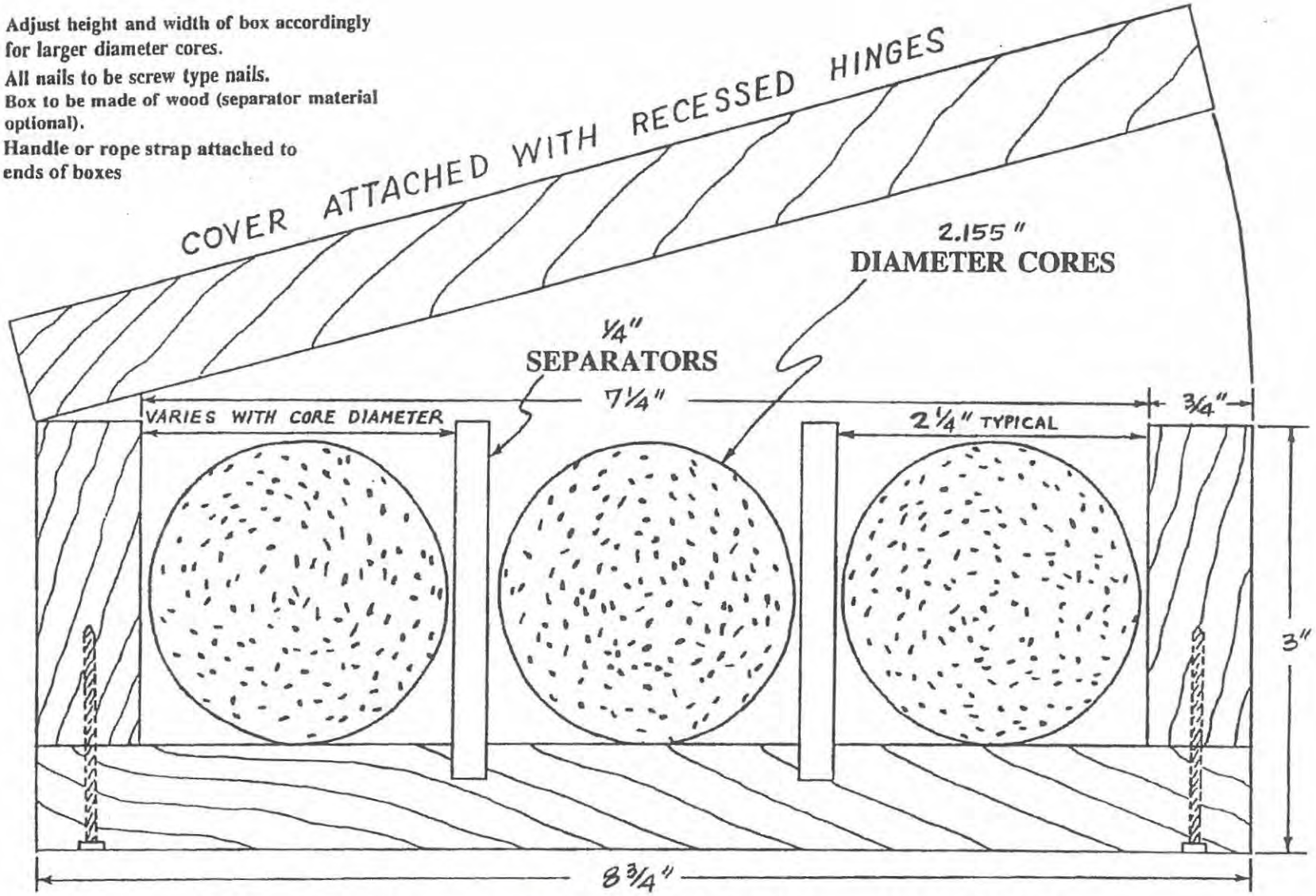
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BOX FOR CORE BORING SAMPLES

● NOTES ●

1. Adjust height and width of box accordingly for larger diameter cores.
2. All nails to be screw type nails.
3. Box to be made of wood (separator material optional).
4. Handle or rope strap attached to ends of boxes



BOX FOR CORE BORING SAMPLES

FULL SIZE SECTIONAL VIEW

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APPENDIX 1B

2020 Subsurface Exploration Results

(12 Sheets)

Notes:

1. For recent 2020 boring locations see Figure 2, ‘As-Drilled 2020 Boring Location Plan’.
2. There are 4 sheets for Borings WB-1, WB-2, and WB-3.
3. The elevations shown on the attached 2020 logs are based on 1988 NAVD datum.
4. Soil sample recovery photos for WB-1 to WB-3 are included in this Appendix.
5. Bedrock core recovery photos for WB-1 to WB-3 are included in this Appendix.

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. WB-1 (Retaining Wall Boring) | Page 1/2
Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: -	Project File No.: 608051	Contract No.: -
Location: State Route 38 (Main Street)		Date & Time Started: 1/7/20 9:15 a.m.	Total Hours:
Groundwater Depth (Feet): 14' Date & Time: 1/7/20 3:00 p.m.		Date & Time Completed: 1/7/20 3:15 p.m.	6
Coordinates: *N 3,024,208 *E 744,149	Ground Elevation (Feet): *103.8'	Inspector's Name: Weijie Dong	
Drilling Company: Northern Drill Services, Inc.		Driller's Name: Zac Nader	Helper's Name: Justin Stevens

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt	9"
S-1	1' - 3'	11 11 21 21	18"	Dry, dense, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	
S-2	4' - 6'	15 8 8 5	8"	Dry, medium dense, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	
S-3	9' - 11'	4 4 6 12	10"	Dry, medium dense, brown, FINE SAND, trace fine gravel, trace inorganic silt.	
S-4	14' - 16'	8 22 42 52	13"	Wet, very dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	16'6"
				Pockets of Cobbles	18'4"
S-5	19' - 19'7"	62 60/1"	0"	No Recovery (Sand & Gravel from wash)	19'7"
				Cobble 20'2"	
S-6	24' - 26'	11 9 10 14	4"	Wet, medium dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, some inorganic silt.	
				Top of Bedrock @ 27'6"	27'6"
				Rollerbit to 28' and begin coring.	

Notes: - Core bit "2 series" was used to core bedrock.
* Moved boring 3'± South & 3'± West of original location due to underground gas line. New coordinates and elevation are estimated.

Arrow-Board: N/A
Signs: 2
Cones: 14

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: ATV D-25
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 14' 28'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. WB-1 (Retaining Wall Boring) | Page 2/2
Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: -	Project File No.: 608051	Contract No.: -
Location: State Route 38 (Main Street)		Date & Time Started: 1/7/20 9:15 a.m.	Total Hours:
Groundwater Depth (Feet): 14' Date & Time: 1/7/20 3:00 p.m.		Date & Time Completed: 1/7/20 3:15 p.m.	6
Coordinates: *N 3,024,208 *E 744,149	Ground Elevation (Feet): *103.8'	Inspector's Name: Weijie Dong	
Drilling Company: Northern Drill Services, Inc.		Driller's Name: Zac Nader	Helper's Name: Justin Stevens

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
C-1	28' - 33'	7 7 7 8 8	48"	Fresh, hard, gray, GRANITE. Percent Recovery = 80% RQD = 44"/60" = 73%	
C-2	33' - 36'	9 10 10	32"	Fresh, hard, gray, GRANITE. Percent Recovery = 89% RQD = 22"/36" = 61% Core barrel is jammed at 36'. RQD value is not representative.	36'
				Bottom of Exploration @ 36'	

Notes: - Core bit "2 series" was used to core bedrock.
* Moved boring 3'± South & 3'± West of original location due to underground gas line. New coordinates and elevation are estimated.

Arrow-Board: N/A
Signs: 2
Cones: 14

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: ATV D-25
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Size: 4" 3"
Depth: 14' 28'
Sampler Type: S/S Size: 1 3/8" ID
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Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. WB-2 (Retaining Wall Boring) | Page 1/1
Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: -	Project File No.: 608051	Contract No.: -
Location: State Route 38 (Main Street)		Date & Time Started: 1/8/20 9:15 a.m.	Total Hours:
Groundwater Depth (Feet): 13' Date & Time: 1/9/20 11:00 a.m.		Date & Time Completed: 1/8/20 11:30 a.m.	7.75
Coordinates: N 3,024,137 E 744,200	Ground Elevation (Feet): 97.6'	Inspector's Name: Weijie Dong	
Drilling Company: Northern Drill Services, Inc.		Driller's Name: Zac Nader	Helper's Name: Justin Stevens

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt	9"
S-1	1' - 3'	6 23 21 19	6"	Dry, dense, brown, FINE TO COARSE SAND, some fine gravel, trace inorganic silt.	
S-2	4' - 6'	4 3 3 4	11"	Dry, loose, brown, FINE SAND, trace fine gravel, trace inorganic silt.	
S-3	9' - 11'	3 3 2 3	8"	Dry, loose, brown, FINE SAND, trace fine gravel, trace inorganic silt.	12'
				Pockets of Cobbles	13'8"
S-4	14' - 16'	9 19 18 18	10"	Wet, dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, some inorganic silt.	
S-5	19' - 20'9"	15 13 9 120/3"	9"	Wet, medium dense, gray, FINE TO COARSE SAND, some fine to coarse gravel, some inorganic silt. Top of Bedrock @ 20'9"	20'9"
				Rollerbit to 21' and begin coring.	
C-1	21' - 23'	60 64	10"	Fresh, hard, gray, GRANITE/QUARTZ. Percent Recovery = 42% RQD = 10"/24" = 42%	
*C-2	23' - 26'	4 4 3	35"	Fresh, hard, gray, GRANITE/QUARTZ. Percent Recovery = 97% RQD = 35"/36" = 97%	
*C-3	26' - 31'	4 5 5 8 8	57"	Fresh, hard, gray, GRANITE/QUARTZ. Percent Recovery = 95% RQD = 57"/60" = 95%	31'
				Bottom of Exploration @ 31'	

Notes:
* Switched to much better "6 series" core bit from "2 series" core bit on 1/9/2020 to core bedrock. Core rate is, thus, reduced.

Arrow-Board: N/A
Signs: 2
Cones: 14

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: ATV D-25
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 14' 21'
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. WB-3 (Retaining Wall Boring) | Page 1/1
Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: -	Project File No.: 608051	Contract No.: -
Location: State Route 38 (Main Street)		Date & Time Started: 1/6/20 9:30 a.m.	Total Hours:
Groundwater Depth (Feet): 12.4' Date & Time: 1/6/20 1:30 p.m.		Date & Time Completed: 1/6/20 2:30 p.m.	5
Coordinates: N 3,024,063 E 744,254	Ground Elevation (Feet): 92.3'	Inspector's Name: Weijie Dong	
Drilling Company: Northern Drill Services, Inc.		Driller's Name: Zac Nader	Helper's Name: Justin Stevens

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt	9"
S-1	1' - 3'	10 11 13 11	11"	Dry, medium dense, brown, FINE SAND, trace fine gravel, trace inorganic silt.	
S-2	4' - 6'	4 3 2 4	14"	Wet, loose, brown, FINE SAND, trace fine gravel, trace inorganic silt.	8'6"
S-3	9' - 11'	31 25 28 25	5"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	11'2"
				Pockets of Cobbles	13'6"
S-4	14' - 16'	17 19 27 43	10"	Wet, dense, gray, FINE TO COARSE SAND, some inorganic silt, trace fine gravel.	
S-5	19' - 21'	23 35 35 50	10"	Wet, very dense, gray, FINE TO COARSE SAND, some inorganic silt, trace fine gravel.	
				Top of Bedrock @ 22'	22'
				Rollerbit to 23'6" and begin coring.	
C-1	23'6" - 28'6"	4 3 3 3 4	52"	Fresh, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 87% RQD = 30"/60" = 50%	
C-2	28'6" - 33'6"	3 3 3 3 3	60"	Slight weathered, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 100% RQD = 32"/60" = 53%	33'6"
				Bottom of Exploration @ 33'6"	

Notes: - Core bit "2 series" was used to core bedrock.

Arrow-Board: N/A
Signs: 2
Cones: 14

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

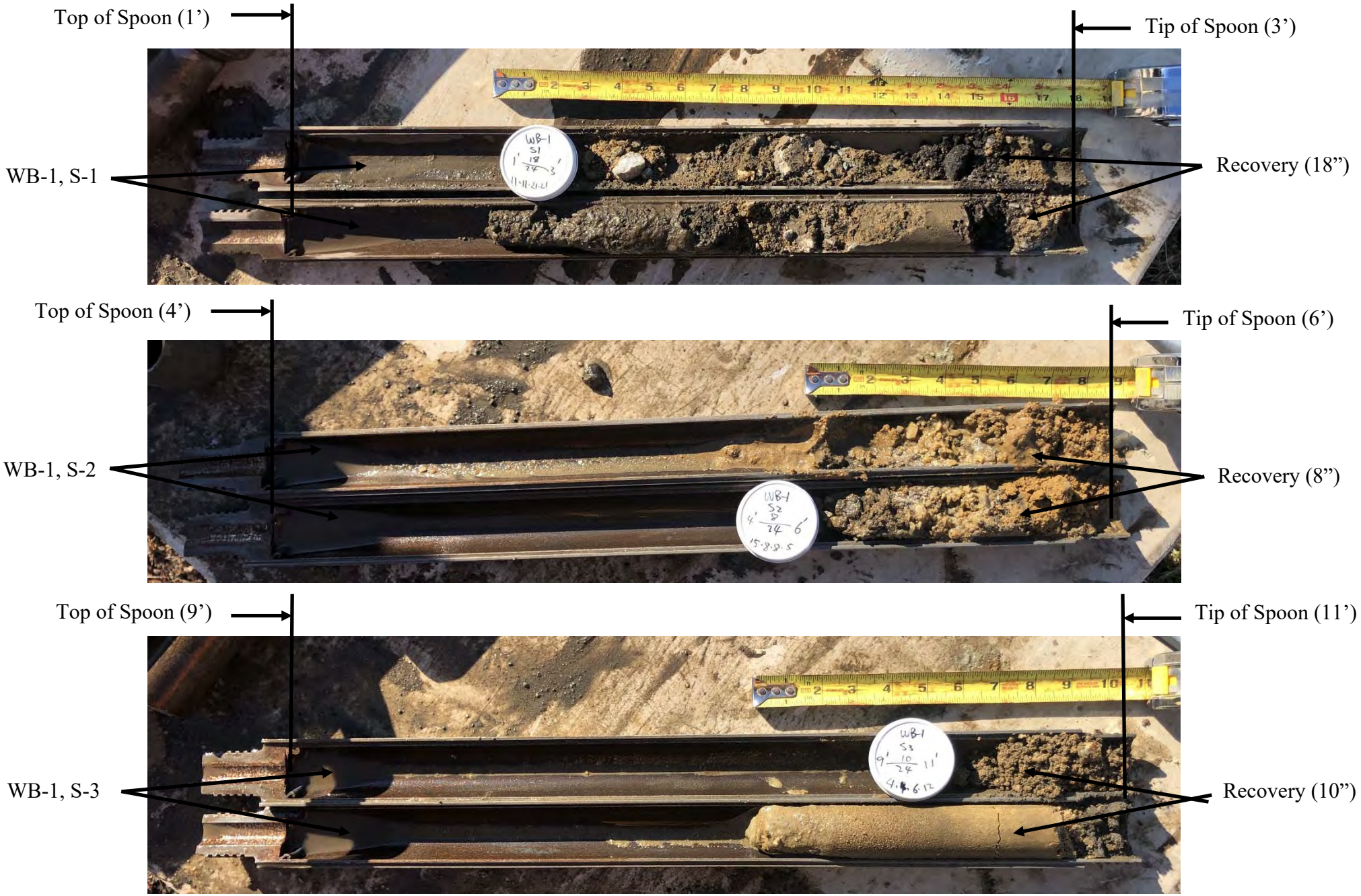
Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: ATV D-25
Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 19' 23'6"
Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight: Fall: 30"
Core Barrel Type: NX Size: 2.15" ID

Soil Sample Recovery Photos

Boring Number	Sample Number	Page Number
WB-1	S-1, S-2 & S-3	1/6
	S-4, S-5 & S-6	2/6
WB-2	S-1, S-2 & S-3	3/6
	S-4 & S-5	4/6
WB-3	S-1	
	S-2, S-3 & S-4	5/6
	S-5	6/6


Top of Spoon (1')
Tip of Spoon (3')
WB-1, S-1
Recovery (18")
Top of Spoon (4')
Tip of Spoon (6')
WB-1, S-2
Recovery (8")
Top of Spoon (9')
Tip of Spoon (11')
WB-1, S-3
Recovery (10")

Top of Spoon (14’)

Tip of Spoon (16’)



WB-1, S-4

Recovery (13”)

Top of Spoon (19’)

Tip of Spoon (19’7”)



WB-1, S-5

Recovery (0”)

Top of Spoon (24’)

Tip of Spoon (26’)



WB-1, S-6

Recovery (4”)


Top of Spoon (1')
Tip of Spoon (3')
WB-2, S-1
Recovery (6")


Top of Spoon (4')
Tip of Spoon (6')
WB-2, S-2
Recovery (11")


Top of Spoon (9')
Tip of Spoon (11')
WB-2, S-3
Recovery (8")


Top of Spoon (14')
Tip of Spoon (16')
WB-2, S-4
Recovery (10")


Top of Spoon (19')
Tip of Spoon (20'9")
WB-2, S-5
Recovery (9")


Top of Spoon (1')
Tip of Spoon (3')
WB-3, S-1
Recovery (11")

Top of Spoon (4’)

Tip of Spoon (6’)

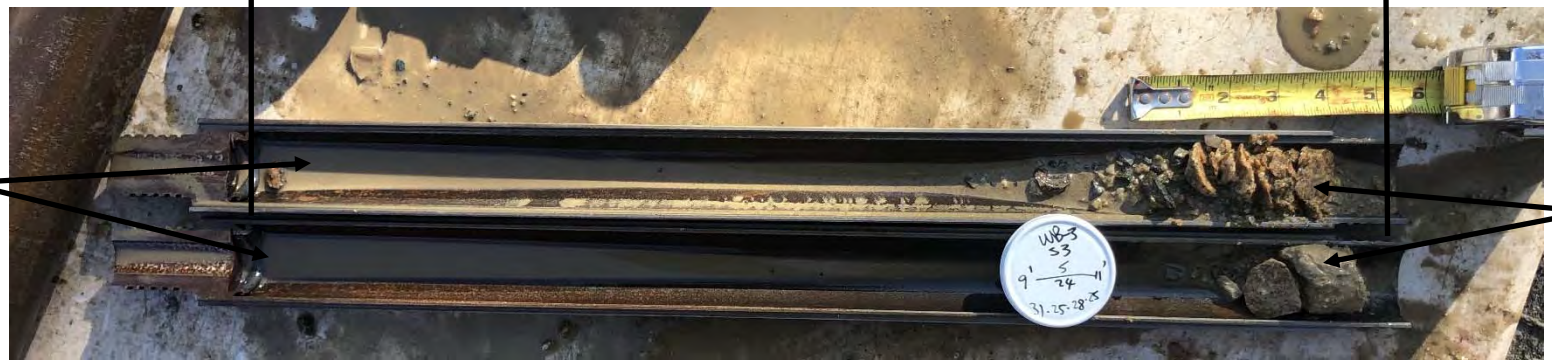


WB-3, S-2

Recovery (14”)

Top of Spoon (9’)

Tip of Spoon (11’)



WB-3, S-3

Recovery (5”)

Top of Spoon (14’)

Tip of Spoon (16’)



WB-3, S-4

Recovery (10”)

Top of Spoon (19')

Tip of Spoon (21')



WB-3, S-5

Recovery (10")

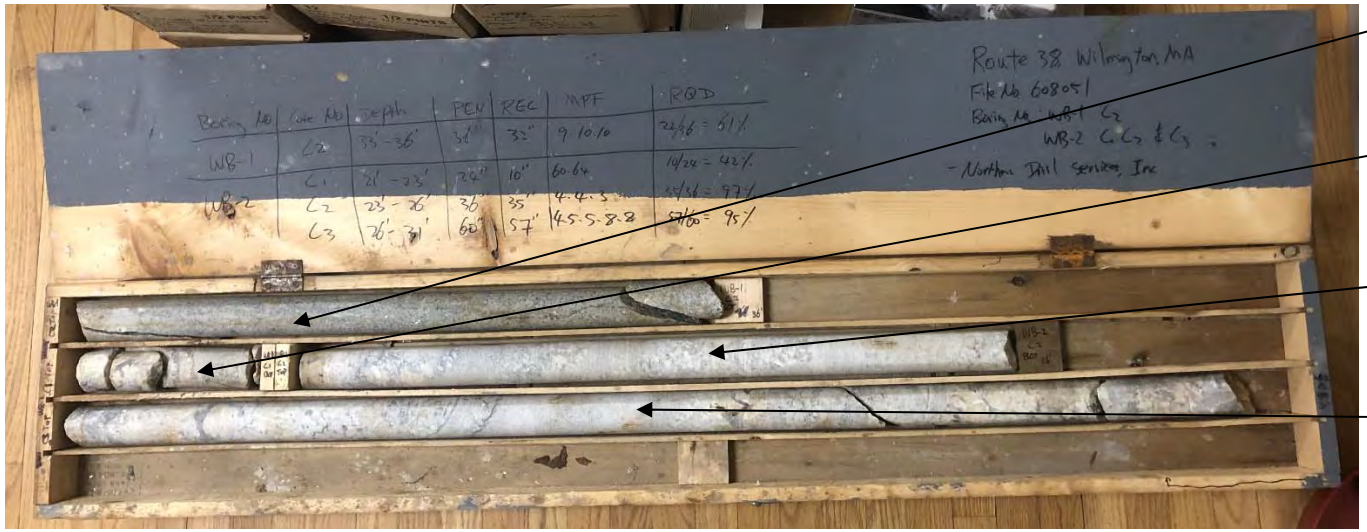
Rock Core Recovery Photos



Boring WB-3,
Core 1 (Granite Gneiss)
REC: 87% RQD: 50%

Boring WB-3,
Core 2 (Granite Gneiss)
REC: 100% RQD: 53%

Boring WB-1,
Core 1 (Granite)
REC: 80% RQD: 73%



Boring WB-1,
Core 2 (Granite)
REC: 89% RQD: 61%

Boring WB-2,
Core 1 (Granite/Quartz)
REC: 42% RQD: 42%

Boring WB-2,
Core 2 (Granite/Quartz)
REC: 97% RQD: 97%

Boring WB-2,
Core 3 (Granite/Quartz)
REC: 95% RQD: 95%

APPENDIX 2

Calculations

INDEX OF CALCULATIONS

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LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street), Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Retaining Walls	Prepared by: WD		Date: 8/2025
Detail:	Summary	Checked by: JJL		Date: 8/2025

Summary

Wall Type III (Sta. 207+20 to 207+70)

- Bottom of Footing = Elev. 93.0±
- Footing Width = 6.5 ft
- Design Wall Height = 12.5 ft Max. (Including Footing Height)
- Factored Bearing Resistance = 5.1 ksf
- Factored Bearing Pressure = 3.4 ksf (Strength I)
- Active Pressure Coefficient = 0.428
- At-rest Pressure Coefficient = 0.470

Wall Type II (Sta. 207+70 to 208+45)

- Bottom of Footing = Elev. 88.0±
- Footing Width = 7.5 ft
- Design Wall Height = 14.0 ft Max. (Including Footing Height)
- Factored Bearing Resistance = 4.8 ksf
- Factored Bearing Pressure = 3.7 ksf (Strength I)
- Active Pressure Coefficient = 0.458
- At-rest Pressure Coefficient = 0.470

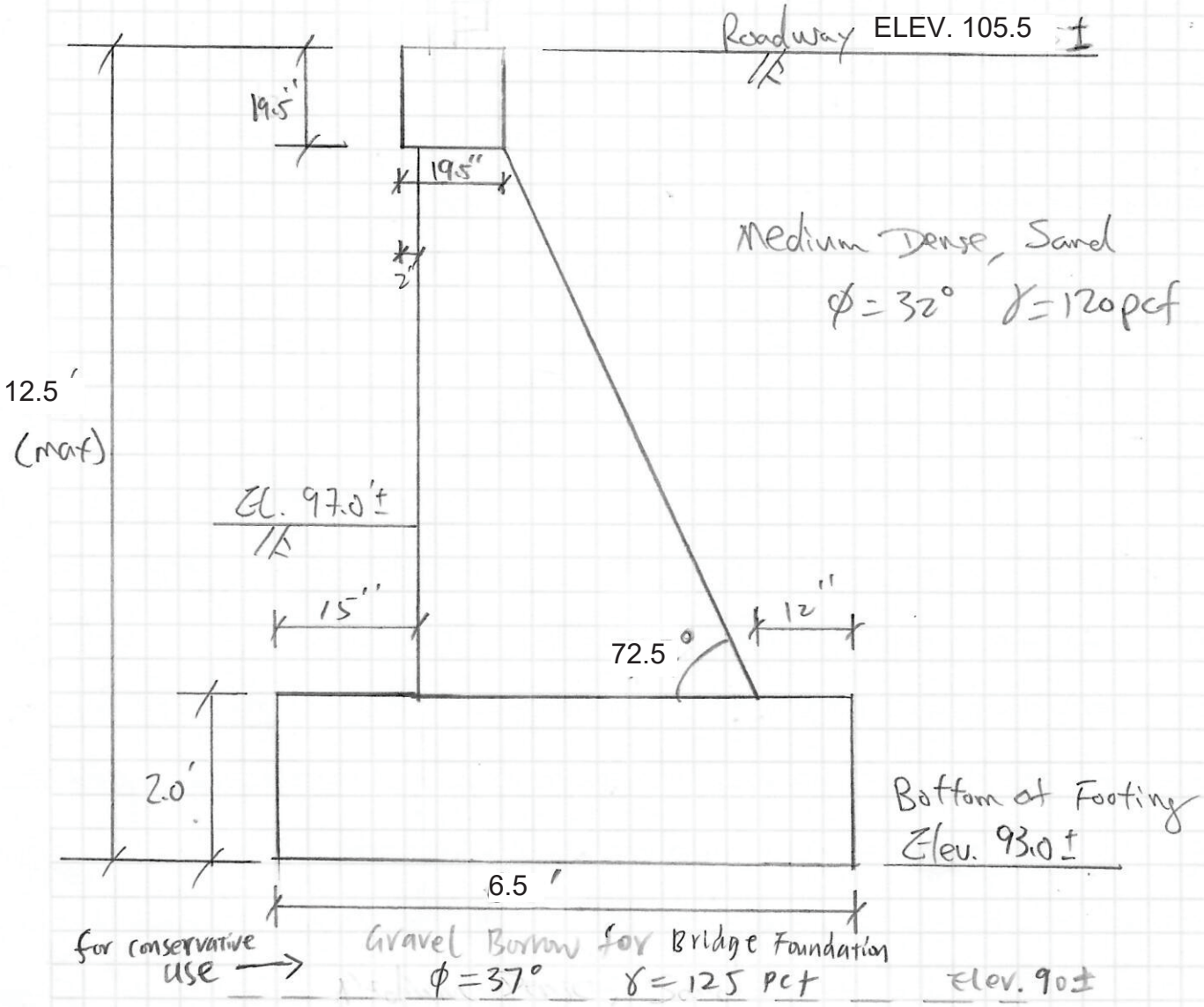
Wall Type I (Sta. 208+45 to 209+00)

- Bottom of Footing = Elev. 85.0±
- Footing Width = 6.5 ft
- Design Wall Height = 11.5 ft Max. (Including Footing Height)
- Factored Bearing Resistance = 6.4 ksf
- Factored Bearing Pressure = 3.2 ksf (Strength I)
- Active Pressure Coefficient = 0.451
- At-rest Pressure Coefficient = 0.470

LAMSON ENGINEERING CORPORATION			Final Page No: 2
Project: Route 38 (Main Street) Retaining Wall	Job No:		Preliminary Sheet No:
Subject: Wall Type III	Prepared by: WD		Date: 7/2020
Detail: Section	Checked by: JJL		Date: 7/2020

Gravity Wall - Wall Type III (Sta. 207+20 to Sta. 207+80)

- Based on Boring WB-1 & Max Wall Height of 12.5'



LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	32	degree
Friction angle between fill and wall, δ	=	21	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	72.5	degree
Unit weight of soil, γ_{soil}	=	0.120	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of fill = Height of wall	=	12.5	ft ±
Distance from back of wall to footing heel, B_{heel}	=	3.79	ft
Height of fill behind footing at heel, $h = H + B_{heel} \tan \beta$	=	12.5	ft ±
Height of water from bottom of footing ,Hw	=	0	ft

Lateral Earth Pressure (EH)

Active pressure coefficient, K_a

$$K_a = \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta)\left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2}$$

$$= 0.428$$

At-rest pressure coefficient, K_o = 1 - sin ϕ'_f = 1 - sin (32)

= 0.470

Per *massDOT* LRFD BM 3.1.5

K_e = Ka

= 0.428

Lateral earth pressure, P_{e1} = $0.5 K_e \gamma_{soil} (h - H_w)^2$

= 0.5 x 0.428 x 0.12 kcf x (12.5 ft - 0 ft)^2

= 4.02 k/ft length of wall

Vertical component of P_{e1}, P_{ev1} = $P_{e1} \sin(90 - \theta + \delta)$

= 4.02 k /ft x sin (90 - 72.5 + 21)

= 2.50 k/ft

Horizontal component of P_{e1}, P_{eh1} = $P_{e1} \cos(90 - \theta + \delta)$

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

= 4.02 k/ft x cos (90 - 72.5 + 21)

= 3.14 k/ft

Lateral earth pressure, P_{e2} = $K_e \gamma_{soil} (h - H_w) H_w$

= 0.428 x 0.12 kcf x (12.5 ft - 0 ft) x 0 ft

= 0.00 k/ft length of wall

Vertical component of P_{e2}, P_{ev2} = $P_{e2} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 72.5 + 21)

= 0.00 k/ft

Horizontal component of P_{e2}, P_{eh2} = $P_{e2} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 72.5 + 21)

= 0.00 k/ft

Lateral earth pressure, P_{e3} = $0.5 K_e \gamma' (H_w)^2$

0.5 x 0.428 x (0.12 kcf - 0.0624 kcf) x 0 ft^2

= 0.00 k/ft length of wall

Vertical component of P_{e3}, P_{ev3} = $P_{e3} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 72.5 + 21)

= 0.00 k/ft

Horizontal component of P_{e3}, P_{eh3} = $P_{e3} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 72.5 + 21)

= 0.00 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

Equivalent height of soil for , h_{eq} = 2.8 ft
vehicular load

Horizontal earth pressure due to live Δ_p = $K_e \gamma_{soil} h_{eq}$
load surcharge = 0.428 x 0.12 kcf x 2.75 ft
= 0.14 ksf

Live load lateral earth pressure, P_{LS} = Δ_p h
= 0.14 ksf x 12.5 ft
= 1.77 k/ft length of wall

Vertical component of P_{LS}, P_{LSV} = $P_{LS} \sin (90 - \alpha + \delta)$
= 1.77 k/ft x sin (90 - 72.5 + 21)
= 1.10 k/ft length of wall

Horizontal component of P_{LS}, P_{LSH} = $P_{LS} \cos (90 - \alpha + \delta)$
= 1.77 k/ft x cos (90 - 72.5 + 21)
= 1.38 k/ft length of wall

Vertical live load surcharge over the heel = B_h x h_{eq} x γ_{soil}
= 1.25 k/ft

Unfactored horizontal load, EH + LSH = $P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH}$
= 3.14 + 0 + 0 + 1.38
= 4.53 k/ft length of wall

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject: Wall Type III	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Bearing Resistance

Bearing Resistance at the Service Limit State

Based on Boring WB-1. Bottom of Footing Elev. 93.0 +/- (NAVD 88)

Presumptive Bearing Resistance for Spread Footing (Table C10.6.2.6.1-1)

Bearing Resistance, q = 5 ksf

Bearing Resistance of Soil at the Strength Limit State Design

Footing length, L = 60 ft (Assume distance between exp. Joints)

Factored bearing resistance, q_R = $\varphi_b\ q_n$ (AASHTO 10.6.3.1.1-1)

Bearing resistance factor, φ_b = 0.55 (AASHTO Table 11.5.7-1)

Nominal bearing resistance, q_n = $c\ N_{cm} + \gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

N_{cm} = $N_c\ s_c\ i_c$

N_{qm} = $N_q\ s_q\ d_q\ i_q$

$N_{\gamma m}$ = $N_\gamma\ s_\gamma\ i_\gamma$

Because of c = 0,

Nominal bearing resistance, q_n = $\gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

i_q = $[\ 1 - H / V\ ]^n$

= See table next page

i_γ = $[\ 1 - H / V\ ]^{(n+1)}$

= See table next page

n = $[(2+L / B) / (1+ L / B)]\cos^2\theta + [(2+B / L) / (1+ B / L)]\sin^2\theta$

= See table next page

Unfactored horizontal load, H = 3.71 kips/ft

Unfactored vertical load, V = 11.69 kips/ft

Project direction of load in the plane of the footing, θ = 90 deg (measured from the side of L)

Soil properties above footing

Angle of internal friction, Φ_{f1} = 32 degree

Moist unit weight of soil, γ_1 = 0.12 kcf

Footing embedment depth, D_f = 4 ft

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject: Wall Type III	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Surcharge bearing capacity factor, N_q = 23.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f1} > 0$ Shape factor, s_q = $1 + (B' / L) \tan \Phi_{f1}$ (AASHTO Table 10.6.3.1.2a-3)

= See table this page

Depth Correction Factor, d_q = 1

Correction factors to account for the location of the ground water table (AASHTO Table 10.6.3.1.2a-2)

C_{wq} = 1.00

Soil properties below footing

Angle of internal friction, Φ_{f2} = 37 degree

Moist unit weight of soil, γ_2 = 0.125 kcf ← γ_2

Unit Weight bearing capacity factor, N_γ = 66.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f2} > 0$ Shape factor, s_γ = $1 - 0.4 (B' / L)$ (AASHTO Table 10.6.3.1.2a-3)

See Table this page

Correction factors to account for the location of the ground water table

$C_{w\gamma}$ = 0.5 (AASHTO Table 10.6.3.1.2a-2)

B = 6.50 ft

e = 0.41 ft B' = B - 2e

B' (ft)	n	i_q	i_γ	s_q	s_γ	N_{qm}	$N_{\gamma m}$	$\gamma_1 D_f N_{qm} C_{wq}$ (ksf)	$0.5 \gamma_2 B' N_{\gamma m} C_{w\gamma}$ (ksf)	q_n (ksf)	q_R (ksf)
5.7	1.91	0.482	0.329	1.06	0.96	11.85	20.91	5.69	3.72	9.41	**5.1**

Factored bearing resistance

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 8/2025
Detail:	Unfactored Dead Load	Checked by: JJL		Date: 8/2025

Unfactored Dead Load

Concrete coping	(19.5 x 19.5) / 144 x 0.15	=	0.396 k/ft
Stem	0.5 x (1.46 + 3.75) x 7.375 x 0.15	=	2.882 k/ft
Concrete Footing	6.5 x 2.0 x 0.15	=	1.95 k/ft
Soil on back of the wall	((1.625 x 3.292) + (0.5 x (1 + 3.292) x 7.375)) x 0.12	=	2.54 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 5/2025

Summary of Factored Loads - Strength IA: 1.25DC + 1.50EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.25	0.40	0.50	1.35	0.67	
Stem	1.25	2.88	3.60	0.61	2.21	
Concrete Footing	1.25	1.95	2.44	0.00	0.00	
Soil on back of the wall	1.35	2.54	3.43	-1.92	-6.58	
P_{v1}	1.50	2.50	3.75	-3.25	-12.19	
P_{v2}	1.50	0.00	0.00	-3.25	0.00	
P_{v3}	1.50	0.00	0.00	-3.25	0.00	
P_{LSV}	1.75	1.10	1.93	-3.25	-6.26	
LS	1.75	1.77	3.09	-1.92	-5.93	
TOTAL		13.14	18.74		-28.07	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	3.14	4.72	4.17	19.65	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.38	2.42	6.25	15.13	
TOTAL		4.53	7.14		34.78	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 5/2025

COEFFICIENT OF FRICTION FOR SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 37 degree

below footing

$\phi_t \tan\Phi_f$ = 0.8 x tan 37

= 0.60

BEARING PRESSURE

Footing width, B = 6.500 ft

Distance from wall face to toe = 1.25 ft

Height of soil over toe from top of footing = 2 ft

Factored vertical soil over toe, V_{st} = 1.35 x 1.3 ft x 2 ft x 0.120 kcf

= 0.405 k/ft

Factored Moment about ℄ , M_{st} = 0.405 k/ft x (6.5 ft - 1.25 ft) / 2

= 1.063 k-ft

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-28.072 + 34.778 + 1.063}{18.735 + 0.405}$

= 0.41 ft < B/3 OK

For Footing founded on Soil

$q_{average}$ = $\dfrac{(\Sigma V_u + V_{st})}{(B - 2e)}$

= $\dfrac{18.74 + 0.41}{(6.5 - 2 \times 0.41)}$ = 3.36 ksf

Factored Bearing Resistance, q_R = 5.10 k/ft^2 > 3.36 OK

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 5/2025

Summary of Factored Loads - Strength IB: 0.90DC + 1.50EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	0.90	0.40	0.36	1.35	0.48	
Stem	0.90	2.88	2.59	0.61	1.59	
Concrete Footing	0.90	1.95	1.76	0.00	0.00	
Soil on back of the wall	1.00	2.54	2.54	-1.92	-4.87	
P_{v1}	1.50	2.50	3.75	-3.25	-12.19	
P_{v2}	1.50	0.00	0.00	-3.25	0.00	
P_{v3}	1.50	0.00	0.00	-3.25	0.00	
P_{LSV}	1.75	1.10	1.93	-3.25	-6.26	
LS	1.75	1.77	3.09	-1.92	-5.93	
TOTAL		13.14	16.02		-27.17	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	3.14	4.72	4.17	19.65	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.38	2.42	6.25	15.13	
TOTAL		4.53	7.14		34.78	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 5/2025

SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 37 degree

below footing

Sliding Factor = $\dfrac{\phi_t \tan\Phi_f (\Sigma V)}{(\Sigma H_u)}$

= $\dfrac{0.8 \times \tan 37 \times 13.14}{7.14}$

Sliding Factor = 1.11 > 1 OK

Eccentricity

Footing width, B	=	6.500	ft			
Distance from wall face to toe	=	1.25	ft			
Height of soil over toe from top of footing	=	2	ft			
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2 ft x 0.120 kcf				
	=	0.300	k/ft			
Factored Moment about ℄ , M_{st}	=	0.3 k/ft x (6.5 ft - 1.25 ft) / 2				
	=	0.788	k-ft			

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-27.174 + 34.778 + 0.788}{16.016 + 0.3}$

= 0.51 ft < B/3 OK

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Service I for Settlement	Checked by: JJL		Date: 5/2025

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.00	0.40	0.40	1.35	0.54	
Stem	1.00	2.88	2.88	0.61	1.77	
Concrete Footing	1.00	1.95	1.95	0.00	0.00	
Soil on back of the wall	1.00	2.54	2.54	-1.92	-4.87	
P_{v1}	1.00	2.50	2.50	-3.25	-8.13	
P_{v2}	1.00	0.00	0.00	-3.25	0.00	
P_{v3}	1.00	0.00	0.00	-3.25	0.00	
P_{LSV}	1.00	1.10	1.10	-3.25	-3.58	
LS	1.00	1.77	1.77	-1.92	-3.39	
TOTAL		13.14	13.14		-17.66	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.00	3.14	3.14	4.17	13.10	
P_{h2}	1.00	0.00	0.00	0.00	0.00	
P_{h3}	1.00	0.00	0.00	0.00	0.00	
P_{LSH}	1.00	1.38	1.38	6.25	8.65	
TOTAL		4.53	4.53		21.74	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type III	Prepared by: WD		Date: 5/2025
Detail:	Service I for Settlement	Checked by: JJL		Date: 5/2025

BEARING PRESSURE

Footing width, B	=	6.500	ft
Distance from wall face to toe	=	1.25	ft
Height of soil over toe from top of footing	=	2	ft
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2 ft x 0.120 kcf	
	=	0.300	k/ft
Factored Moment about ℄ , M_{st}	=	0.3 k/ft x (6.5 ft - 1.25 ft) / 2	
	=	0.788	k-ft

Eccentricity of load, e

$$= \frac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$$

$$= \frac{-17.657 + 21.744 + 0.788}{13.137 + 0.3}$$

= 0.36 ft

For Footing founded on Soil

$$q_{average} = \frac{(\Sigma V_u + V_{st})}{(B - 2e)}$$

$$= \frac{13.14 + 0.3}{(6.5 - 2 \times 0.36)} = 2.33 \text{ ksf}$$

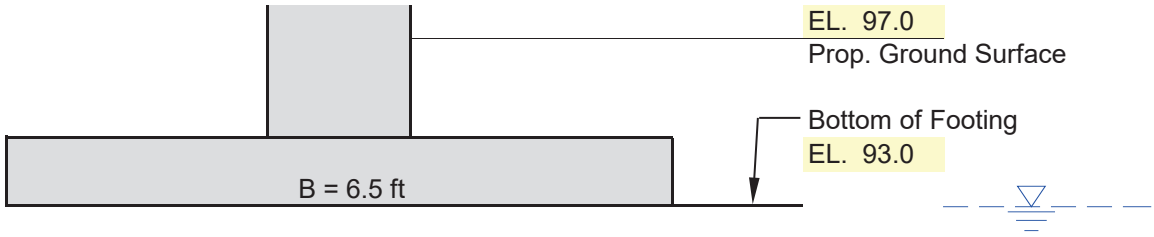
LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type III	Prepared by: WD	Date: 5/2025
Detail:	Service I for Settlement	Checked by: JJL	Date: 5/2025

Section A Settlement (AASHTO 10.6.2.4.2)

Based on WB-1

Footing Width, B = 6.5 ft

Footing Length, L = 60 ft



Sand γ_{soil} = 0.12 kcf

Average N_1 = 49 blows per ft

EL. 84.7
Mid-Layer below footing

Top of Bedrock EL. 76.3

LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type III	Prepared by: WD	Date: 5/2025
Detail:	Service I for Settlement	Checked by: JJL	Date: 5/2025

The total settlement, S_t = $S_e + S_c + S_s$

Total settlement, S_t = S_e for footing on cohesionless soils $S_c = S_s = 0$

Immediate settlement, S_e = $\sum_{i=1}^{n} \Delta H_i$

ΔH_i = elastic settlement of layer i (ft.)

= $H_c \frac{1}{C'} \log\left(\frac{\sigma_o' + \Delta\sigma_v}{\sigma_o'}\right)$

n = number of soil layers within zone of stress influence of the footing

= 1

H_c = initial heigh of layer i (ft.)

= 16.7 ft.

C' = bearing capacity index from Figure 10.6.2.4.2-1

= 170 (for Fine to Coarse Sand and N1 = 49)

σ'_o = initial vertical effective stress at the midpoint of layer i

= 0.12 x (EL. 97.0 - EL. 93.0) + (0.12-0.0624) x (EL. 93.0 - EL. 84.7)

= 0.961 ksf

Max. Service I (No Exist. Soil Weight)

σ_v = 2.33 ksf

$\Delta\sigma_v$ = increase in vertical stress at the midspan of layer i

= $0.18\ \sigma_v$ From Figure 10.6.2.4.1-1, L>5B

$\Delta\sigma_v$ = 0.419 ksf

ΔH_i = (16.7 / 170) log [(0.961 + 0.419) / 0.961]

= 0.02 ft = 0.2 in.

LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type III	Prepared by: WD	Date: 5/2025
Detail:	Corrected *SPT* blow count	Checked by: JJL	Date: 5/2025

WB-1

Water table = 14 ft γ_w 0.0624 kcf

γ_m 0.120 kcf

Depth ft	σ'_v ksf	C_N	N blows/ft	$N1 = C_N N$ blows/ft
2.00	0.24	1.71	32	55
5.00	0.60	1.40	16	22
10.00	1.20	1.17	10	12
15.00	1.74	1.05	64	67
20.00	2.03	1.00	120	100
25.00	2.31	0.95	19	18

Exist Ground Elev. 103.8

Bottom of Footing Elev. 93.0

Average $N1$ 49 (below footing)

For example

Depth = 10 ft

C_N = 0.77 $\log_{10}$ (40 / σ'_v) < 2 (AASHTO 10.4.6.2.4-1)

σ'_v = vertical effective stress (ksf)

= 10 ft x 0.12 kcf

= 1.200 ksf

C_N = 0.77 $\log_{10}$ (40 / 1.2)

= 1.173 < 2

N = uncorrected *SPT* blow count (blows/ft.)

= 10 blows /ft

$N1$ = $C_N N$

= 1.173 x 10 blows/ft ≤ 100 blows/ft

= 12 blows/ft < 100 blows/ft

Overall Stability - Wall Type III

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PROJECT IDENTIFICATION

Title: Overall Stability - Wall Type III
Project Number: Retaining Wall Type III -
Client: Green / massDOT
Designer: WD
Station Number:

Description:
Overall Stability

Company's information:

Name: Lamson Engineering Coporation
Street: 437 Cherry Street
Newton, MA 02465
Telephone #: 617-558-0101
Fax #:
E-Mail:

Original file path and name: C:\Program ..... eSSA(3.0)\Route 38 (Main Street) Wall Type III.MSE
Original date and time of creating this file: Thur April 7 2020

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

========== Soil Layer #: ==========	Unit weight, γ [lb/ft^3]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft^2]
....1.....Gravel Borrow.....	120.0	32.0	0.0
....2.....Medium Dense, Fine Sand.....	120.0	32.0	0.0
....3.....Medium Dense, Fine Sand.....	125.0	37.0	0.0
....4.....	130.0	38.0	0.0

REINFORCEMENT

Analysis of slope WITHOUT reinforcement.

WATER

Unit weight of water = 62.45 [lb/ft^3]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

SEISMICITY

Not Applicable

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DRAWING OF SPECIFIED GEOMETRY - COMPLEX - Quick Input

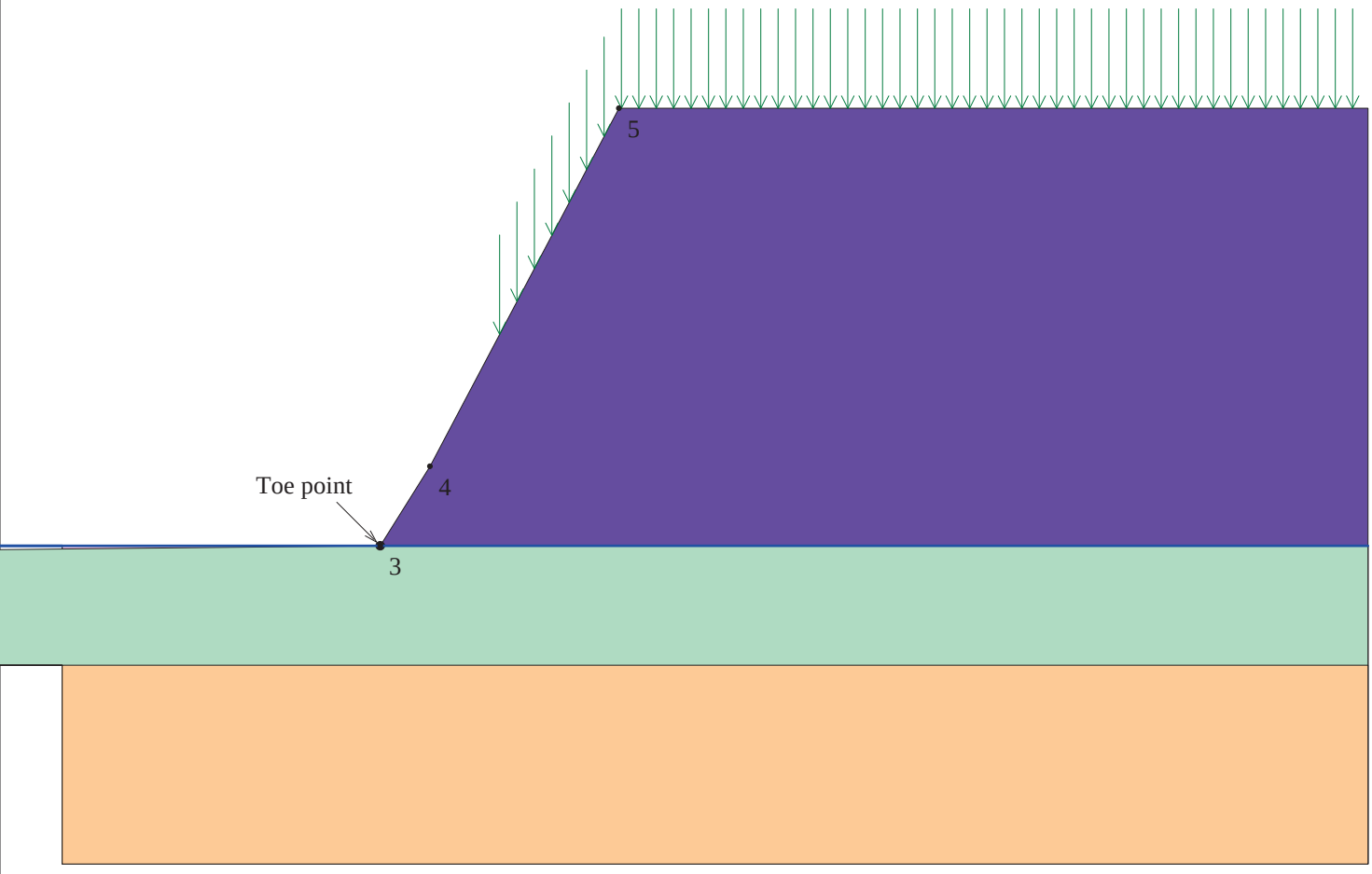
-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY
Soil profile contains 4 layers (see details in next page)

WATER GEOMETRY
Phreatic line was specified.

UNIFORM SURCHARGE
Load Q1 = 240.00 [lb/ft^2] inclined from verical at 0.00 degrees, starts at X1s = 3.00 and ends at X1e = 30.00 [ft].
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD
.....None.....



SCALE:

0 2 4 6[ft]

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	20.00	11.00	-13.21	0.09	-2.95	24.87	26.82	1.43	. On extreme X-entry
2	20.50	11.00	-13.17	0.07	-3.00	26.06	27.91	1.45	
3	21.00	11.00	-12.16	0.06	-2.43	26.29	27.98	1.48	
4	21.50	11.00	-14.19	0.07	-3.49	28.87	30.73	1.50	
5	22.00	11.00	-13.19	0.07	-2.95	29.20	30.88	1.53	
6	22.50	11.00	-14.20	0.07	-3.38	30.83	32.61	1.55	
7	23.00	11.00	-14.21	0.07	-3.49	32.36	34.03	1.57	
8	23.50	11.00	-13.23	0.07	-2.97	32.79	34.29	1.60	
9	24.00	11.00	-14.33	0.10	-3.42	34.60	36.18	1.63	
10	24.50	11.00	-15.24	0.08	-3.86	36.43	38.09	1.66	
11	25.00	11.00	-14.25	0.07	-3.39	37.01	38.50	1.69	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points)

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	-15.18	0.08	20.00	11.00	-3.95	26.03	28.28	1.44	
2	-14.16	0.07	20.00	11.00	-3.34	25.11	27.28	1.44	
. 3	-13.21	0.09	20.00	11.00	-2.95	24.87	26.82	1.43	. OK
4	-12.15	0.06	20.00	11.00	-2.33	23.93	25.81	1.44	
5	-11.32	0.13	20.00	11.00	-1.93	23.63	25.31	1.44	
6	-10.25	0.10	20.00	11.00	-1.30	22.68	24.29	1.45	
7	-9.12	0.04	20.00	11.00	-0.88	22.32	23.75	1.46	
8	-8.23	0.08	20.00	11.00	-0.45	21.93	23.19	1.47	
9	-7.10	0.03	20.00	11.00	0.21	20.94	22.15	1.50	
10	-6.27	0.09	20.00	11.00	0.66	20.49	21.55	1.52	
11	-5.16	0.05	20.00	11.00	1.12	20.01	20.92	1.54	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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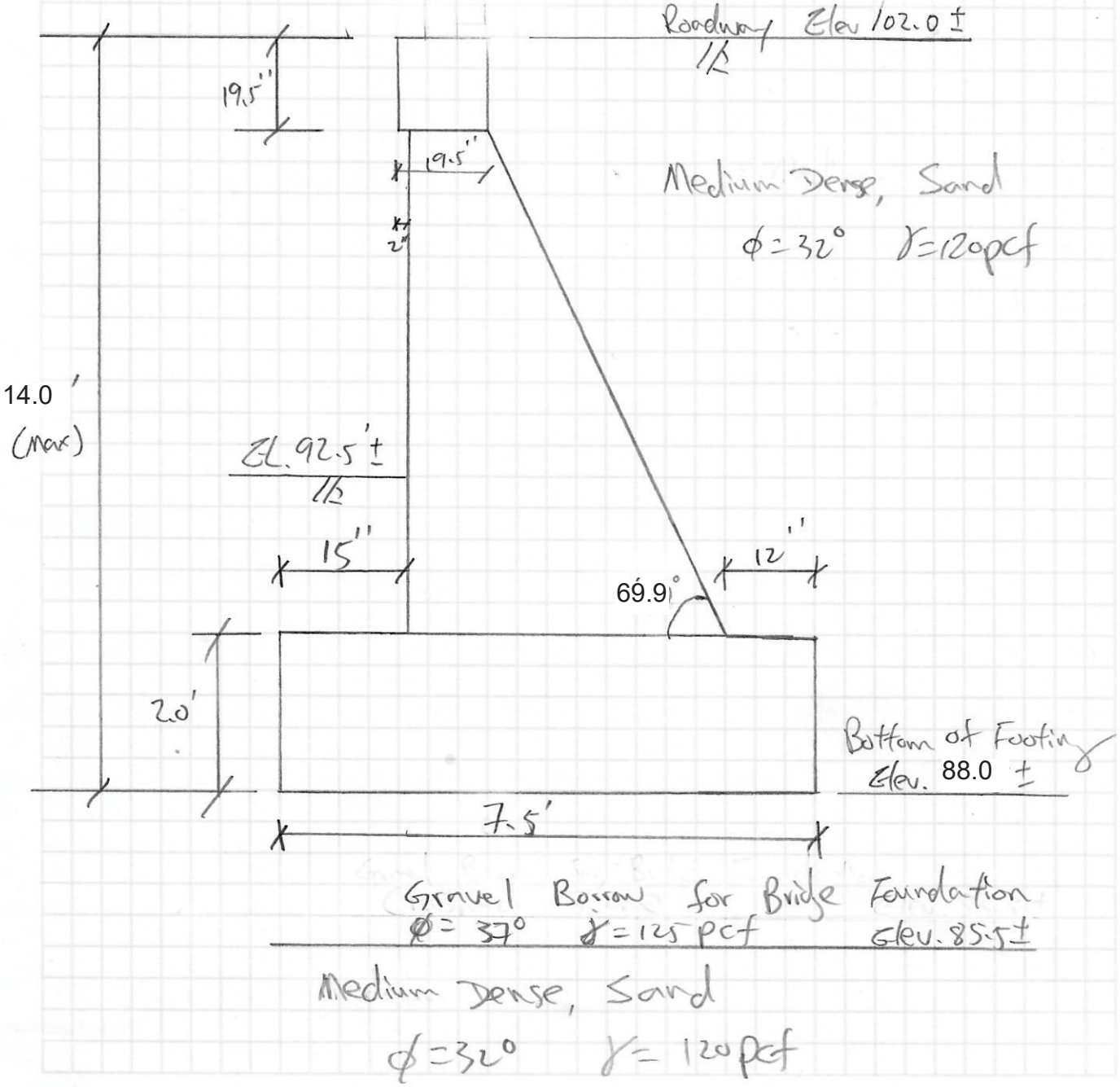
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LAMSON ENGINEERING CORPORATION		Final Page No: 26	
Project: Route 38 (Main Street) Retaining Wall	Job No:	Preliminary Sheet No:	
Subject: Wall Type II	Prepared by: WD		Date: 7/2020
Detail: Section	Checked by: JJL		Date: 7/2020

Gravity Wall - Wall Type II (Sta. 207+80 to 208+40)

- Based on Boring WB-2 & Max Wall Height of 14.0'



LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	32	degree
Friction angle between fill and wall, δ	=	21	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	69.9	degree
Unit weight of soil, γ_{soil}	=	0.120	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of fill = Height of wall	=	14.0	ft ±
Distance from back of wall to footing heel, B_{heel}	=	4.79	ft
Height of fill behind footing at heel, h = H + B_{heel} tan β	=	14.0	ft ±
Height of water from bottom of footing ,Hw	=	0	ft

Lateral Earth Pressure (EH)

Active pressure coefficient, K_a

$$= \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta)\left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2}$$

$$= 0.458$$

At-rest pressure coefficient, K_o = 1 - sin ϕ'_f = 1 - sin (32)

= 0.470

Per *massDOT* LRFD BM 3.1.5

K_e = Ka

= 0.458

Lateral earth pressure, P_{e1} = $0.5 K_e \gamma_{soil} (h - H_w)^2$

= 0.5 x 0.458 x 0.12 kcf x (14 ft - 0 ft)^2

= 5.39 k/ft length of wall

Vertical component of P_{e1}, P_{ev1} = P_{e1} sin (90 - θ + δ)

= 5.39 k /ft x sin (90 - 69.9 + 21)

= 3.54 k/ft

Horizontal component of P_{e1}, P_{eh1} = P_{e1} cos (90 - θ + δ)

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

= 5.39 k/ft x cos (90 - 69.9 + 21)

= 4.06 k/ft

Lateral earth pressure, P_{e2} = $K_e \gamma_{soil} (h - H_w) H_w$

= 0.458 x 0.12 kcf x (14 ft - 0 ft) x 0 ft

= 0.00 k/ft length of wall

Vertical component of P_{e2}, P_{ev2} = $P_{e2} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 69.9 + 21)

= 0.00 k/ft

Horizontal component of P_{e2}, P_{eh2} = $P_{e2} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 69.9 + 21)

= 0.00 k/ft

Lateral earth pressure, P_{e3} = $0.5 K_e \gamma' (H_w)^2$

0.5 x 0.458 x (0.12 kcf - 0.0624 kcf) x 0 ft^2

= 0.00 k/ft length of wall

Vertical component of P_{e3}, P_{ev3} = $P_{e3} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 69.9 + 21)

= 0.00 k/ft

Horizontal component of P_{e3}, P_{eh3} = $P_{e3} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 69.9 + 21)

= 0.00 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

Equivalent height of soil for , h_{eq} = 2.6 ft
vehicular load

Horizontal earth pressure due to live Δ_p = $K_e \gamma_{soil} h_{eq}$
load surcharge = 0.458 x 0.12 kcf x 2.6 ft
= 0.14 ksf

Live load lateral earth pressure, P_{LS} = Δ_p h
= 0.14 ksf x 14 ft
= 2.00 k/ft length of wall

Vertical component of P_{LS}, P_{LSV} = $P_{LS} \sin (90 - \alpha + \delta)$
= 2 k/ft x sin (90 - 69.9 + 21)
= 1.32 k/ft length of wall

Horizontal component of P_{LS}, P_{LSH} = $P_{LS} \cos (90 - \alpha + \delta)$
= 2 k/ft x cos (90 - 69.9 + 21)
= 1.51 k/ft length of wall

Vertical live load surcharge over the heel = B_h x h_{eq} x γ_{soil}
= 1.50 k/ft

Unfactored horizontal load, EH + LSH = $P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH}$
= 4.06 + 0 + 0 + 1.51
= 5.57 k/ft length of wall

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject: Wall Type II	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Bearing Resistance

Bearing Resistance at the Service Limit State

Based on Boring WB-2. Bottom of Footing Elev. 88.0 +/- (NAVD 88)

Presumptive Bearing Resistance for Spread Footing (Table C10.6.2.6.1-1)

Bearing Resistance, q = 4 ksf

Bearing Resistance of Soil at the Strength Limit State Design

Footing length, L = 60 ft (Assume distance between exp. Joints)

Factored bearing resistance, q_R = $\varphi_b\ q_n$ (AASHTO 10.6.3.1.1-1)

Bearing resistance factor, φ_b = 0.55 (AASHTO Table 11.5.7-1)

Nominal bearing resistance, q_n = $c\ N_{cm} + \gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

N_{cm} = $N_c\ s_c\ i_c$

N_{qm} = $N_q\ s_q\ d_q\ i_q$

$N_{\gamma m}$ = $N_\gamma\ s_\gamma\ i_\gamma$

Because of c = 0,

Nominal bearing resistance, q_n = $\gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

i_q = $[\ 1 - H / V\ ]^n$

= See table next page

i_γ = $[\ 1 - H / V\ ]^{(n+1)}$

= See table next page

n = $[(2+L / B) / (1+ L / B)]\cos^2\theta + [(2+B / L) / (1+ B / L)]\sin^2\theta$

= See table next page

Unfactored horizontal load, H = 5.57 kips/ft

Unfactored vertical load, V = 18.33 kips/ft

Project direction of load in the plane of the footing, θ = 90 deg (measured from the side of L)

Soil properties above footing

Angle of internal friction, Φ_{f1} = 32 degree

Moist unit weight of soil, γ_1 = 0.12 kcf

Footing embedment depth, D_f = 4.5 ft

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject: Wall Type II	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Surcharge bearing capacity factor, N_q = 23.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f1} > 0$ Shape factor, s_q = $1 + (B' / L) \tan \Phi_{f1}$ (AASHTO Table 10.6.3.1.2a-3)

= See table this page

Depth Correction Factor, d_q = 1

Correction factors to account for the location of the ground water table (AASHTO Table 10.6.3.1.2a-2)

C_{wq} = 1.00

Soil properties below footing

Angle of internal friction, Φ_{f2} = 32 degree

Moist unit weight of soil, γ_2 = 0.12 kcf ← γ_2

Unit Weight bearing capacity factor, N_γ = 30.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f2} > 0$ Shape factor, s_γ = $1 - 0.4 (B' / L)$ (AASHTO Table 10.6.3.1.2a-3)

See Table this page

Correction factors to account for the location of the ground water table

$C_{w\gamma}$ = 0.5 (AASHTO Table 10.6.3.1.2a-2)

B = 7.50 ft

e = 0.25 ft B' = B - 2e

B' (ft)	n	i_q	i_γ	s_q	s_γ	N_{qm}	$N_{\gamma m}$	$\gamma_1 D_f N_{qm} C_{wq}$ (ksf)	$0.5 \gamma_2 B' N_{\gamma m} C_{w\gamma}$ (ksf)	q_n (ksf)	q_R (ksf)
7.0	1.90	0.504	0.351	1.07	0.95	12.51	10.07	6.76	2.12	8.88	**4.8**

Factored bearing resistance

LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type II	Prepared by: WD	Date: 8/2025
Detail:	Unfactored Dead Load	Checked by: JJL	Date: 8/2025

Unfactored Dead Load

Concrete coping	(19.5 x 19.5) / 144 x 0.15	=	0.396 k/ft
Stem	0.5 x (1.46 + 5.25) x 9.875 x 0.15	=	4.970 k/ft
Concrete Footing	7.5 x 2.0 x 0.15	=	2.25 k/ft
Soil on back of the wall	((1.625 x 4.792) + (0.5 x (1 + 4.792) x 9.875)) x 0.12	=	4.37 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Strength IA: 1.25DC + 1.50EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.25	0.40	0.50	1.85	0.92	
Stem	1.25	4.97	6.21	0.64	4.00	
Concrete Footing	1.25	2.25	2.81	0.00	0.00	
Soil on back of the wall	1.35	4.37	5.89	-2.16	-12.73	
P_{v1}	1.50	3.54	5.31	-3.75	-19.92	
P_{v2}	1.50	0.00	0.00	-3.75	0.00	
P_{v3}	1.50	0.00	0.00	-3.75	0.00	
P_{LSV}	1.75	1.32	2.30	-3.75	-8.63	
LS	1.75	1.50	2.62	-2.16	-5.65	
TOTAL		18.33	25.65		-42.02	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	4.06	6.09	4.67	28.42	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.51	2.64	7.00	18.47	
TOTAL		5.57	8.73		46.89	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 8/2025

COEFFICIENT OF FRICTION FOR SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 32 degree

below footing

$\phi_t \tan\Phi_f$ = 0.8 x tan 32

= 0.50

BEARING PRESSURE

Footing width, B = 7.500 ft

Distance from wall face to toe = 1.25 ft

Height of soil over toe from top of footing = 2.5 ft

Factored vertical soil over toe, V_{st} = 1.35 x 1.3 ft x 2.5 ft x 0.120 kcf

= 0.506 k/ft

Factored Moment about ℄ , M_{st} = 0.506 k/ft x (7.5 ft - 1.25 ft) / 2

= 1.582 k-ft

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-42.021 + 46.894 + 1.582}{25.645 + 0.506}$

= 0.25 ft < B/3 OK

For Footing founded on Soil

$q_{average}$ = $\dfrac{(\Sigma V_u + V_{st})}{(B - 2e)}$

= $\dfrac{25.65 + 0.51}{(7.5 - 2 \times 0.25)}$ = 3.73 ksf

Factored Bearing Resistance, q_R = 4.80 k/ft^2 > 3.73 OK

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Strength IB: 0.90DC + 1.50EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	0.90	0.40	0.36	1.85	0.66	
Stem	0.90	4.97	4.47	0.64	2.88	
Concrete Footing	0.90	2.25	2.03	0.00	0.00	
Soil on back of the wall	1.00	4.37	4.37	-2.16	-9.43	
P_{v1}	1.50	3.54	5.31	-3.75	-19.92	
P_{v2}	1.50	0.00	0.00	-3.75	0.00	
P_{v3}	1.50	0.00	0.00	-3.75	0.00	
P_{LSV}	1.75	1.32	2.30	-3.75	-8.63	
LS	1.75	1.50	2.62	-2.16	-5.65	
TOTAL		18.33	21.45		-40.10	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	4.06	6.09	4.67	28.42	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.51	2.64	7.00	18.47	
TOTAL		5.57	8.73		46.89	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 8/2025

SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 32 degree

below footing

Sliding Factor = $\dfrac{\phi_t \tan\Phi_f (\Sigma V)}{(\Sigma H_u)}$

= $\dfrac{0.8 \times \tan 32 \times 18.33}{8.73}$

Sliding Factor = 1.05 > 1 OK

Eccentricity

Footing width, B	=	7.500	ft			
Distance from wall face to toe	=	1.25	ft			
Height of soil over toe from top of footing	=	2.5	ft			
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2.5 ft x 0.120 kcf				
	=	0.375	k/ft			
Factored Moment about ℄ , M_{st}	=	0.375 k/ft x (7.5 ft - 1.25 ft) / 2				
	=	1.172	k-ft			

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-40.097 + 46.894 + 1.172}{21.452 + 0.375}$

= 0.37 ft < B/3 OK

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.00	0.40	0.40	1.85	0.73	
Stem	1.00	4.97	4.97	0.64	3.20	
Concrete Footing	1.00	2.25	2.25	0.00	0.00	
Soil on back of the wall	1.00	4.37	4.37	-2.16	-9.43	
P_{v1}	1.00	3.54	3.54	-3.75	-13.28	
P_{v2}	1.00	0.00	0.00	-3.75	0.00	
P_{v3}	1.00	0.00	0.00	-3.75	0.00	
P_{LSV}	1.00	1.32	1.32	-3.75	-4.93	
LS	1.00	1.50	1.50	-2.16	-3.23	
TOTAL		18.33	18.33		-26.94	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.00	4.06	4.06	4.67	18.95	
P_{h2}	1.00	0.00	0.00	0.00	0.00	
P_{h3}	1.00	0.00	0.00	0.00	0.00	
P_{LSH}	1.00	1.51	1.51	7.00	10.56	
TOTAL		5.57	5.57		29.50	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type II	Prepared by: WD		Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL		Date: 8/2025

BEARING PRESSURE

Footing width, B	=	7.500	ft
Distance from wall face to toe	=	1.25	ft
Height of soil over toe from top of footing	=	2.5	ft
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2.5 ft x 0.120 kcf	
	=	0.375	k/ft
Factored Moment about ℄ , M_{st}	=	0.375 k/ft x (7.5 ft - 1.25 ft) / 2	
	=	1.172	k-ft

Eccentricity of load, e

$$= \frac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$$

$$= \frac{-26.941 + 29.504 + 1.172}{18.334 + 0.375}$$

= 0.20 ft

For Footing founded on Soil

$$q_{average} = \frac{(\Sigma V_u + V_{st})}{(B - 2e)}$$

$$= \frac{18.33 + 0.38}{(7.5 - 2 \times 0.2)} = 2.63 \text{ ksf}$$

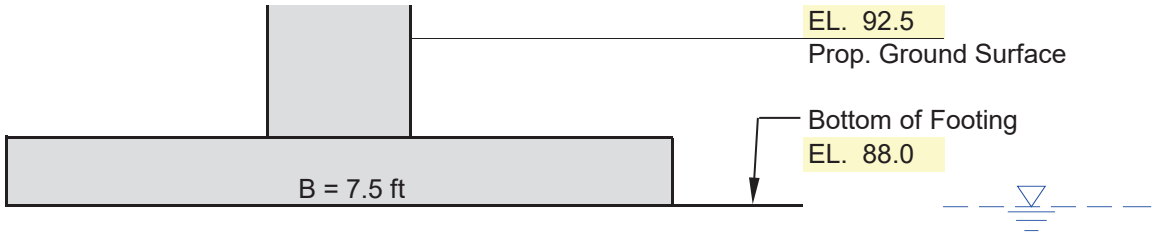
LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type II	Prepared by: WD	Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL	Date: 8/2025

Section A Settlement (AASHTO 10.6.2.4.2)

Based on WB-2

Footing Width, B = 7.5 ft

Footing Length, L = 60 ft



Sand γ_{soil} = 0.12 kcf

Average $N1$ = 22 blows per ft

EL. 82.5
Mid-Layer below footing

Top of Bedrock EL. 76.9

LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type II	Prepared by: WD	Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL	Date: 8/2025

The total settlement, S_t = $S_e + S_c + S_s$

Total settlement, S_t = S_e for footing on cohesionless soils $S_c = S_s = 0$

Immediate settlement, S_e = $\sum_{i=1}^{n} \Delta H_i$

ΔH_i = elastic settlement of layer i (ft.)

= $H_c \frac{1}{C'} \log\left(\frac{\sigma_o' + \Delta\sigma_v}{\sigma_o'}\right)$

n = number of soil layers within zone of stress influence of the footing

= 1

H_c = initial heigh of layer i (ft.)

= 11.1 ft.

C' = bearing capacity index from Figure 10.6.2.4.2-1

= 75 (for Fine to Coarse Sand and N1 = 22)

σ'_o = initial vertical effective stress at the midpoint of layer i

= 0.12 x (EL. 92.5 - EL. 88.0) + (0.12-0.0624) x (EL. 88.0 - EL. 82.7)

= 0.860 ksf

Max. Service I (No Exist. Soil Weight)

σ_v = 2.63 ksf

$\Delta\sigma_v$ = increase in vertical stress at the midspan of layer i

= $0.35\ \sigma_v$ From Figure 10.6.2.4.1-1, L>5B

$\Delta\sigma_v$ = 0.922 ksf

ΔH_i = (11.1 / 75) log [(0.86 + 0.922) / 0.86]

= 0.05 ft = 0.6 in.

LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type II	Prepared by: WD	Date: 5/2025
Detail:	Corrected *SPT* blow count	Checked by: JJL	Date: 5/2025

WB-2

Water table = 13 ft γ_w 0.0624 kcf

γ_m 0.120 kcf

Depth ft	σ'_v ksf	C_N	N blows/ft	$N1 = C_N N$ blows/ft
2.00	0.24	1.71	44	75
5.00	0.60	1.40	6	8
10.00	1.20	1.17	5	6
15.00	1.68	1.06	37	39
20.00	1.96	1.01	22	22

Exist Ground Elev. 97.6

Bottom of Footing Elev. 88.0

Average $N1$ 22 (below footing)

For example

Depth = 10 ft

C_N = 0.77 $\log_{10}$ (40 / σ'_v) < 2 (AASHTO 10.4.6.2.4-1)

σ'_v = vertical effective stress (ksf)

= 10 ft x 0.12 kcf

= 1.200 ksf

C_N = 0.77 $\log_{10}$ (40 / 1.2)

= 1.173 < 2

N = uncorrected *SPT* blow count (blows/ft.)

= 5 blows /ft

$N1$ = $C_N N$

= 1.173 x 5 blows/ft ≤ 100 blows/ft

= 6 blows/ft < 100 blows/ft

Overall Stability - Wall Type II

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PROJECT IDENTIFICATION

Title: Overall Stability - Wall Type II
Project Number: Retaining Wall Type II -
Client: Green / massDOT
Designer: WD
Station Number:

Description:
Overall Stability

Company's information:

Name: Lamson Engineering Coporation
Street: 437 Cherry Street
Newton, MA 02465
Telephone #: 617-558-0101
Fax #:
E-Mail:

Original file path and name: C:\Program ..... ReSSA(3.0)\Route 38 (Main Street) Wall Type II.MSE
Original date and time of creating this file: Thur April 7 2020

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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DRAWING OF SPECIFIED GEOMETRY - COMPLEX - Quick Input

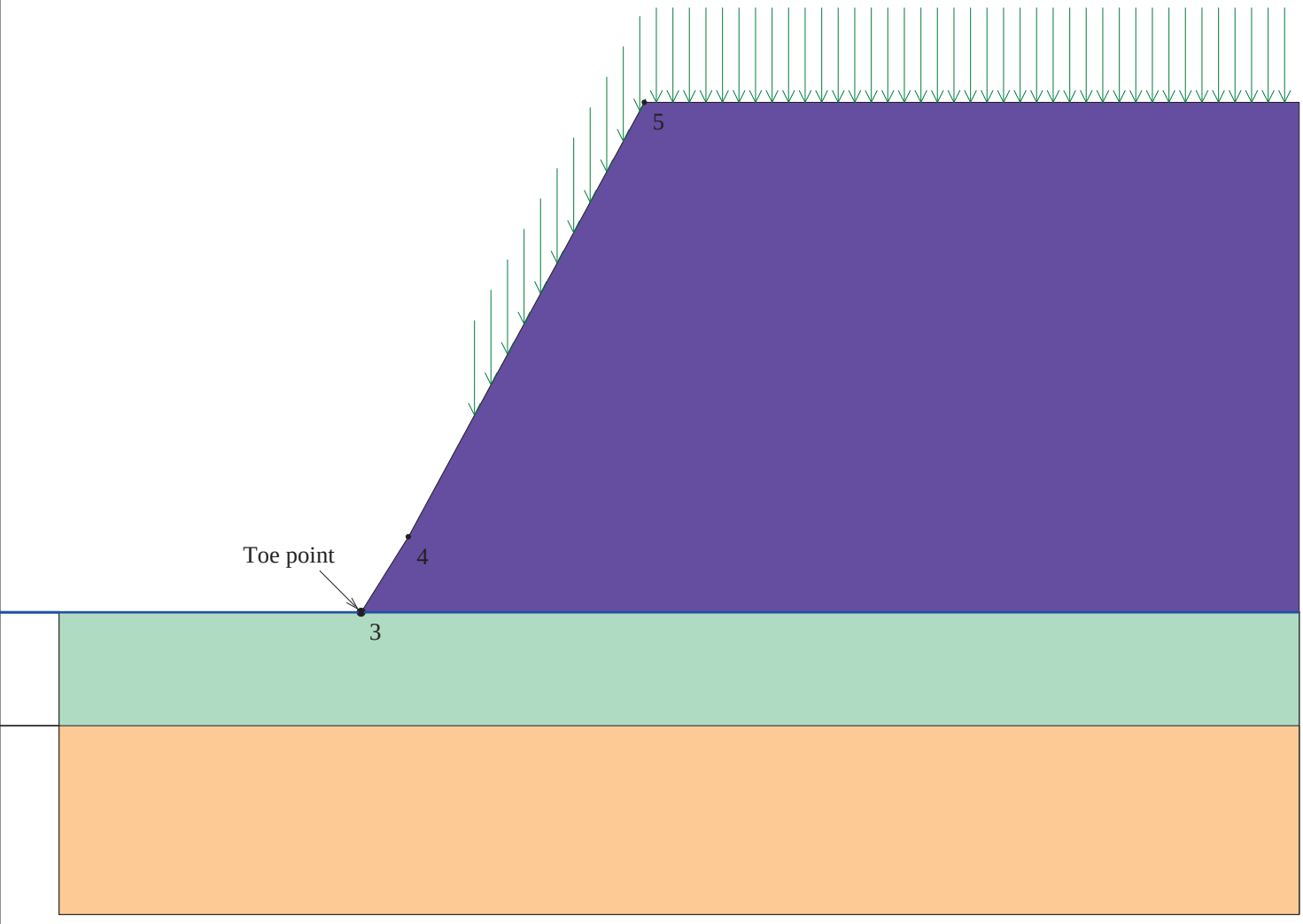
-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY
Soil profile contains 4 layers (see details in next page)

WATER GEOMETRY
Phreatic line was specified.

UNIFORM SURCHARGE
Load Q1 = 240.00 [lb/ft^2] inclined from verical at 0.00 degrees, starts at X1s = 3.00 and ends at X1e = 30.00 [ft].
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD
.....None.....



SCALE:

0 2 4 6 [ft]

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	21.00	13.50	-14.12	0.05	-3.23	24.20	26.49	1.30	. On extreme X-entry
2	21.50	13.50	-13.36	0.16	-2.65	24.39	26.49	1.32	
3	22.00	13.50	-15.14	0.06	-3.73	26.56	28.85	1.33	
4	22.50	13.50	-14.00	0.00	-3.17	26.81	28.92	1.36	
5	23.00	13.50	-15.10	0.04	-3.61	28.18	30.40	1.37	
6	23.50	13.50	-15.01	0.00	-3.70	29.43	31.53	1.38	
7	24.00	13.50	-14.26	0.10	-3.17	29.75	31.66	1.40	
8	24.50	13.50	-15.37	0.14	-3.62	31.25	33.26	1.42	
9	25.00	13.50	-15.27	0.09	-3.75	32.67	34.56	1.44	
10	25.50	13.50	-15.30	0.10	-3.57	33.20	35.12	1.47	
11	26.00	13.50	-15.19	0.06	-3.71	34.73	36.52	1.48	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points)

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	-15.28	0.13	21.00	13.50	-3.62	24.41	26.93	1.32	
. 2	-14.12	0.05	21.00	13.50	-3.23	24.20	26.49	1.30	. OK
3	-13.05	0.02	21.00	13.50	-2.60	23.37	25.58	1.31	
4	-12.26	0.11	21.00	13.50	-2.19	23.11	25.11	1.31	
5	-11.19	0.08	21.00	13.50	-1.55	22.27	24.20	1.32	
6	-10.03	0.01	21.00	13.50	-1.12	21.97	23.69	1.32	
7	-9.21	0.08	21.00	13.50	-0.70	21.63	23.17	1.33	
8	-8.14	0.05	21.00	13.50	-0.03	20.77	22.25	1.36	
9	-7.10	0.04	21.00	13.50	0.42	20.40	21.70	1.38	
10	-6.04	0.01	21.00	13.50	0.88	19.99	21.14	1.39	
11	-5.26	0.09	21.00	13.50	1.35	19.55	20.56	1.42	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

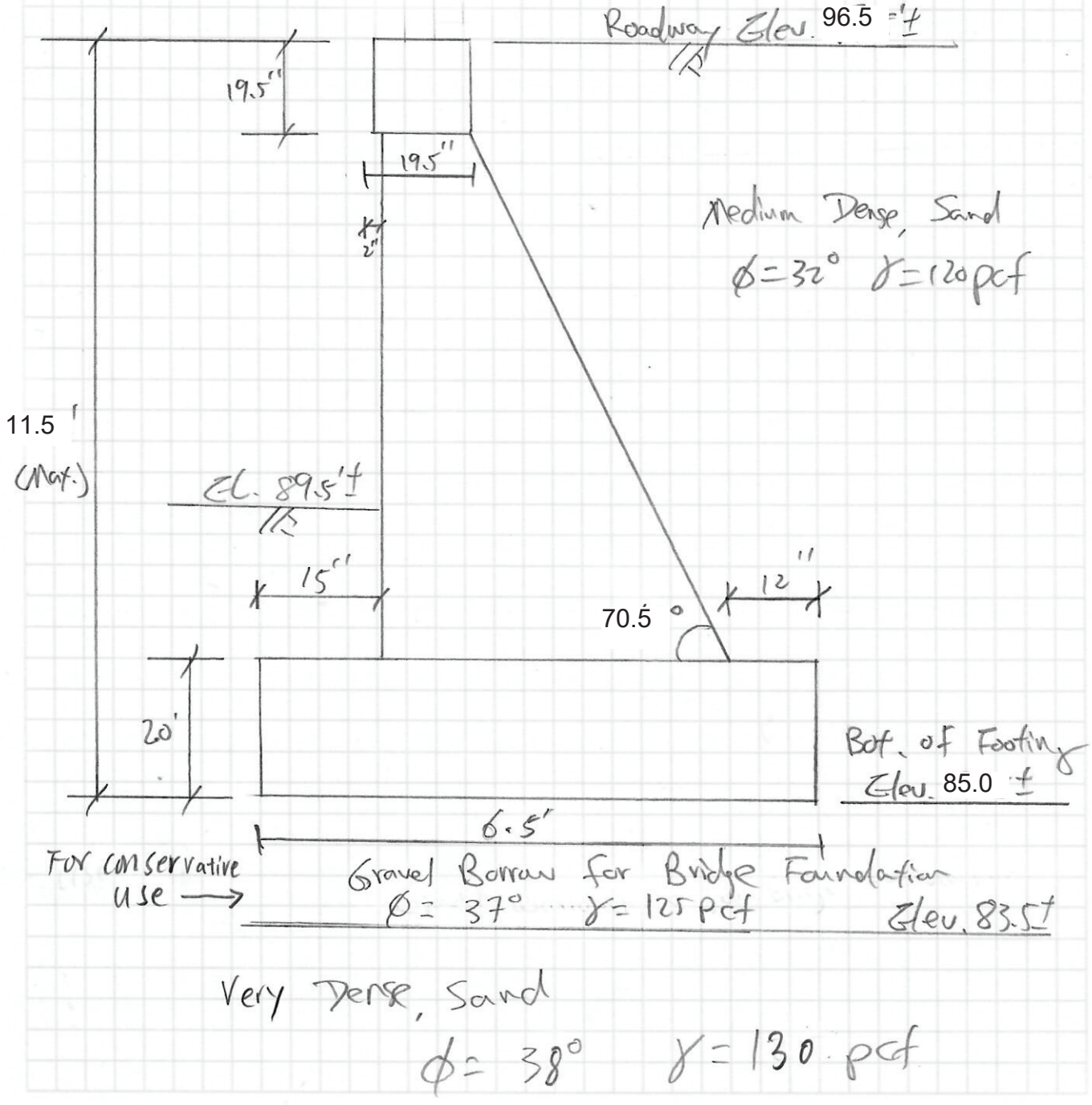
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LAMSON ENGINEERING CORPORATION		Final Page No: 50	
Project: Route 38 (Main Street) Retaining Wall	Job No:	Preliminary Sheet No:	
Subject: Wall Type I	Prepared by: WD		Date: 7/2020
Detail: Section	Checked by: JJL		Date: 7/2020

Gravity Wall – Wall Type I (Sta. 208+40 to Sta. 209+05)
– Based on Boring WB-3 & Max Wall Height of 11.5 '



LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type I	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Determine Unfactored Horizontal Load

Effective angle of internal friction ϕ'_f	=	32	degree
Friction angle between fill and wall, δ	=	21	degree
Angle of fill to the horizontal, β	=	0.00	degree
Angle of back of wall to the horizontal, θ	=	70.5	degree
Unit weight of soil, γ_{soil}	=	0.120	kcf
Total unit weight of water, γ_w	=	0.0624	kcf
Height of fill = Height of wall	=	11.5	ft ±
Distance from back of wall to footing heel, B_{heel}	=	3.79	ft
Height of fill behind footing at heel, h = H + B_{heel} tan β	=	11.5	ft ±
Height of water from bottom of footing ,Hw	=	0	ft

Lateral Earth Pressure (EH)

Active pressure coefficient, K_a

$$= \frac{\sin^2(\theta + \phi'_f)}{\sin^2\theta \sin(\theta - \delta)\left[1 + \sqrt{\frac{\sin(\phi'_f + \delta)\sin(\phi'_f - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2}$$

$$= 0.451$$

At-rest pressure coefficient, K_o = 1 - sin ϕ'_f = 1 - sin (32)

= 0.470

Per *massDOT* LRFD BM 3.1.5

K_e = Ka

= 0.451

Lateral earth pressure, P_{e1} = $0.5 K_e \gamma_{soil} (h - H_w)^2$

= 0.5 x 0.451 x 0.12 kcf x (11.5 ft - 0 ft)^2

= 3.58 k/ft length of wall

Vertical component of P_{e1}, P_{ev1} = P_{e1} sin (90 - θ + δ)

= 3.58 k /ft x sin (90 - 70.5 + 21)

= 2.32 k/ft

Horizontal component of P_{e1}, P_{eh1} = P_{e1} cos (90 - θ + δ)

LAMSON ENGINEERING CORPORATION			Final Page No.:	
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Subject:	Wall Type I	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

= 3.58 k/ft x cos (90 - 70.5 + 21)

= 2.72 k/ft

Lateral earth pressure, P_{e2} = $K_e \gamma_{soil} (h - H_w) H_w$

= 0.451 x 0.12 kcf x (11.5 ft - 0 ft) x 0 ft

= 0.00 k/ft length of wall

Vertical component of P_{e2}, P_{ev2} = $P_{e2} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 70.5 + 21)

= 0.00 k/ft

Horizontal component of P_{e2}, P_{eh2} = $P_{e2} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 70.5 + 21)

= 0.00 k/ft

Lateral earth pressure, P_{e3} = $0.5 K_e \gamma' (H_w)^2$

0.5 x 0.451 x (0.12 kcf - 0.0624 kcf) x 0 ft^2

= 0.00 k/ft length of wall

Vertical component of P_{e3}, P_{ev3} = $P_{e3} \sin (90 - \theta + \delta)$

= 0 k/ft x sin (90 - 70.5 + 21)

= 0.00 k/ft

Horizontal component of P_{e3}, P_{eh3} = $P_{e3} \cos (90 - \theta + \delta)$

= 0 k/ft x cos (90 - 70.5 + 21)

= 0.00 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
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Subject:	Wall Type I	Prepared by: WD		Date: 5/2025
Detail:	Lateral Earth Pressure	Checked by: JJL		Date: 5/2025

Live Load Surcharge (LS) (AASHTO LRFD 3.11.6.4)

Equivalent height of soil for , h_{eq} = 2.9 ft
vehicular load

Horizontal earth pressure due to live Δ_p = $K_e \gamma_{soil} \ h_{eq}$
load surcharge = 0.451 x 0.12 kcf x 2.85 ft
= 0.15 ksf

Live load lateral earth pressure, P_{LS} = Δ_p h
= 0.15 ksf x 11.5 ft
= 1.77 k/ft length of wall

Vertical component of P_{LS}, P_{LSV} = $P_{LS} \sin (90 - \alpha + \delta)$
= 1.77 k/ft x sin (90 - 70.5 + 21)
= 1.15 k/ft length of wall

Horizontal component of P_{LS}, P_{LSH} = $P_{LS} \cos (90 - \alpha + \delta)$
= 1.77 k/ft x cos (90 - 70.5 + 21)
= 1.35 k/ft length of wall

Vertical live load surcharge over the heel = $B_h \times h_{eq} \times \gamma_{soil}$
= 1.30 k/ft

Unfactored horizontal load, EH + LSH = $P_{eh1} + P_{eh2} + P_{eh3} + P_{LSH}$
= 2.72 + 0 + 0 + 1.35
= 4.07 k/ft length of wall

LAMSON ENGINEERING CORPORATION		Final Page No.:	
Project: Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject: Wall Type I	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Bearing Resistance

Bearing Resistance at the Service Limit State

Based on Boring WB-3. Bottom of Footing Elev. 85.0 +/- (NAVD 88)

Presumptive Bearing Resistance for Spread Footing (Table C10.6.2.6.1-1)

Bearing Resistance, q = 5 ksf

Bearing Resistance of Soil at the Strength Limit State Design

Footing length, L = 65 ft

Factored bearing resistance, q_R = $\varphi_b\ q_n$ (AASHTO 10.6.3.1.1-1)

Bearing resistance factor, φ_b = 0.55 (AASHTO Table 11.5.7-1)

Nominal bearing resistance, q_n = $c\ N_{cm} + \gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

N_{cm} = $N_c\ s_c\ i_c$

N_{qm} = $N_q\ s_q\ d_q\ i_q$

$N_{\gamma m}$ = $N_\gamma\ s_\gamma\ i_\gamma$

Because of c = 0,

Nominal bearing resistance, q_n = $\gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

i_q = $[\ 1 - H / V\ ]^n$

= See table next page

i_γ = $[\ 1 - H / V\ ]^{(n+1)}$

= See table next page

n = $[(2+L / B) / (1+ L / B)]\cos^2\theta + [(2+B / L) / (1+ B / L)]\sin^2\theta$

= See table next page

Unfactored horizontal load, H = 4.07 kips/ft

Unfactored vertical load, V = 14.33 kips/ft

Project direction of load in the plane of the footing, θ = 90 deg (measured from the side of L)

Soil properties above footing

Angle of internal friction, Φ_{f1} = 32 degree

Moist unit weight of soil, γ_1 = 0.12 kcf

Footing embedment depth, D_f = 4.5 ft

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Subject: Wall Type I	Prepared by: WD		Date: 8/2025
Detail: Bearing Resistance	Checked by: JJL		Date: 8/2025

Surcharge bearing capacity factor, N_q = 23.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f1} > 0$ Shape factor, s_q = $1 + (B' / L) \tan \Phi_{f1}$ (AASHTO Table 10.6.3.1.2a-3)

= See table this page

Depth Correction Factor, d_q = 1

Correction factors to account for the location of the ground water table (AASHTO Table 10.6.3.1.2a-2)

C_{wq} = 1.00

Soil properties below footing

Angle of internal friction, Φ_{f2} = 37 degree

Moist unit weight of soil, γ_2 = 0.125 kcf ← γ_2

Unit Weight bearing capacity factor, N_γ = 66.2 (AASHTO Table 10.6.3.1.2a-1)

For $\Phi_{f2} > 0$ Shape factor, s_γ = $1 - 0.4 (B' / L)$ (AASHTO Table 10.6.3.1.2a-3)

See Table this page

Correction factors to account for the location of the ground water table

$C_{w\gamma}$ = 0.5 (AASHTO Table 10.6.3.1.2a-2)

B = 6.50 ft

e = 0.05 ft B' = B - 2e

B' (ft)	n	i_q	i_γ	s_q	s_γ	N_{qm}	$N_{\gamma m}$	$\gamma_1 D_f N_{qm} C_{wq}$ (ksf)	$0.5 \gamma_2 B' N_{\gamma m} C_{w\gamma}$ (ksf)	q_n (ksf)	q_R (ksf)
6.4	1.91	0.528	0.378	1.06	0.96	12.98	24.02	7.01	4.80	11.81	**6.4**

Factored bearing resistance

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Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Unfactored Dead Load	Checked by: JJL		Date: 8/2025

Unfactored Dead Load

Concrete coping	(19.5 x 19.5) / 144 x 0.15	=	0.396 k/ft
Stem	0.5 x (1.46 + 4.25) x 7.875 x 0.15	=	3.372 k/ft
Concrete Footing	6.5 x 2.0 x 0.15	=	1.95 k/ft
Soil on back of the wall	((1.625 x 3.792) + (0.5 x (1 + 3.792) x 8.375)) x 0.12	=	3.15 k/ft

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Strength IA: 1.25DC + 1.50EH + 1.35EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.25	0.40	0.50	1.35	0.67	
Stem	1.25	3.37	4.22	0.46	1.94	
Concrete Footing	1.25	1.95	2.44	0.00	0.00	
Soil on back of the wall	1.35	3.15	4.25	-1.94	-8.24	
P_{v1}	1.50	2.32	3.49	-3.25	-11.33	
P_{v2}	1.50	0.00	0.00	-3.25	0.00	
P_{v3}	1.50	0.00	0.00	-3.25	0.00	
P_{LSV}	1.75	1.15	2.02	-3.25	-6.55	
LS	1.75	1.77	3.10	-1.94	-6.02	
TOTAL		14.12	20.01		-29.54	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	2.72	4.08	3.83	15.65	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.35	2.36	5.75	13.58	
TOTAL		4.07	6.44		29.23	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
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Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Bearing Resistance	Checked by: JJL		Date: 8/2025

COEFFICIENT OF FRICTION FOR SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 37 degree

below footing

$\phi_t \tan\Phi_f$ = 0.8 x tan 37

= 0.60

BEARING PRESSURE

Footing width, B = 6.500 ft

Distance from wall face to toe = 1.25 ft

Height of soil over toe from top of footing = 2.5 ft

Factored vertical soil over toe, V_{st} = 1.35 x 1.3 ft x 2.5 ft x 0.120 kcf

= 0.506 k/ft

Factored Moment about ℄ , M_{st} = 0.506 k/ft x (6.5 ft - 1.25 ft) / 2

= 1.329 k-ft

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-29.543 + 29.226 + 1.329}{20.005 + 0.506}$

= 0.05 ft < B/3 OK

For Footing founded on Soil

$q_{average}$ = $\dfrac{(\Sigma V_u + V_{st})}{(B - 2e)}$

= $\dfrac{20.01 + 0.51}{(6.5 - 2 \times 0.05)}$ = 3.20 ksf

Factored Bearing Resistance, q_R = 6.40 k/ft^2 > 3.20 OK

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Strength IB: 0.90DC + 1.50EH + 1.0EV + 1.75 LS

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	0.90	0.40	0.36	1.35	0.48	
Stem	0.90	3.37	3.04	0.46	1.40	
Concrete Footing	0.90	1.95	1.76	0.00	0.00	
Soil on back of the wall	1.00	3.15	3.15	-1.94	-6.11	
P_{v1}	1.50	2.32	3.49	-3.25	-11.33	
P_{v2}	1.50	0.00	0.00	-3.25	0.00	
P_{v3}	1.50	0.00	0.00	-3.25	0.00	
P_{LSV}	1.75	1.15	2.02	-3.25	-6.55	
LS	1.75	1.77	3.10	-1.94	-6.02	
TOTAL		14.12	16.90		-28.14	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.50	2.72	4.08	3.83	15.65	
P_{h2}	1.50	0.00	0.00	0.00	0.00	
P_{h3}	1.50	0.00	0.00	0.00	0.00	
P_{LSH}	1.75	1.35	2.36	5.75	13.58	
TOTAL		4.07	6.44		29.23	ΣM_H

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Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Strength I for Sliding and Eccentricity	Checked by: JJL		Date: 8/2025

SLIDING

Resistance Factor, ϕ_t = 0.8 Cast-in- Place Concrete on Sand

Effective angle of internal friction Φ_f = 37 degree

below footing

Sliding Factor = $\dfrac{\phi_t \tan\Phi_f (\Sigma V)}{(\Sigma H_u)}$

= $\dfrac{0.8 \times \tan 37 \times 14.12}{6.44}$

Sliding Factor = 1.32 > 1 OK

Eccentricity

Footing width, B	=	6.500	ft			
Distance from wall face to toe	=	1.25	ft			
Height of soil over toe from top of footing	=	2.5	ft			
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2.5 ft x 0.120 kcf				
	=	0.375	k/ft			
Factored Moment about ℄ , M_{st}	=	0.375 k/ft x (6.5 ft - 1.25 ft) / 2				
	=	0.984	k-ft			

Eccentricity of load, e = $\dfrac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$

= $\dfrac{-28.136 + 29.226 + 0.984}{16.902 + 0.375}$

= 0.12 ft < B/3 OK

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Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
Subject:	Wall Type I	Prepared by: WD		Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL		Date: 8/2025

Summary of Factored Loads - Service I: 1.0DC + 1.0EH + 1.0EV

Vertical Loads and Vertical Moments

Item	Load Factor γ	Vertical load, V (k/ft)	Factored vertical load, V_u (k/ft)	Arm about ℄ Footing	Factored Moment	
Coping	1.00	0.40	0.40	1.35	0.54	
Stem	1.00	3.37	3.37	0.46	1.55	
Concrete Footing	1.00	1.95	1.95	0.00	0.00	
Soil on back of the wall	1.00	3.15	3.15	-1.94	-6.11	
P_{v1}	1.00	2.32	2.32	-3.25	-7.56	
P_{v2}	1.00	0.00	0.00	-3.25	0.00	
P_{v3}	1.00	0.00	0.00	-3.25	0.00	
P_{LSV}	1.00	1.15	1.15	-3.25	-3.74	
LS	1.00	1.77	1.77	-1.94	-3.44	
TOTAL		14.12	14.12		-18.76	ΣM_V

Horizontal Loads and Horizontal Moments

Item	Load Factor γ	Horizontal load H (k/ft)	Factored horizontal load, H_u (k/ft)	Arm about ℄ Footing	Factored Moment	
P_{h1}	1.00	2.72	2.72	3.83	10.43	
P_{h2}	1.00	0.00	0.00	0.00	0.00	
P_{h3}	1.00	0.00	0.00	0.00	0.00	
P_{LSH}	1.00	1.35	1.35	5.75	7.76	
TOTAL		4.07	4.07		18.19	ΣM_H

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:	
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Detail:	Service I for Settlement	Checked by: JJL		Date: 8/2025

BEARING PRESSURE

Footing width, B	=	6.500	ft
Distance from wall face to toe	=	1.25	ft
Height of soil over toe from top of footing	=	2.5	ft
Factored vertical soil over toe, V_{st}	=	1.0 x 1.3 ft x 2.5 ft x 0.120 kcf	
	=	0.375	k/ft
Factored Moment about ℄ , M_{st}	=	0.375 k/ft x (6.5 ft - 1.25 ft) / 2	
	=	0.984	k-ft

Eccentricity of load, e

$$= \frac{\Sigma M_V + \Sigma M_H + M_{st}}{\Sigma V_U + V_{st}}$$

$$= \frac{-18.76 + 18.191 + 0.984}{14.117 + 0.375}$$

= 0.03 ft

For Footing founded on Soil

$$q_{average} = \frac{(\Sigma V_u + V_{st})}{(B - 2e)}$$

$$= \frac{14.12 + 0.38}{(6.5 - 2 \times 0.03)} = 2.25 \text{ ksf}$$

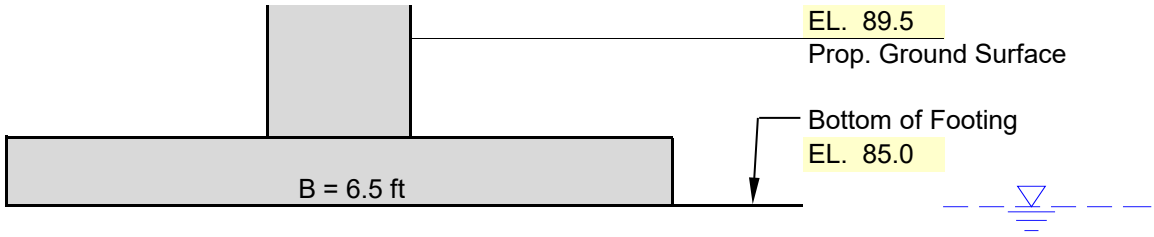
LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type I	Prepared by: WD	Date: 8/2025
Detail:	Service I for Settlement	Checked by: JJL	Date: 8/2025

Section A Settlement (AASHTO 10.6.2.4.2)

Based on WB-3

Footing Width, B = 6.5 ft

Footing Length, L = 65 ft



Sand γ_{soil} = 0.13 kcf

Average $N1$ = 61 blows per ft

EL. 77.7
Mid-Layer below footing

Top of Bedrock EL. 70.3

LAMSON ENGINEERING CORPORATION			Final Page No.:
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Detail:	Service I for Settlement	Checked by: JJL	Date: 8/2025

The total settlement, S_t = $S_e + S_c + S_s$

Total settlement, S_t = S_e for footing on cohesionless soils $S_c = S_s = 0$

Immediate settlement, S_e = $\sum_{i=1}^{n} \Delta H_i$

ΔH_i = elastic settlement of layer i (ft.)

= $H_c \frac{1}{C'} \log\left(\frac{\sigma_o' + \Delta\sigma_v}{\sigma_o'}\right)$

n = number of soil layers within zone of stress influence of the footing

= 1

H_c = initial heigh of layer i (ft.)

= 14.7 ft.

C' = bearing capacity index from Figure 10.6.2.4.2-1

= 175 (for Fine to Coarse Sand and N1 = 61)

σ'_o = initial vertical effective stress at the midpoint of layer i

= 0.125 x (EL. 89.5 - EL. 85.5) + (0.125-0.0624) x (EL. 85.5 - EL. 77.9

= 1.082 ksf

Max. Service I (No Exist. Soil Weight)

σ_v = 2.25 ksf

$\Delta\sigma_v$ = increase in vertical stress at the midspan of layer i

= $0.2\ \sigma_v$ From Figure 10.6.2.4.1-1, L>5B

$\Delta\sigma_v$ = 0.450 ksf

ΔH_i = (14.7 / 175) log [(1.082 + 0.45) / 1.082]

= 0.01 ft = 0.2 in.

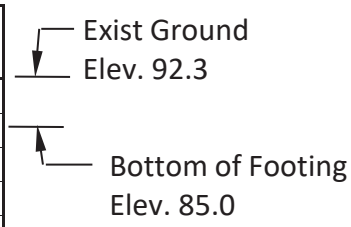
LAMSON ENGINEERING CORPORATION			Final Page No.:
Project:	Route 38 (Main Street) Retaining Wall	Job No.:	Preliminary Sheet No.:
Subject:	Wall Type I	Prepared by: WD	Date: 5/2025
Detail:	Corrected *SPT* blow count	Checked by: JJL	Date: 5/2025

WB-3

Water table = 12.4 ft γ_w 0.0624 kcf

γ_m 0.120 kcf

Depth ft	σ'_v ksf	C_N	N blows/ft	$N1 = C_N N$ blows/ft
2.00	0.24	1.71	24	41
5.00	0.60	1.40	5	7
10.00	1.20	1.17	53	62
15.00	1.64	1.07	46	49
20.00	1.93	1.01	70	71



Average $N1$ 61 (below footing)

For example

Depth = 10 ft

C_N = 0.77 $\log_{10}$ (40 / σ'_v) < 2 (AASHTO 10.4.6.2.4-1)

σ'_v = vertical effective stress (ksf)

= 10 ft x 0.12 kcf

= 1.200 ksf

C_N = 0.77 $\log_{10}$ (40 / 1.2)

= 1.173 < 2

N = uncorrected *SPT* blow count (blows/ft.)

= 53 blows /ft

$N1$ = $C_N N$

= 1.173 x 53 blows/ft ≤ 100 blows/ft

= 62 blows/ft < 100 blows/ft

Overall Stability - Wall Type I

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PROJECT IDENTIFICATION

Title: Overall Stability - Wall Type I
Project Number: Retaining Wall Type I -
Client: Green / massDOT
Designer: WD
Station Number:

Description:
Overall Stability

Company's information:

Name: Lamson Engineering Coporation
Street: 437 Cherry Street
Newton, MA 02465
Telephone #: 617-558-0101
Fax #:
E-Mail:

Original file path and name: C:\Program ..... \ReSSA(3.0)\Route 38 (Main Street) Wall Type I.MSE
Original date and time of creating this file: Thur April 7 2020

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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Version 3.0 ReSSA Version 3.0

INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

========== Soil Layer #: ==========	Unit weight, γ [lb/ft^3]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft^2]
....1.....Gravel Borrow.....	120.0	32.0	0.0
....2.....Medium Dense, Fine Sand.....	120.0	32.0	0.0
....3.....Gravel Borrow for Bridgel Foundations	125.0	37.0	0.0
....4.....Dense, Fine Sand.....	130.0	37.0	0.0

REINFORCEMENT

Analysis of slope WITHOUT reinforcement.

WATER

Unit weight of water = 62.45 [lb/ft^3]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

SEISMICITY

Not Applicable

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DRAWING OF SPECIFIED GEOMETRY - COMPLEX - Quick Input

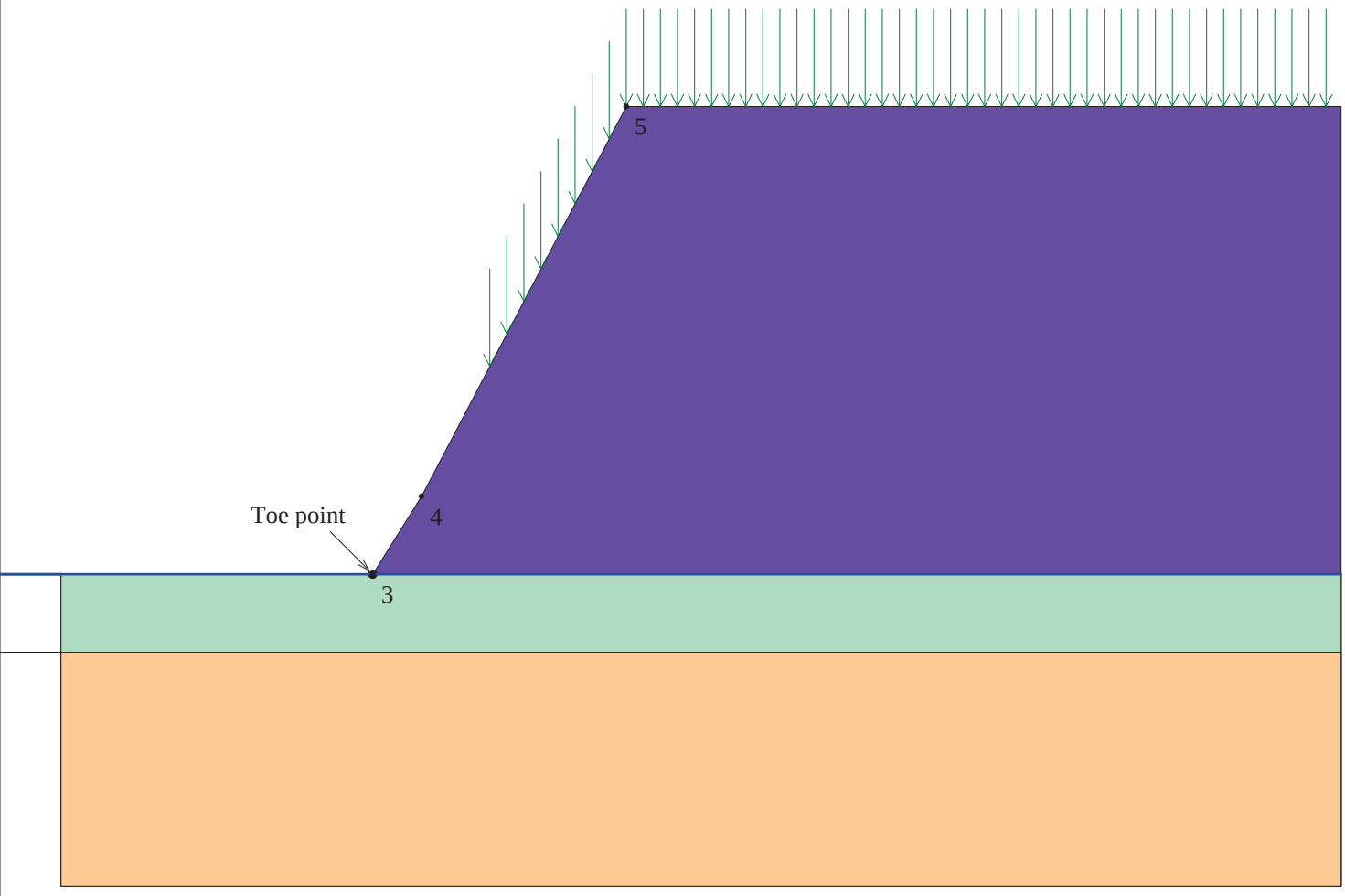
-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY
Soil profile contains 4 layers (see details in next page)

WATER GEOMETRY
Phreatic line was specified.

UNIFORM SURCHARGE
Load Q1 = 240.00 [lb/ft^2] inclined from verical at 0.00 degrees, starts at X1s = 3.00 and ends at X1e = 30.00 [ft].
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD
.....None.....



SCALE:

0 2 4 6[ft]

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	20.00	12.00	-13.04	0.01	-3.17	24.34	26.25	1.34 .	On extreme X-entry
2	20.50	12.00	-13.33	0.13	-3.22	25.47	27.28	1.36	
3	21.00	12.00	-14.06	0.02	-3.67	26.91	28.83	1.38	
4	21.50	12.00	-14.35	0.13	-3.74	28.18	29.98	1.40	
5	22.00	12.00	-15.07	0.02	-4.19	29.71	31.61	1.42	
6	22.50	12.00	-14.30	0.11	-3.65	30.05	31.78	1.44	
7	23.00	12.00	-13.14	0.04	-3.13	30.38	31.95	1.46	
8	23.50	12.00	-15.31	0.10	-4.22	33.18	34.88	1.48	
9	24.00	12.00	-14.13	0.04	-3.72	33.62	35.16	1.51	
10	24.50	12.00	-13.34	0.10	-3.23	34.07	35.44	1.53	
11	25.00	12.00	-14.03	0.01	-3.70	35.91	37.36	1.56	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points)

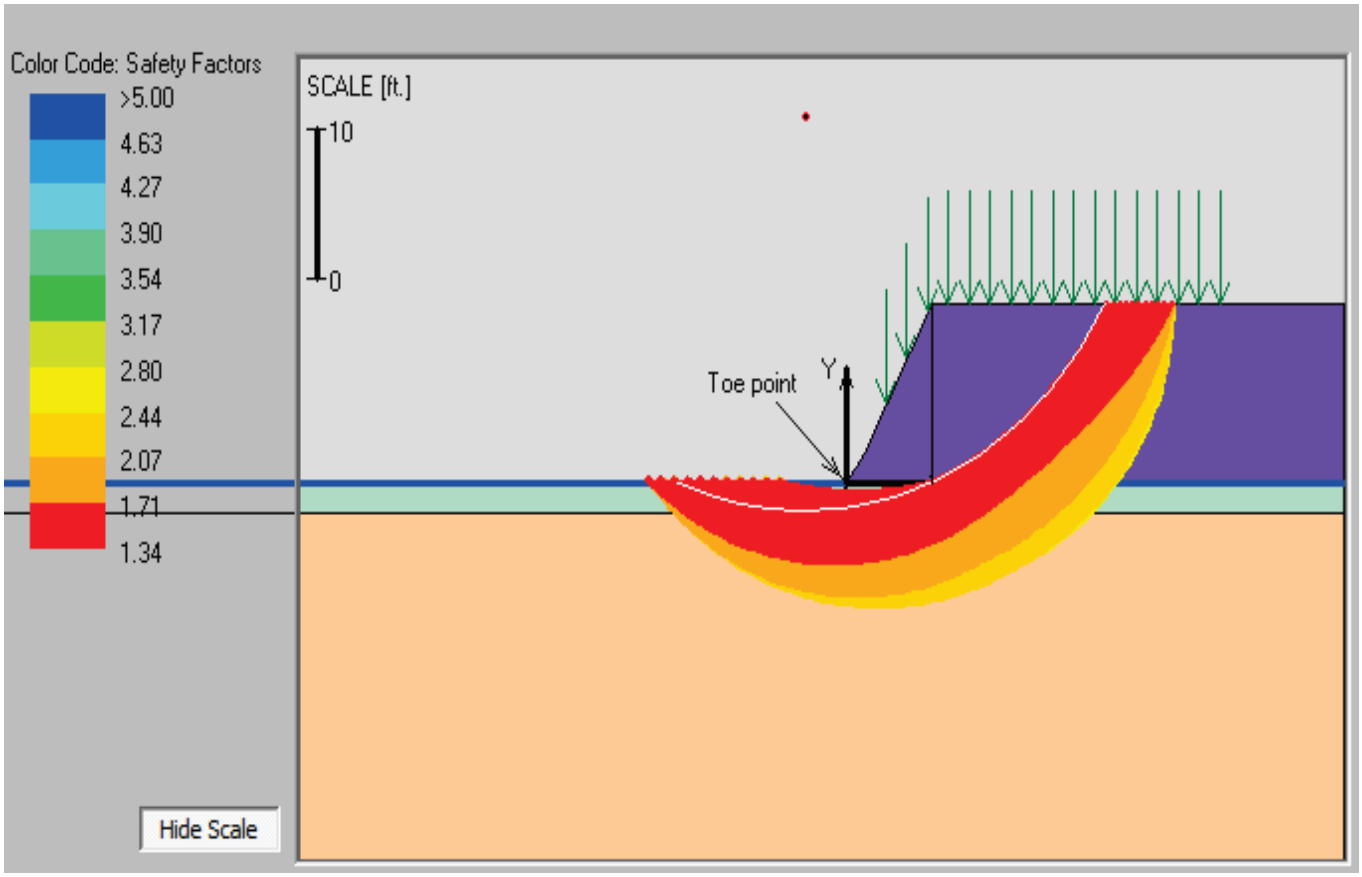
Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	-15.22	0.10	20.00	12.00	-4.18	25.49	27.69	1.35	
2	-14.11	0.05	20.00	12.00	-3.56	24.59	26.72	1.35	
. 3	-13.04	0.01	20.00	12.00	-3.17	24.34	26.25	1.34 .	OK
4	-12.32	0.13	20.00	12.00	-2.53	23.43	25.27	1.35	
5	-11.15	0.06	20.00	12.00	-2.12	23.12	24.77	1.35	
6	-10.32	0.12	20.00	12.00	-1.71	22.78	24.24	1.34	
7	-9.25	0.09	20.00	12.00	-1.05	21.84	23.24	1.36	
8	-8.08	0.03	20.00	12.00	-0.62	21.44	22.68	1.37	
9	-7.22	0.07	20.00	12.00	-0.17	21.02	22.10	1.39	
10	-6.22	0.07	20.00	12.00	0.28	20.56	21.49	1.41	
11	-5.11	0.03	20.00	12.00	0.75	20.06	20.87	1.43	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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SAFETY MAP: BISHOP ROTATIONAL ANALYSIS MODE



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APPENDIX 3

Seismic Design Information

(6 Sheets)

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Retaining Wall, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Seismic Calculations	Prepared by: WD		Date: 8/2025
Detail:	N1 blow count & Seismic Design Coefficients	Checked by: JJL		Date: 8/2025

WB-1

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	32	2	0.06
5.00	16	3	0.19
10.00	10	5	0.50
15.00	64	5	0.08
19.00	100	4	0.04
25.00	19	6	0.32
28.00	100	3	0.03
110.00	100	82	0.82
	Sum	100.0	1.3

Ground Surface Elev. 103.8

Bottom of footing at Elev. 93.0

Assume N value = 100 blows/ft for bedrock or refusal materials.
Bedrock is assumed between 28 ft and 110 ft.
Native soil materials below bottom of footing and above Elev. 90.0 will be replaced by Gravel Borrow for Bridge Foundation.

Below bottom of footing:

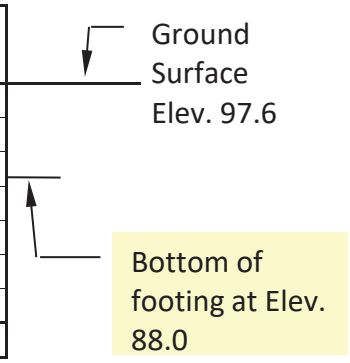
50 < $\bar{N}$ = 77.9

The site class is C per Table 3.4.2.1-1 of AASHTO Guide Specification.

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Retaining Wall, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Seismic Calculations	Prepared by: WD		Date: 8/2025
Detail:	N1 blow count & Seismic Design Coefficients	Checked by: JJL		Date: 8/2025

WB-2

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	44	2	0.05
5.00	6	3	0.50
10.00	5	5	1.00
15.00	37	5	0.14
20.00	22	5	0.23
21.00	100	1	0.01
110.00	100	89	0.89
	Sum	100.0	1.3



Assume N value = 100 blows/ft for bedrock or refusal materials.
Bedrock is assumed between 21 ft and 110 ft.
Loose materials below bottom of footing and above Elev. 85.5 will be replaced by Gravel Borrow for Bridge Foundation.

Below bottom of footing:

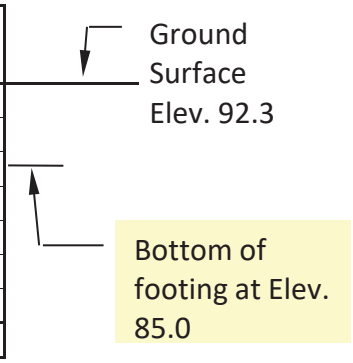
50 < $\bar{N}$ = 79.2

The site class is C per Table 3.4.2.1-1 of AASHTO Guide Specification.

LAMSON ENGINEERING CORPORATION			Final Page No.:	
Project:	Retaining Wall, Wilmington	Job No.:	Preliminary Sheet No.:	
Subject:	Seismic Calculations	Prepared by: WD		Date: 8/2025
Detail:	N1 blow count & Seismic Design Coefficients	Checked by: JJL		Date: 8/2025

WB-3

Depth ft	N blows/ft	d_i ft	d_i / N_i ft^2/blow
2.00	24	2	0.08
5.00	5	3	0.60
10.00	53	5	0.09
15.00	46	5	0.11
20.00	70	5	0.07
22.00	100	2	0.02
105.00	100	83	0.83
	Sum	100.0	1.1



Assume N value = 100 blows/ft for bedrock or refusal materials.
Bedrock is assumed between 22 ft and 105 ft.
Loose materials below bottom of footing and above Elev. 83.5 will be replaced by Gravel Borrow for Bridge Foundation.

Below bottom of footing:

50 < $\overline{N}$ = 88.9

Therefore, the site class is C per Table 3.4.2.1-1 of AASHTO Guide Specification.

Based on Borings WB-1 to WB-3, the controlling site class is C.

From Seismic Design Maps:

PGA	=	0.08 g
S_s	=	0.16 g
S_1	=	0.04 g

Per Tables 3.4.2.3-1 & 3.4.2.3-2 of AASHTO Guide Specification

F_{pga}	=	1.2	
F_a	=	1.2	
F_v	=	1.7	
Therefore,			
A_s	=	0.096 g	
S_{DS}	=	0.192 g	
S_{D1}	=	0.068 g	< 0.15g

Seismic Design Category (SDC) = A

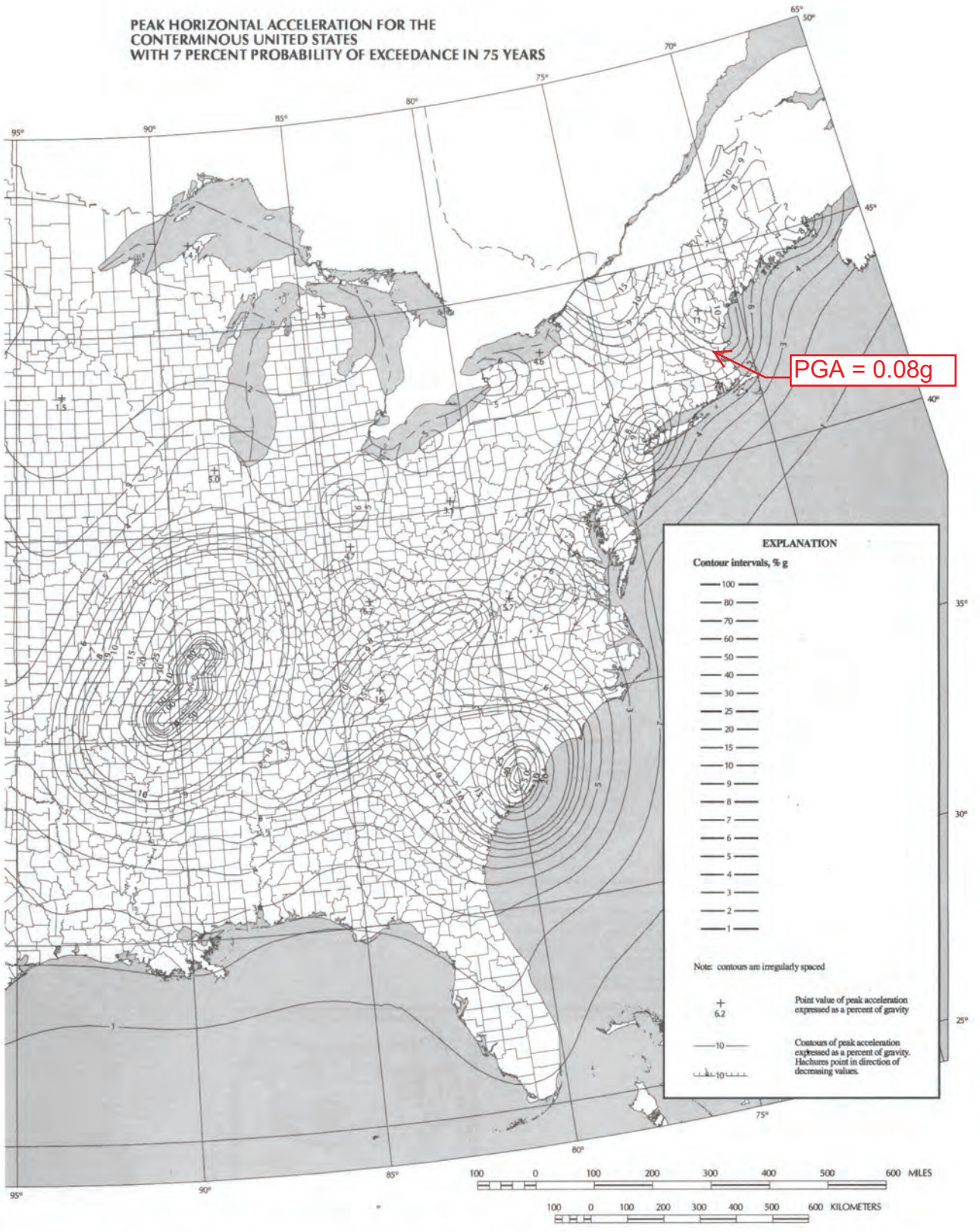


Figure 3.4.1-2b—Horizontal Peak Ground Acceleration Coefficient for the Conterminous United States (*PGA*) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period)

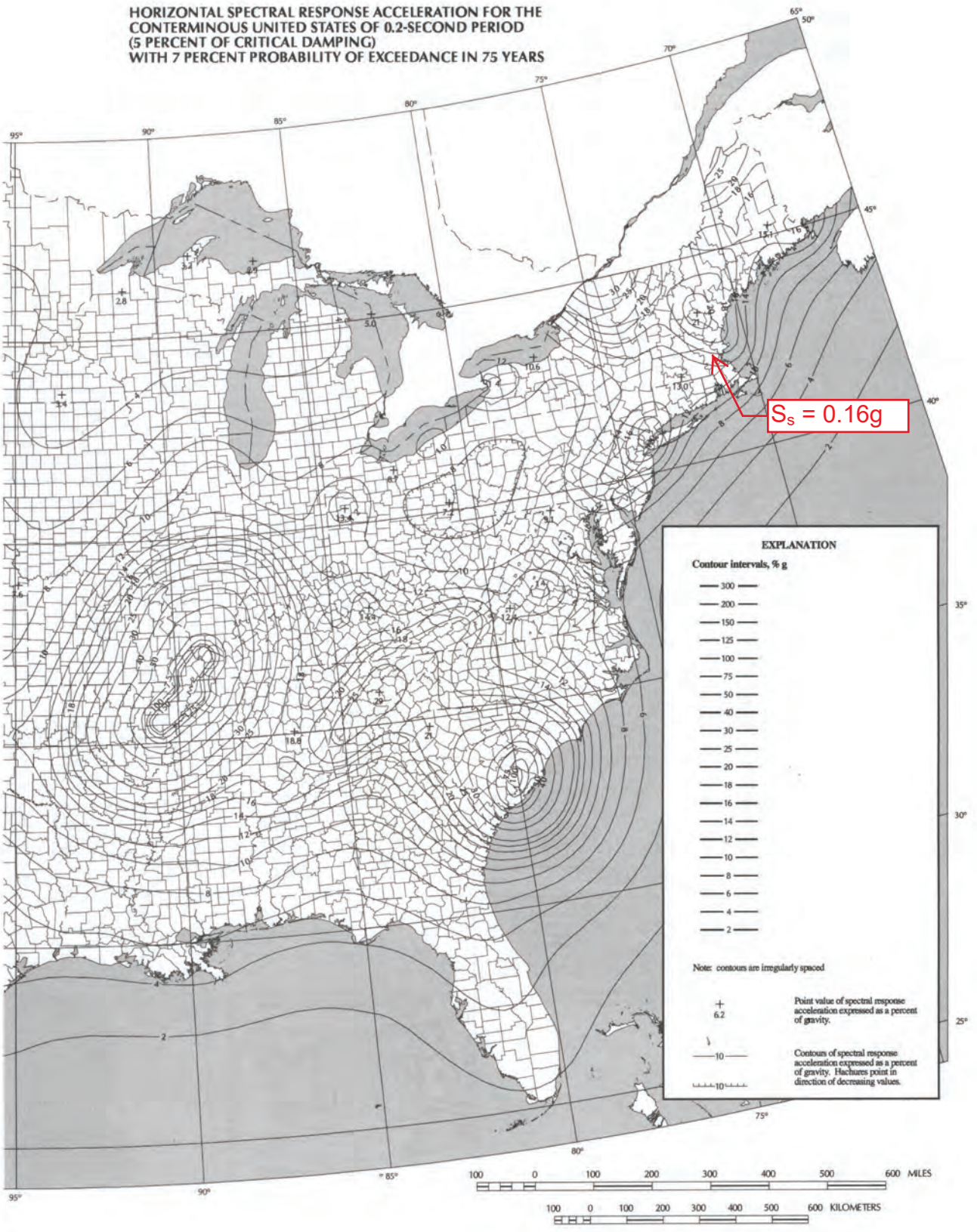


Figure 3.4.1-3b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 0.2-sec (S_s) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

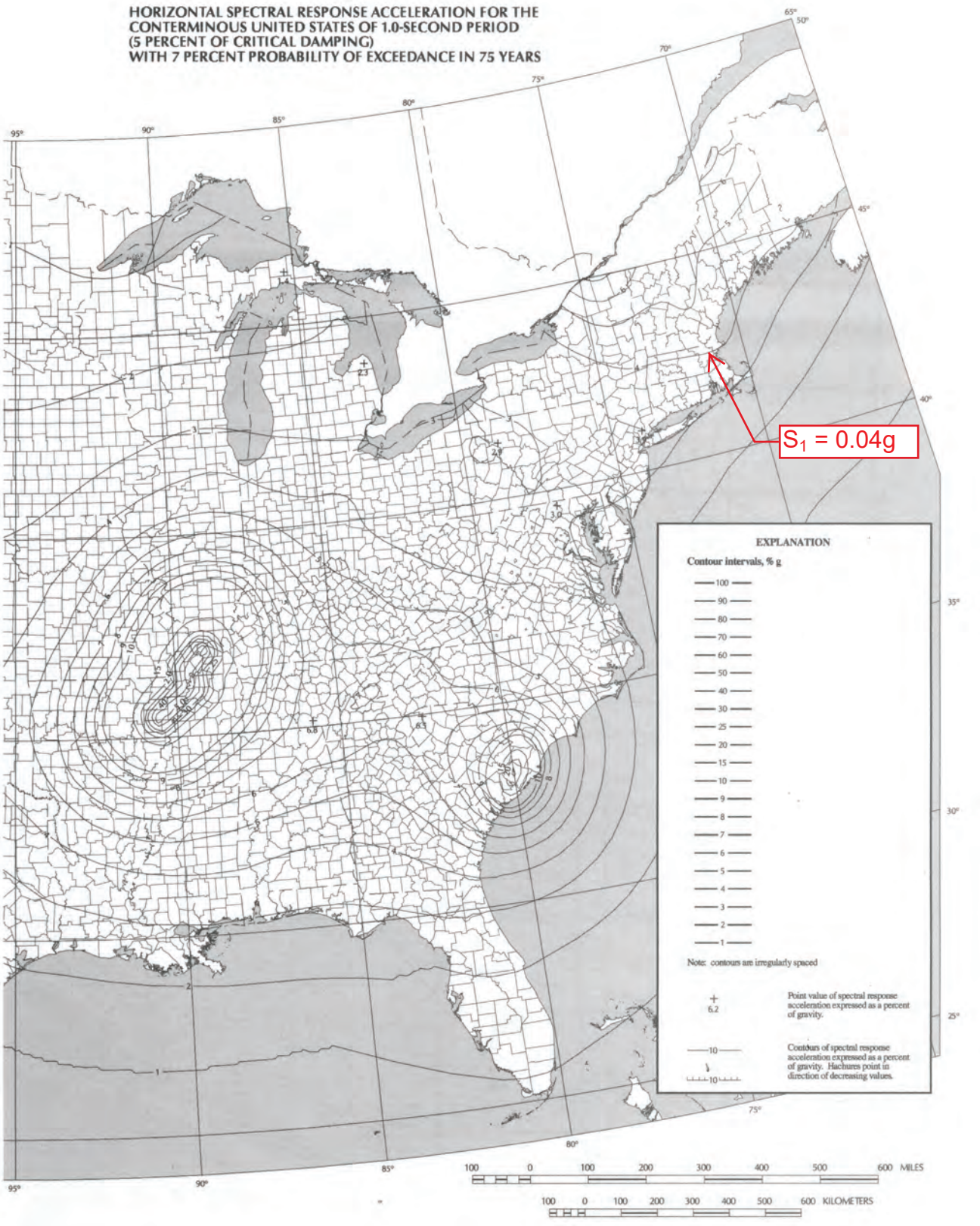


Figure 3.4.1-4b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 1.0-sec (S_1) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping

APPENDIX 4

Information from Green International Affiliates, Inc.

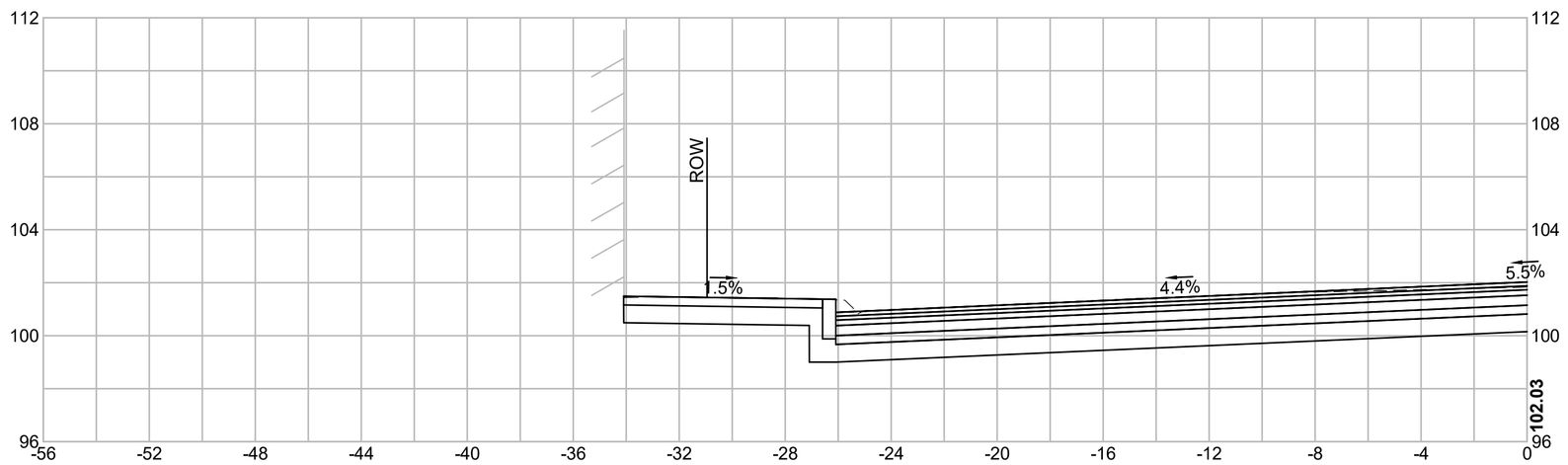
(4 Sheets)

WILMINGTON, MA
ROUTE 38 (MAIN STREET)

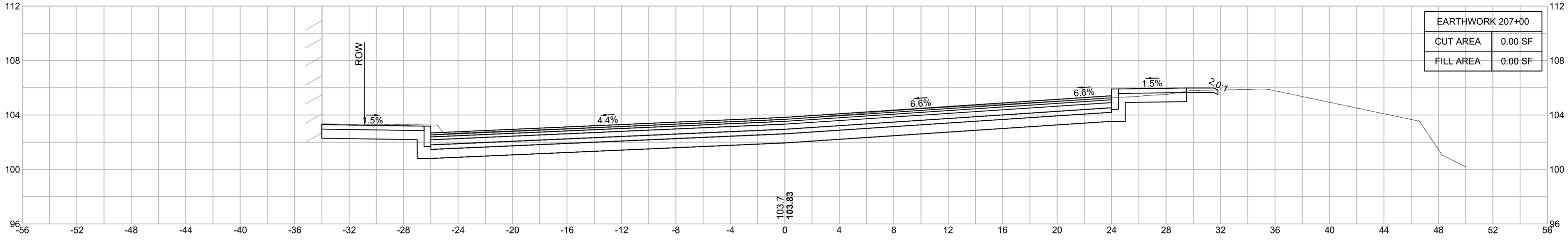
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PROJECT FILE NO.	608051		

CROSS SECTIONS - 3

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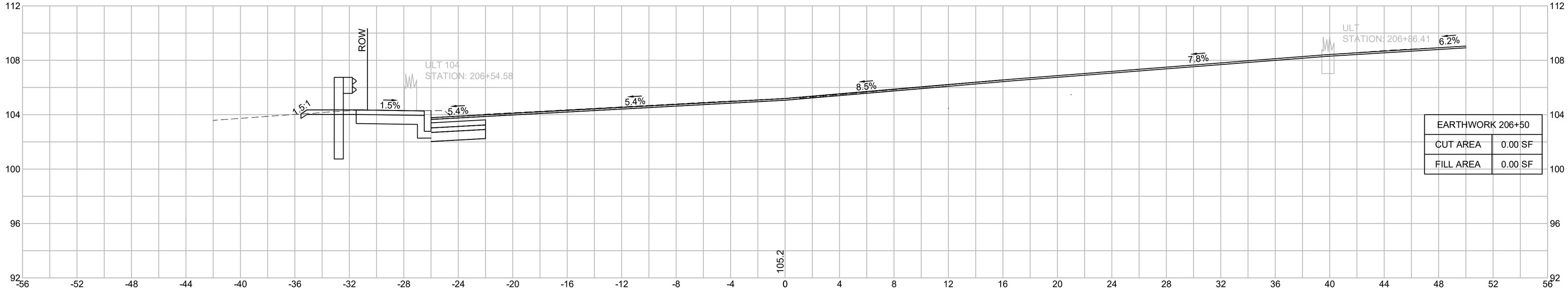


207+00



EARTHWORK 207+00	
CUT AREA	0.00 SF
FILL AREA	0.00 SF

206+50



EARTHWORK 206+50	
CUT AREA	0.00 SF
FILL AREA	0.00 SF

HOR. SCALE IN FEET
4 0 4 8
4 0 4 8
VER. SCALE IN FEET

608051_HD11(CROSS SECTIONS).DWG Plotted on 24-Jul-2019 10:19 AM

Proposal No. 608051 - 132406

A008896 - 128

WILMINGTON, MA
ROUTE 38 (MAIN STREET)

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MA	-	----	260
PROJECT FILE NO.	608051		

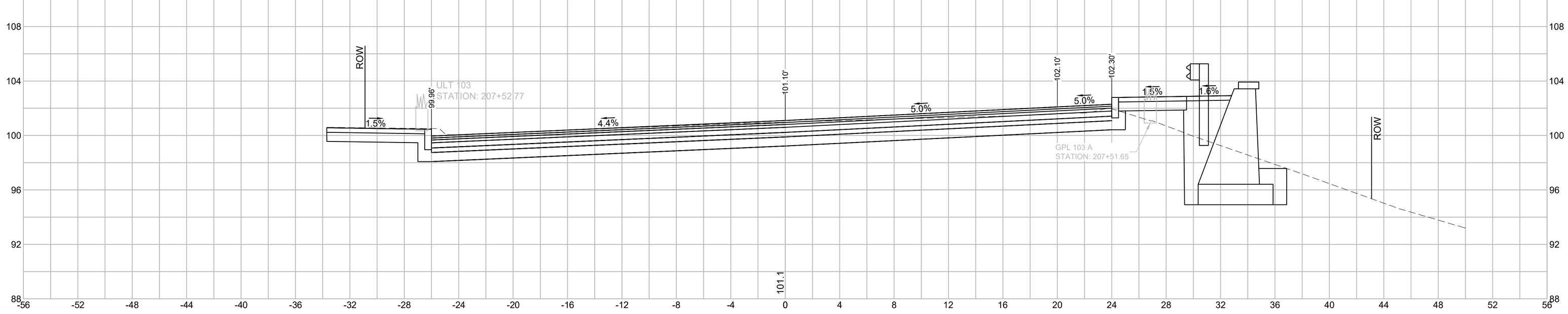
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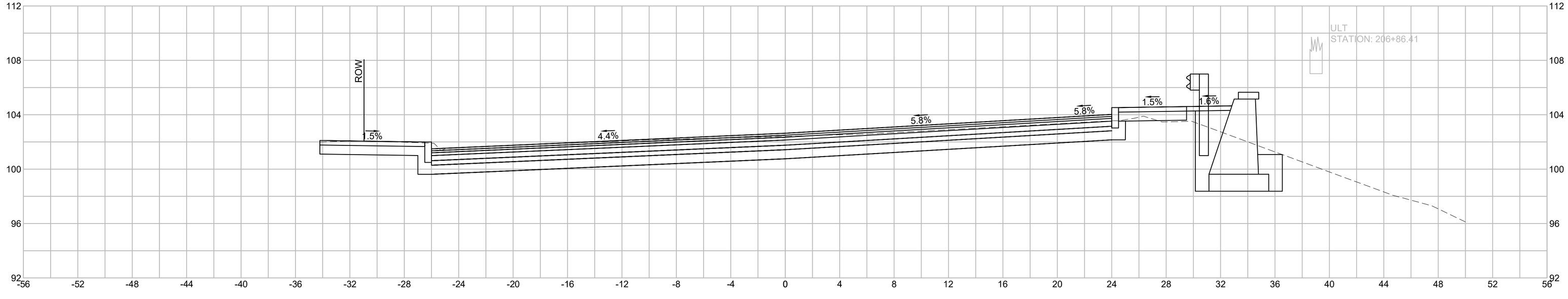
Proposal No. 608051 - 132406

A00886 - 129

207+50



207+25



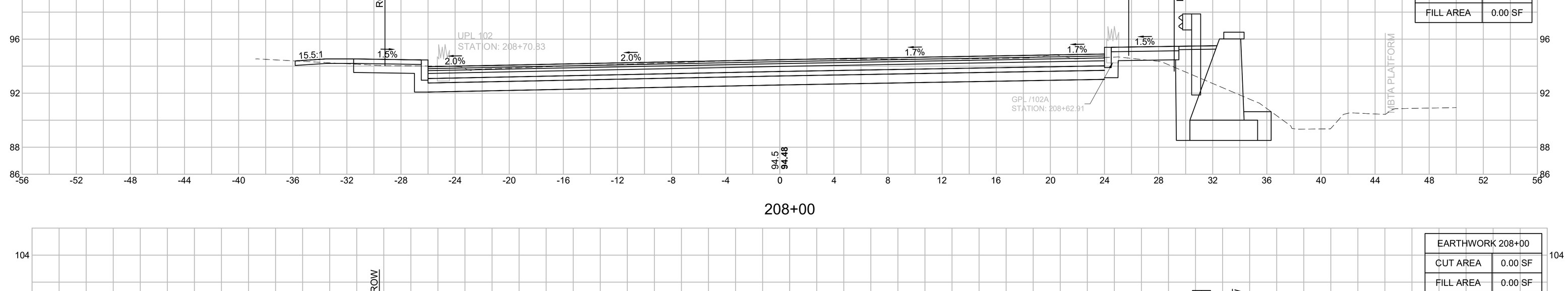
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VER. SCALE IN FEET

WILMINGTON, MA
ROUTE 38 (MAIN STREET)

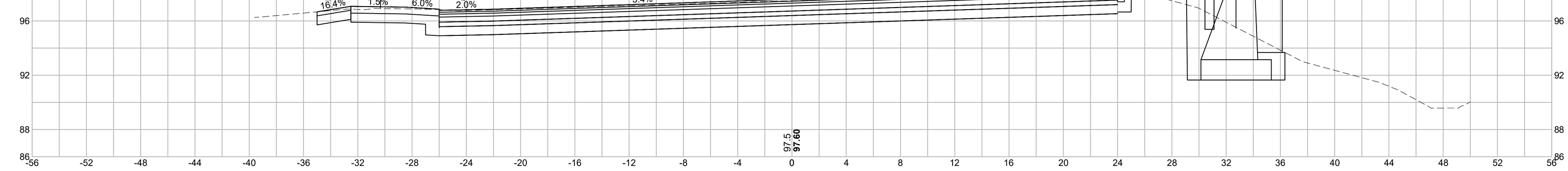
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PROJECT FILE NO.	608051		

CROSS SECTIONS - 4

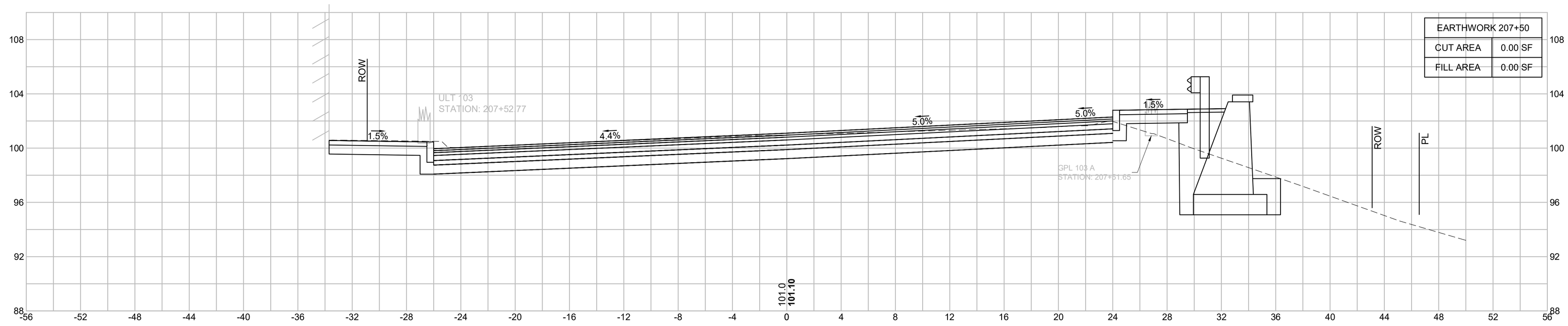
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208+00



207+50



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VER. SCALE IN FEET

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Proposal No. 608051 - 132406

A00886 - 130

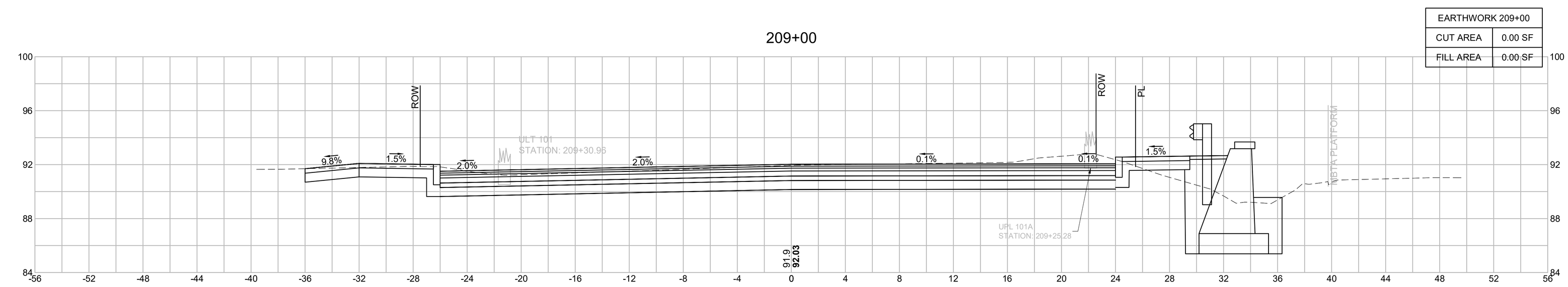
WILMINGTON, MA
ROUTE 38 (MAIN STREET)

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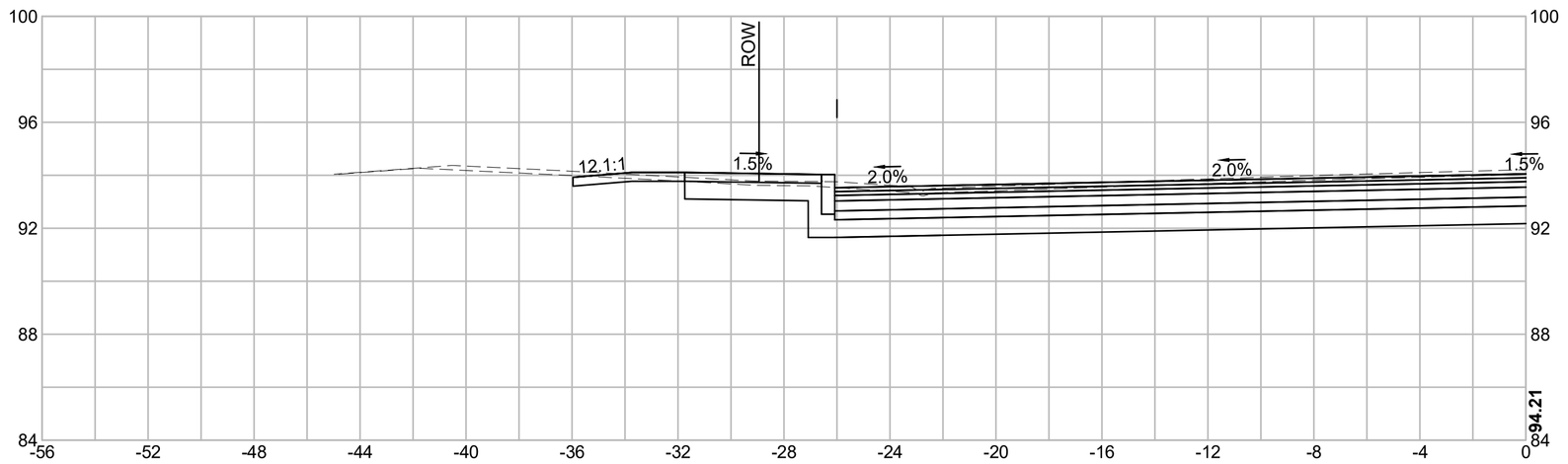
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EARTHWORK 209+00	
CUT AREA	0.00 SF
FILL AREA	0.00 SF

209+00



208+58.22



HOR. SCALE IN FEET
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VER. SCALE IN FEET

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Proposal No. 608051 - 132406
A00886 - 131

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DOCUMENT B00420

PROPOSAL

WILMINGTON

For: **Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.**

COMMONWEALTH OF MASSACHUSETTS

LOCATION

The work referred to herein is in the Town of WILMINGTON in Middlesex County, in the Commonwealth of Massachusetts, and is shown by the locus map (Document 00331) in the Proposal Pamphlet, the work locations extend as follows:

Route 38 (Main Street)

Beginning – Station 203+55.00 +/-
Ending –Station 319+20.77 +/-

The contract prices shall include the furnishing of all materials (except as otherwise herein specified), the performing of all the labor requisite or proper, the providing of all necessary machinery, tools, apparatus and other means of construction, the doing of all the abovementioned work in the manner set forth, described and shown in the specifications and on the drawings for the work, and in the form of contract, and the completion thereof within **1969 CALENDAR DAYS** upon receipt of a Notice to Proceed, except that if the completion date falls between December 1 and March 15 then the same number of days beyond December 1st will be extended after March 15th.

The Work of this project is described by the following Items and quantities.

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Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
100.99	1	MBTA TRACK DEFORMATION MONITORING AT _____ LUMP SUM		
101.	1.6	CLEARING AND GRUBBING AT _____ PER ACRE		
102.1	2,575	TREE TRIMMING AT _____ PER FOOT		
102.3	20	HERBICIDE TREATMENT FOR INVASIVE PLANTS AT _____ PER HOUR		
102.33	8	INVASIVE PLANT MANAGEMENT STRATEGY AT _____ PER HOUR		
102.511	49	TREE PROTECTION - ARMORING AND PRUNING AT _____ EACH		
102.521	1,980	TREE AND PLANT PROTECTION FENCE AT _____ PER FOOT		
102.531	1	TREE CARE - PRUNING AT _____ EACH		
103.	10	TREE REMOVED - DIAMETER UNDER 24 INCHES AT _____ EACH		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
104.	4	TREE REMOVED - DIAMETER 24 INCHES AND OVER AT _____ EACH		
114.1	1	DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. W-38-011 (802) AT _____ LUMP SUM		
120.01	160	EXCAVATION IN FLOOD COMPENSATION AREA AT _____ PER CUBIC YARD		
120.1	27,950	UNCLASSIFIED EXCAVATION AT _____ PER CUBIC YARD		
122.	580	PRESPLITTING ROCK AT _____ PER SQUARE YARD		
140.	1,180	BRIDGE EXCAVATION AT _____ PER CUBIC YARD		
141.	189	CLASS A TRENCH EXCAVATION AT _____ PER CUBIC YARD		
141.1	150	TEST PIT FOR EXPLORATION AT _____ PER CUBIC YARD		
142.	1,175	CLASS B TRENCH EXCAVATION AT _____ PER CUBIC YARD		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
143.	560	CHANNEL EXCAVATION AT _____ PER CUBIC YARD		
144.	475	CLASS B ROCK EXCAVATION AT _____ PER CUBIC YARD		
146.	28	DRAINAGE STRUCTURE REMOVED AT _____ EACH		
150.	200	ORDINARY BORROW AT _____ PER CUBIC YARD		
150.1	110	SPECIAL BORROW AT _____ PER CUBIC YARD		
151.	15,700	GRAVEL BORROW AT _____ PER CUBIC YARD		
151.1	50	GRAVEL BORROW FOR BRIDGE FOUNDATION AT _____ PER CUBIC YARD		
151.2	2,600	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES AT _____ PER CUBIC YARD		
156.	1,620	CRUSHED STONE AT _____ PER TON		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
156.1	60	CRUSHED STONE FOR BRIDGE FOUNDATIONS AT _____ PER TON		
160.3	30	CONTROLLED LOW-STRENGTH MATERIAL (> 300 PSI) AT _____ PER CUBIC YARD		
170.	49,000	FINE GRADING AND COMPACTING - SUBGRADE AREA AT _____ PER SQUARE YARD		
180.01	1	ENVIRONMENTAL HEALTH AND SAFETY PROGRAM AT _____ LUMP SUM		
180.02	8	PERSONAL PROTECTION LEVEL C UPGRADE AT _____ PER HOUR		
180.03	40	LICENSED SITE PROFESSIONAL SERVICES AT _____ PER HOUR		
181.11	11,570	DISPOSAL OF UNREGULATED SOIL AT _____ PER TON		
181.12	9,050	DISPOSAL OF REGULATED SOIL - IN-STATE FACILITY AT _____ PER TON		
181.13	1,400	DISPOSAL OF REGULATED SOIL - OUT-OF-STATE FACILITY AT _____ PER TON		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
181.14	10	DISPOSAL OF HAZARDOUS WASTE AT _____ PER TON		
182.1	1	INSPECTION AND TESTING FOR ASBESTOS AT _____ LUMP SUM		
182.2	250	REMOVAL OF ASBESTOS AT _____ PER FOOT		
183.1	180,000	TREATMENT OF CONTAMINATED GROUNDWATER AT _____ PER GALLON		
183.2	2,467	DISPOSAL OF GRANULAR ACTIVATED CARBON AT _____ PER POUND		
184.1	5	DISPOSAL OF TREATED WOOD PRODUCTS AT _____ PER TON		
201.	94	CATCH BASIN AT _____ EACH		
201.7	4	CATCH BASIN - DOUBLE GRATE AT _____ EACH		
201.9	13	CATCH BASIN (6.5 FOOT AND OVER) AT _____ EACH		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
202.	73	MANHOLE AT _____ EACH		
202.2	22	MANHOLE (9 TO 14 FOOT DEPTH) AT _____ EACH		
202.5	7	MANHOLE (5 FT DIAMETER) AT _____ EACH		
203.2	2	CURB COVER AND FRAME AT _____ EACH		
203.6	3	OUTLET CONTROL STRUCTURE AT _____ EACH		
204.	15	GUTTER INLET AT _____ EACH		
205.21	1	SUBSURFACE INFILTRATION SYSTEM NO. 1 AT _____ LUMP SUM		
205.22	1	SUBSURFACE INFILTRATION SYSTEM NO. 2 AT _____ LUMP SUM		
220.	18	DRAINAGE STRUCTURE ADJUSTED AT _____ EACH		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
220.3	3	DRAINAGE STRUCTURE CHANGE IN TYPE AT _____ EACH		
220.5	4	DRAINAGE STRUCTURE REMODELED AT _____ EACH		
220.7	10	SANITARY STRUCTURE ADJUSTED AT _____ EACH		
220.8	2	SANITARY STRUCTURE REMODELED AT _____ EACH		
221.	130	FRAME AND COVER AT _____ EACH		
222.1	140	FRAME AND GRATE - MASSDOT CASCADE TYPE AT _____ EACH		
223.1	40	FRAME AND GRATE (OR COVER) REMOVED AND STACKED AT _____ EACH		
224.12	110	12 INCH HOOD AT _____ EACH		
227.3	35	REMOVAL OF DRAINAGE STRUCTURE SEDIMENT AT _____ PER CUBIC YARD		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
227.31	100	REMOVAL OF DRAINAGE PIPE SEDIMENT AT _____ PER FOOT		
227.4	36	MASONRY PLUG AT _____ PER SQUARE FOOT		
234.12	2,250	12 INCH DRAINAGE PIPE - OPTION AT _____ PER FOOT		
234.15	1,350	15 INCH DRAINAGE PIPE - OPTION AT _____ PER FOOT		
234.18	1,600	18 INCH DRAINAGE PIPE - OPTION AT _____ PER FOOT		
234.24	400	24 INCH DRAINAGE PIPE - OPTION AT _____ PER FOOT		
235.12	3	12 INCH DRAINAGE PIPE FLARED END - OPTION AT _____ EACH		
235.15	2	15 INCH DRAINAGE PIPE FLARED END - OPTION AT _____ EACH		
238.10	20	10 INCH DUCTILE IRON PIPE AT _____ PER FOOT		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
238.12	1,400	12 INCH DUCTILE IRON PIPE AT _____ PER FOOT		
241.36	10	36 INCH REINFORCED CONCRETE PIPE CLASS III AT _____ PER FOOT		
244.12	3,500	12 INCH REINFORCED CONCRETE PIPE CLASS V AT _____ PER FOOT		
244.15	900	15 INCH REINFORCED CONCRETE PIPE CLASS V AT _____ PER FOOT		
244.18	500	18 INCH REINFORCED CONCRETE PIPE CLASS V AT _____ PER FOOT		
244.24	180	24 INCH REINFORCED CONCRETE PIPE CLASS V AT _____ PER FOOT		
258.	150	STONE FOR PIPE ENDS AT _____ PER SQUARE YARD		
302.12	6,200	12 INCH DUCTILE IRON WATER PIPE (RUBBER GASKET) AT _____ PER FOOT		
303.06	200	6 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
303.08	300	8 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
303.10	300	10 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
303.12	1,800	12 INCH DUCTILE IRON WATER PIPE (MECHANICAL JOINT) AT _____ PER FOOT		
309.	22,000	DUCTILE IRON FITTINGS FOR WATER PIPE AT _____ PER POUND		
309.12	185	12 INCH MECHANICAL RESTRAINED JOINT AT _____ EACH		
347.1	1,300	1 INCH COPPER TUBING TYPE K AT _____ PER FOOT		
350.06	11	6 INCH GATE AND GATE BOX AT _____ EACH		
350.08	6	8 INCH GATE AND GATE BOX AT _____ EACH		
350.10	1	10 INCH GATE AND GATE BOX AT _____ EACH		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
350.12	17	12 INCH GATE AND GATE BOX AT _____ EACH		
353.1	21	GATE AND GATE BOX REMOVED AND DISPOSED AT _____ EACH		
358.	25	GATE BOX ADJUSTED AT _____ EACH		
363.1	64	1 INCH CORPORATION COCK AT _____ EACH		
367.08	4	8 INCH CAST IRON PLUG AT _____ EACH		
367.10	4	10 INCH CAST IRON PLUG AT _____ EACH		
367.12	6	12 INCH CAST IRON PLUG AT _____ EACH		
371.08	7	8 INCH COUPLING AT _____ EACH		
371.10	2	10 INCH COUPLING AT _____ EACH		

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Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
371.12	7	12 INCH COUPLING AT _____ EACH		
373.12	30	12 INCH WATER PIPE INSULATION AT _____ PER FOOT		
374.	70	ALUMINUM JACKET AND PIPE INSULATION FOR EXPOSED PIPE AT _____ PER FOOT		
374.24	35	24 INCH DUCTILE IRON PIPE CASING FOR WATER PIPE AT _____ PER FOOT		
375.08	1	8 INCH INSERTION VALVE AND BOX AT _____ EACH		
375.12	2	12 INCH INSERTION VALVE AND BOX AT _____ EACH		
376.	11	HYDRANT AT _____ EACH		
377.	11	HYDRANT REMOVED AND DISPOSED AT _____ EACH		
381.	43	SERVICE BOX AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
381.3	21	SERVICE BOX ADJUSTED AT _____ EACH		
384.	64	CURB STOP AT _____ EACH		
386.	1	TEMPORARY WATER MAIN BY-PASS SYSTEM AT _____ LUMP SUM		
402.	4,172	DENSE GRADED CRUSHED STONE FOR SUB-BASE AT _____ PER CUBIC YARD		
415.2	14,500	PAVEMENT FINE MILLING AT _____ PER SQUARE YARD		
431.	20	HIGH EARLY STRENGTH CEMENT CONCRETE BASE COURSE AT _____ PER SQUARE YARD		
440.	153,000	CALCIUM CHLORIDE FOR ROADWAY DUST CONTROL AT _____ PER POUND		
443.	189	WATER FOR ROADWAY DUST CONTROL AT _____ PER 1000 GALLONS		
450.231	5,100	SUPERPAVE SURFACE COURSE - 12.5 POLYMER (SSC - 12.5 - P) AT _____ PER TON		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
450.311	5,200	SUPERPAVE INTERMEDIATE COURSE - 12.5 POLYMER (SIC -12.5 - P) AT _____ PER TON		
450.32	5,200	SUPERPAVE INTERMEDIATE COURSE - 19.0 (SIC - 19.0) AT _____ PER TON		
450.42	9,400	SUPERPAVE BASE COURSE - 37.5 (SBC - 37.5) AT _____ PER TON		
451.	2,620	HMA FOR PATCHING AT _____ PER TON		
452.	14,150	ASPHALT EMULSION FOR TACK COAT AT _____ PER GALLON		
453.	34,500	HMA JOINT ADHESIVE AT _____ PER FOOT		
470.3	2,900	HOT MIX ASPHALT BERM, TYPE A - MODIFIED AT _____ PER FOOT		
472.	3,850	TEMPORARY ASPHALT PATCHING AT _____ PER TON		
477.2	7,350	MILLED RUMBLE STRIP (TYPE C) AT _____ PER FOOT		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
482.5	5,000	SAWCUTTING ASPHALT PAVEMENT FOR BOX WIDENING AT _____ PER FOOT		
506.	9,750	GRANITE CURB TYPE VB - STRAIGHT AT _____ PER FOOT		
506.1	810	GRANITE CURB TYPE VB - CURVED AT _____ PER FOOT		
509.	975	GRANITE TRANSITION CURB FOR PEDESTRIAN CURB RAMPS - STRAIGHT AT _____ PER FOOT		
509.1	970	GRANITE TRANSITION CURB FOR PEDESTRIAN CURB RAMPS - CURVED AT _____ PER FOOT		
514.	48	GRANITE CURB INLET - STRAIGHT AT _____ EACH		
580.	2,050	CURB REMOVED AND RESET AT _____ PER FOOT		
594.	1,300	CURB REMOVED AND DISCARDED AT _____ PER FOOT		
596.	26	CURB CORNER REMOVED AND DISCARDED AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
620.12	2,080	GUARDRAIL, TL-2 (SINGLE FACED) AT _____ PER FOOT		
620.131	900	GUARDRAIL, DEEP POST (SINGLE FACED) AT _____ PER FOOT		
620.32	76	GUARDRAIL - CURVED, TL-2 (SINGLE FACED) AT _____ PER FOOT		
627.1	15	TRAILING ANCHORAGE AT _____ EACH		
627.82	8	GUARDRAIL TANGENT END TREATMENT, TL-2 AT _____ EACH		
628.21	1	TRANSITION TO NCHRP 350 GUARDRAIL AT _____ EACH		
628.24	3	TRANSITION TO BRIDGE RAIL AT _____ EACH		
628.305	9	TEMPORARY IMPACT ATTENUATOR, NON-REDIRECTIVE, TL-3 AT _____ EACH		
628.312	2	PERMANENT IMPACT ATTENUATOR, REDIRECTIVE, TL-2 AT _____ EACH		

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Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
628.39	1	TEMPORARY IMPACT ATTENUATOR, BI-DIRECTIONAL, REDIRECTIVE (TL-3) AT _____ EACH		
628.4	15	TEMPORARY IMPACT ATTENUATOR, REMOVED AND RESET AT _____ EACH		
629.2	382	PRECAST CONCRETE MEDIAN BARRIER - DOUBLE FACED AT _____ PER FOOT		
630.	380	HIGHWAY GUARD REMOVED AND RESET AT _____ PER FOOT		
630.2	3,500	HIGHWAY GUARD REMOVED AND DISCARDED AT _____ PER FOOT		
634.1	1	THRIE BEAM GUARD PANEL AT _____ EACH		
644.196	800	96 INCH CHAIN LINK FENCE (SPRING TENSION WIRE) VINYL COATED (LINE POST OPTION) AT _____ PER FOOT		
650.096	40	96 INCH CHAIN LINK GATE WITH GATE POSTS AT _____ PER FOOT		
657.	775	TEMPORARY FENCE AT _____ PER FOOT		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
657.5	390	TEMPORARY FENCE REMOVED AND RESET AT _____ PER FOOT		
666.	375	CHAIN LINK FENCE REMOVED AND RESET AT _____ PER FOOT		
669.	290	FENCE REMOVED AND STACKED AT _____ PER FOOT		
693.	180	REMOVE AND STACK BALANCE STONE WALL AT _____ PER FOOT		
697.	420	SEDIMENTATION FENCE AT _____ PER FOOT		
697.1	160	SILT SACK AT _____ EACH		
698.3	100	GEOTEXTILE FABRIC FOR SEPARATION AT _____ PER SQUARE YARD		
698.31	68	GEOTEXTILE FABRIC FOR TEMPORARY SOIL PROTECTION AT _____ PER SQUARE YARD		
701.	6,600	CEMENT CONCRETE SIDEWALK AT _____ PER SQUARE YARD		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
701.1	2,300	CEMENT CONCRETE SIDEWALK AT DRIVEWAYS AT _____ PER SQUARE YARD		
701.2	350	CEMENT CONCRETE PEDESTRIAN CURB RAMP AT _____ PER SQUARE YARD		
702.	1,300	HOT MIX ASPHALT SIDEWALK OR DRIVEWAY AT _____ PER TON		
706.1	5	BRICK WALK REMOVED AND RELAID AT _____ PER SQUARE YARD		
706.7	38	POROUS STONE PAVING AT _____ PER SQUARE FOOT		
707.8	2	STEEL BOLLARD AT _____ EACH		
711.	5	BOUND REMOVED AND RESET AT _____ EACH		
715.	25	RURAL MAIL BOX REMOVED AND RESET AT _____ EACH		
720.	208	REMOVE AND RESET BOULDER AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
722.1	1	SCHEDULE OF OPERATIONS (TYPE A) - FIXED PRICE $145,000 AT One Hundred Forty Five Thousand Dollars LUMP SUM	$145,000.00	$145,000.00
740.	66	ENGINEER'S FIELD OFFICE AND EQUIPMENT (TYPE A) AT _____ PER MONTH		
745.	1	PEDESTRIAN BUS SHELTER AT _____ EACH		
748.	1	MOBILIZATION AT _____ LUMP SUM		
748.1	4	EMERGENCY RESPONSE AT _____ EACH		
751.	1,600	LOAM FOR ROADSIDES AT _____ PER CUBIC YARD		
751.1	240	LOAM FOR LAWNS AT _____ PER CUBIC YARD		
751.7	100	COMPOST BLANKET AT _____ PER CUBIC YARD		
755.35	1	INLAND WETLAND REPLICATION AREA AT _____ LUMP SUM		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
755.45	330	WETLAND RESTORATION AT _____ PER SQUARE YARD		
755.75	46	WETLAND SPECIALIST AT _____ PER HOUR		
755.76	1	WETLANDS MONITORING REPORTS AT _____ LUMP SUM		
756.	1	NPDES STORMWATER POLLUTION PREVENTION PLAN AT _____ LUMP SUM		
758.1	1	INFILTRATION BASIN AT _____ LUMP SUM		
765.	11,250	SEEDING AT _____ PER SQUARE YARD		
765.21	15	ANNUAL COVER CROP FOR NATIVE SEEDING AT _____ PER POUND		
765.411	15	SHORT GRASSLAND SEED MIX AT _____ PER POUND		
765.451	15	PART SHADE ROADSIDE SEED MIX AT _____ PER POUND		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
765.554	20	WETLAND SEED - SEASONALLY FLOODED MIX AT _____ PER POUND		
765.635	3,600	NATIVE SEEDING AND ESTABLISHMENT AT _____ PER SQUARE YARD		
767.121	11,800	SEDIMENT CONTROL BARRIER AT _____ PER FOOT		
767.122	200	SEDIMENT BARRIER - COIR LOG AT _____ PER FOOT		
767.9	720	JUTE MESH AT _____ PER SQUARE YARD		
769.	3,300	PAVEMENT MILLING MULCH UNDER GUARD RAIL AT _____ PER FOOT		
775.141	3	LINDEN - AMERICAN - REDMOND 2-2.5 INCH CALIPER AT _____ EACH		
776.524	3	MAPLE - RED - ARMSTRONG 2-2.5 INCH CALIPER AT _____ EACH		
776.543	6	MAPLE - RED - 'OCTOBER GLORY' 2-2.5 INCH CALIPER AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
777.136	1	OAK - PIN 1-1.5 INCH CALIPER AT _____ EACH		
777.231	5	OAK - SCARLET 1-1.5 INCH CALIPER AT _____ EACH		
777.242	2	OAK - SCARLET 2-2.5 INCH CALIPER AT _____ EACH		
778.425	1	CRABAPPLE - IVORY SPEAR 1.5 - 2 INCH CALIPER AT _____ EACH		
783.053	6	SHAD TREE- SERVICEBERRY 4-5 FEET MULTI-STEMMED AT _____ EACH		
783.337	5	TULIP TREE 1-1.5 INCH CALIPER AT _____ EACH		
783.441	4	TULIP TREE 2-2.5 INCH CALIPER AT _____ EACH		
789.333	5	BAYBERRY SHRUB - NORTHERN 2-3 FEET / #3 AT _____ EACH		
790.633	9	DOGWOOD - REDOSIER 2-3 FEET / #3 AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
790.721	15	DOGWOOD - GRAY 2-3 FEET / #3 AT _____ EACH		
794.332	15	SUMAC SHRUB - FRAGRANT 2-3 FEET / #3 AT _____ EACH		
794.803	15	SWEETFERN #1 AT _____ EACH		
795.011	5	VIBURNUM - NORTHERN ARROWWOOD 2-3 FEET/#3 AT _____ EACH		
795.012	15	VIBURNUM - ARROWWOOD 2-3 FEET / #3 AT _____ EACH		
796.447	20	LITTLE BLUESTEM - THE BLUES 1 GALLON AT _____ EACH		
796.457	20	SWITCH GRASS - CLOUD NINE 1 GALLON AT _____ EACH		
796.459	13	SWITCH GRASS - SHENANDOAH 1 GALLON AT _____ EACH		
801.412	7,100	4 INCH ELECTRICAL CONDUIT - TYPE NM (12 BANK) AT _____ PER FOOT		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
801.414	330	4 INCH ELECTRICAL CONDUIT - TYPE NM (14 BANK) AT _____ PER FOOT		
801.416	275	4 INCH ELECTRICAL CONDUIT - TYPE NM (16 BANK) AT _____ PER FOOT		
801.42	275	4 INCH ELECTRICAL CONDUIT - TYPE NM (DOUBLE) AT _____ PER FOOT		
801.44	230	4 INCH ELECTRICAL CONDUIT - TYPE NM (4 BANK) AT _____ PER FOOT		
804.3	1,500	3 INCH ELECTRICAL CONDUIT TYPE NM - PLASTIC -(UL) AT _____ PER FOOT		
810.1	7,000	FIRE ALARM CABLE REMOVED AND DISCARDED AT _____ PER FOOT		
811.22	2	ELECTRIC HANDHOLE - SD2.022 AT _____ EACH		
811.31	21	PULL BOX 12 X 12 INCHES - SD2.031 AT _____ EACH		
811.35	1	PULL BOX ADJUSTED AT _____ EACH		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
811.38	1	ELECTRIC HANDHOLE REMOVED AND RESET AT _____ EACH		
811.391	8	ELECTRIC HANDHOLE REMOVED AND DISCARDED AT _____ EACH		
813.811	10	PRIVATE TELECOMMUNICATION SERVICE RISER RELOCATION AT _____ EACH		
813.812	5	ELECTRIC SERVICE RISER RELOCATION AT _____ EACH		
815.1	1	TRAFFIC CONTROL SIGNAL LOCATION NO. 1 AT _____ LUMP SUM		
816.02	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 2 AT _____ LUMP SUM		
816.03	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 3 AT _____ LUMP SUM		
816.04	1	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 4 AT _____ LUMP SUM		
816.81	1	TEMPORARY TRAFFIC CONTROL SIGNAL AT _____ LUMP SUM		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
816.82	1	TEMPORARY TRAFFIC CONTROL SIGNAL LOCATION 2 AT _____ LUMP SUM		
816.83	1	TEMPORARY TRAFFIC SIGNAL RECONSTRUCTION - RETIMING LOCAL SIGNALS AT _____ LUMP SUM		
821.72	1	LIGHT POLE AND LUMINAIRE REMOVED AND STACKED AT _____ EACH		
825.101	2	RRFB (2-POST ASSEMBLY SYSTEM-AC-POWERED) AT _____ EACH		
831.11	480	ROADSIDE GUIDE SIGN (MA-D1-XX) - ALUMINUM PANEL (TYPE A) AT _____ PER SQUARE FOOT		
832.	580	WARNING-REGULATORY AND ROUTE MARKER - ALUMINUM PANEL (TYPE A) AT _____ PER SQUARE FOOT		
833.7	26	DELINEATION FOR GUARD RAIL TERMINI AT _____ EACH		
841.11	9	SUPPORT FOR GUIDE SIGN (MA-D1-XX) - 5 INCH TUBULAR - STEEL AT _____ EACH		
847.1	135	SIGN SUP (N/GUIDE)+RTE MKR W/1 BRKWAY POST ASSEMBLY - STEEL AT _____ EACH		

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Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
850.41	2,000	ROADWAY FLAGGER AT _____ PER HOUR		
851.1	1,440	TRAFFIC CONES FOR TRAFFIC MANAGEMENT AT _____ PER DAY		
851.91	3	TEMPORARY SPEED HUMP AT _____ EACH		
852.	925	SAFETY SIGNING FOR TRAFFIC MANAGEMENT AT _____ PER SQUARE FOOT		
852.11	1,120	TEMPORARY PEDESTRIAN BARRICADE AT _____ PER FOOT		
852.12	18	TEMPORARY PEDESTRIAN CURB RAMP AT _____ EACH		
853.1	10	PORTABLE BREAKAWAY BARRICADE TYPE III AT _____ EACH		
853.21	2,100	TEMPORARY BARRIER REMOVED AND RESET AT _____ PER FOOT		
853.23	900	TEMPORARY BARRIER (TL-3) AT _____ PER FOOT		

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ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
853.33	504	TEMPORARY BARRIER - LIMITED DEFLECTION (TL-3) AT _____ PER FOOT		
853.331	621	TEMPORARY BARRIER - LIMITED DEFLECTION (TL-3) REMOVED AND RESET AT _____ PER FOOT		
853.8	75	TEMPORARY ILLUMINATION FOR WORK ZONE AT _____ PER DAY		
853.9	4	PORTABLE SPEED FEEDBACK DISPLAY TRAILER AT _____ PER MONTH		
854.016	52,500	TEMPORARY PAVING MARKINGS - 6 INCH (PAINTED) AT _____ PER FOOT		
854.036	7,750	TEMPORARY PAVING MARKINGS - 6 INCH (TAPE) AT _____ PER FOOT		
854.1	1,500	PAVEMENT MARKING REMOVAL AT _____ PER SQUARE FOOT		
856.	2,880	ARROW BOARD AT _____ PER DAY		
856.12	7,200	PORTABLE CHANGEABLE MESSAGE SIGN AT _____ PER DAY		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
859.	95,000	REFLECTORIZED DRUM AT _____ PER DAY		
859.1	8,400	REFLECTORIZED DRUMS WITH SEQUENTIAL FLASHING WARNING LIGHTS AT _____ PER DAY		
864.04	765	PAVEMENT ARROWS AND LEGENDS REFLECTORIZED WHITE (THERMOPLASTIC) AT _____ PER SQUARE FOOT		
864.1	1,900	COLORIZED PAVEMENT MARKINGS AT _____ PER SQUARE FOOT		
866.062	26,000	6 INCH. REFL. WHITE LINE (ALL WEATHER THERMO.) (RECESSED) AT _____ PER FOOT		
866.106	900	6 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC) AT _____ PER FOOT		
866.112	4,800	12 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC) AT _____ PER FOOT		
867.062	26,000	6 INCH. REFLECTORIZED YELLOW LINE (ALL WEATHER THERMO.) (RECESSED) AT _____ PER FOOT		
867.106	440	6 INCH REFLECTORIZED YELLOW LINE (THERMOPLASTIC) AT _____ PER FOOT		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
867.112	500	12 INCH REFLECTORIZED YELLOW LINE (THERMOPLASTIC) AT _____ PER FOOT		
868.06	550	6 INCH REFLECTORIZED WHITE LINE (EPOXY) AT _____ PER FOOT		
868.12	35	12 INCH REFLECTORIZED WHITE LINE (EPOXY) AT _____ PER FOOT		
869.06	280	6 INCH REFLECTORIZED YELLOW LINE (EPOXY) AT _____ PER FOOT		
871.9	1	MOTORIZE TRAFFIC DATA MONITORING PROGRAM AT _____ LUMP SUM		
874.	28	STREET NAME SIGN AT _____ EACH		
874.2	7	TRAFFIC SIGN REMOVED AND RESET AT _____ EACH		
874.41	106	TRAFFIC SIGN REMOVED AND DISCARDED AT _____ EACH		
901.	11	4000 PSI, 1.5 INCH, 565 CEMENT CONCRETE AT _____ PER CUBIC YARD		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
903.	32	3000 PSI, 1.5 INCH, 470 CEMENT CONCRETE AT _____ PER CUBIC YARD		
910.	170	STEEL REINFORCEMENT FOR STRUCTURES AT _____ PER POUND		
945.1	1,600	DRILLED MICROPILE AT _____ PER FOOT		
948.6	1	MICROPILE VERIFICATION LOAD TEST AT _____ EACH		
948.61	2	MICROPILE PROOF LOAD TEST AT _____ EACH		
950.5	1	TEMPORARY EARTH SUPPORT SYSTEM AT _____ LUMP SUM		
953.1	1	TEMPORARY SUPPORT OF EXCAVATION - BRIDGE NO. W-38-011 AT _____ LUMP SUM		
953.12	1	TEMPORARY STABILIZATION OF EXISTING MASONRY ABUTMENTS AT _____ LUMP SUM		
953.31	1	EXCAVATION SUPPORT SYSTEM FOR SPECIAL DRAINAGE STRUCTURE NO. 1 AT _____ LUMP SUM		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
983.	2,100	DUMPED RIPRAP AT _____ PER TON		
983.6	1	STREAMBED RESTORATION AT _____ LUMP SUM		
988.01	65	SEDIMENT FOREBAY PAVERS AT _____ PER SQUARE FOOT		
990.1	1	COFFERDAM STRUCTURE NO. 1 AT _____ LUMP SUM		
990.2	1	COFFERDAM STRUCTURE NO. 2 AT _____ LUMP SUM		
991.1	1	CONTROL OF WATER - STRUCTURE NO. W-38-011 (CVE) AT _____ LUMP SUM		
991.21	1	CONTROL OF WATER - SPECIAL DRAINAGE STRUCTURE NO. 1 AT _____ LUMP SUM		
993.2	1	TEMPORARY PEDESTRIAN BRIDGE AT _____ LUMP SUM		
994.01	1	TEMPORARY PROTECTIVE SHIELDING BRIDGE NO. W-38-011 (CVE) AT _____ LUMP SUM		

Project # 608051	Contract # 132406			
Location : WILMINGTON				
Description : Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.				
ITEM #	**QUANTITY**	**ITEM WITH UNIT BID PRICE WRITTEN IN WORDS**	**UNIT PRICE**	**AMOUNT**
995.01	1	BRIDGE STRUCTURE, BRIDGE NO. W-38-011 (CVE) AT _____ LUMP SUM		
996.01	1	WALL STRUCTURE, WALL NO. 1 AT _____ LUMP SUM		
997.01	1	SPECIAL DRAINAGE STRUCTURE NO. 1 AT _____ LUMP SUM		
998.101	1	SPECIALTY SERVICES #1 AT _____ LUMP SUM		
998.102	1	SPECIALTY SERVICES #2 AT _____ LUMP SUM		
998.103	1	SPECIALTY SERVICES #3 AT _____ LUMP SUM		
998.104	1	SPECIALTY SERVICES #4 AT _____ LUMP SUM		
998.105	1	SPECIALTY SERVICES #5 AT _____ LUMP SUM		
Total Qty:	964,786.6			

DOCUMENT B00853

SCHEDULE OF PARTICIPATION
BY DISADVANTAGED BUSINESS ENTERPRISES (DBEs)

PRIME BIDDER: _____

DATE OF BID OPENING: _____ MassDOT PROJECT NO.: 608051

FEDERAL AID PROJECT NUMBER: STP/CMQ/HSI-0034(030)X

PROJECT LOCATION: WILMINGTON

Name Address and Phone Number of DBE	Name of Activity	NAICS Code(s)	(a) DBE Contractor Activity Amount *Construction Work*	(b) DBE Other Business Amount *Services, Supplies, Material*	(c) Total amount eligible for credit
Total Bid Amount	TOTALS:		$		$
	DBE Percentage of Total bid:		%		%

A copy of the DBE's most recent certification and an original affidavit must be attached to this document.

Is a Joint Check Approval being submitted for any of the above? ☐ Yes X No
Will any of the contractors listed above be using a third party to deliver materials or perform any portion of work?
☐ Yes X No
(i.e. manufacturing)

SIGNATURE:_____ DATE_____

NAME AND TITLE (*PRINT*):_____

EMAIL ADDRESS: _____TEL NO.:_____

Rev'd 5/8/13

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DOCUMENT B00854

DBE Letter of Intent

(To be completed by the DBE – Page 1 of 2)

The DBE firm will also include the latest MassUCP letter with this Letter of Intent.

To: _____ (Prime Bidder)

From: _____ (DBE Firm)

Federal Aid Project No.: STP/CMQ/HSI-0034(030)X Bid Opening or Due Date: _____

Project Name: Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L. Project Location: WILMINGTON

I, _____, authorized signatory of the above-reference DBE firm hereby declare:

(Print Name)

(a) My company is currently certified as a Disadvantaged Business Enterprise (DBE) by the Massachusetts Supplier Diversity Office (SDO), as a (check all that apply):

☐ CONTRACTOR ☐ REGULAR DEALER ☐ OTHER
☐ MANUFACTURER ☐ TRUCKING OPERATIONS ☐ PROFESSIONAL SERVICES

[Additional guidance is available at Title 49, Code of Federal Regulations, Part 26.55 (49 CFR Part 26.55)]

(b) My firm has the ability to manage, supervise and perform the activity described on page 3 of this Letter of Intent. If you are awarded the contract, my company intends to enter into a contract with your firm to perform the items of work or other activity described on the following sheet for the prices indicated.

(c) There have been no changes affecting the ownership, control or independence of my company since my last certification review on _____. If any such change is planned or occurs prior to my company's completion of this proposed work, I will give prior written notification to your firm and to the Office of Diversity and Civil Rights (ODCR)(MBTA/MassDOT) and SDO.

(d) I have read the MassDOT proposal for the Project, and acknowledge that my company will comply with that document and the requirements of 49 CFR Part 26.

(e) For the purpose of obtaining subcontractor approval from the MassDOT, my firm will provide to you:

a. ***The following construction work:***
   i. a complete list of contact information for proposed Superintendent, i.e., address, phone number and e-mail address, and;
   ii. a list of projects completed in the last 10 years. I shall also include, for each project: the name and telephone number of a contact person for the contracting authority, person, or organization; project title / location (City/State), dollar value of the work; a description of the work; and the date project completed .

b. The following professional services work:
   i. resume, stating the qualifications and experience of person responsible for project oversight and contact information, i.e., address, phone number and e-mail address.
   ii. proposed team and organization,
   iii. resumes of key personnel;
   iv. example projects

c. The following services, materials or supplies:
   i. a written agreement and invoices for the materials or supplies, and any other documents evidencing the terms of providing such items to be sent to the Office of Diversity and Civil Rights Government Compliance Unit designee;
   ii. information concerning brokers fees and commissions for providing services or materials.

DBE Firm Authorized Signature _____ Date _____

DBE Letter of Intent (Continued)

(To be completed by the DBE – Page 2 of 2)

Prime Bidder: _____

DBE Firm: _____

Federal Aid Project No.: STP/CMQ/HSI-0034(030)X Bid Opening or Due Date: _____

Project Name: Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L. Project Location: WILMINGTON

Item number if applicable	NAICS Code	Description of Activity with notations such as Services, or Brokerage, Labor Only, Material Only, or Complete	Quantity	Unit Price	Amount
			TOTAL AMOUNT:		

Please give full explanations, attach additional sheets if necessary.

I HEREBY VERIFY THAT _____

(DBE Firm)

WILL SOLELY PERFORM THE WORK, OR PROVIDE THE SERVICES OR MATERIALS, AS DESCRIBED ABOVE.

DBE Authorized Signature: _____

_____

Name (Print): _____

Title: _____

Email Address: _____

Phone Number: _____ Fax Number: _____

END OF DOCUMENT

DOCUMENT B00855

DBE JOINT CHECK ARRANGEMENT APPROVAL FORM

(to be submitted by Prime Contractor)

Contract No: 132406 **Project No.** 608051 **Federal Aid No.:** STP/CMQ/HSI-0034(030)X

Location: WILMINGTON **Bid Opening Date:** _____

Project Description: Reconstruction on Route 38 (Main Street), from Route 62 to the Woburn C.L.

We have received the attached request for the use of a joint check arrangement from _____ _____ , a DBE on the above- referenced Contract and _____ _____, a Material Supplier/Vendor for the subject Contract. The DBE has complied with the requirements of 49 CFR Part 26.55(c)(1). In particular, the DBE has:

- a written agreement with the material supplier/vendor;
- applied for credit with the subject material supplier and has supplied the vendor's response;
- shown that it will place all orders to the subject material supplier/vendor;
- made and retains all decision-making responsibilities concerning the materials; and
- provided a Joint Check Agreement that is acceptable to MassDOT;

As the Contractor for the Project, we agree to issue joint checks (made payable to the Material Supplier/Vendor and the DBE) for payment of sums due pursuant to invoices from the Supplier/Vendor and DBE.

Contractor:

_____ _____

Company Name Signature
Duly Authorized

_____

Printed Name

_____ _____

Date Title

SubContractor:

_____ _____

Company Name Signature –
Duly Authorized

_____

Printed Name

_____ _____

Date Title

*** END OF DOCUMENT ***

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DOCUMENT B00856

JOINT VENTURE AFFIDAVIT

(All Firms)

- All Information Requested By This Schedule Must Be Answered. Additional Sheets May Be Attached.
- If, there is any change in the information submitted, the Joint Venture parties must inform MassDOT Pre-Qualifications Office (and, if one of the companies is a DBE, the Director of Contract Compliance, Office of Civil Rights) *prior* to such change, in writing, either directly or through the Prime Contractor if the Joint Venture is a subcontractor.
- If the Joint Venture Entity will be the bidder on a prime Contract, it must bid and submit all required documents (insurance, worker's compensation, bonds, etc.) in the name of the Joint Venture Entity.

I. Name of Joint Venture: _____

Type of Entity if applicable (Corp., LLC):_____Filing State _____

Address of joint venture: _____

_____

Phone No(s) for JV Entity: _____E-mail:_____

Contact Person(s)_____

Tax ID/EIN of Joint Venture: _____Vendor Code:_____

II. Identify each firm or party to the Joint Venture:

Name of Firm: _____

Address: _____

Phone : _____E-mail:_____

Contact person(s) _____

Name of Firm: _____

Address: _____

Phone: _____E-mail:_____

Contact Person(s)_____

III. Describe the role(s) of the each party to the Joint Venture:

_____

_____

IV. Attach a copy of the Joint Venture Agreement. The proposed Joint Venture Agreement should include specific details including, but not limited to: (1) the contributions of capital and equipment; (2) work items to be performed by each company's forces, (3) work items to be performed under the supervision of any DBE Venturer; (4) the commitment of management, supervisory and operative personnel employed by the DBE to be dedicated to the performance of the Project; and (5) warranty, guaranty, and indemnification clauses.

V. Attach any applicable Corporate or LLC Votes, Authorizations, etc.

VI. Ownership of the Joint Venture:

A. What is the percentage(s) of each company's ownership in the Joint Venture?

ownership percentage(s): _____

ownership percentage(s): _____

B. Specify percentages for each of the following (provide narrative descriptions and other detail as applicable):

1. Sharing of profit and loss: _____

2. Capital contributions:

(a) Dollar amounts of initial contribution: _____

(b) Dollar amounts of anticipated on-going contributions: _____

(c) Contributions of equipment (specify types, quality and quantities of equipment to be provided by each firm): _____

_____

4. Other applicable ownership interests, including ownership options or other agreements, which restrict or limit ownership and/or control:

_____

_____

5. Provide copies of all other written agreements between firms concerning bidding and operation of this Project or projects or contracts.

6. Identify all current contracts and contracts completed during the past two (2) years by either of the Joint Venture partners to this Joint Venture:

_____

_____

VII. Control of and Participation in the Joint Venture. Identify by name and firm those individuals who are, or will be, responsible for and have the authority to engage in the following management functions and policy decisions. (Indicate any limitations to their authority such as dollar limits and co-signatory requirements.):

A. Joint Venture check signing:

_____

_____

B. Authority to enter Contracts on behalf of the Joint Venture:

_____

_____

C. Signing, co-signing and/or collateralizing loans:

_____

_____

D. Acquisition of lines of credit:

E. Acquisition and indemnification of payment and performance bonds:

F. Negotiating and signing labor agreements:

G. Management of contract performance. *(Identify by name and firm only)*:

1. Supervision of field operations:
2. Major purchases:
3. Estimating:
4. Engineering:

VIII. Financial Controls of Joint Venture:

A. Which firm and/or individual will be responsible for keeping the books of account?

B. Identify the "Managing Partner," if any, and describe the means and measure of their compensation:

C. What authority does each firm have to commit or obligate the other to insurance and bonding companies, financing institutions, suppliers, subcontractors, and/or other parties participating in the performance of this Contract or the work of this Project?

IX. Personnel of Joint Venture: State the approximate number of personnel (by trade) needed to perform the Joint Venture's work under this Contract. Indicate whether they will be employees of the majority firm, DBE firm, or the Joint Venture.

	Firm 1 (number)	Firm 2 (number)	Joint Venture (number)
Trade			
Professional			
Administrative/Clerical			
Unskilled Labor			

Will any personnel proposed for this Project be employees of the Joint Venture?: _____

If so, who: _____

A. Are any proposed Joint Venture employees currently employed by either firm?

Employed by Firm 1: _____ Employed by firm 2 _____

B. Identify by name and firm the individual who will be responsible for Joint Venture hiring: ____

_____

X. Additional Information. Please state any material facts and additional information pertinent to the control and structure of this Joint Venture.

_____

_____

XI. AFFIDAVIT OF JOINT VENTURE PARTIES. The undersigned affirm that the foregoing statements and attached documents are correct and include all material information necessary to identify and explain the terms and operations of our Joint Venture and the intended participation of each firm in the undertaking. Further, the undersigned covenant and agree to provide to MassDOT current, complete and accurate information regarding actual Joint Venture work, payments, and any proposed changes to any provisions of the Joint Venture, or the nature, character of each party to the Joint Venture. We understand that any material misrepresentation will be grounds for terminating any Contract awarded and for initiating action under Federal or State laws concerning false statements.

Firm 1	Firm 2
Signature Duly Authorized	Signature Duly Authorized
Printed Name and Title	Printed Name and Title
Date	Date

*** END OF DOCUMENT ***