

Date: July 21, 2021 Job No.: 4722
 To: Justin Curewitz, PE, PTOE
 Cc:
 From: Christopher Jones, P.E.
 Subject: 605178; Billerica – Boston Road (Route 3A) Roadway Reconstruction
 Traffic Signal Mast Arm Foundation Recommendations

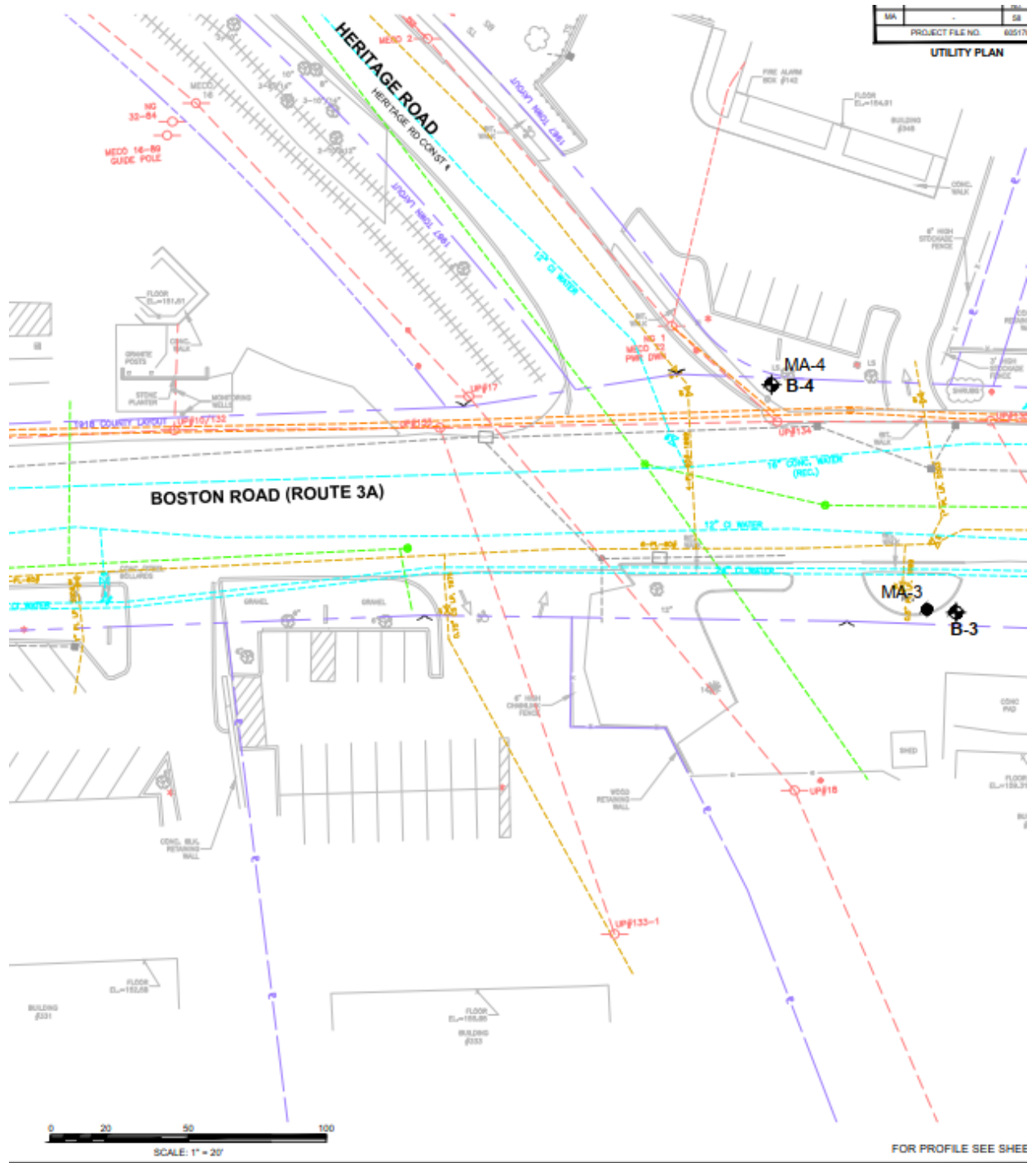
This memorandum details the findings of the soil exploration program relevant to the traffic signal mast arms and the foundation recommendations for those structures. A summary of the recommendations is shown in the table below:

Mast Arm	Arm Length	Foundation Size			
		Diameter	Depth	Vert. Bars	Ties
MA-1	25'	3'-6"	9'-0"	18-#8	#5 @ 12"
MA-2	35'	3'-6"	10'-6"	18-#8	#5 @ 9"
MA-3	40'	3'-6"	10'-6"	18-#8	#5 @ 9"
MA-4	35'	3'-6"	14'-6"	18-#8	#5 @ 9"
MA-5	35'	3'-6"	14'-6"	18-#8	#5 @ 9"
MA-6	45'	4'-0"	11'-6"	18-#9	#5 @ 9"
MA-7	25'	3'-6"	9'-0"	18-#8	#5 @ 12"
MA-8	40'	3'-6"	14'-6"	18-#8	#5 @ 9"

NOTE: BORING B-8 AT MA-8 ENCOUNTERED BEDROCK AT A DEPTH OF 11'-6". THE FOUNDATION FOR MA-8 SHALL BE CORED AND SOCKETED INTO BEDROCK TO THE SPECIFIED FOUNDATION DEPTH.

Supporting information for these recommendations is contained on following pages.

Wind Zone for foundation selection: 110 mph



Boring & Mast Arm Location Plan 2



Boring & Mast Arm Location Plan 4

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Mast Arm MA1 / Boring B1

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd Mast Arms		B-1
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd, Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 6/30/2021				TYPE	HW	S/S
Date Completed: 6/30/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER		140
Site Rep.:				FALL		30"
Ground Water level: 5.7'						
SAMPLE				Blows/6"	Strata Change	SAMPLE DESCRIPTION
No.	Depth	Pen. In.	Rec. In.			
S-1	.5'-2.5'	24"	12"	8-7-5-5		S-1: Medium dense, dark brown silty fine sand some tan coarse sand, trace coarse gravel.
S-2	4'-6'	24"	12"	7-12-16-14		S-2: Medium dense, tan fine sand, little medium to coarse gravel, trace coarse sand.
S-3	9'-11'	24"	17"	10-11-13-16		S-3: Medium dense, tan fine sand, some medium to coarse gravel, trace coarse sand.
S-4	14'-16'	24"	10"	12-21-36-24		S-4: Very dense, gray fine sand, some medium to coarse gravel, some silt, trace coarse sand.
S-5	19'-21'	15"	6"	38-48-100/3"		S-5: Very dense, gray fine sand, some medium gravel, trace coarse sand. Glacial till
S-6	24'-26'	15"	4"	47-51-100/3		S-6: Very dense, gray fine sand, some coarse sand, some medium to coarse gravel.
						Bottom of Exploration = 25.5'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Standard Penetration Value: 28

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 25'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	9'-0"	18-#8	#5 @ 12"



Mast Arm MA2 / Boring B2

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-2
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd, Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 6/25/2021				TYPE	HW	S/S
Date Completed: 6/25/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER	140	
Site Rep.:				FALL	30"	
				Ground Water level: 4.5'		
SAMPLE				Blows/6"	Strata Change	SAMPLE DESCRIPTION
No.	Depth	Pen. In.	Rec. In.			
S-1	0-2'	24"	16"	3-2-2-4		S-1: Loose, brown fine to medium sand, trace, medium to coarse gravel.
S-2	4'-6'	24"	14"	16-18-17-15		S-2: Dense, tan fine sand, some medium to coarse gravel, some silt, trace coarse sand.
S-3	9'-11'	24"	6"	11-14-11-9		S-3: Medium Dense, tan fine sand, some medium to large gravel. Little silt, trace coarse sand.
S-4	14'-16'	24"	12"	71-44-22-19		S-4: Very dense, gray coarse sand and medium to coarse gravel, some fine sand, trace silt.
S-5	19'-21'	15"	9"	34-48-100/3"		S-5: Very dense, gray fine to medium sand and medium to coarse gravel, trace fine sand.
S-6	24'-26'	0"	0"	100/0"		20.5'- 1' boulder S-6: Split spoon refusal- no recovery
						Bottom of Exploration = 26'

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard

Average Standard Penetration Value: 30

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 35'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	10'-6"	18-#8	#5 @ 9"



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Mast Arm MA3 / Boring B3

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-3
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd, Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 6/28/2021				TYPE	HW	S/S
Date Completed: 6/28/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER	140	
Site Rep.:				FALL	30"	
				Ground Water level: 5.5'		
SAMPLE						
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Strata	SAMPLE DESCRIPTION
S-1	0'-2'	24"	6"	6-3-6-7		S-1: Loose, brown medium to coarse sand, some small to medium gravel, trace fine sand.
S-2	4'-6'	24"	3"	35-19-14-18		S-2: Dense, gray/tan coarse sand and medium to coarse gravel. Trace fine sand. Strong petroleum odor.
S-3	9'-11'	24"	12"	14-11-12-13		S-3: Medium dense, gray fine sand, some tan coarse sand, trace silt.
S-4	14'-16'	23"	10"	26-45-66-100/5"		S-4: Very dense, gray fine sand, some coarse sand and coarse gravel, trace coarse sand.
Bottom of Exploration = 15.5'						

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 28

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 40'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	10'-6"	18-#8	#5 @ 9"



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Mast Arm MA4 / Boring B4

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd Mast Arms		B-4
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd, Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 6/30/2021				TYPE	HW	S/S
Date Completed: 6/30/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER		140
Site Rep.:				FALL		30"
Ground Water level: 6.2'						
SAMPLE				Strata		
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Change	SAMPLE DESCRIPTION
S-1	0'-2'	24"	20"	5-8-9-8		S-1: Medium dense, brown fine to medium sand, some medium to coarse gravel, trace fine sand.
S-2	4'-6'	24"	12"	3-6-9-13		S-2: Medium dense, grey fine sand, some coarse sand, trace coarse gravel, trace silt.
S-3	9'-11'	24"	18"	9-9-10-9		S-3: Medium dense, gray fine sand, some silt, trace coarse gravel, trace coarse sand.
S-4	14'-16'	5"	2"	100/5"		S-4: Very dense, tan coarse gravel, some fine sand, some silt.
C-1	17'-22'	60"	59"		13'-15'	C-1: RQD=59% Gray Sandstone
C-2	22'-27'	60"	60"			C-2: RQD= 96% Gray Sandstone/ white granite.
Bottom of Exploration = 27'						

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 17

Assign generalized soil classification: Wet Sand (Loose)

Mast Arm Length: 35'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6"	18-#8	#5 @ 9"



Mast Arm MA5 / Boring B5

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-5
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 6/28/2021				TYPE	HW	S/S
Date Completed: 6/28/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER	140	
Site Rep.:				FALL	30"	
Ground Water level: 5.1'						
SAMPLE				Blows/6"	Strata Change	SAMPLE DESCRIPTION
No.	Depth	Pen. In.	Rec. In.			
S-1	5'-2.5'	24"	12"	6-8-8-4		S-1: Medium dense, brown fine to medium sand, some medium to coarse gravel.
S-2	4'-6'	3"	0	100/3"		S-2: No recovery. 1.5' boulder 4'-5.5'
S-3	9'-11'	24"	15"	11-12-11-16		S-3: Medium dense, tan fine to medium sand, some coarse gravel, trace silt.
S-4	14'-16'	24"	19"	16-25-24-32		S-4: Dense, gray fine sand, some silt, trace coarse gravel, trace coarse sand.
S-5	19'-21'	3"	2"	100/3"	19'	S-5: Very dense, gray coarse sand, some fine sand, some coarse gravel. weathered rock at 19', advance boring to 24'
S-6	24'-26'	8"	2"	32-100/2"		S-6: Very dense, gray coarse sand and coarse gravel. Trace fine sand. Decomposed rock.
Bottom of Exploration = 24.5'						
Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense						

Average Standard Penetration Value: A boulder was encountered from 4'-6'. Although blow counts between 9'-11' had N=23, resulting in a dense sand classification, this would be only at the very bottom of the foundation. Therefore conservatively classify as a loose sand over the full shaft length.

Assign generalized soil classification: Wet Sand (loose)

Mast Arm Length: 35'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6"	18-#8	#5 @ 9"



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Mast Arm MA6 / Boring B6

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-6
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 7/1/2021				TYPE	HW	S/S
Date Completed: 7/1/2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER		140
Site Rep.:				FALL		30"
Ground Water level: 6.2'						
SAMPLE				Blows/6"	Strata Change	SAMPLE DESCRIPTION
No.	Depth	Pen. In.	Rec. In.			
S-1	0-2"	24"	7"	3-2-3-4		S-1: Loose, brown fine sand, some coarse sand, trace coarse gravel.
S-2	4'-6'	23"	8"	11-60-100/5"		S-2: Very dense, tan coarse sand and medium to coarse gravel, some fine sand.
S-3	9'-11'	24"	13"	21-19-90-100/3"		S-3: Very Dense, tan fine sand and medium to coarse gravel, some coarse sand, trace silt.
C-1:	12'-17'	60"	55"			C-1: RQD= 62% Gray Sandstone
C-2:	17'-22'	60"	60"			C-2: RQD= 72% Gray Sandstone
Bottom of Exploration = 22'						
Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense						

Average Standard Penetration Value: 84

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 45'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
4'-0"	11'-6"	18-#9	#5 @ 9"



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Mast Arm MA7 / Boring B7

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-7
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA		Page 1 OF 1
File #:				CASING	SAMPLER	CORE BARREL
Date Started: 7-1-2021				TYPE	HW	S/S
Date Completed: 7-1-2021				SIZE	4"	2"
Driller: Justin Raymond				HAMMER		140
Site Rep.:				FALL		30"
Ground Water level: 6.8'						
SAMPLE						
No.	Depth	Pen. In.	Rec. In.	Blows/6"	Strata Change	SAMPLE DESCRIPTION
S-1	0-2'	24"	12"	1-2-1-2		S-1: Loose, brown fine sand, some coarse sand, trace coarse gravel.
S-2	4'-6'	24"	19"	7-9-11-10		S-2: Medium dense, tan fine to medium sand, some medium to coarse gravel, trace coarse sand.
S-3	9'-11'	24"	9"	11-11-15-47	11'	S-3: Medium dense, tan coarse sand and trace fine sand. weathered rock encountered 11'.
C-1	13'-18'	60"	60"			C-1: RQD= 40%
C-2	18'-13'	60"	60"			C-2: RQD=65%
Bottom of Exploration = 23'						

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 20

Assign generalized soil classification: Wet Sand (Dense)

Mast Arm Length: 25'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	9'-0"	18-#8	#5 @ 12"



Mast Arm MA8 / Boring B8

Northern Drill Service, Inc.				Client: BETA Group, Inc.		Boring #	
130 East Main Street, Northborough, MA 01532				Project: Boston Rd. Mast Arms		B-8	
TEL 508-393-6900 FAX 508-393-6901				Location: Boston Rd. Billerica, MA		Page 1 OF 1	
File #:				CASING	SAMPLER	CORE BARREL	
Date Started: 6/23/2021				TYPE	HW	S/S	NX
Date Completed: 6/23/2021				SIZE	4"	2"	
Driller: Justin Raymond				HAMMER		140	
Site Rep.:				FALL		30"	
Ground Water level: 7.1'							
SAMPLE				Blows/6"	Strata Change	SAMPLE DESCRIPTION	
No.	Depth	Pen. In.	Rec. In.				
S-1	0'-2'	24"	12"	13-4-4-3		S-1: Loose, brown fine to medium sand, some some small coarse gravel.	
S-2	4'-6'	24"	18"	4-4-8-30	7'	S-2: M-Dense, tan fine to medium sand, Some coarse gravel, Trace coarse sand Boulder from 7'-10.5'.	
S-3	10.5'-12.5'	5"	3"	100/5"		S-3: Very dense, tan fine sand, some silt, trace coarse sand, trace small coarse gravel. Top of rock 11.5'	
C-1	13'-18'	60"	56"			C-1: RQD= 23% Light gray granite	
C-2	18'-23'	60"	60"			C-2: RQD= 48% Light gray granite	
Bottom of Exploration = 23'							

Cohesionless Density Blows/ft: 0-10 Loose 10-30 Medium-Dense 30-50 Dense 50+ Very Dense

Average Standard Penetration Value: 12

Assign generalized soil classification: Wet Sand (Loose)

Mast Arm Length: 40'

Corresponding Foundation Parameters from MassDOT Standard Details

Diameter	Depth	Vert. Bars	Tie Bars
3'-6"	14'-6"	18-#8	#5 @ 9"

Note: Bedrock was encountered at a depth of 11.5'. Core and socket the final 3' of the foundation into the bedrocks

