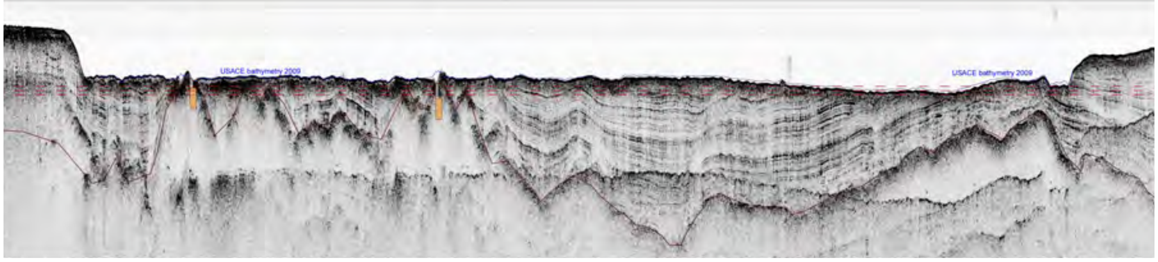
Department Of The Army
US Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742

Contract #W912DS-12-D-0002, DB01
Marine Geophysical and Geological Investigation, Boston Harbor, Boston Massachusetts



Appendix II

June 15, 2015

e4sciences | Earthworks, LLC
27 Glen Road, North Entrance
Sandy Hook, Connecticut 06482
P.O. Box 178, Newtown, CT 06470
(203) 270-8100, Fax (203) 364-0480
www.e4sciences.com

Appendix II
Core boring descriptions and sample analyses per boring

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-01**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 813,676.0'
Northing 2,960,595.2'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 01:20 pm November 25, 2014
boring completed at 06:03 pm November 25, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -48.6' MLLW
Boring bottom elevation = -61.6' MLLW
Total depth below channel floor = 13.0'

Top of all rock elevation = -59.9' MLLW
Rock refusal elevation = 60.1' MLLW
Number of rock core runs = 0

Rock encountered: argillite (based on cuttings)
Thickness of sediment = > 11.3'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)

- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▦ Gravel
- ░ Sand & gravel
- ▦ Silt, sand & gravel
- ▨ Clay & gravel

Rock (Rock)

- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations

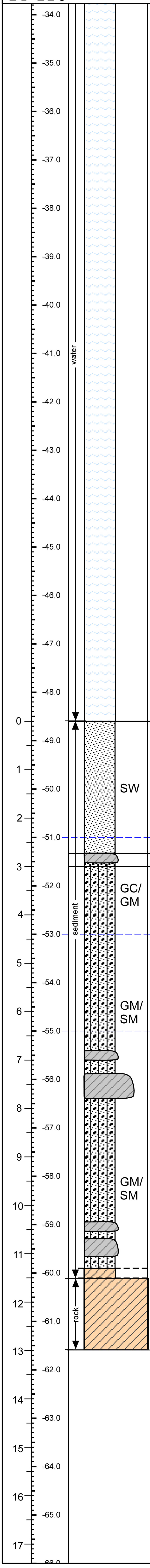
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations

wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Sample interval	Recovery (feet)	Blow counts (blows/6")	Soil sample	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**
	North Channel										
	*Channel floor elevation = -48.6' MLLW**										
SW	Holocene Brown c SAND, some gravel, cross laminae, and gray layers	Brown c SAND, white shell fragments, trace recovery, resampled. subangular diabase pebble	3" split spoon # 1		recovery = 0.00'	18 36 40 15					
		-50.6' Brown c SAND, white shell fragments, cross lamination	3" split spoon # 2		recovery = 2.00'	22 20 17 17					
	Holocene GRAVEL	Gray COBBLE over Black SAND with f gravel, charcoal fragments									
GC/ GM	-51.6' Top of Pleistocene Till Yellow-brown Silty SAND & GRAVEL Pleistocene	1.52' Till - Yellow brown silty SAND & GRAVEL pebbles black argillite, granite, weathered									
GM/ SM		*-52.6'* 0.88' Till - Yellow brown silty SAND & GRAVEL, trace clay weathered pebbles	3" split spoon # 3		recovery = 1.30'	17 30 23 20					
		-54.6' 0.20' light green silty SAND & GRAVEL, angular argillite clasts, broken	spn # 4		0.80'	26 50/3"					
	Till Yellow-brown Silty SAND & GRAVEL layers of light green silty sand; argillite clasts, weathered and decomposed pebbles Pleistocene	*-55.4'* Ground down through cobbles/small boulder			drilling smoothly in top 3" and bottom 6" otherwise chattering						
GM/ SM		*-56.6'* 0.2l' Till brown silty sand & GRAVEL, black argillite clasts Decomposed rock fragments	3" split spoon # 5		recovery = 0.90'	6 10 17 25					
		-58.4' 1.12' Till - silty SAND & GRAVEL, angular rock clasts (argillite) over sand, trace pebbles	3" split spoon # 6		recovery = 1.10'	22 15 15 100/2"					
	Top of refusal Apparent rock	*-60.1'* Ground down to confirm rock refusal				drilling advanced smoothly cuttings indicate argillite rock					

*Bottom of boring elevation = -61.6' MLLW**

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-02**

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page 1 of 1

Easting 812,377.4'
Northing 2,959,626.0'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 08:12 am December 12, 2014
boring completed at 04:30 pm December 12, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -44.3' MLLW
Boring bottom elevation = -59.5' MLLW
Total depth below channel floor = 15.2'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = > 15.2'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

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- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

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m = medium-grain
c = coarse grained

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Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
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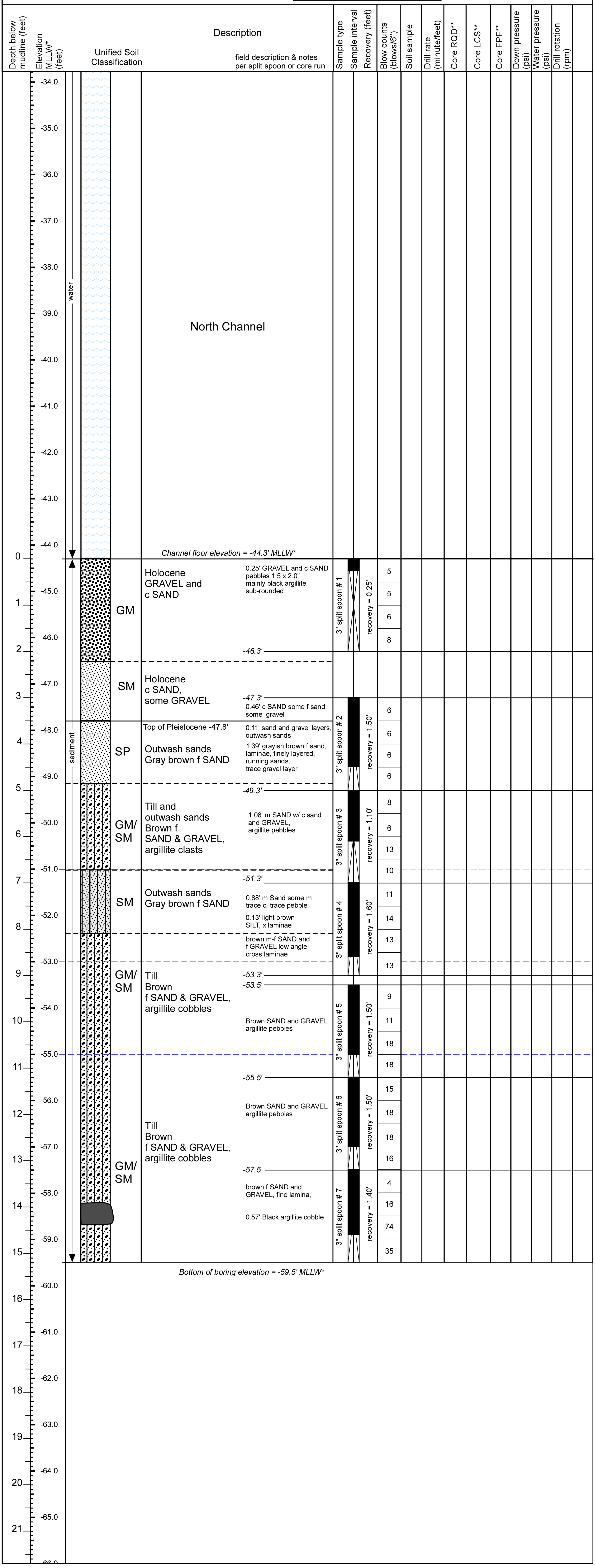

North Channel

Channel floor elevation = -44.3' MLLW

Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")
GM	Holocene GRAVEL and c SAND	0.25' GRAVEL and c SAND pebbles 1.5 x 2.0" mainly black argillite, sub-rounded *-46.3'*	3" split spoon # 1	recovery = 0.25'	5 5 6 8
SM	Holocene c SAND, some GRAVEL	*-47.3'* 0.46' c SAND some f sand, some gravel	3" split spoon # 2	recovery = 1.50'	6
SP	Top of Pleistocene -47.8' Outwash sands Gray brown f SAND	0.11' sand and gravel layers, outwash sands 1.39' grayish brown f sand, laminae, finely layered, running sands, trace gravel layer			6 6 6
GM/ SM	Till and outwash sands Brown f SAND & GRAVEL, argillite clasts	*-49.3'* 1.08' m SAND w/ c sand and GRAVEL, argillite pebbles	3" split spoon # 3	recovery = 1.10'	8 6 13 10
SM	Outwash sands Gray brown f SAND	*-51.3'* 0.88' m Sand some m trace c, trace pebble 0.13' light brown SILT, x laminae	3" split spoon # 4	recovery = 1.60'	11 14
GM/ SM	Till Brown f SAND & GRAVEL, argillite cobbles	brown m-f SAND and f GRAVEL low angle cross laminae *-53.3'*			13 13
		-53.5' Brown SAND and GRAVEL argillite pebbles	3" split spoon # 5	recovery = 1.50'	9 11 18 18
GM/ SM	Till Brown f SAND & GRAVEL, argillite cobbles	*-55.5'* Brown SAND and GRAVEL argillite pebbles	3" split spoon # 6	recovery = 1.50'	15 18 18 16
		-57.5 brown f SAND and GRAVEL, fine lamina, 0.57' Black argillite cobble	3" split spoon # 7	recovery = 1.40'	4 16 74 35

*Bottom of boring elevation = -59.5' MLLW**

US Army Corps
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New England District

Boston Harbor

boring **FD14-03**

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page 1 of 1

Easting 813,065.2'
Northing 2,958,558.8'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 01:20 pm November 25, 2014
boring completed at 06:03 pm November 25, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -34.8' MLLW
Boring bottom elevation = -57.6' MLLW
Total depth below channel floor = 22.8'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = > 22.8'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
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Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
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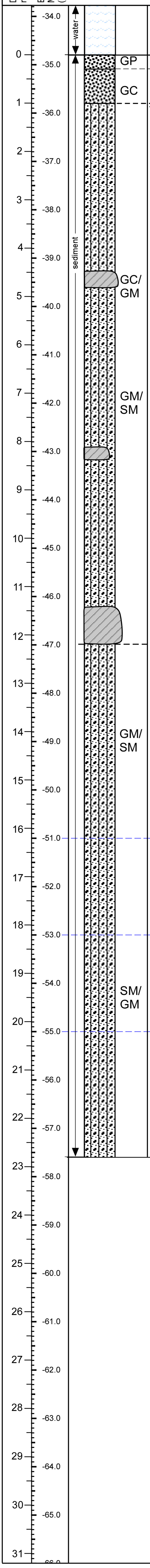

North Channel

*Channel floor elevation = -34.8' MLLW**

Unified Soil Classification	Description
GP	GRAVEL
GC	Holocene GRAVEL some sand
	Top of Pleistocene -35.8'
	Till SAND and GRAVEL
	Till GRAVEL and m-c SAND
GC/ GM	argillite, pebbles up to 2"
GM/ SM	Till c SAND and f GRAVEL argillite and quartzite sand
	Till c SAND and GRAVEL
	Till c SAND and GRAVEL
GM/ SM	Till c-m SAND and f GRAVEL
SM/ GM	Till c-m SAND and f GRAVEL

field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")	Soil sample
GRAVEL 0.5 to 1.0" well-rounded clasts, quartzite, argillite, granite Silty SAND and GRAVEL argillite pebbles, finer quartzite pebbles 2" pebbles of argillte and quartzite	3" split spoon # 1	recovery = 0.00'	wor/2' 6 12 17 10	*resampled recoverd 16"*
-36.8' 2.5" x 1.5" granite pebble GRAVEL little coarse sand, gravel well-rounded Well-rounded GRAVEL and c sand, some m sand 1' quartzite pebble	3" split spoon # 2	recovery = 1.33'	8 9 11 11	
-38.8' GRAVEL some m sand 0.5 - 1.0" clasts, subrounded, granite, argillite c sand, some m sand 1' quartzite	3" split spoon # 3	recovery = 0.92'	10 30 12 12	*sat on cobble for 30 blows*
-40.8' 2" argillite pebbles c SAND and GRAVEL some m sand argillite and quartzite clasts c SAND and GRAVEL orange stained quartzite layer	3" split spoon # 4	recovery = 0.92'	13 10 9 7	
-42.8' m Sand and Gravel, 0.5 to 1.0" pebbles of argillite 2" argillite pebbles argillite clasts up to 1", granite, m sand weathered brown argilllite pebble	3" split spoon # 5	recovery = 0.88'	30 12 9 4	
-44.6' GRAVEL and c SAND, trace m sand dark gray argillite pebbles up to 1"; angular 0.5" gravel of pink granite 2.5" argillite pebbles: 4" weathered argillite pebble w/ mafic dike *-46.2'*	3" split spoon # 6	recovery = 1.17'	10 13 5 5	
	ground down through cobble			
-47.1' c SAND and f GRAVEL trace brown silt, rounded gravel, argillite angular pebble 1x3"	3" split spoon # 7	recovery =0.71'	11 9 9 6	
-49.1' c SAND and f GRAVEL 1" subrounded pebbles of dark gray argillite	3" split spoon # 8	recovery = 1.00'	8 7 6 6	
-51.1' c SAND and f GRAVEL 1" argillite pebbles, pink granite sand is quartzite and argillite dark gray c-m SAND, little gravel 1" and 2" argillite pebbles	3" split spoon # 9	recovery = 1.58'	6 7 6 8	
-53.1' c SAND and f Gravel mostly argillite 0.5" pebbles, trace m sand	3" split spoon # 10	recovery = 0.67'	5 5 9 7	
-55.1' 1' argillite rounded pebble *-55.6'*	# 11	0.50'	50	*refusal*
m SAND little gravel, little c sand, pink granite and argillite clasts c SAND some m sand, f gravel, up to 0.5" argillite pebbles, yellow orange granite.	3" split spoon # 12	recovery = 1.13'	9 6 6 6	

*Bottom of boring elevation = -57.6' MLLW**

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-04**

e4sciences | Earthworks, LLC

Easting 810,721.4'
Northing 2,954,735.4'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 06:21 am December 13, 2014
boring completed at 01:05 pm December 13, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -43.2' MLLW
Boring bottom elevation = -56.8' MLLW
Total depth below channel floor = 13.6'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0 (cored cobbles & boulders)

Rock encountered: not encountered
Thickness of sediment = > 13.6'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

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- Silt, sand & gravel
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- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
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Geological Formations

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Rock-core description
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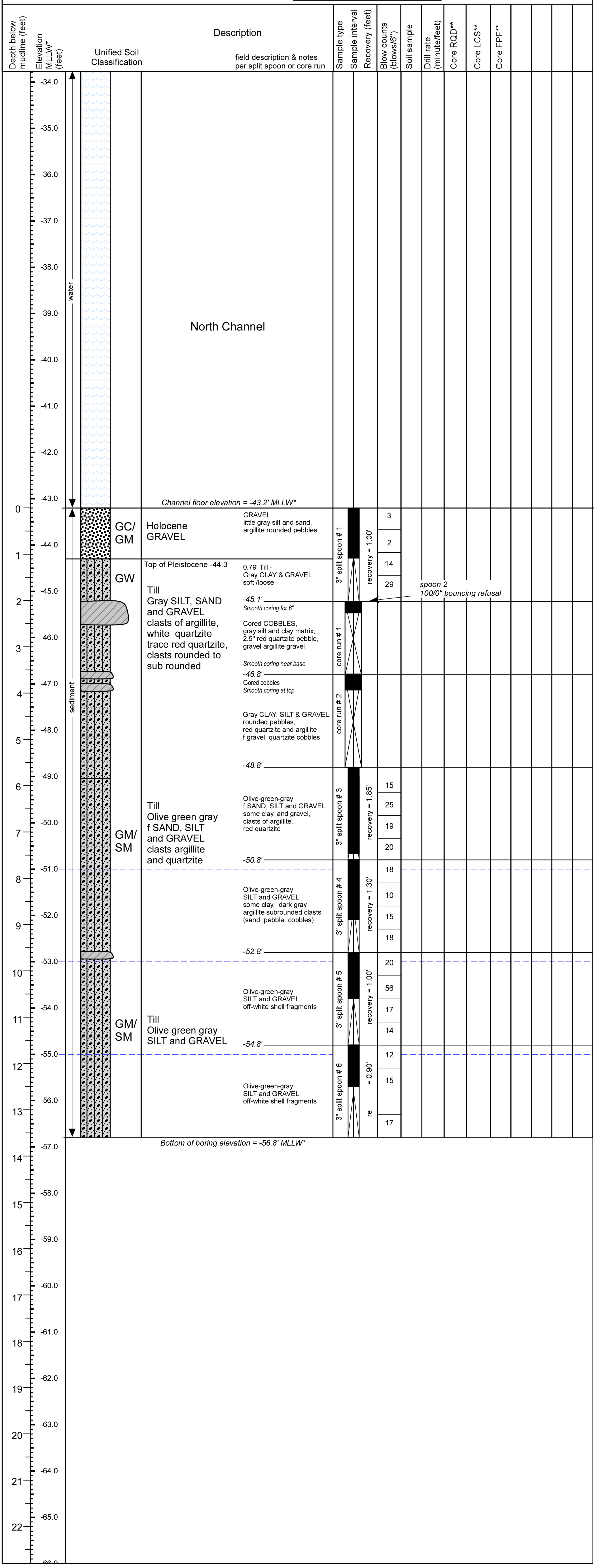

Channel floor elevation = -43.2' MLLW*

Unified Soil Classification	Description	field description & notes	Sample type	Recovery (feet)	Blow counts (blows/6")
GC/ GM	Holocene GRAVEL	GRAVEL little gray silt and sand, argillite rounded pebbles	3" split spoon # 1	recovery = 1.00'	3 2
GW	Top of Pleistocene -44.3 Till Gray SILT, SAND and GRAVEL clasts of argillite, white quartzite trace red quartzite, clasts rounded to sub rounded	0.79' Till - Gray CLAY & GRAVEL, soft /loose			14 29
		-45.1' *Smooth coring for 6"* Cored COBBLES, gray silt and clay matrix; 2.5" red quartzite pebble, gravel argillite gravel *Smooth coring near base*	core run # 1		
		-46.8' Cored cobbles *Smooth coring at top* Gray CLAY, SILT & GRAVEL, rounded pebbles, red quartzite and argillite f gravel, quartzite cobbles	core run # 2		
GM/ SM	Till Olive green gray f SAND, SILT and GRAVEL clasts argillite and quartzite	-48.8' Olive-green-gray f SAND, SILT and GRAVEL some clay, and gravel, clasts of argillite, red quartzite	3" split spoon # 3	recovery = 1.85'	15 25 19 20
		-50.8' Olive-green-gray SILT and GRAVEL, some clay, dark gray argillite subrounded clasts (sand, pebble, cobbles)	3" split spoon # 4	recovery = 1.30'	18 10 15 18
GM/ SM	Till Olive green gray SILT and GRAVEL	-52.8' Olive-green-gray SILT and GRAVEL, off-white shell fragments	3" split spoon # 5	recovery = 1.00'	20 56 17 14
		-54.8' Olive-green-gray SILT and GRAVEL, off-white shell fragments	3" split spoon # 6	re = 0.90'	12 15 17

*Bottom of boring elevation = -56.8' MLLW**

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-05**

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page 1 of 1

Easting 809,602.6'
Northing 2,954,318.1'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 11:38 am December 15, 2014
boring completed at 04:45 pm December 15, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.9' MLLW
Boring bottom elevation = -58.9' MLLW
Total depth below channel floor = 16.0'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = > 16.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
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Key

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- Black silt
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- Clay & gravel

Sediment

Rock

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- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
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Rock

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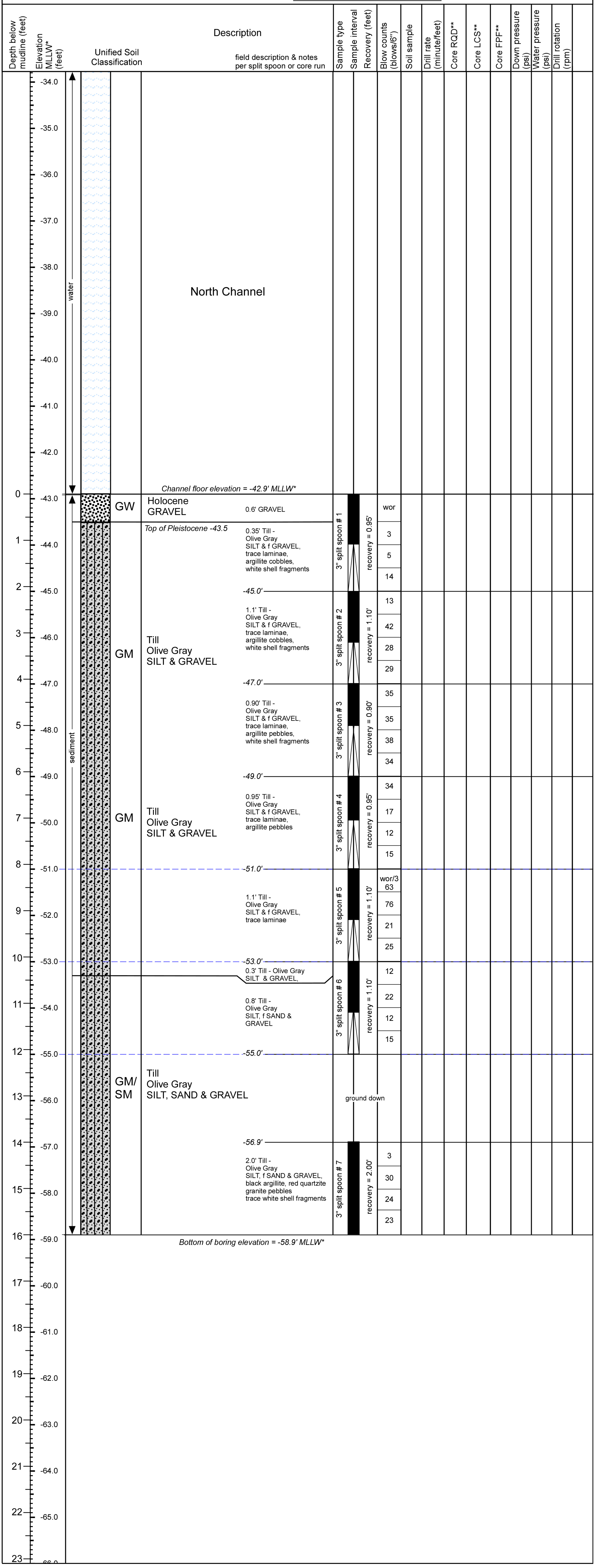

Channel floor elevation = -42.9' MLLW*

Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")
GW	Holocene GRAVEL	0.6' GRAVEL	3" split spoon # 1	recovery = 0.95'	wor
GM	Till Olive Gray SILT & GRAVEL Top of Pleistocene -43.5	0.35' Till - Olive Gray SILT & f GRAVEL, trace laminae, argillite cobbles, white shell fragments			3 5 14
		-45.0' 1.1' Till - Olive Gray SILT & f GRAVEL, trace laminae, argillite cobbles, white shell fragments	3" split spoon # 2	recovery = 1.10'	13 42 28 29
		-47.0' 0.90' Till - Olive Gray SILT & f GRAVEL, trace laminae, argillite pebbles, white shell fragments	3" split spoon # 3	recovery = 0.90'	35 35 38 34
GM	Till Olive Gray SILT & GRAVEL	-49.0' 0.95' Till - Olive Gray SILT & f GRAVEL, trace laminae, argillite pebbles	3" split spoon # 4	recovery = 0.95'	34 17 12 15
		-51.0' 1.1' Till - Olive Gray SILT & f GRAVEL, trace laminae	3" split spoon # 5	recovery = 1.10'	wor/3 63 76 21 25
		-53.0' 0.3' Till - Olive Gray SILT & GRAVEL,	3" split spoon # 6	recovery = 1.10'	12
GM/ SM	Till Olive Gray SILT, SAND & GRAVEL	0.8' Till - Olive Gray SILT, f SAND & GRAVEL			22 12 15
		-55.0' ground down			
		-56.9' 2.0' Till - Olive Gray SILT, f SAND & GRAVEL, black argillite, red quartzite granite pebbles trace white shell fragments	3" split spoon # 7	recovery = 2.00'	3 30 24 23

Bottom of boring elevation = -58.9' MLLW*

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-06a**

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page 1 of 1

Easting 809,186.5'
Northing 2,953,344.1'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 01:17 pm December 13, 2014
boring completed at 05:10 pm December 13, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.9' MLLW
Boring bottom elevation = -54.1' MLLW
Total depth below channel floor = 11.2'

Top of all rock elevation = -54.1'MLLW
Rock refusal elevation = -54.1'MLLW
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = 11.2'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

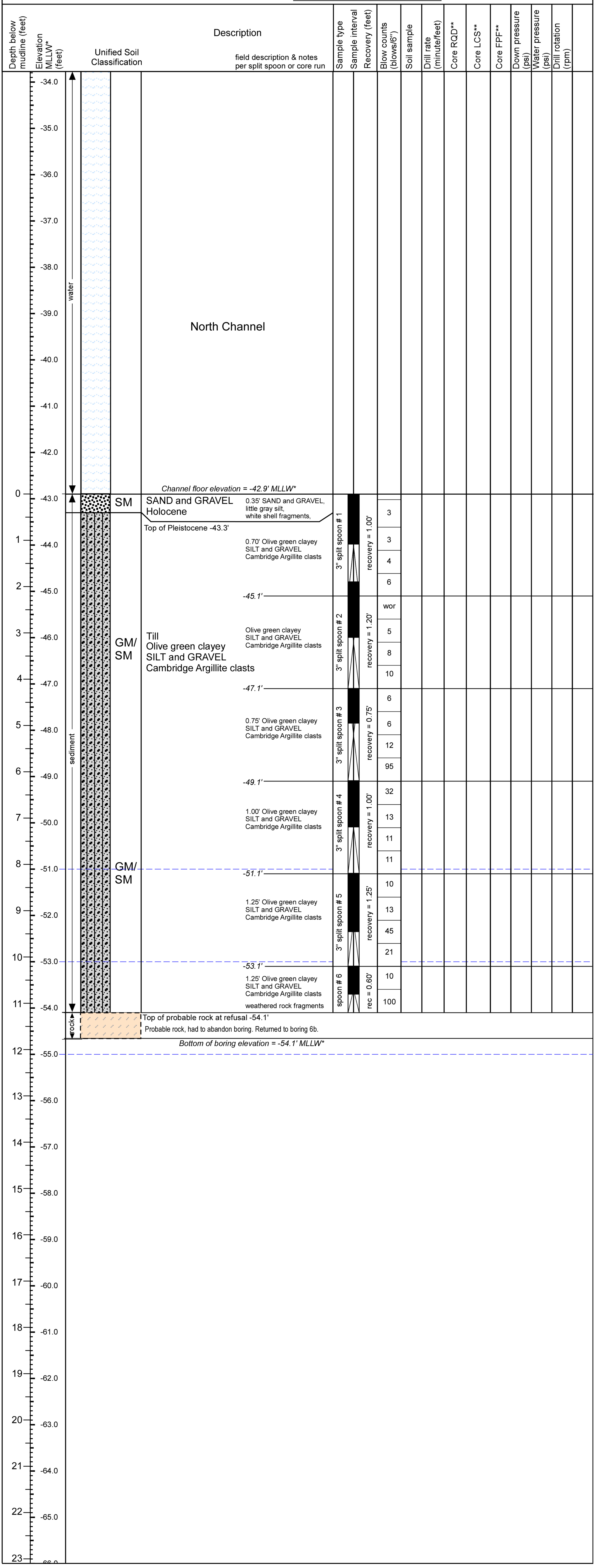
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



North Channel

*Channel floor elevation = -42.9' MLLW**

SAND and GRAVEL
Holocene

Top of Pleistocene -43.3'

Till
Olive green clayey
SILT and GRAVEL
Cambridge Argillite clasts

Unified Soil Classification	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")
SM	0.35' SAND and GRAVEL, little gray silt, white shell fragments,	3" split spoon # 1	recovery = 1.00'	3 3 4 6
GM/ SM	0.70' Olive green clayey SILT and GRAVEL Cambridge Argillite clasts			
	-45.1'			
	Olive green clayey SILT and GRAVEL Cambridge Argillite clasts	3" split spoon # 2	recovery = 1.20'	wor 5 8 10
	-47.1'			
	0.75' Olive green clayey SILT and GRAVEL Cambridge Argillite clasts	3" split spoon # 3	recovery = 0.75'	6 6 12 95
	-49.1'			
	1.00' Olive green clayey SILT and GRAVEL Cambridge Argillite clasts	3" split spoon # 4	recovery = 1.00'	32 13 11 11
	-51.1'			
GM/ SM	1.25' Olive green clayey SILT and GRAVEL Cambridge Argillite clasts	3" split spoon # 5	recovery = 1.25'	10 13 45 21
	-53.1'			
	1.25' Olive green clayey SILT and GRAVEL Cambridge Argillite clasts weathered rock fragments	spoon # 6	rec = 0.60'	10 100

Top of probable rock at refusal -54.1'
Probable rock, had to abandon boring. Returned to boring 6b.

*Bottom of boring elevation = -54.1' MLLW**

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Boston Harbor

boring **FD14-06b**

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page 1 of 1

Easting 809,190.2'
Northing 2,953,336.1'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 07:07 am December 15, 2014
boring completed at 11:28 am December 15, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.7 MLLW
Boring bottom elevation = -58.5' MLLW
Total depth below channel floor = 15.8'

Top of all rock elevation = -54.9' MLLW
Rock refusal elevation = -58.5' MLLW
Number of rock core runs = 0

Rock encountered: Cambridge Argillite
Thickness of sediment = 12.2'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

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- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

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- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

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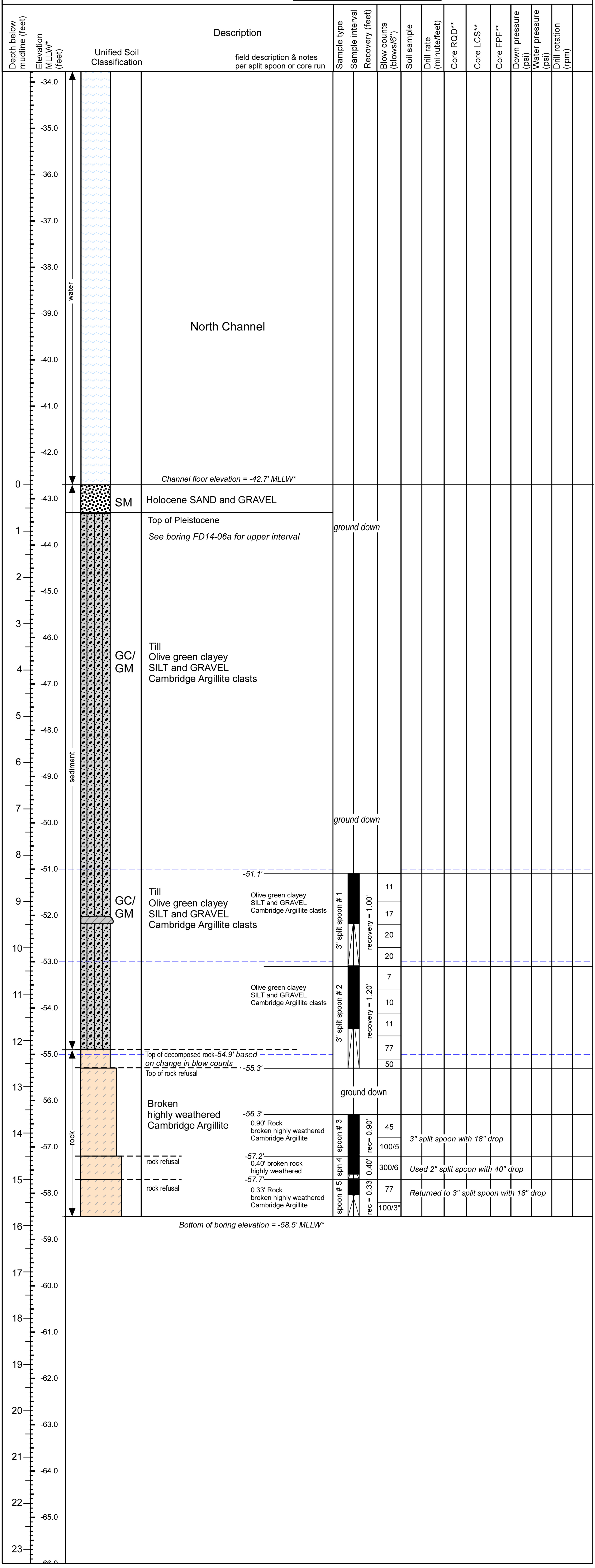
Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-06B spoon 3

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-06Bs3a
Boring: FD14-06B spoon 3

1" x 2" thin section
elevation:

Formation: Cambridge Argillite.

Lithology: argillite
shale-dominated argllite

Sedimentary textures:

layering thin to very thin layers of clay-rich layers with some quartz grains
silt laminae

layers disrupted by pressure solution seams/cleavage

Deformation features:

lithologic layers at angle to cleavage

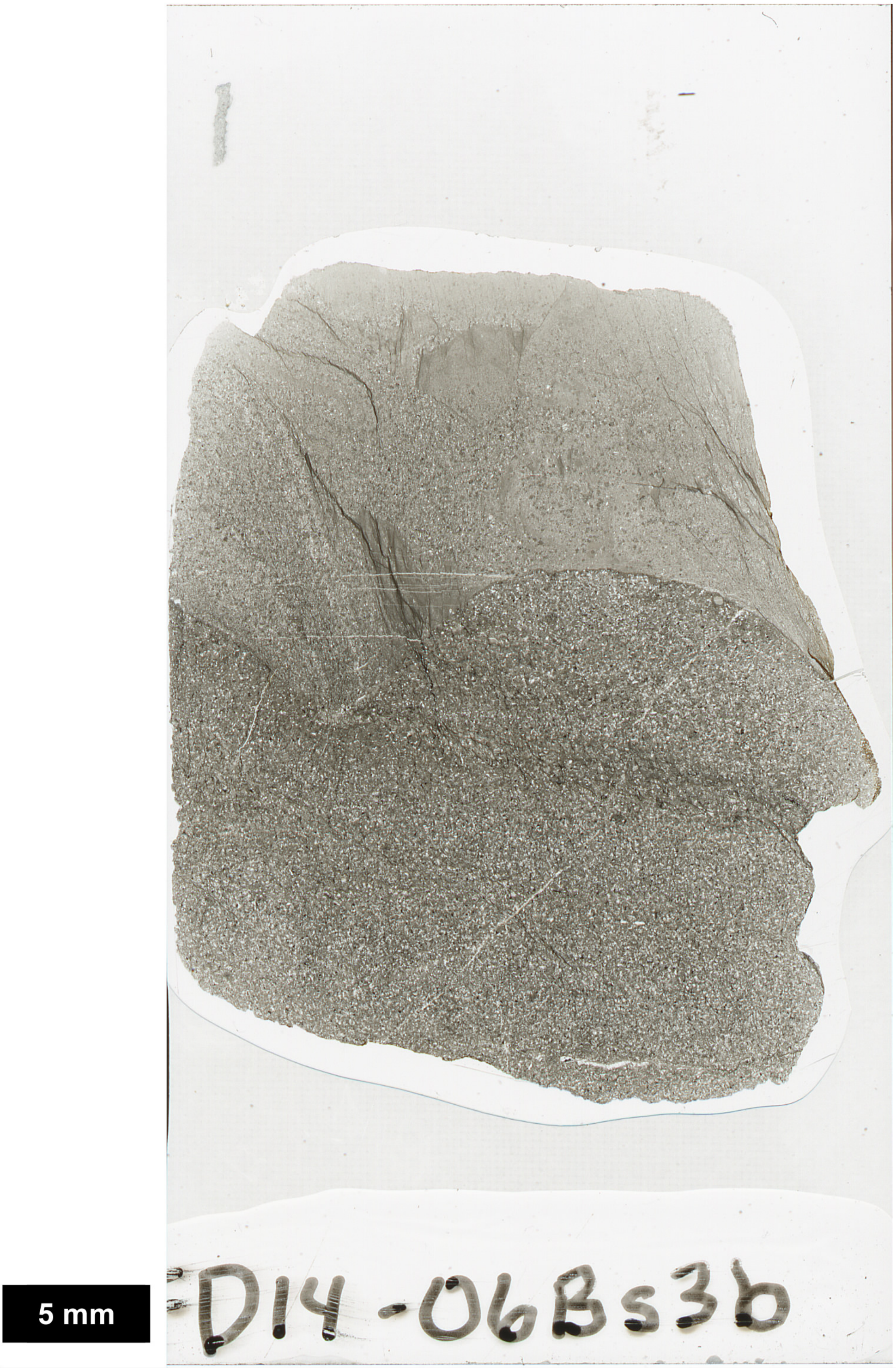
pressure-solution seams
stylolites

fractures calcite-filled
oxidation/weathering along pressure solution seams

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary
opaques - detrital and secondary

Boring FD-14-06B spoon 3
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-06Bs3b
Boring: FD14-06B spoon 3

1" x 2" thin section
elevation:

Formation: Cambridge Argillite.

Lithology: argillite
shale-dominate
thin section face appears to be sub-parallel to bedding surface

Sedimentary textures:

thinly layered
laminae

possible section through slump fold?

Deformation features:

lithologic layers at angle to pressure-solution cleavage

pressure-solution seams parallel to lithological layers
pressure solution cleavage
stylolites

calcite-filled fractures
2 orientations: sub-perpendicular to lithogical layers
sub-perpendicular to pressure-solution cleavage

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
opaques - detrital and secondary

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Boston Harbor

boring **FD14-07**

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Easting 809,822.3'
Northing 2,953,217.9'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

North Channel

boring started at 07:55 am November 25, 2014
boring completed at 12:34 pm November 25, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.9' MLLW
Boring bottom elevation = -56.9' MLLW
Total depth below channel floor = 14.0'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = > 14.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)

- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)

- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
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Paleozoic	Felsic igneous dikes & sills
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c = coarse grained

Blow-count abbreviations

wor = weight of rod
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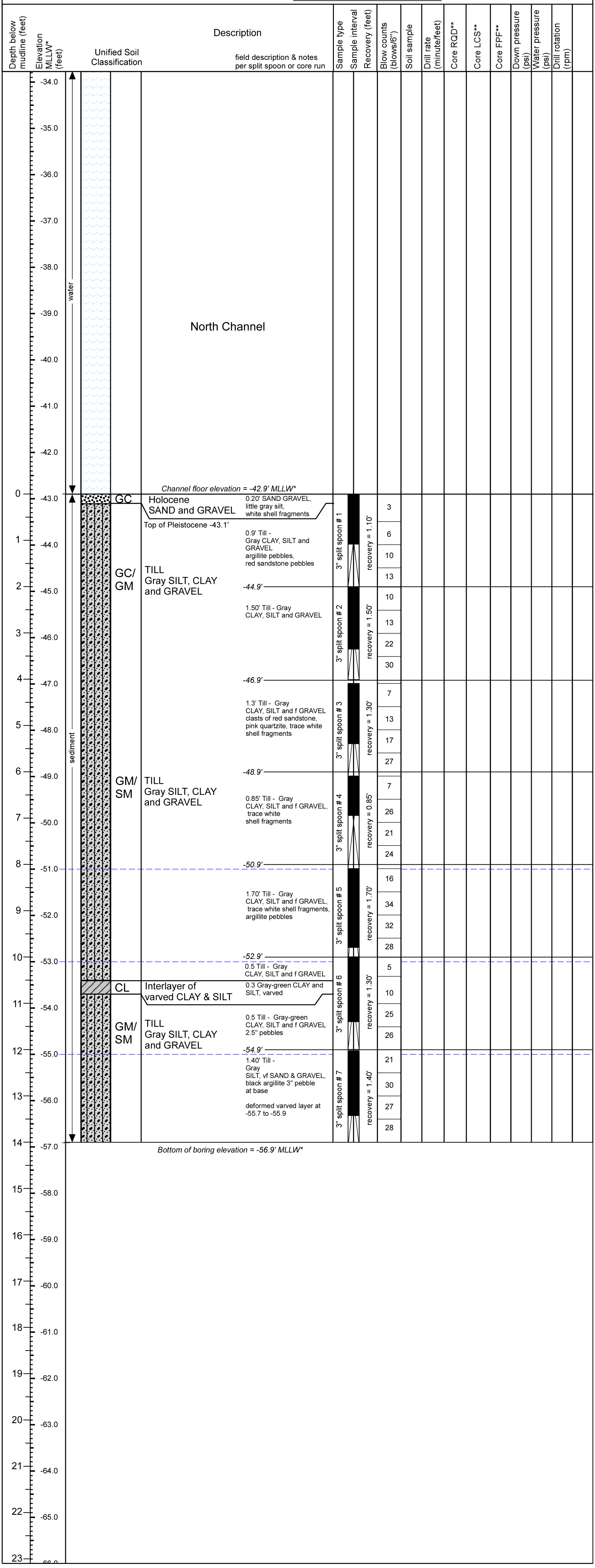
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



North Channel

*Channel floor elevation = -42.9' MLLW**

Holocene
SAND and GRAVEL

0.20' SAND GRAVEL, little gray silt, white shell fragments

Top of Pleistocene -43.1'

TILL
Gray SILT, CLAY and GRAVEL

0.9' Till - Gray CLAY, SILT and GRAVEL argillite pebbles, red sandstone pebbles

-44.9'

1.50' Till - Gray CLAY, SILT and GRAVEL

-46.9'

1.3' Till - Gray CLAY, SILT and f GRAVEL clasts of red sandstone, pink quartzite, trace white shell fragments

-48.9'

TILL
Gray SILT, CLAY and GRAVEL

0.85' Till - Gray CLAY, SILT and f GRAVEL, trace white shell fragments

-50.9'

1.70' Till - Gray CLAY, SILT and f GRAVEL, trace white shell fragments, argillite pebbles

-52.9'

0.5 Till - Gray CLAY, SILT and f GRAVEL

Interlayer of varved CLAY & SILT

0.3 Gray-green CLAY and SILT, varved

TILL
Gray SILT, CLAY and GRAVEL

0.5 Till - Gray-green CLAY, SILT and f GRAVEL 2.5" pebbles

-54.9'

1.40' Till - Gray SILT, vf SAND & GRAVEL, black argillite 3" pebble at base

deformed varved layer at -55.7 to -55.9

*Bottom of boring elevation = -56.9' MLLW**

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Boston Harbor

boring **FD14-08**

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page 1 of 1

Easting 809,822.3'
Northing 2,953,217.9'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 07:04 pm December 20, 2014
boring completed at 06:03 pm December 20, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.6 MLLW
Boring bottom elevation = -57.6' MLLW
Total depth below channel floor = 15.0'

Top of all rock elevation = -44.6' MLLW
Rock refusal elevation = -44.9' MLLW
Number of rock core runs = 5

Rock encountered: Cambridge Argillite
Thickness of sediment = 2.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils

- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▦ Gravel
- ▦ Sand & gravel
- ▦ Silt, sand & gravel
- ▦ Clay & gravel

Rock

- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
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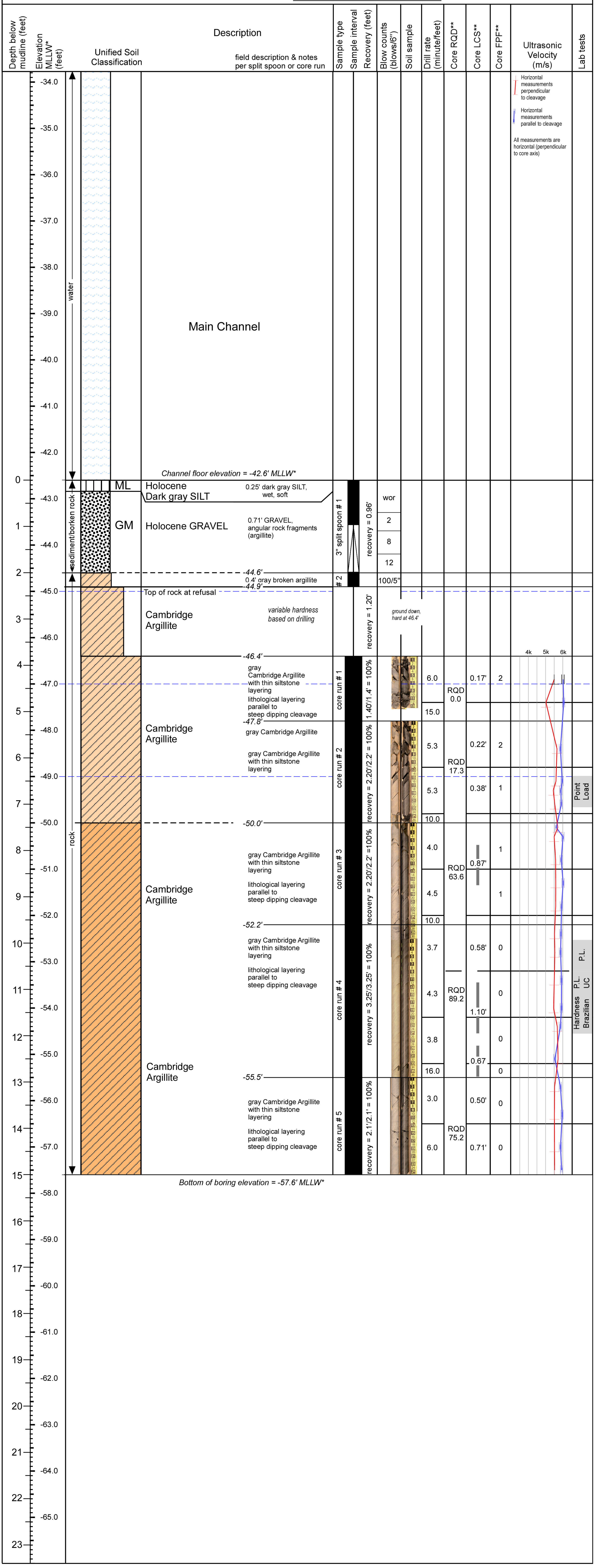
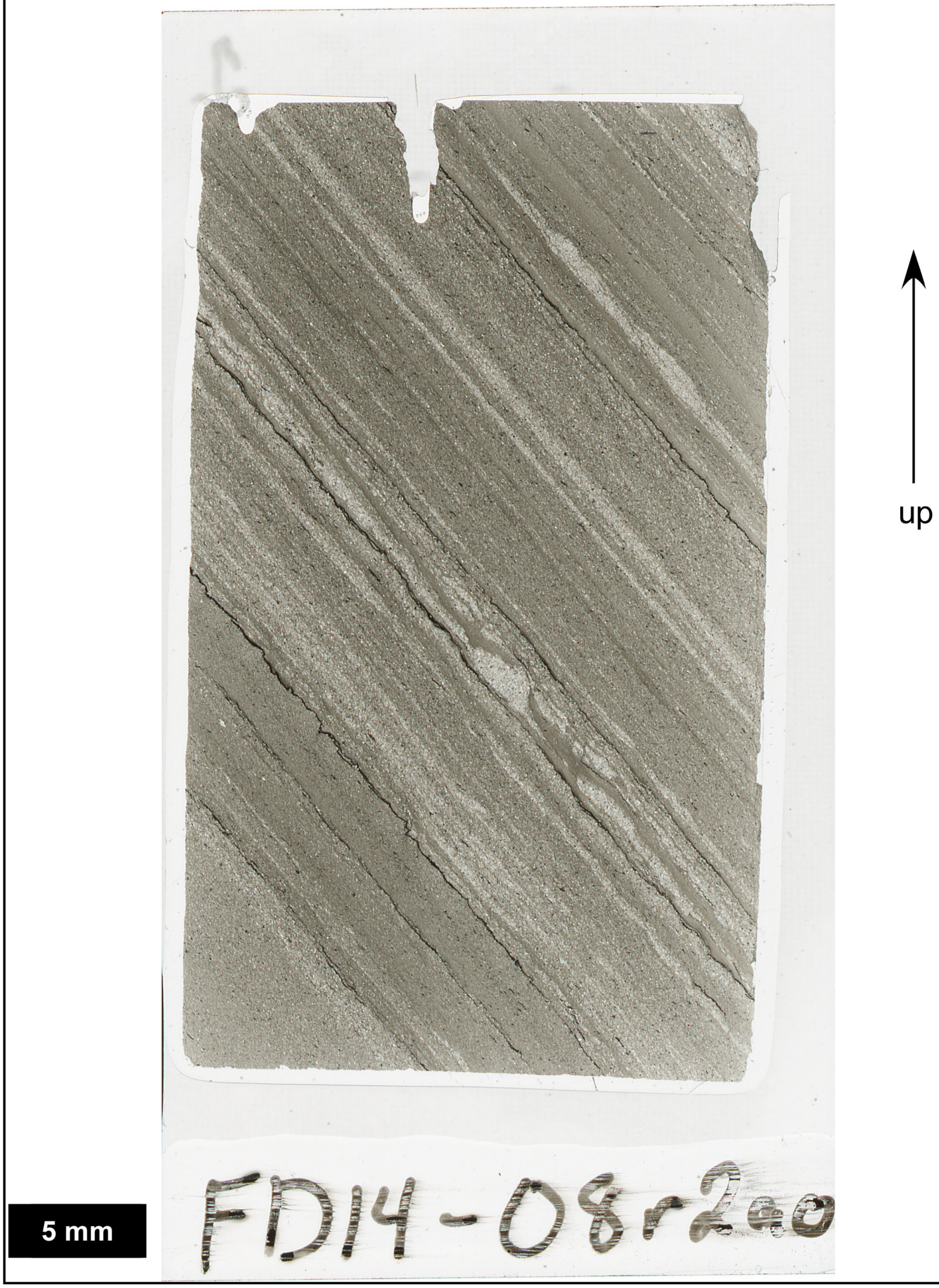
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-08 core run 2 piece ao
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD-14-08r2ao 1" x 2" thin section
Boring: FD14-08 core run 2 piece ao elevation: -49.00 to -49.15ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
steeply dipping, thinly laminated shale-dominated argillite

Sedimentary textures:

layering thin to laminated quartz silt and clay-rich laminae,
coarse silt laminae
darker layers clay-sized particles

lensing/thicking of silt laminae
graded layers

Deformation features:

steeply dipping lithologic layers

pressure-solution seams and stylolites parallel to lithological layering`

no apparent fractures

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary
opaques - detrital and secondary

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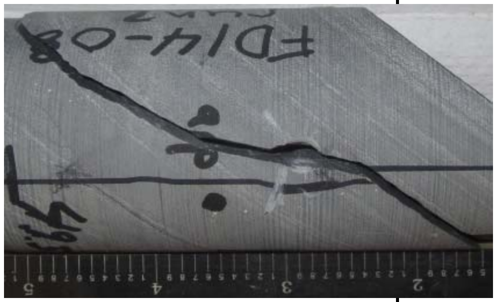
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-08	2	ap	- 49.18 to -49.6	0.06			PL	Diametral					4.6	15625					
FD14-08	2	ap	- 49.18 to -49.6				PL	Axial					8.2	24078					
FD14-08	4	bn	-53.21 to -54.24				M		3.5										
FD14-08	4	bn	-53.21 to -53.5	0.04			PL	Diametral					5.6	18889					
FD14-08	4	bn	-53.21 to -53.5				PL	Axial					7.6	24430					
FD14-08	4	bn	-53.5 to -53.9	0.06	171.5	171.3	UCmod									14260	0.14	1.1E+07	0.24
FD14-08	4	bn	-53.9 to -54.1	0.04	169.5	169.4	B-1	A							1777				
FD14-08	4	bn	-53.9 to -54.1	0.05	167.6	167.5	B-2	B							2025				

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	34.6		22.4	
Specimen Width, W (mm)	50.1		44.8	
D (mm)	51.0		23.5	
D' (mm)	51.0		23.5	
D_e (mm)	51.0		36.6	
Failure Load, P (lb)	2663		2856	
Point Load (N)	**11846**		**12704**	
Point Load (Mpa)	**4.60**		**8.23**	
Index, Is50 (psi)	**670**		**1190**	
Unconfined Compressive Strength (psi)	**15625**		**24078**	
Specimen /Failure Sketch				
Tare No.	M-26			
Wet + Tare (gm)	282.74			
Dry + Tare (gm)	282.6			
Tare (gm)	51.52			
Water Content%	**0.06**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

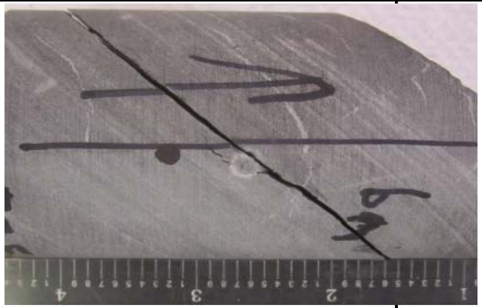
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-08 Run: 2 - piece ap
Elevation: - 49.18 to -49.6 ft.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	24.4		30.7	
Specimen Width, W (mm)	50.1		51.0	
D (mm)	51.0		33.0	
D' (mm)	51.0		31.0	
D_e (mm)	51.0		44.9	
Failure Load, P (lb)	3249		3632	
Point Load (N)	**14452**		**16156**	
Point Load (Mpa)	**5.61**		**7.64**	
Index, Is50 (psi)	**810**		**1110**	
Unconfined Compressive Strength (psi)	**18889**		**24430**	
Specimen /Failure Sketch				
Tare No.	M-9			
Wet + Tare (gm)	306.19			
Dry + Tare (gm)	306.09			
Tare (gm)	50.12			
Water Content%	**0.04**			
Comments				

Test by: RAT Test Date: 4/3/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-08 Run: 4 - piece bn
Elevation: -53.21 to -53.5 ft.

Analysis File: PLV4 (9/09)

4/22/2015
PL14-08-run4bn.xlsx

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001 **Test by:** GT **Sta:** FD14-08

Project Name: Boston Harbor **Test Date:** 4/20/15 **Run:** 4 - piece bn

SPECIMEN READINGS

Test Number: B-1

Elevation: -53.9 to -54.1

Specimen mass(gm): 136.97

Thickness (inch)	Diameter (inch)
1.018	1.973
0.992	1.972
1.014	1.973
Average 1.008	1.973

Thickness / Diameter, (t/d): 0.51

t/D ratio between 0.2 and 0.75 yes

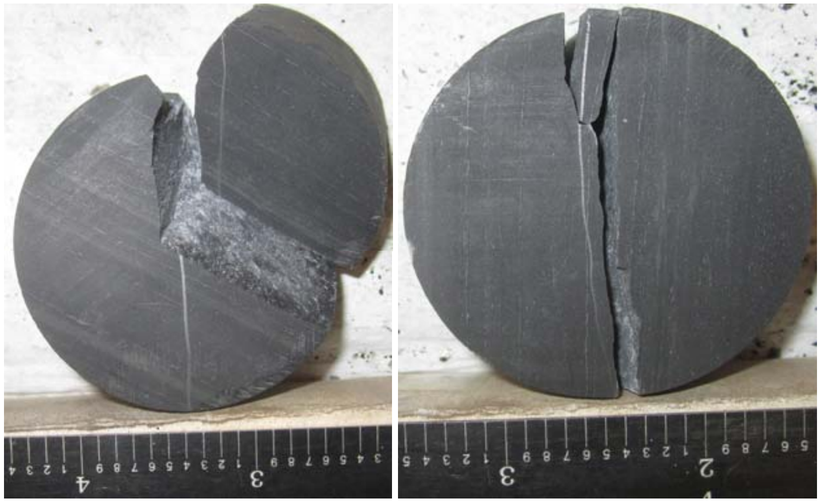
Largest Grain Diameter 0.010 inch

meets mineral size spec.

Data Acquisition File B14-08R04A

Maximum Load 5548 lb

	After Test
Container No.:	LA-130
Initial Mass + cont. (g):	171.21
Dry Mass + cont. (g):	171.15
Mass of cont. (g):	34.15
Water content (%):	**0.04**
Total unit weight (pcf):	169.49
Dry unit weight (pcf):	169.42
Splitting Tensile Strength (psi)	1777.27



Failure Photo

Test Number: B-2

Elevation: -53.9 to -54.1

Specimen mass(gm): 139.78

Thickness (inch)	Diameter (inch)
1.009	1.972
1.108	1.973
1.004	1.972
Average 1.040	1.972

Thickness / Diameter, (t/d): 0.53

t/D ratio between 0.2 and 0.75 yes

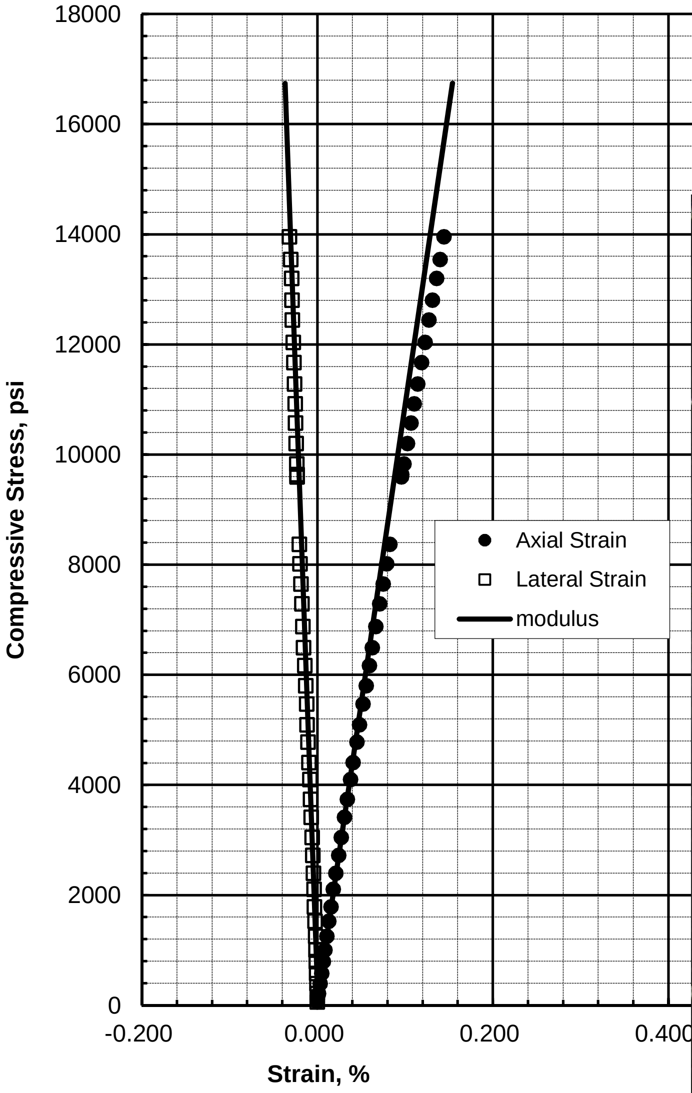
Largest Grain Diameter 0.010 inch

Data Acquisition File B14-08R04B

Maximum Load 6523 lb

	After Test
Container No.:	LA-205
Initial Mass + cont. (g):	172.02
Dry Mass + cont. (g):	171.95
Mass of cont. (g):	32.95
Water content (%):	**0.05**
Total unit weight (pcf):	167.62
Dry unit weight (pcf):	167.54
Splitting Tensile Strength (psi)	2024.65

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-08** **Run: 4 - piece bn Elevation: -53.9 to -54.1 ft.**
TerraSense, LLC	7803-15001		



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.06	171	171	4.633	1.973

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.10	0.14	14260	1.08E+07	0.24

FAILURE PHOTO

Tested by: GT Test Date: Mar-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-08 Run: 4 bn
Elevation -53.5 to -53.9 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-08	1	-46.9	llfrac	6,008.3	19,712.3
FD14-08	1	-46.9	xfrac	5,493.8	18,024.2
FD14-08	1	-47.4	llfrac	6,046.4	19,837.4
FD14-08	1	-47.4	xfrac	5,013.3	16,447.8
FD14-08	2	-48.4	llfrac	5,857.4	19,217.3
FD14-08	2	-48.4	xfrac	5,654.1	18,550.2
FD14-08	2	-49.1	llfrac	5,956.1	19,541.0
FD14-08	2	-49.1	xfrac	5,593.5	18,351.4
FD14-08	2	-49.3	llbed	5,877.5	19,283.1
FD14-08	2	-49.3	xbed	5,438.7	17,843.6
FD14-08	2	-49.6	llbed	5,905.2	19,374.0
FD14-08	2	-49.6	xbed	5,527.0	18,133.2
FD14-08	2	-50.1	llfrac	5,612.9	18,415.2
FD14-08	2	-50.1	xfrac	5,700.2	18,701.6
FD14-08	3	-50.3	llbed	6,003.6	19,697.0
FD14-08	3	-50.3	xbed	5,489.0	18,008.6
FD14-08	3	-50.8	llbed	5,902.8	19,366.2
FD14-08	3	-50.8	xbed	5,573.9	18,287.0
FD14-08	3	-51.3	llbed	6,012.8	19,726.9
FD14-08	3	-51.3	xbed	5,580.1	18,307.5
FD14-08	3	-51.8	llbed	5,920.2	19,423.2
FD14-08	3	-51.8	xbed	5,579.5	18,305.6
FD14-08	4	-52.4	llbed	5,886.4	19,312.4
FD14-08	4	-52.4	xbed	5,508.9	18,073.8
FD14-08	4	-52.8	llbed	5,864.8	19,241.6
FD14-08	4	-52.8	xbed	5,531.8	18,148.9
FD14-08	4	-53.4	llbed	5,917.2	19,413.3
FD14-08	4	-53.4	xbed	5,496.4	18,032.7
FD14-08	4	-54.0	llbed	5,915.7	19,408.4
FD14-08	4	-54.0	xbed	5,456.9	17,903.1
FD14-08	4	-54.4	llbed	5,854.5	19,207.6
FD14-08	4	-54.4	xbed	5,671.9	18,608.6
FD14-08	4	-55.1	llfrac	5,532.6	18,151.5
FD14-08	4	-55.1	xfrac	5,719.0	18,763.2
FD14-08	5	-55.7	llbed	5,857.4	19,217.3
FD14-08	5	-55.7	xbed	5,515.0	18,093.8
FD14-08	5	-56.3	llbed	5,958.8	19,549.8
FD14-08	5	-56.3	xbed	5,503.3	18,055.6
FD14-08	5	-57.0	llbed	5,860.4	19,227.0
FD14-08	5	-57.0	xbed	5,507.5	18,069.3
FD14-08	5	-57.5	llbed	5,926.2	19,442.8
FD14-08	5	-57.5	xbed	5,515.9	18,096.7

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-09**

e4sciences | Earthworks, LLC

Easting 801,520.2'
Northing 2,949,424.3'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 12:47 pm December 19, 2014
boring completed at 05:30 pm December 19, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.7' MLLW
Boring bottom elevation = -62.6' MLLW
Total depth below channel floor = 19.9'

Top of all rock elevation = not encountered
Rock refusal elevation = not encountered
Number of rock core runs = 0

Rock encountered: not encountered
Thickness of sediment = > 19.9'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot

Depth below mudline (feet): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Elevation MLLW* (feet): -34.0 -35.0 -36.0 -37.0 -38.0 -39.0 -40.0 -41.0 -42.0 -43.0 -44.0 -45.0 -46.0 -47.0 -48.0 -49.0 -50.0 -51.0 -52.0 -53.0 -54.0 -55.0 -56.0 -57.0 -58.0 -59.0 -60.0 -61.0 -62.0 -63.0 -64.0 -65.0 -66.0

water (-34.0 to -42.7); sediment (-42.7 to -62.6)

Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Sample interval	Recovery (feet)	Blow counts (blows/6")	Soil sample	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**
	President Roads Anchorage										
	*Channel floor elevation = -42.7' MLLW**										
OL	BLACK Organic SILT	0.25' Dark gray silt, wet	3" split spoon # 1		recovery = 1.70'	wor 4/4in 7 5					
ML/ SM	Holocene Green-gray SILT	0.44' Gray-green SILT, wet, trace sand									
SW /SM	Holocene Gray-green to dark gray f SAND, little silt, trace shell fragments, trace micas	1.00' Gray-green f SAND									
		-44.7' 1.60' Dark gray f SAND, little silt, laminae, trace micas, shell fragments, fish odor	3" split spoon # 2		recovery = 1.60'	6 9 9 10					
		-46.7'	*casing at angle repositioned deck of liftboat ground down to -48.6*								
		-48.6' 1.50' Dark gray f SAND, little silt, laminae, trace micas shell fragment, brown laminae	3" split spoon # 3		recovery = 1.50'	5 5 6 6					
SW /SM	Holocene Gray-green to dark gray f SAND, little silt, trace shell fragments, trace micas	*-50.6'* 1.20' Dark gray f SAND, little silt, laminae, trace micas trace shell fragment	3" split spoon # 4		recovery = 1.20'	2 2 2 2					
		-52.6' 1.60' Dark gray f SAND, little silt, laminae, trace micas trace shell fragment	3" split spoon # 5		recovery = 1.60'	5 4 6 5					
		-54.6' 2.0' Dark gray f SAND, little silt, finely layered	3" split spoon # 6		recovery = 2.00'	wor 7 7 10					
SW /SM	Gray-green to dark gray f SAND, little silt, trace shell fragments, trace micas	*-56.6'* 1.80' Dark gray f SAND, little silt, laminae, trace micas trace shell fragment	3" split spoon # 7		recovery = 1.80'	7 7 7 9					
		-58.6'	*ground down to -58.6*								
		-58.6' 1.00' Dark gray f SAND, little silt, laminae, trace micas, trace shell fragment	3" split spoon # 8		recovery = 1.80'	3 3 3 2					
SP	Holocene Gray well-sorted f SAND	0.65' well sorted gray f SAND, little silt, trace shells									
SM	Holocene Gray f SAND, little clay										

*Bottom of boring elevation = -62.6' MLLW**

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-10**

e4sciences | Earthworks, LLC

Easting 801,520.2'
Northing 2,949,424.3'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 06:57 pm December 19, 2014
boring completed at 12:35 pm December 19, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.7' MLLW
Boring bottom elevation = -62.6' MLLW
Total depth below channel floor = 19.9'

Top of all rock elevation = not reached
Rock refusal elevation = not reached
Number of rock core runs = 0

Rock encountered: N/A
Thickness of sediment = > 19.9'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

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- Mafic igneous rock with RQD >50
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- Hornfels & contact-metamorphic altered argillite RQD >50
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- Argillite with RQD >50

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c = coarse grained

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**LCS = Longest Core Segment within foot interval
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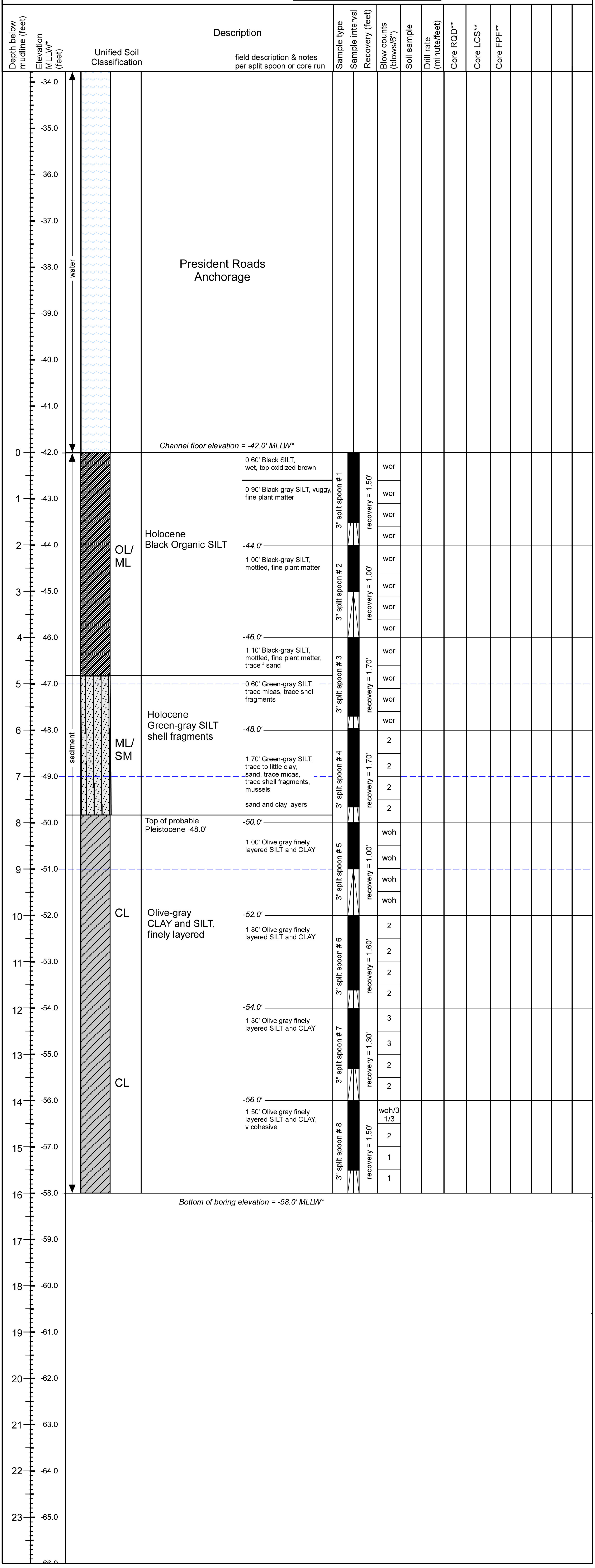

	0.60' Black SILT, wet, top oxidized brown 0.90' Black-gray SILT, vuggy, fine plant matter	3" split spoon # 1	recovery = 1.50'	wor wor wor wor
-44.0'	1.00' Black-gray SILT, mottled, fine plant matter	3" split spoon # 2	recovery = 1.00'	wor wor wor wor
-46.0'	1.10' Black-gray SILT, mottled, fine plant matter, trace f sand 0.60' Green-gray SILT, trace micas, trace shell fragments	3" split spoon # 3	recovery = 1.70'	wor wor wor wor
-48.0'	1.70' Green-gray SILT, trace to little clay, sand, trace micas, trace shell fragments, mussels sand and clay layers	3" split spoon # 4	recovery = 1.70'	2 2 2 2
-50.0'	1.00' Olive gray finely layered SILT and CLAY	3" split spoon # 5	recovery = 1.00'	woh woh woh woh
-52.0'	1.80' Olive gray finely layered SILT and CLAY	3" split spoon # 6	recovery = 1.60'	2 2 2 2
-54.0'	1.30' Olive gray finely layered SILT and CLAY	3" split spoon # 7	recovery = 1.30'	3 3 2 2
-56.0'	1.50' Olive gray finely layered SILT and CLAY, v cohesive	3" split spoon # 8	recovery = 1.50'	woh/3 1/3 2 1 1

US Army Corps
of Engineers®
New England District

Boston Harbor

e4sciences | Earthworks, LLC

boring FD14-11

President Roads Anchorage

Easting 796,866.6'
Northing 2,949,656.3'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

boring started at 11:45 am December 18, 2014
boring completed at 05:01 pm December 18, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -44.1 MLLW
Boring bottom elevation = -59.4 MLLW
Total depth below channel floor = 15.3'

Top of all rock elevation = -47.7'MLLW
Rock refusal elevation = -48.5'MLLW
Number of rock core runs = 2

Rock encountered: Cambridge Argillite
Thickness of sediment = 3.7'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▦ Gravel
- ▩ Sand & gravel
- ▤ Silt, sand & gravel
- ▧ Clay & gravel

Rock (Rock)
- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

Geological Formations

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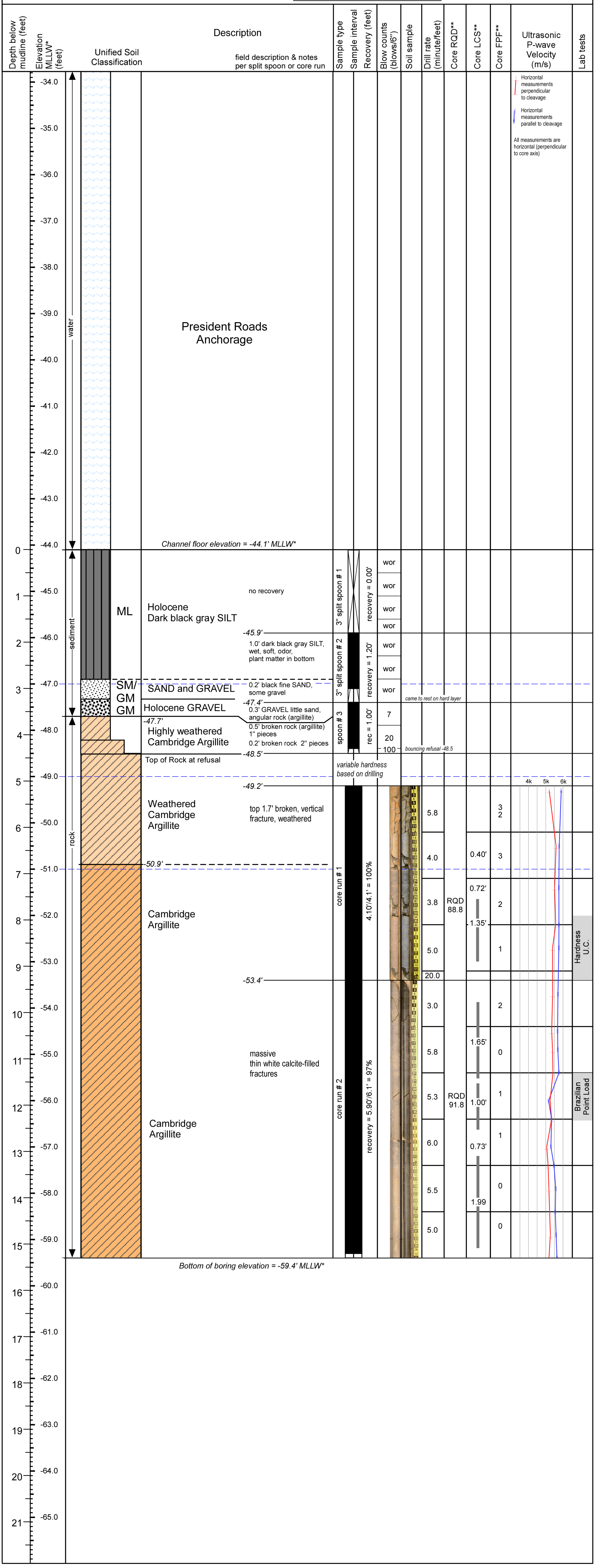
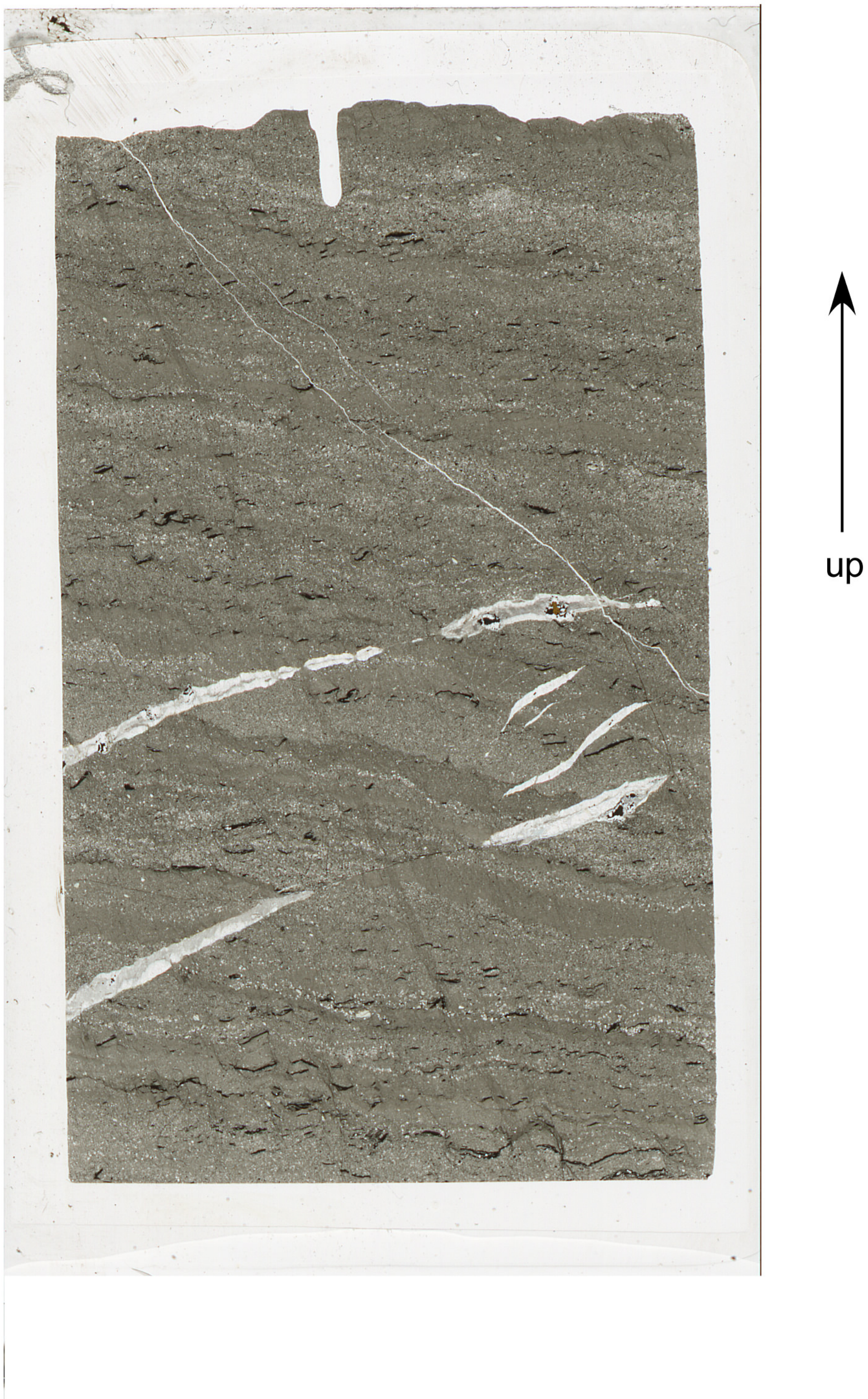


Boring FD-14-11 core run 1 piece a

Thin section of Cambridge Argillite.

Transmitted-light image.



Petrographic summary

Sample: FD-14-11 r1a 1" x 2" thin section
Boring: FD14-11 core run 1 piece a elevation:-49.20 to -49.34ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite

Sedimentary textures:

thinly layered with coarse silt and clay-rich mudstone
darker layers clay-sized particles

cross-lamination
graded layers
slump fold

Deformation features:

shallow dipping lithologic layers
pressure-solution seams
pressure-solution cleavage
stylolites

two sets of fractures at angles to lithological layering:

1. tension gashes/fractures
2. thin calcite filled fractures cross-cutting other fractures

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
quartz - secondary in fractures
calcite - secondary in fractures
pyrite
opaques in apparent fractures

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIENTATION (3)	HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
									Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COMPRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-11	1	ad	-51.8 to -52.93				M		3.5										
FD14-11	1	ad	-51.8 to -52.4				TH			42.6	1.1	44.0							
FD14-11	1	ad	-52.4 to -52.8	0.08	170.4	170.3	UCmod									17700	0.22	8.1E+06	0.12
FD14-11	2	aj	-55.41 to -56.4				M		3.5										
FD14-11	2	aj	-55.41 to -55.75	0.09			PL	Diametral					6.1	19198					
FD14-11	2	aj	-55.75 to -56.15	0.08	169.6	169.5	UCmod									16920	0.21	8.2E+06	0.11
FD14-11	2	aj	-56.2 to -56.4	0.07	168.1	168.0	B-1	A							1227				
FD14-11	2	aj	-56.2 to -56.4	0.10	167.7	167.5	B-2	B							666				

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-11
Sample: Run 1 - piece ad
Elevation: -51.8 to -52.4
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	Anvil Calibration Readings	Specimen Readings	D >7?
1	72.0	44.0	
2	72.0	43.0	
3	72.0	45.0	
4	70.0	45.0	
5	71.0	46.0	
6	70.0	44.0	
7	70.0	40.0	
8	70.0	43.0	
9	70.0	41.0	
10	71.0	40.0	
average	70.8	43.1	
theoretical reading on anvil	70.0		
correction factor	0.989		

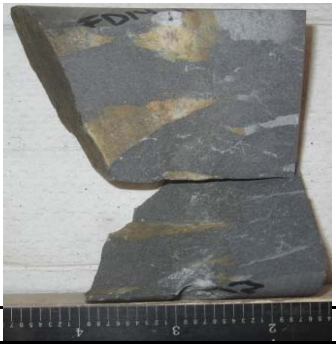
Corrected Average corrected reading, Hr: 42.6

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	37.71	33.06
Specimen Mass after 400 revolutions (grams)	37.19	32.61
Specimen Mass after 800 revolutions (grams)	36.72	32.17
dM after 400 revolutions (grams)	0.52	0.45
dM after 800 revolutions (grams)	0.99	0.89
Average ΔM (800 revolutions)	0.94	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	1.064	

Total Hardness, $H_T = H_R*(H_A)^{0.5}$ = 43.95

Boston Harbor		DATA SHEET TOTAL HARDNESS TEST Boring: FD14-11 Sample: Run 1 - piece ad Elevation: -51.8 to -52.4 ft	Data Sheet
e4sciences			
TerraSense, LLC	7803-15001		

Elevation:				
Load Orientation:	Diametral	Diametral		
Length to nearest free end, L (mm)	23.7	23.7		
Specimen Width, W (mm)	50.1	50.1		
D (mm)	51.0	47.0		
D' (mm)	47.0	44.0		
D_e (mm)	47.0	44.0		
Failure Load, P (lb)	2189	2806		
Point Load (N)	**9737**	**12482**		
Point Load (Mpa)	**4.29**	**6.09**		
Index, Is50 (psi)	**620**	**880**		
Unconfined Compressive Strength (psi)	**13939**	**19198**		
Specimen /Failure Sketch				
Tare No.				
Wet + Tare (gm)		360.68		
Dry + Tare (gm)		360.4		
Tare (gm)		50.68		
Water Content%		**0.09**		
Comments	Invalid Break			

Test by: RAT Test Date: 3/30/2015 Reviewed by: GET

Boston Harbor		**POINT LOAD STRENGTH INDEX OF ROCK** **ASTM D5731**
E4science		**Boring: FD14-11 Run: 2 - piece aj** **Elevation: -55.41 to -55.75 ft.**
TerraSense, LLC	7803-15001	

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-11
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 2 - piece aj

SPECIMEN READINGS

Test Number: B-1
Elevation: -56.2 to -56.4
Specimen mass(gm): 99.79

	Thickness (inch)	Diameter (inch)
	0.738	1.975
	0.738	1.976
	0.739	1.975
Average	0.738	1.975

Thickness / Diameter, (t/d): 0.37
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.

Data Acquisition File B14-11R2A
Maximum Load 2809 lb

	After Test
Container No.:	LC-4
Initial Mass + cont. (g):	133.07
Dry Mass + cont. (g):	133.00
Mass of cont. (g):	33.41
Water content (%):	**0.07**
Total unit weight (pcf):	168.11
Dry unit weight (pcf):	167.99
Splitting Tensile Strength (psi)	1226.62

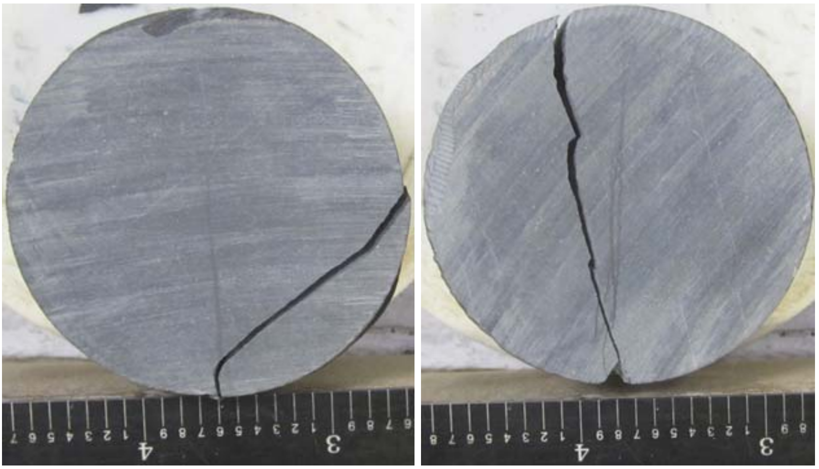
Test Number: B-2
Elevation: -56.2 to -56.4
Specimen mass(gm): 86.67

	Thickness (inch)	Diameter (inch)
	0.639	1.973
	0.648	1.974
	0.644	1.975
Average	0.644	1.974

Thickness / Diameter, (t/d): 0.33
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch

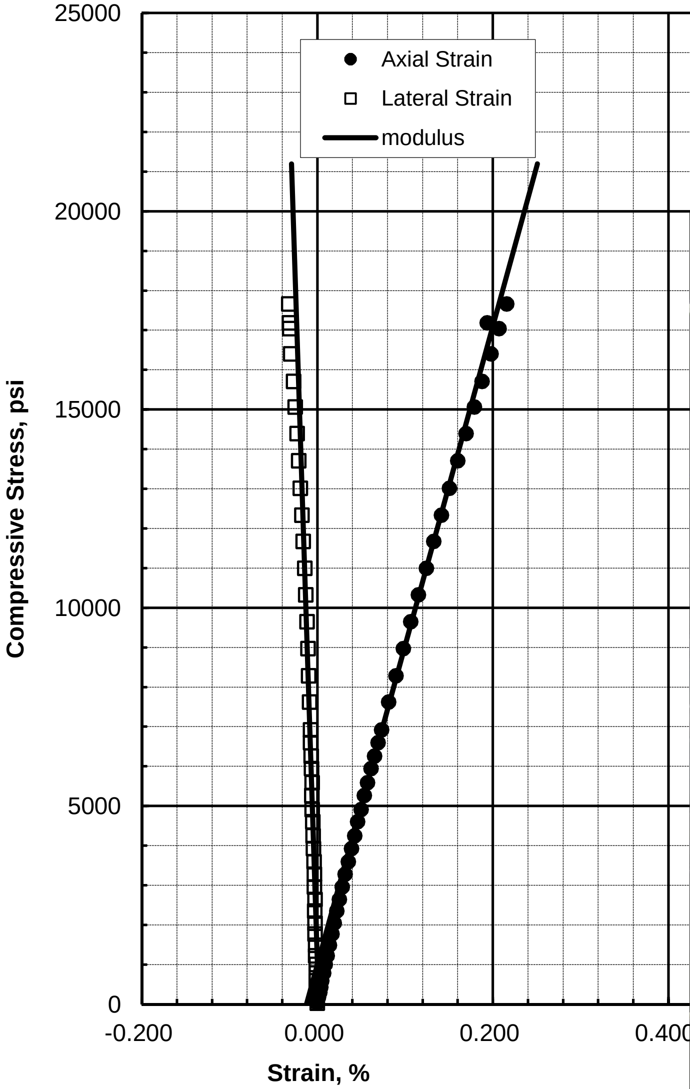
Data Acquisition File B14-11R2B
Maximum Load 1329 lb

	After Test
Container No.:	LA-219
Initial Mass + cont. (g):	119.62
Dry Mass + cont. (g):	119.53
Mass of cont. (g):	32.97
Water content (%):	**0.10**
Total unit weight (pcf):	167.66
Dry unit weight (pcf):	167.49
Splitting Tensile Strength (psi)	666.05



Failure Photo

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-11** **Run: 2 - piece aj Elevation: -56.2 to -56.4 ft.**
TerraSense, LLC	7803-15001		



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.08	170	170	4.864	1.971

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.11	0.22	17700	8.06E+06	0.12

FAILURE PHOTO

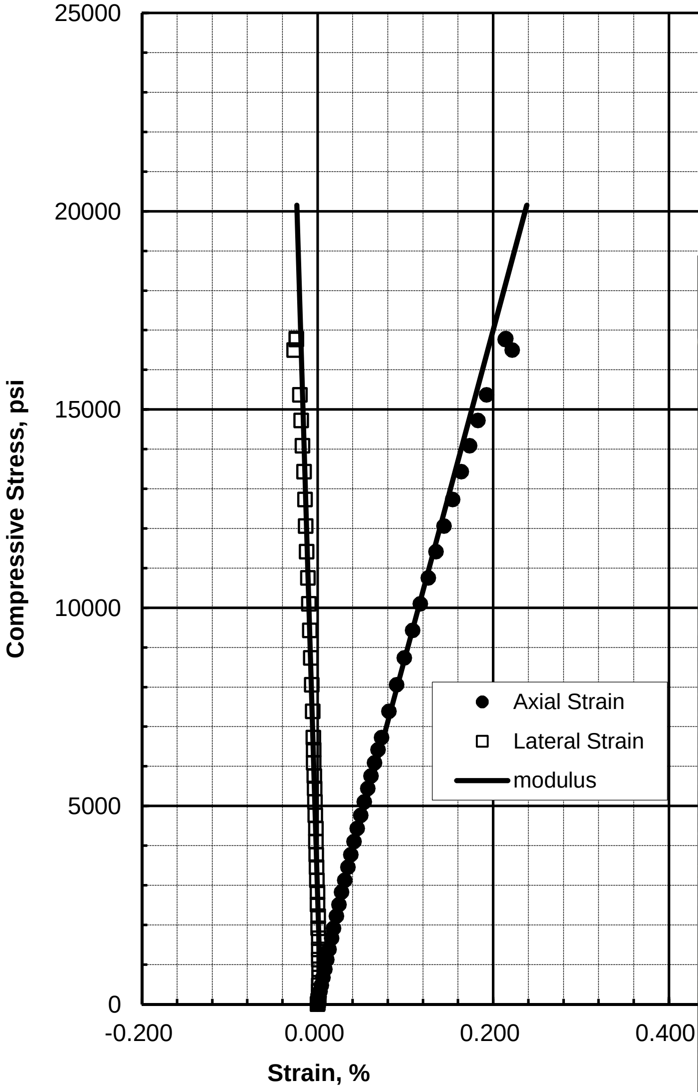
Tested by: GT Test Date: Apr-07-15

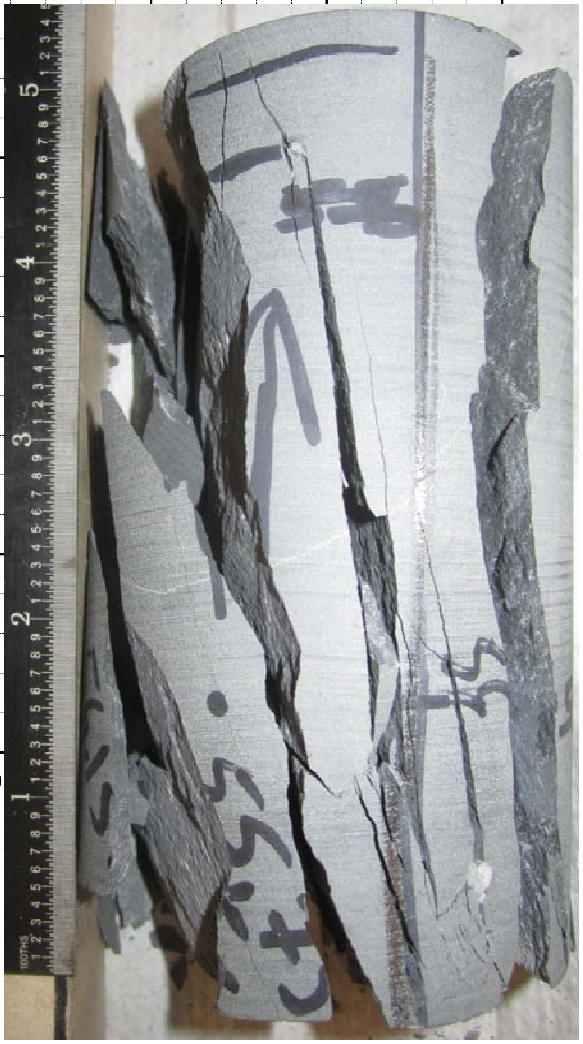
e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-11 Run: 1 ad
Elevation -52.4 to -52.8 ft.





Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.08	170	169	4.715	1.974

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.11	0.21	16920	8.23E+06	0.11

FAILURE PHOTO

Tested by: GT Test Date: Apr-07-15

e4sciences	**Boston Harbor**	**COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST**
TerraSense, LLC Project # 7803-15001		**Boring: FD14-11 Run: 2 aj Elevation -55.75 to -56.15 ft.**

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-11	1	-49.3	llbed	5,891.3	19,328.4
FD14-11	1	-49.3	xbed	5,191.1	17,031.3
FD14-11	1	-50.5	ll frac	5,773.4	18,941.6
FD14-11	1	-50.5	xfrac	5,592.3	18,347.5
FD14-11	1	-51.4	llbed	5,754.4	18,879.3
FD14-11	1	-51.4	xbed	5,507.1	18,067.8
FD14-11	1	-52.2	llbed	5,758.8	18,893.7
FD14-11	1	-52.2	xbed	5,571.1	18,277.8
FD14-11	1	-52.7	llbed	5,753.0	18,874.5
FD14-11	1	-52.7	xbed	5,387.3	17,674.7
FD14-11	2	-53.7	llbed	5,702.0	18,707.4
FD14-11	2	-53.7	xbed	5,391.4	17,688.2
FD14-11	2	-54.5	llbed	5,678.9	18,631.6
FD14-11	2	-54.5	xbed	5,336.7	17,508.9
FD14-11	2	-54.9	llbed	5,694.8	18,683.7
FD14-11	2	-54.9	xbed	5,387.3	17,674.7
FD14-11	2	-55.4	llbed	5,758.8	18,893.7
FD14-11	2	-55.4	xbed	5,410.5	17,750.9
FD14-11	2	-56.0	llbed	5,159.9	16,928.7
FD14-11	2	-56.0	xbed	5,244.7	17,207.1
FD14-11	2	-56.4	llbed	5,329.9	17,486.7
FD14-11	2	-56.4	xbed	5,332.6	17,495.6
FD14-11	2	-57.0	llbed	5,291.7	17,361.1
FD14-11	2	-57.0	xbed	5,048.0	16,561.7
FD14-11	2	-57.4	llbed	5,469.6	17,944.9
FD14-11	2	-57.4	xbed	5,128.1	16,824.6
FD14-11	2	-57.9	llbed	5,572.5	18,282.4
FD14-11	2	-57.9	xbed	5,174.5	16,976.6
FD14-11	2	-58.4	llbed	5,545.0	18,192.3
FD14-11	2	-58.4	xbed	5,216.3	17,113.7
FD14-11	2	-58.9	llbed	5,593.1	18,350.1
FD14-11	2	-58.9	xbed	5,260.7	17,259.4
FD14-11	2	-59.4	llbed	5,646.7	18,525.8
FD14-11	2	-59.4	xbed	5,178.0	16,988.2

US Army Corps
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New England District

e4sciences | Earthworks, LLC

Boston Harbor

boring **FD14-12**

President Roads Anchorage

Easting 801,520.2'
Northing 2,949,424.3'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

boring started at 06:49 am December 18, 2014
boring completed at 11:20 am December 18, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -47.7' MLLW
Boring bottom elevation = -65.7' MLLW
Total depth below channel floor = 18.0'

Top of all rock elevation = not reached
Rock refusal elevation = not reached
Number of rock core runs = 0

Rock encountered: not reached
Thickness of sediment = > 18.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▩ Gravel
- ▒ Sand & gravel
- ▦ Silt, sand & gravel
- ▩ Clay & gravel

Rock (Rock)
- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

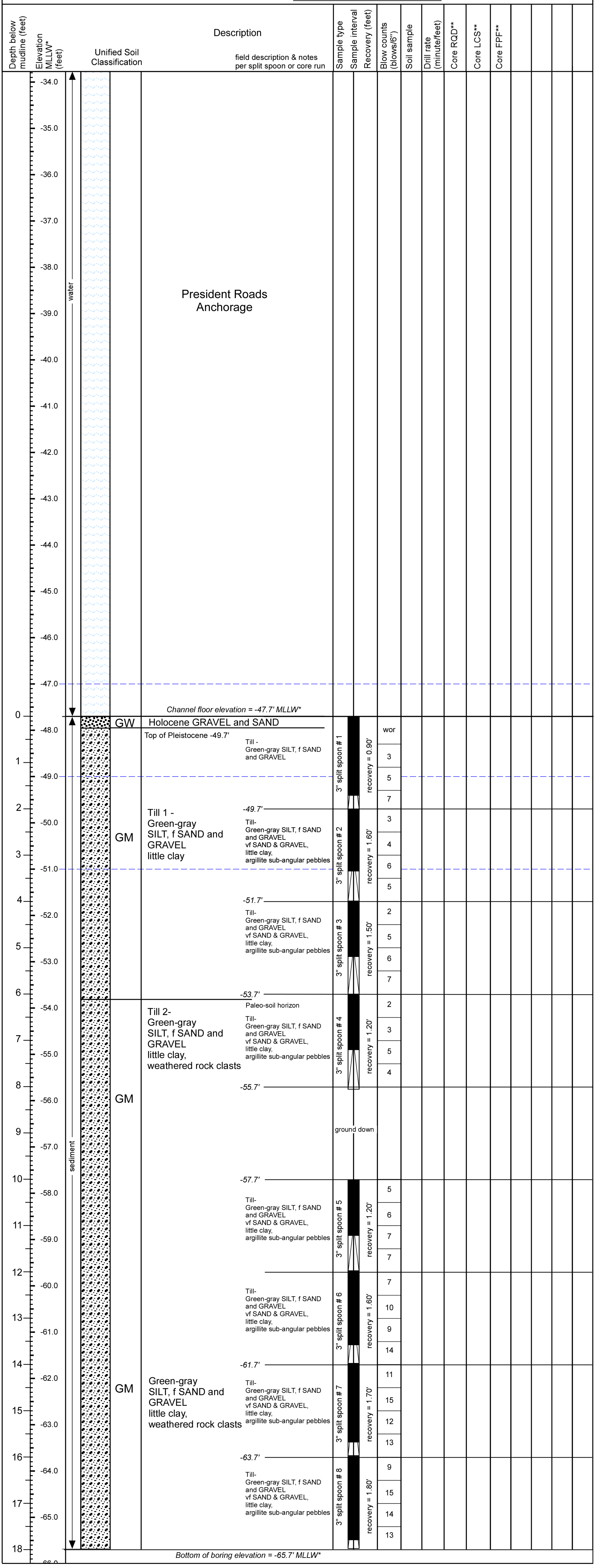
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



President Roads
Anchorage

*Channel floor elevation = -47.7' MLLW**

Holocene GRAVEL and SAND

Top of Pleistocene -49.7'

Till 1 -
Green-gray
SILT, f SAND and
GRAVEL
little clay

Till 2-
Green-gray
SILT, f SAND and
GRAVEL
little clay,
weathered rock clasts

Green-gray
SILT, f SAND and
GRAVEL
little clay,
weathered rock clasts

Elevation	Field description & notes	Sample type	Recovery (feet)	Blow counts (blows/6")
	Till - Green-gray SILT, f SAND and GRAVEL	3" split spoon # 1	recovery = 0.90'	wor 3 5 7
-49.7'	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 2	recovery = 1.60'	3 4 6 5
-51.7'	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 3	recovery = 1.50'	2 5 6 7
-53.7'	Paleo-soil horizon Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 4	recovery = 1.20'	2 3 5 4
-55.7'		ground down		
-57.7'	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 5	recovery = 1.20'	5 6 7 7
	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 6	recovery = 1.60'	7 10 9 14
-61.7'	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 7	recovery = 1.70'	11 15 12 13
-63.7'	Till- Green-gray SILT, f SAND and GRAVEL vf SAND & GRAVEL, little clay, argillite sub-angular pebbles	3" split spoon # 8	recovery = 1.80'	9 15 14 13

*Bottom of boring elevation = -65.7' MLLW**

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Boston Harbor

boring **FD14-13**

page 1 of 1

Easting 798,442.4'
Northing 2,948,352.1'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 12:23 pm December 17, 2014
boring completed at 05:26 pm December 17, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -45.1 MLLW	Top of all rock elevation = -47.9' MLLW	Rock encountered: Cambridge Argillite
Boring bottom elevation = -60.0 MLLW	Rock refusal elevation = -49.8' MLLW	Thickness of sediment = 2.8'
Total depth below channel floor = 14.9'	Number of rock core runs = 3	

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
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described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

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Rock
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

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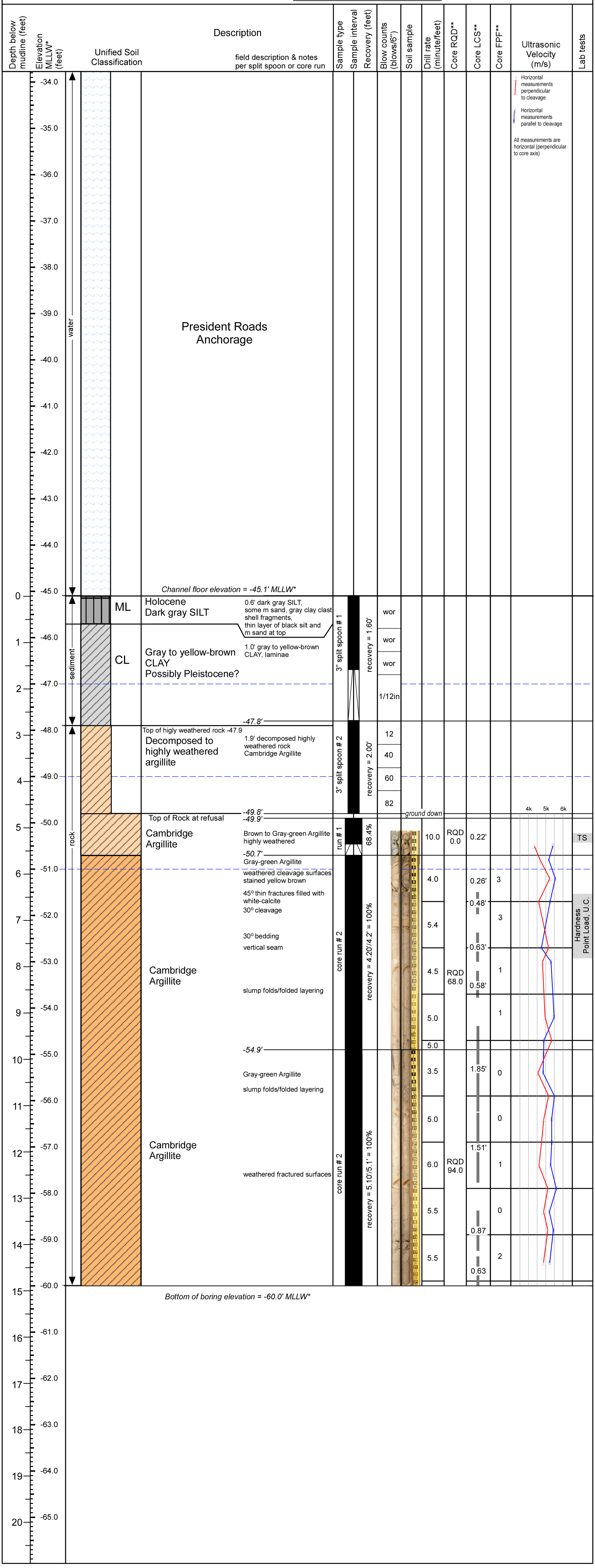


Horizontal measurements perpendicular to cleavage

Horizontal measurements parallel to cleavage

All measurements are horizontal (perpendicular to core axis)

President Roads Anchorage

Channel floor elevation = -45.1' MLLW

ML — Holocene Dark gray SILT — 0.6' dark gray SILT, some m sand, gray clay clast shell fragments, thin layer of black silt and m sand at top

CL — Gray to yellow-brown CLAY Possibly Pleistocene? — 1.0' gray to yellow-brown CLAY, laminae

3" split spoon # 1 — recovery = 1.60' — blow counts: wor, wor, wor, 1/12in

-47.8'

Top of higly weathered rock -47.9

Decomposed to highly weathered argillite — 1.9' decomposed highly weathered rock Cambridge Argillite

3" split spoon # 2 — recovery = 2.00' — blow counts: 12, 40, 60, 82

-49.8'
-49.9'

Top of Rock at refusal

Cambridge Argillite — Brown to Gray-green Argillite highly weathered

run # 1 — 68.4% — drill rate 10.0 — RQD 0.0 — LCS 0.22' — TS

-50.7'

Cambridge Argillite — Gray-green Argillite
weathered cleavage surfaces stained yellow brown
45° thin fractures filled with white-calcite
30° cleavage
30° bedding
vertical seam
slump folds/folded layering

core run # 2 — recovery = 4.20'/4.2' = 100% — drill rate 4.0, 5.4, 4.5, 5.0, 5.0 — RQD 68.0 — LCS 0.26', 0.48', 0.63', 0.58' — FPF 3, 3, 1, 1 — Hardness Point Load, U.C.

-54.9'

Cambridge Argillite — Gray-green Argillite
slump folds/folded layering
weathered fractured surfaces

core run # 2 — recovery = 5.10'/5.1' = 100% — drill rate 3.5, 5.0, 6.0, 5.5, 5.5 — RQD 94.0 — LCS 1.85', 1.51', 0.87, 0.63 — FPF 0, 0, 1, 0, 2

Bottom of boring elevation = -60.0' MLLW

Boring FD-14-13 spoon 2 piece ca

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-13s2ca

1" x 2" thin section

Boring: FD14-13 spoon 2 piece ca

Formation: Cambridge Argillite.

Lithology: argillite

Sedimentary textures:

thin layers
silt and sand-sized mud clasts
elongate mud clast or pressure-solution truncated layer
altered grains

Deformation features:

steeply dipping lithologic layers

minor pressure-solution seams

no-apparent fractures

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic

grains replaced by chlorit

Boring FD-14-13 core run 1 piece a

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-13r1a
Boring: FD14-13 core run 1 piece a

1" x 2" thin section
elevation: -49.90 to -50.05ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
shale-dominated argillite

Sedimentary textures:

thin layers
mud clasts
altered grains

Deformation features:

near-vertical dipping lithologic layers

minor pressure-solution seams

no-apparent fractures

Key minerals:

quartz - detrital silt-sized grains
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary

grains replaced by chlorite

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-13	2	j	-50.94 to -51.12				M		3.5										
FD14-13	2	j	-50.94 to -51.12	0.21			PL	Diametral					0.3	1166					
FD14-13	2	j	-50.94 to -51.12				PL	Axial					4.2	12874					
FD14-13	2	p	-52.31 to -52.93				M		3.5										
FD14-13	2	p	-52.3 to -52.4	0.15			PL	Diametral					0.9	3032					
FD14-13	2	p	-52.4 to -52.8	0.14	167.9	167.7	UCmod									12810	0.13	7.2E+06	0.09

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral			
Length to nearest free end, L (mm)	20.2			
Specimen Width, W (mm)	49.9			
D (mm)	51.0			
D' (mm)	51.0			
D_e (mm)	51.0			
Failure Load, P (lb)	526			
Point Load (N)	**2340**			
Point Load (Mpa)	**0.91**			
Index, Is50 (psi)	**130**			
Unconfined Compressive Strength (psi)	**3032**			
Specimen /Failure Sketch				
Tare No.	M-7			
Wet + Tare (gm)	245.4			
Dry + Tare (gm)	245.1			
Tare (gm)	51.29			
Water Content%	**0.15**			
Comments				

Test by: RAT Test Date: 3/30/2015 Reviewed by: GET

Boston Harbor

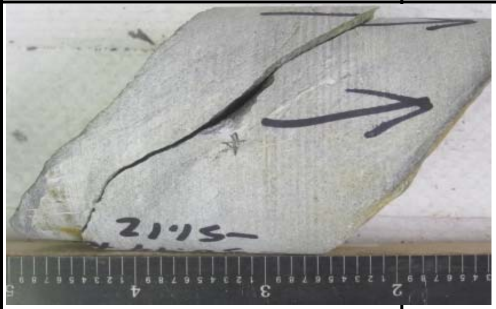
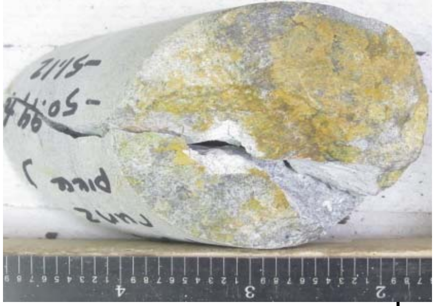
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-13 Run: 2 - piece p
Elevation: -52.3 to -52.4 ft.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	22.5		25.1	
Specimen Width, W (mm)	50.0		50.2	
D (mm)	51.0		30.0	
D' (mm)	51.0		26.0	
D_e (mm)	51.0		40.8	
Failure Load, P (lb)	196		1732	
Point Load (N)	**872**		**7704**	
Point Load (Mpa)	**0.34**		**4.23**	
Index, Is50 (psi)	**50**		**610**	
Unconfined Compressive Strength (psi)	**1166**		**12874**	
Specimen /Failure Sketch				
Tare No.	M-23			
Wet + Tare (gm)	229.36			
Dry + Tare (gm)	228.98			
Tare (gm)	50.96			
Water Content%	**0.21**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

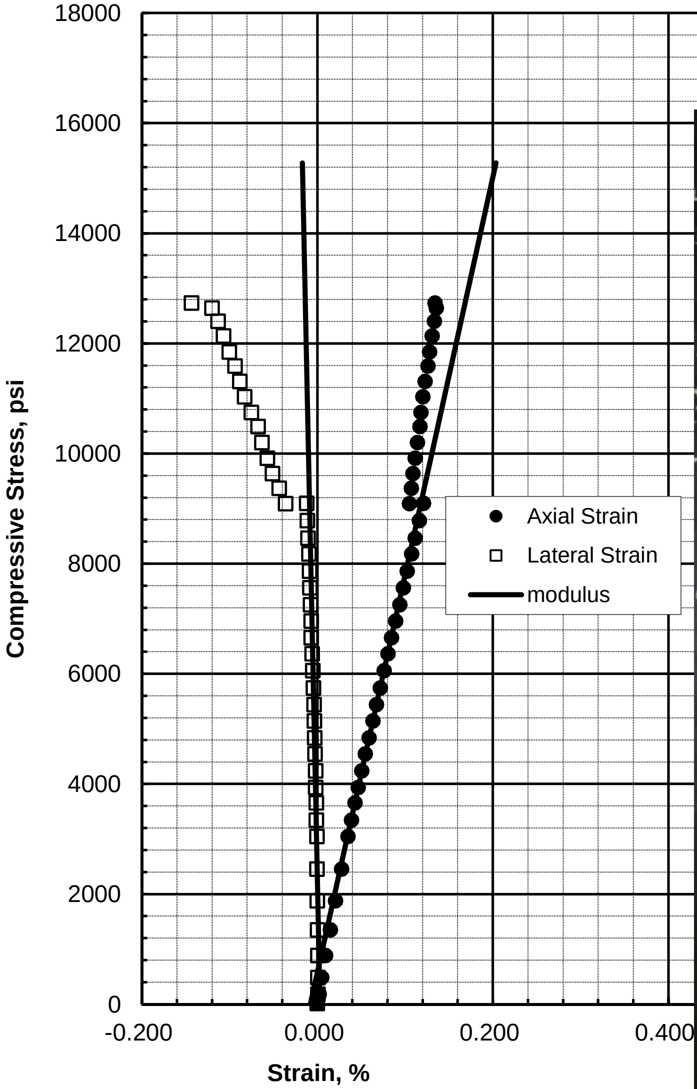
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

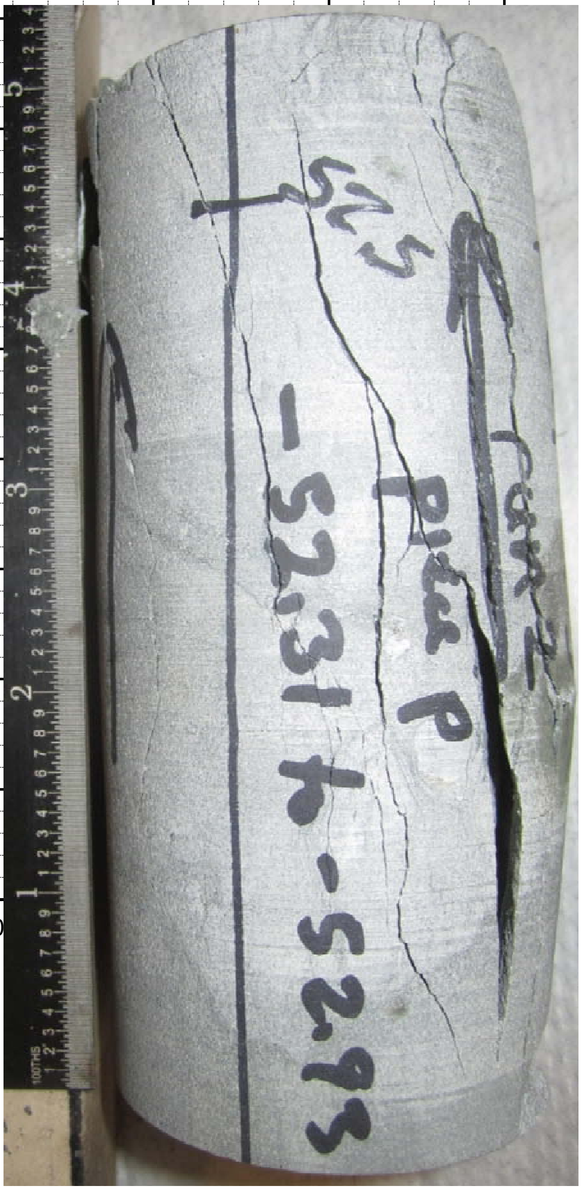
E4science

TerraSense, LLC

7803-15001

Boring: FD14-13 Run: 2 - piece j
Elevation: -50.94 to -51.12 ft.





Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.14	168	168	4.801	1.961

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.12	0.13	12810	7.23E+06	0.09

FAILURE PHOTO

Tested by: GT Test Date: Apr-07-15

e4sciences	**Boston Harbor**	**COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST**
TerraSense, LLC Project # 7803-15001		**Boring: FD14-13 Run: 2 p Elevation -52.4 to -52.8 ft.**

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-13	1	-50.5	llfrac	5,404.3	17,730.8
FD14-13	1	-50.5	xfrac	4,330.0	14,206.2
FD14-13	2	-50.8	llfrac	5,169.2	16,959.4
FD14-13	2	-50.8	xfrac	4,661.8	15,294.6
FD14-13	2	-51.2	llfrac	5,546.4	18,196.9
FD14-13	2	-51.2	xfrac	5,225.5	17,144.1
FD14-13	2	-51.7	llfrac	5,242.8	17,200.6
FD14-13	2	-51.7	xfrac	4,579.9	15,025.9
FD14-13	2	-52.7	llbed	4,739.6	15,549.7
FD14-13	2	-52.7	xbed	5,156.1	16,916.3
FD14-13	2	-53.0	llbed	5,296.6	17,377.3
FD14-13	2	-53.0	xbed	4,800.2	15,748.7
FD14-13	2	-54.2	llbed	5,479.7	17,977.9
FD14-13	2	-54.2	xbed	4,951.5	16,245.0
FD14-13	2	-54.7	llbed	4,880.8	16,013.1
FD14-13	2	-54.7	xbed	5,335.4	17,504.4
FD14-13	3	-55.0	llbed	4,865.0	15,961.4
FD14-13	3	-55.4	llbed	4,837.3	15,870.3
FD14-13	3	-55.4	xbed	4,539.3	14,892.8
FD14-13	3	-55.9	llbed	5,494.6	18,026.7
FD14-13	3	-55.9	xbed	5,159.7	16,928.2
FD14-13	3	-56.4	llbed	5,334.0	17,500.0
FD14-13	3	-56.4	xbed	4,876.2	15,997.9
FD14-13	3	-56.9	llbed	5,338.1	17,513.3
FD14-13	3	-56.9	xbed	4,748.1	15,577.7
FD14-13	3	-57.4	llbed	5,274.8	17,305.7
FD14-13	3	-57.4	xbed	4,599.1	15,088.8
FD14-13	3	-57.9	llbed	5,611.1	18,409.0
FD14-13	3	-57.9	xbed	5,116.3	16,785.7
FD14-13	3	-58.4	llbed	5,202.5	17,068.6
FD14-13	3	-58.4	xbed	4,867.5	15,969.5
FD14-13	3	-58.8	llbed	5,434.6	17,830.1
FD14-13	3	-58.8	xbed	5,112.1	16,772.1
FD14-13	3	-59.5	llbed	5,220.2	17,126.7
FD14-13	3	-59.5	xbed	4,860.1	15,945.2

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-14**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 798,623.9'
Northing 2,948,720.7'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 6:40 am December 17, 2014
boring completed at 11:45 am December 17, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.8 MLLW
Boring bottom elevation = -57.1 MLLW
Total depth below channel floor = 14.3'

Top of all rock elevation = -44.1' MLLW
Rock refusal elevation = -44.4' MLLW
Number of rock core runs = 3

Rock encountered: Cambridge Argillite
Thickness of sediment = 1.3'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils

- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Sediment

Rock

- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Rock

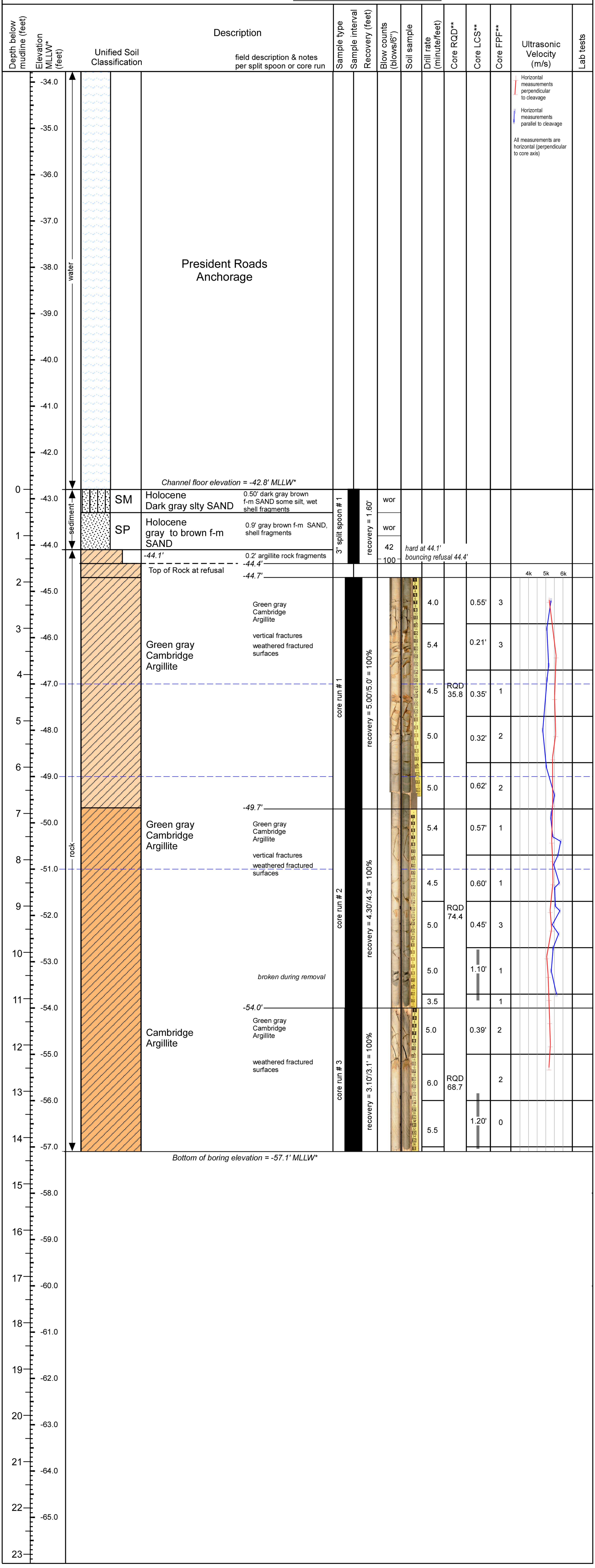
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-14 core run 1 piece h

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-14r1h
Boring: FD14-14 core run 1 piece h

1" x 2" thin section
elevation: -47.71 to -47.89ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
thinly layered shale-dominated argillite

Sedimentary textures:

thin layering
mud clasts
darker layers dominantly clay-sized particles

steeply dipping lithologic layers

pressure-solution seams parallel to lithological layering
slight crenulation

calcite-filled fractures at high-angle to layering

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-14	1	-45.2	llbed	5,297.0	17,378.7
FD14-14	1	-45.2	xbed	4,488.2	14,725.2
FD14-14	1	-45.8	llfrac	5,057.0	16,591.1
FD14-14	1	-45.8	xfrac	4,290.8	14,077.6
FD14-14	1	-46.6	llfrac	5,162.0	16,935.6
FD14-14	1	-46.6	xfrac	5,076.6	16,655.6
FD14-14	1	-46.9	llbed	5,067.2	16,624.7
FD14-14	1	-46.9	xbed	4,401.6	14,440.8
FD14-14	1	-48.0	llfrac	4,817.5	15,805.3
FD14-14	1	-48.0	xfrac	5,156.5	16,917.7
FD14-14	1	-48.8	llbed	5,029.0	16,499.3
FD14-14	1	-48.8	xbed	5,145.1	16,880.1
FD14-14	1	-49.4	llbed	5,496.4	18,032.7
FD14-14	1	-49.4	xbed	4,656.3	15,276.5
FD14-14	1	-49.9	llbed	5,289.0	17,352.3
FD14-14	1	-49.9	xbed	4,909.4	16,107.0
FD14-14	2	-49.8	llbed	5,313.7	17,433.5
FD14-14	2	-49.8	xbed	4,817.5	15,805.3
FD14-14	2	-50.3	llfrac	5,397.5	17,708.3
FD14-14	2	-50.3	xfrac	4,957.3	16,264.2
FD14-14	2	-50.9	llbed	5,454.1	17,894.0
FD14-14	2	-50.9	xbed	4,961.6	16,278.1
FD14-14	2	-51.4	llbed	5,511.7	18,083.0
FD14-14	2	-51.4	xbed	4,504.4	14,778.2
FD14-14	2	-51.8	llbed	5,550.6	18,210.7
FD14-14	2	-51.8	xbed	5,328.9	17,483.2
FD14-14	2	-52.2	llbed	5,375.7	17,636.8
FD14-14	2	-52.2	xbed	5,690.6	18,669.9
FD14-14	2	-52.7	llbed	5,422.2	17,789.5
FD14-14	2	-52.7	xbed	5,125.5	16,816.1
FD14-14	2	-53.2	llbed	5,312.7	17,430.3
FD14-14	2	-53.2	xbed	5,175.8	16,980.9
FD14-14	2	-53.7	llbed	5,615.3	18,423.0
FD14-14	2	-53.7	xbed	5,142.7	16,872.4
FD14-14	3	-50.4	llbed	5,858.9	19,222.2
FD14-14	3	-50.4	xbed	5,080.0	16,666.7
FD14-14	3	-50.7	llfrac	5,702.0	18,707.4
FD14-14	3	-50.7	xfrac	4,551.5	14,932.8
FD14-14	3	-51.3	llbed	5,773.5	18,942.0
FD14-14	3	-51.3	xbed	4,783.1	15,692.6
FD14-14	3	-51.9	llbed	5,810.5	19,063.5
FD14-14	3	-51.9	xbed	4,668.9	15,317.9
FD14-14	3	-52.4	llbed	5,735.3	18,816.6
FD14-14	3	-52.4	xbed	4,957.8	16,265.7

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-15**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 792,108.6'
Northing 2,947,589.6'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 06:50 am December 11, 2014
boring completed at 01:15 pm December 11, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -40.4 MLLW
Boring bottom elevation = -58.4' MLLW
Total depth below channel floor = 18.0'

Top of all rock elevation = -49.1'MLLW
Rock refusal elevation = not reached
Number of rock core runs = 0

Rock encountered: not reached
Thickness of sediment = 8.7'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

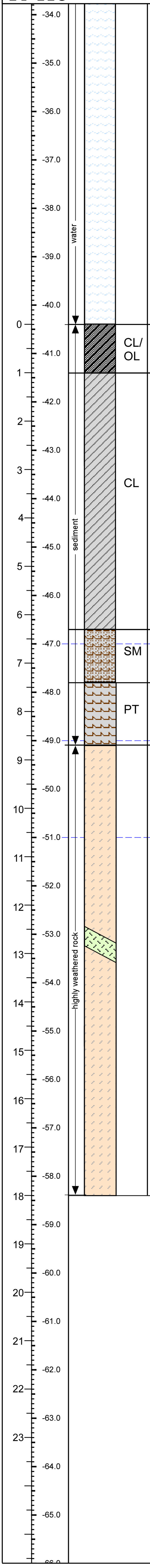
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Main Channel

*Channel floor elevation = -40.4' MLLW**

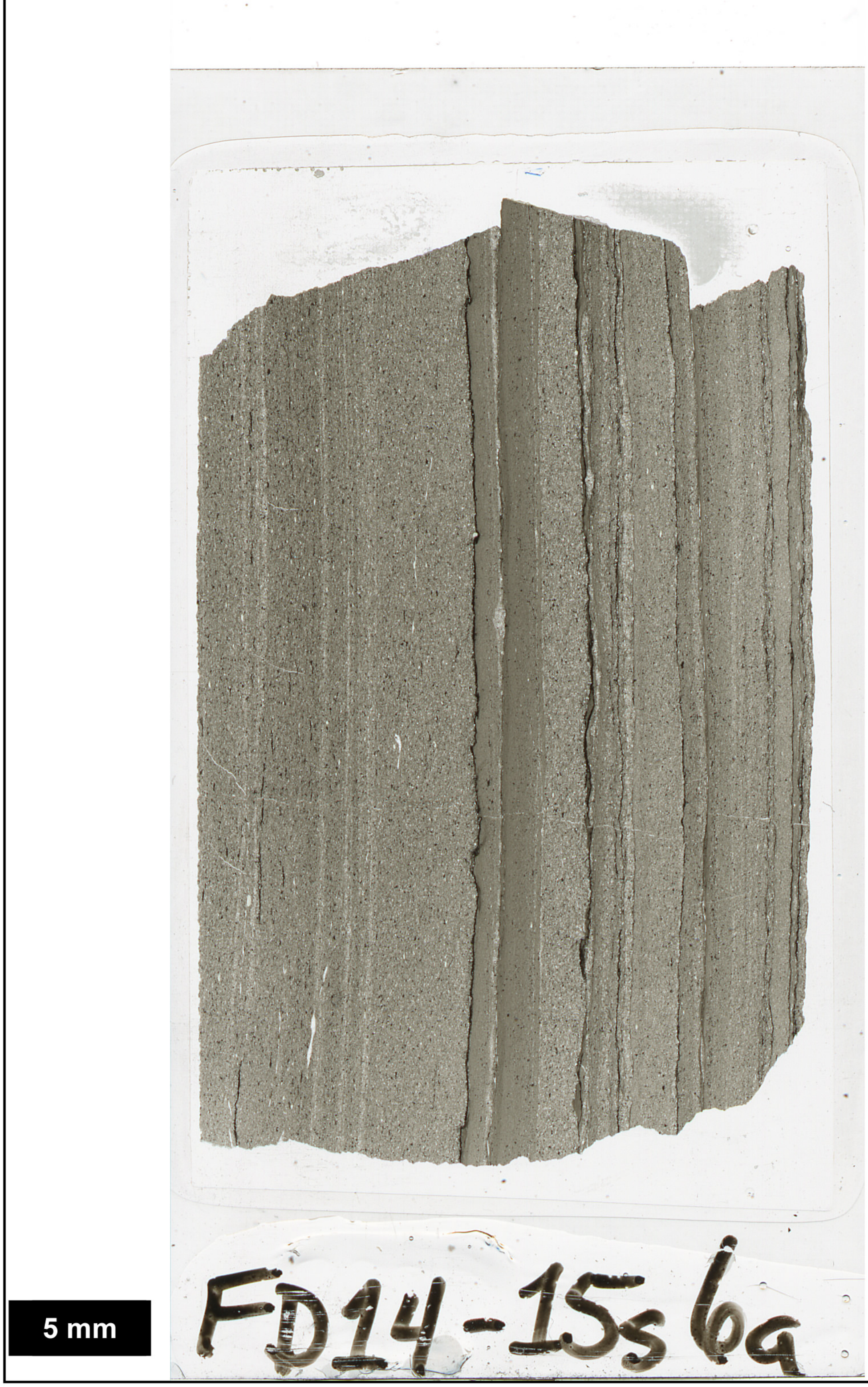
Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")	Lab tests
CL/ OL CL	Reworked green-gray clayey SILT, BLACK SILT laminae and shell fragments Holocene Green-gray clayey SILT, fine micas, organic laminae	Predominantly reworked green-gray SILT, some clay, with BLACK SILT laminae and shell fragments Green-gray SILT, some clay, trace fine micas Green-gray CLAY and SILT	3" split spoon # 1	recovery = 2.00'	wor wor wor wor	
		-42.4' Green-gray SILT, some clay, trace fine micas, laminae, organic lamina	3" split spoon # 2	recovery = 1.40'	wor wor wor wor	
		-44.4' Green-gray SILT, some clay, trace fine micas, laminae, organic lamina	3" split spoon # 3	recovery = 1.85'	wor wor wor wor	
SM PT	Holocene PEATY SAND Holocene PEAT	*-46.4'* Green-gray SILT, some clay PEATY SAND, trace f gravel (argillite), trace shells, wood fragment top grades upward into clayey silt PEAT little f sand, rootlets, trace f micas	3" split spoon # 4	recovery = 1.8'	wor 2 1 3	
	-49.1' Decomposed to highly weathered and fractured CAMBRIDGE ARGILLITE	*-48.4'* PEAT little f sand, rootlets, trace f micas, trace f gravel (argillite) ARGILLITE, high-angled cleavage, in place	3" split spoon # 5	recovery = 1.50'	19 29 18 11	
		-50.4' Broken ARGILLITE, and highly weathered, light-gray clay stained, shaley argillite	3" split spoon # 6	recovery = 0.75'	29 14 14 17	TS
	Thin DIABASE dike or sill	*-52.4'* Broken ARGILLITE, and highly weathered, light-gray clay stained, piece of DIABASE	3" split spoon # 7	recovery = 0.30'	19 41 21 14	TS
		-54.4' Broken ARGILLITE, and highly weathered, light-gray clay stained, shaley argillite	3" split spoon # 8	recovery = 1.12'	10 14 14 14	
	Broken highly weathered Cambridge Argillite	*-56.4'* Broken ARGILLITE, and highly weathered, light-gray clay stained, shaley argillite	3" split spoon # 9	recovery = 1.00'	17 16 17 11	

Sample interval | Soil sample | Drill rate (minute/feet) | Core RQD** | Core LCS** | Core FPF**

*Bottom of boring elevation = -58.4' MLLW**

Boring FD-14-15 spoon 6 piece a

Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-15s6a

1" x 2" thin section

Boring: FD14-15 spoon 6 piece a

Formation: Cambridge Argillite.

Lithology: argillite
laminated shake-dominated argillite

Sedimentary textures:

thinly layered
laminae

cross-lamination
graded layers
slump fold

Deformation features:

orientation unknown (unoriented sample from split spoon)
lithologic layers parallel to pressure solution features

pressure-solution seams stylolites

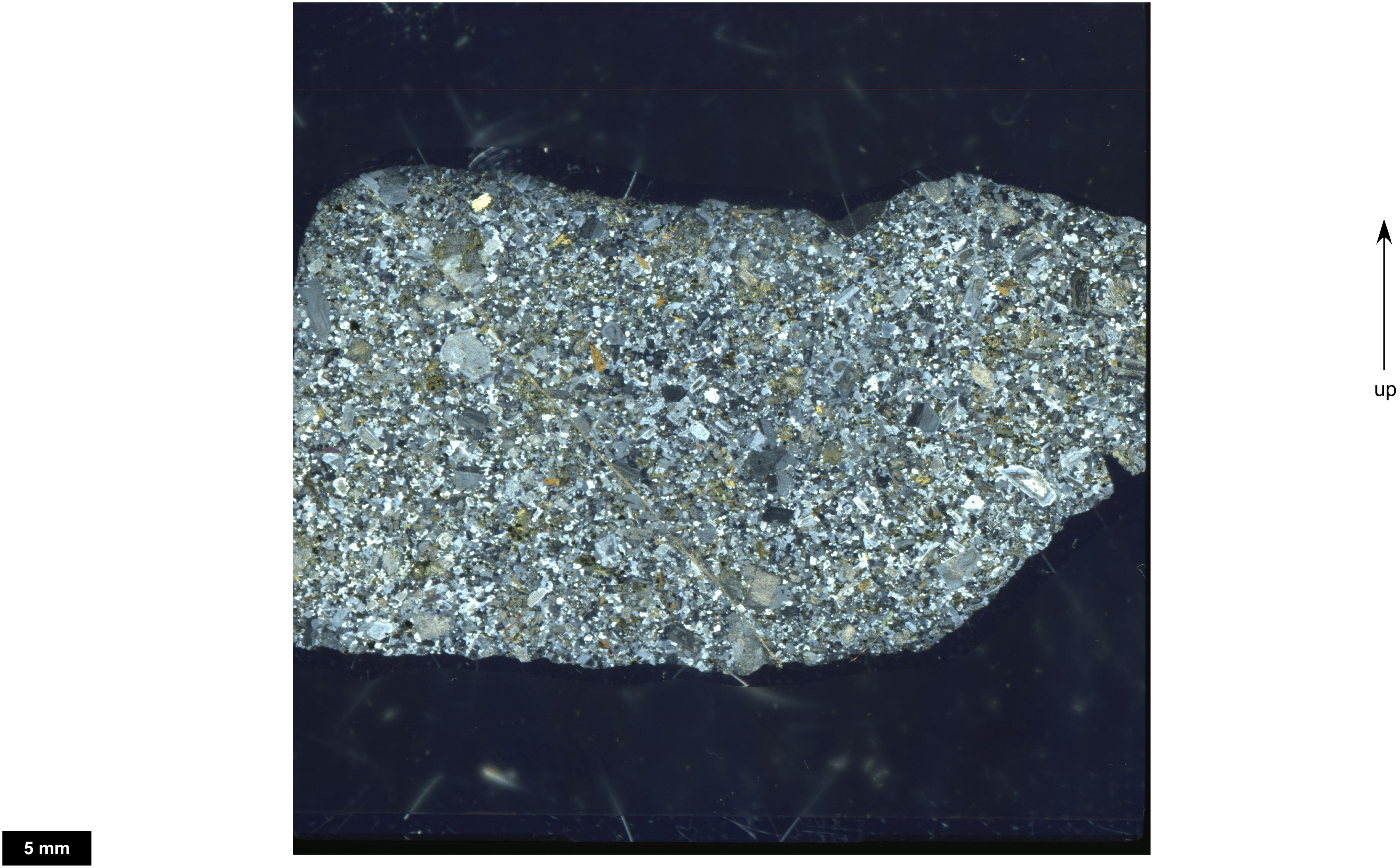
two fracture orientations

1. calcite-filled fractures sub-perpendicular to lithological layering
2. subtle calcite-filled fractures low angle to layering

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques - secondary

Boring FD-14-25 spoon 7
Thin section of Diabase
Transmitted-light crossed-polarized light image.



Petrographic summary

Sample: FD14-15s7

2" x 3" thin section

Boring: FD14-15 spoon 7

Formation: Diabase intruded into the Cambridge Argillite.

Lithology: diabase

Sedimentary textures:

no laminae
no lithological layering

crystalline igneous texture
subophitic texture

Deformation features:

no cleavage apparent in thin section
no pressure-solution seams apparent

Key minerals:

plagioclase
olivine
augite
opaques primary and secondary
olivine pseudomorphs
chlorite - secondary/metamorphic
white mica/sericite - secondary

chlorite replaced crystals
white mica/sericite replaced crystals

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-16**

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page 1 of 1

Easting 791,668.2'
Northing 2,947,381.6'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 01:50 pm December 11, 2014
boring completed at 08:01 pm December 11, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -43.7 MLLW
Boring bottom elevation = -58.3 MLLW
Total depth below channel floor = 14.6'

Top of all rock elevation = -51.2' MLLW
Rock refusal elevation = -51.7 'MLLW
Number of rock core runs = 2

Rock encountered: Cambridge Argillite
Thickness of sediment = > 0.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ▒ Sand
- ▓ Gravel
- ▒ Sand & gravel
- ▦ Silt, sand & gravel
- ▨ Clay & gravel

Rock (Rock)
- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

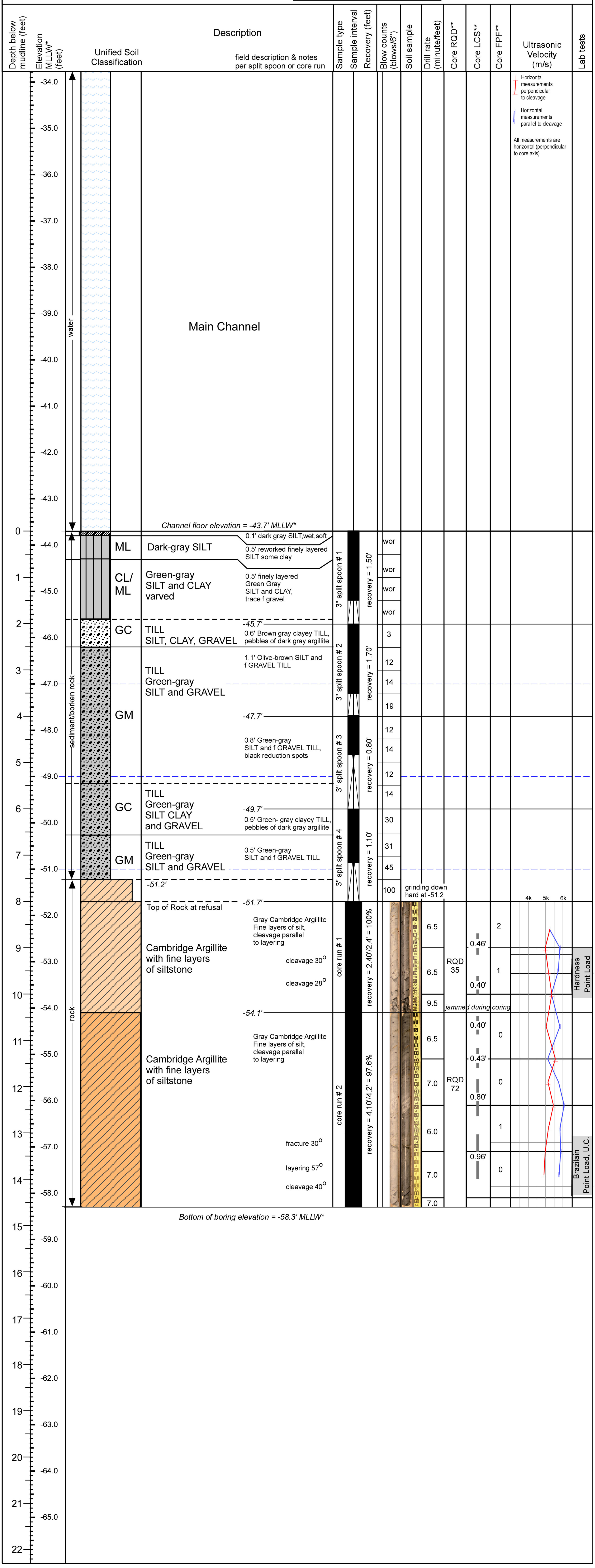
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

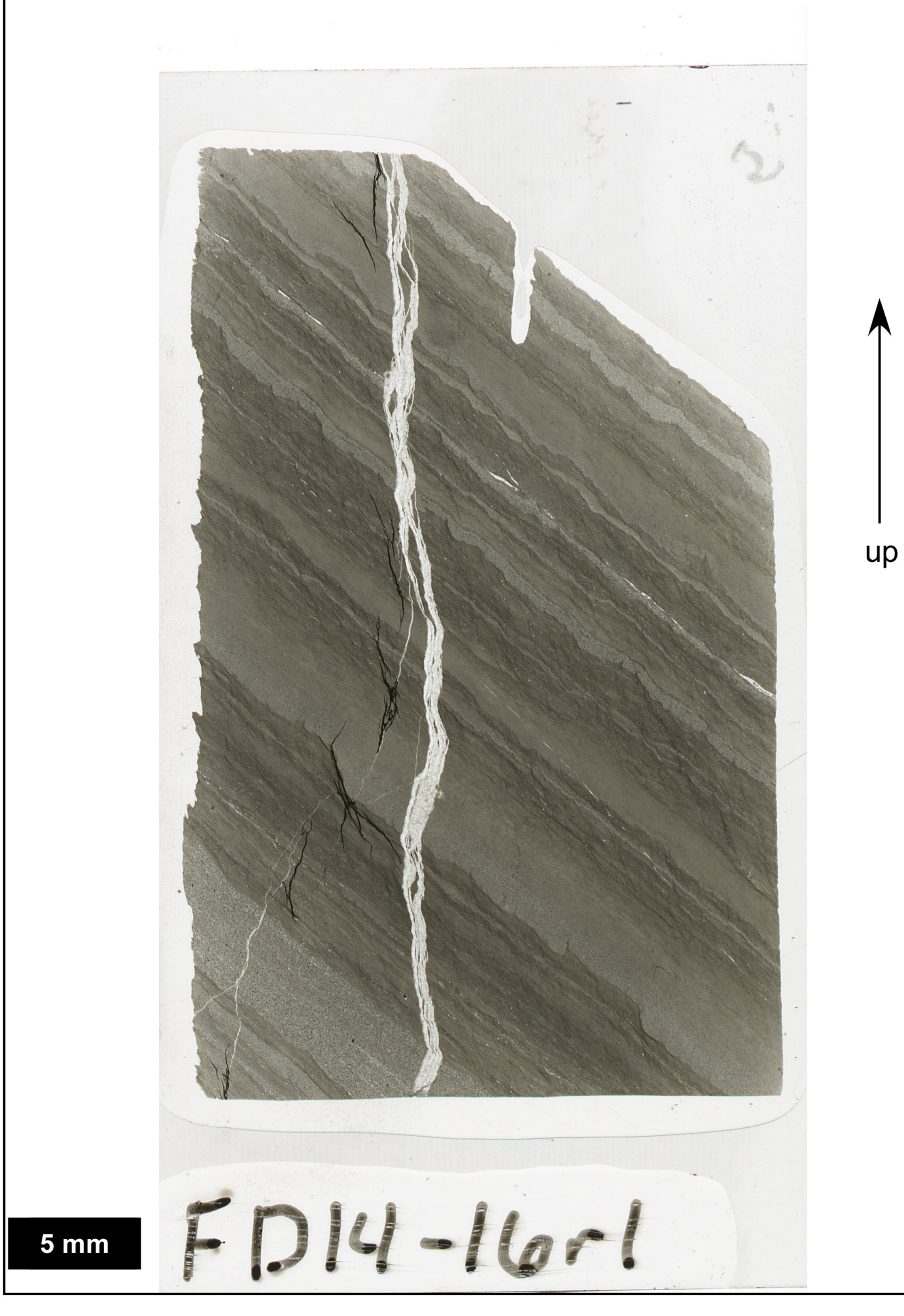
Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-16 core run 1

Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-16r1
Boring: FD14-16 core run 1

1" x 2" thin section
elevation: -52.97 to 53.11ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite

Sedimentary textures:

interbedded clay-rich and fine silt-rich thin layers

Deformation features:

steeply dipping lithologic layers

crenulation along layering
pressure-solution seams parallel and sub-perpendicular to layering

near vertical multi-generation anastomosing thin fractures filled with calcite

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
pyrite - secondar
opaques - secondar

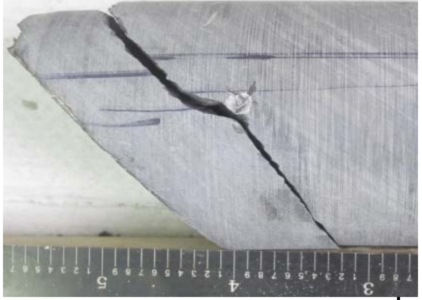
e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-16	1	i	-52.84 to -53.04				M		3.5										
FD14-16	1	i	-52.84 to -53.04	0.12			PL	Diametral					1.6	5408					
FD14-16	1	i	-52.84 to -53.04				PL	Axial					6.2	18481					
FD14-16	2	ai	-56.92 to -57.86				M		2.5										
FD14-16	2	ai	-56.92 to -57.1	0.12			PL	Diametral					2.6	8862					
FD14-16	2	ai	-56.92 to -57.1				PL	Axial					7.2	19546					
FD14-16	2	ai	-57.1 to -57.5	0.08	168.2	168.1	UCmod									4130	0.10	4.8E+06	0.14
FD14-16	2	ai	-57.5 to -57.7	0.11	168.3	168.1	B-1	A							1622				
FD14-16	2	ai	-57.5 to -57.7	0.11	166.7	166.5	B-2	B							675				

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	22.0		17.9	
Specimen Width, W (mm)	50.3		35.7	
D (mm)	51.0		18.0	
D' (mm)	51.0		18.0	
D_e (mm)	51.0		28.6	
Failure Load, P (lb)	1534		1702	
Point Load (N)	**6824**		**7571**	
Point Load (Mpa)	**2.65**		**7.19**	
Index, Is50 (psi)	**380**		**1040**	
Unconfined Compressive Strength (psi)	**8862**		**19546**	
Specimen /Failure Sketch				
Tare No.	M-36			
Wet + Tare (gm)	162.79			
Dry + Tare (gm)	162.65			
Tare (gm)	49.45			
Water Content%	**0.12**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-16 Run: 2 - piece ai
Elevation: -56.92 to -57.1 ft.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	24.2		23.8	
Specimen Width, W (mm)	50.3		47.5	
D (mm)	52.0		24.0	
D' (mm)	52.0		24.0	
D_e (mm)	52.0		38.1	
Failure Load, P (lb)	928		2296	
Point Load (N)	**4128**		**10213**	
Point Load (Mpa)	**1.55**		**6.22**	
Index, Is50 (psi)	**230**		**900**	
Unconfined Compressive Strength (psi)	**5408**		**18481**	
Specimen /Failure Sketch				
Tare No.	M-7			
Wet + Tare (gm)	214.51			
Dry + Tare (gm)	214.31			
Tare (gm)	51.27			
Water Content%	**0.12**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

E4science

TerraSense, LLC

7803-15001

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

Boring: FD14-16 Run: 1 - piece i
Elevation: -52.84 to -53.04 ft.

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-16
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 2 - piece ai

SPECIMEN READINGS

Test Number: B-1
Elevation: -57.5 to -57.7
Specimen mass(gm): 96.92

Thickness (inch)	Diameter (inch)
0.708	1.979
0.715	1.980
0.717	1.979
Average 0.713	1.979

Thickness / Diameter, (t/d): 0.36
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.

Data Acquisition File B14-16R2A
Maximum Load 3598 lb

	After Test
Container No.:	LA-106
Initial Mass + cont. (g):	129.58
Dry Mass + cont. (g):	129.48
Mass of cont. (g):	34.25
Water content (%):	**0.11**
Total unit weight (pcf):	168.25
Dry unit weight (pcf):	168.07
Splitting Tensile Strength (psi)	1622.43

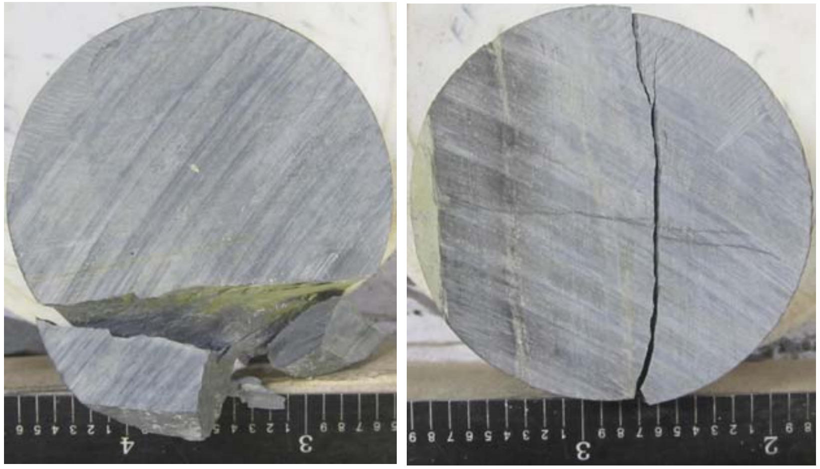
Test Number: B-2
Elevation: -57.5 to -57.7
Specimen mass(gm): 100.41

Thickness (inch)	Diameter (inch)
0.756	1.977
0.741	1.978
0.745	1.978
Average 0.747	1.977

Thickness / Diameter, (t/d): 0.38
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch

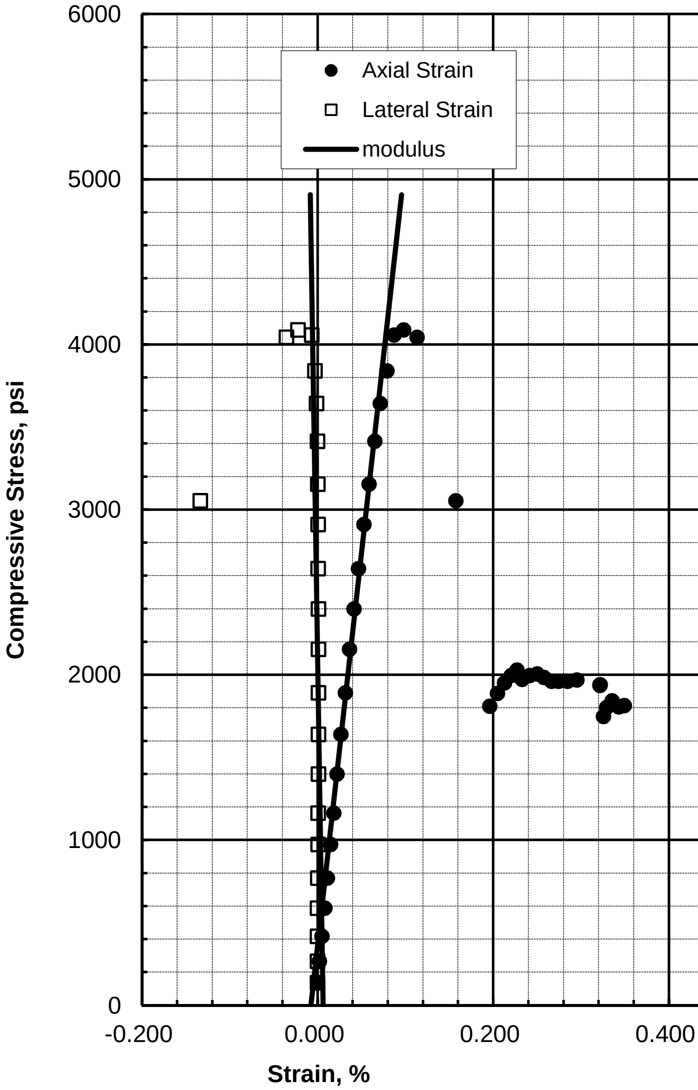
Data Acquisition File B14-16R2B
Maximum Load 1566 lb

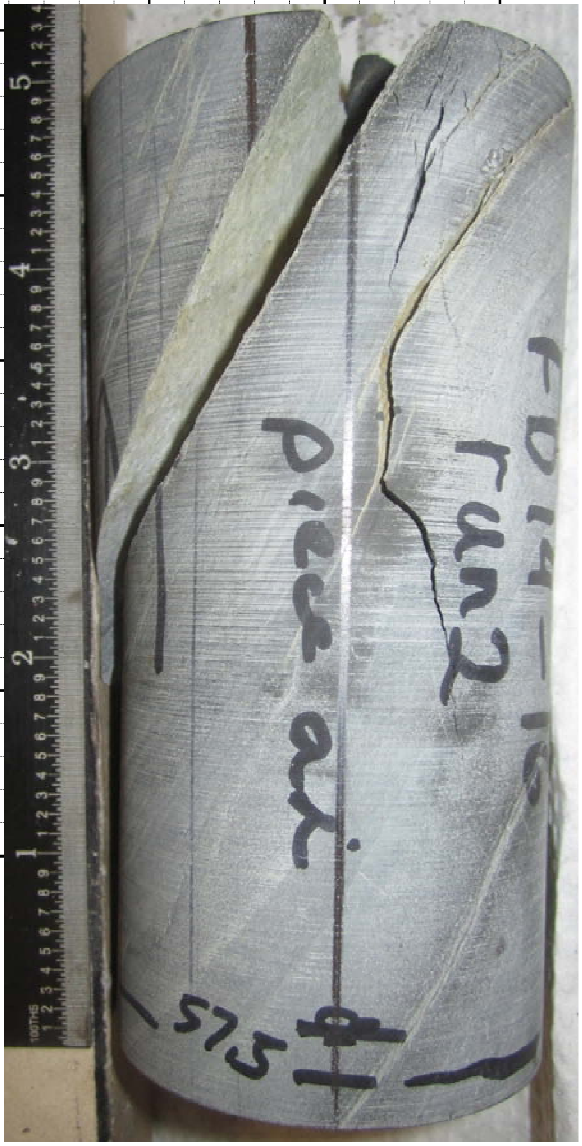
	After Test
Container No.:	LB-18
Initial Mass + cont. (g):	133.05
Dry Mass + cont. (g):	132.94
Mass of cont. (g):	32.59
Water content (%):	**0.11**
Total unit weight (pcf):	166.73
Dry unit weight (pcf):	166.54
Splitting Tensile Strength (psi)	674.80



Failure Photo

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-16** **Run: 2 - piece ai Elevation: -57.5 to -57.7 ft.**
TerraSense, LLC	7803-15001		





Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.08	168	168	4.784	1.979

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.18	0.10	4130	4.76E+06	0.14

FAILURE PHOTO

Tested by: GT Test Date: Apr-07-15

e4sciences	**Boston Harbor**	**COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST** **Boring: FD14-16 Run: 2 ai** **Elevation -57.1 to -57.5 ft.**
TerraSense, LLC **Project # 7803-15001**		

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-16	1	-52.3	llfrac	5,226.2	17,146.4
FD14-16	1	-52.3	xfrac	5,240.4	17,193.0
FD14-16	1	-52.7	llbed	5,822.3	19,102.0
FD14-16	1	-52.7	xbed	4,970.8	16,308.5
FD14-16	1	-53.2	llbed	5,730.8	18,801.8
FD14-16	1	-53.2	xbed	5,154.2	16,910.0
FD14-16	1	-53.7	llbed	5,332.9	17,496.5
FD14-16	1	-53.7	xbed	5,354.3	17,566.5
FD14-16	2	-54.4	llbed	5,822.3	19,102.0
FD14-16	2	-54.4	xbed	5,030.5	16,504.2
FD14-16	2	-55.1	llbed	5,113.6	16,776.8
FD14-16	2	-55.1	xbed	5,563.3	18,252.2
FD14-16	2	-55.6	llbed	5,746.9	18,854.6
FD14-16	2	-55.6	xbed	5,130.5	16,832.5
FD14-16	2	-56.1	llbed	6,070.8	19,917.5
FD14-16	2	-56.1	xbed	5,445.6	17,866.2
FD14-16	2	-56.6	llbed	5,825.2	19,111.7
FD14-16	2	-56.6	xbed	5,157.4	16,920.7
FD14-16	2	-57.1	llbed	5,872.3	19,266.0
FD14-16	2	-57.1	xbed	4,969.6	16,304.3
FD14-16	2	-57.6	llbed	5,777.6	18,955.5
FD14-16	2	-57.6	xbed	4,897.9	16,069.1

US Army Corps
of Engineers®
New England District

Boston Harbor
boring **FD14-17**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 791,574.0'
Northing 2,947,927.8'
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 01:50 pm December 10, 2014
boring completed at 08:30 pm December 10, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -38.7 MLLW
Boring bottom elevation = -59.0 MLLW
Total depth below channel floor = 20.3'
Top of all rock elevation = -42.7' MLLW
Rock refusal elevation = -48.7' MLLW
Number of rock core runs = 3
Rock encountered: Cambridge Argillite
Thickness of sediment = 4.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▦ Gravel
- ░ Sand & gravel
- ▦ Silt, sand & gravel
- ▨ Clay & gravel

Rock
- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

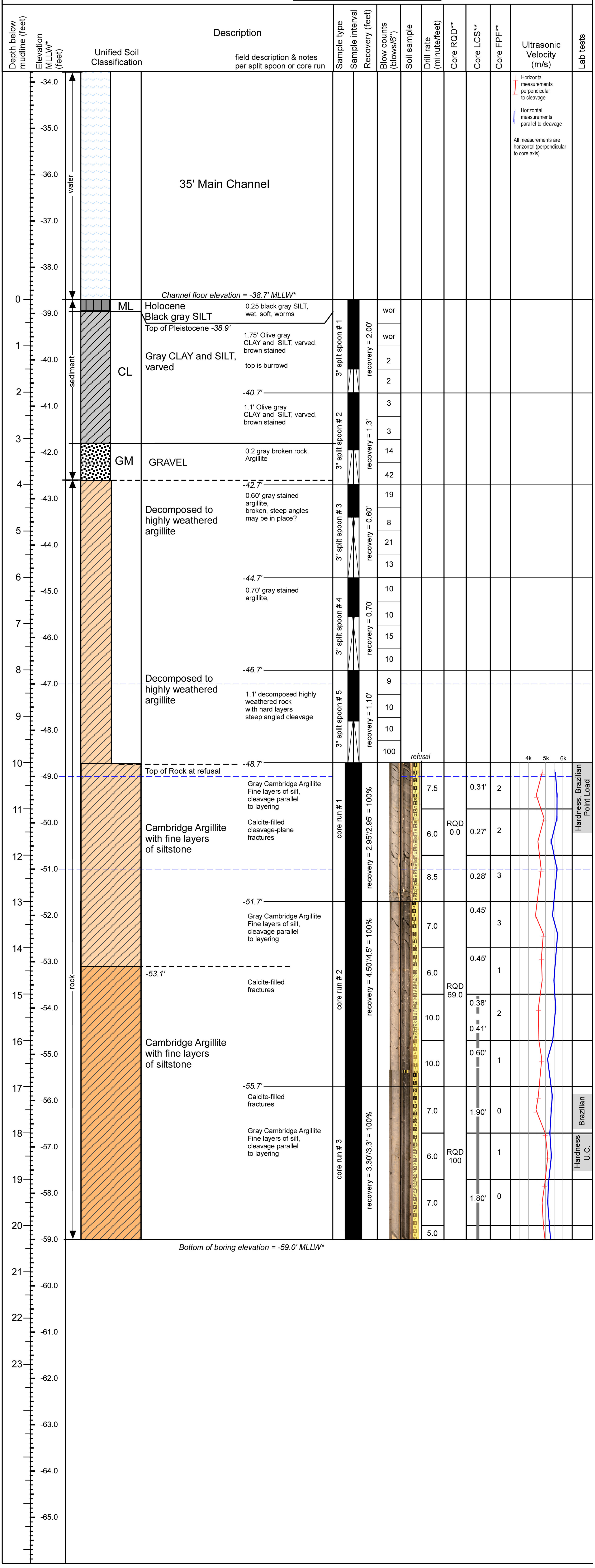
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Horizontal measurements perpendicular to cleavage

Horizontal measurements parallel to cleavage

All measurements are horizontal (perpendicular to core axis)

35' Main Channel

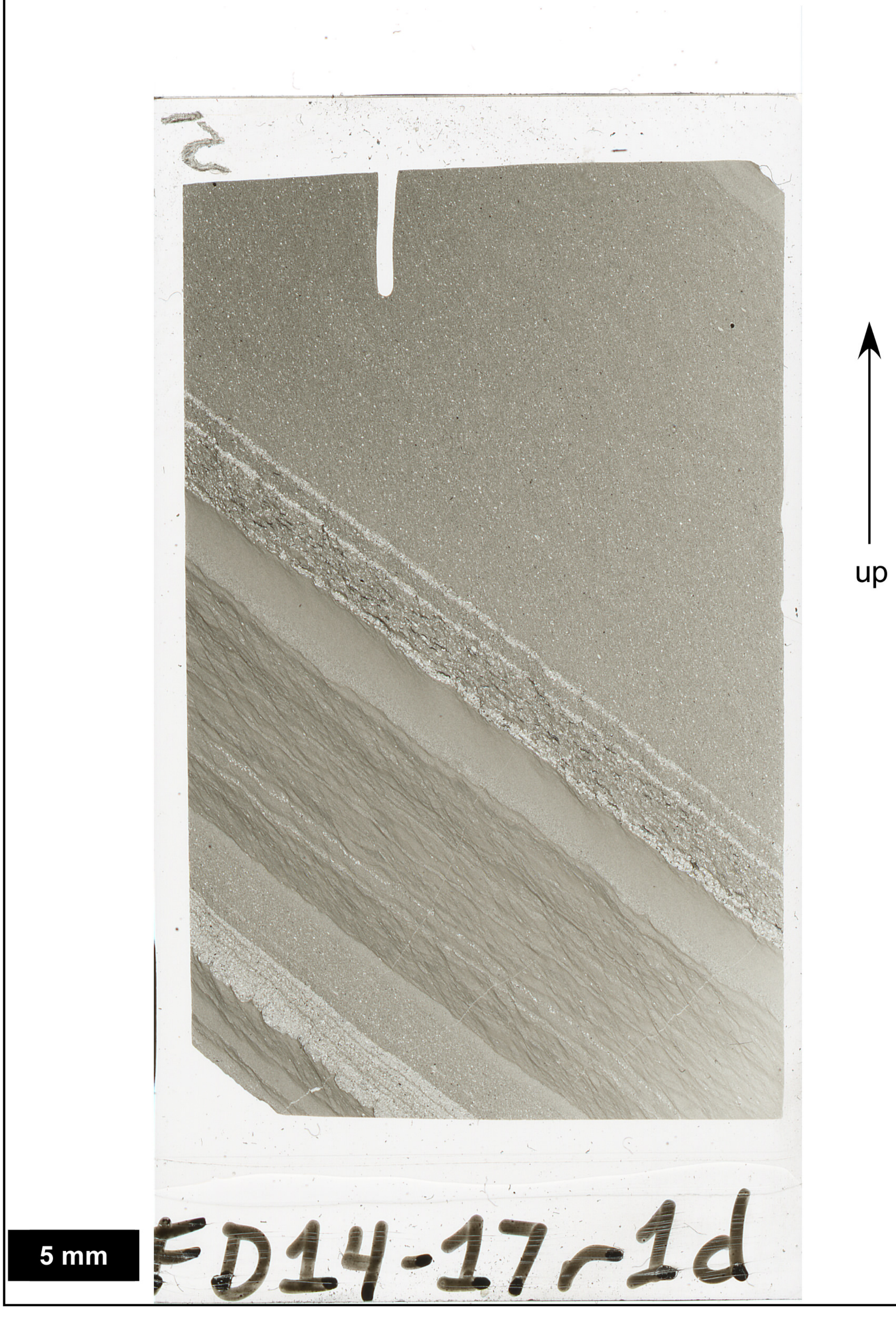
*Channel floor elevation = -38.7' MLLW**

Elevation MLLW* (feet)	Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")
-38.7' to -40.7'	ML	Holocene Black gray SILT	0.25 black gray SILT, wet, soft, worms	3" split spoon # 1	recovery = 2.00'	wor wor 2 2
	CL	Top of Pleistocene *-38.9'* Gray CLAY and SILT, varved	1.75' Olive gray CLAY and SILT, varved, brown stained top is burrowd			
-40.7' to *-42.7'*			1.1' Olive gray CLAY and SILT, varved, brown stained	3" split spoon # 2	recovery = 1.3'	3 3 14 42
	GM	GRAVEL	0.2 gray broken rock, Argillite			
-42.7' to *-44.7'*		Decomposed to highly weathered argillite	0.60' gray stained argillite, broken, steep angles may be in place?	3" split spoon # 3	recovery = 0.60'	19 8 21 13
-44.7' to *-46.7'*			0.70' gray stained argillite,	3" split spoon # 4	recovery = 0.70'	10 10 15 10
-46.7' to *-48.7'*		Decomposed to highly weathered argillite	1.1' decomposed highly weathered rock with hard layers steep angled cleavage	3" split spoon # 5	recovery = 1.10'	9 10 10 100

Elevation MLLW* (feet)	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**	Lab tests
-48.7' to *-51.7'*	Top of Rock at refusal Cambridge Argillite with fine layers of siltstone	Gray Cambridge Argillite Fine layers of silt, cleavage parallel to layering Calcite-filled cleavage-plane fractures	core run # 1	recovery = 2.95'/2.95' = 100%	7.5 6.0 8.5	RQD 0.0	0.31' 0.27' 0.28'	2 2 3	Hardness, Brazilian Point Load
-51.7' to *-55.7'*	*-53.1'* Cambridge Argillite with fine layers of siltstone	Gray Cambridge Argillite Fine layers of silt, cleavage parallel to layering Calcite-filled fractures	core run # 2	recovery = 4.50'/4.5' = 100%	7.0 6.0 10.0 10.0	RQD 69.0	0.45' 0.45' 0.38' 0.41' 0.60'	3 1 2 1	
-55.7' to -59.0		Calcite-filled fractures Gray Cambridge Argillite Fine layers of silt, cleavage parallel to layering	core run # 3	recovery = 3.30'/3.3' = 100%	7.0 6.0 7.0 5.0	RQD 100	1.90' 1.80'	0 1 0	Brazilian Hardness U.C.

*Bottom of boring elevation = -59.0' MLLW**

Boring FD-14-17 core run 1 piece d
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-17r1d
Boring: FD14-17 core run 1 piece d

1" x 2" thin section
elevation:-48.92 to -49.03ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
thin siltstone layers

Sedimentary textures:

thinly layered
silt laminae

graded layers
loading features/soft sediment deformation

Deformation features:

steeply dipping lithologic layers

crenulation
anastomosing pressure-solution seams
in clay-rich layers pressure solution seams subparallel to high angle to layering
resulting cleavage at high angle

very thin calcite-filled fractures sub-perpendicular to lithological layering

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
pyrite
opaques

Boring FD-14-17 core run 2 piece bk

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-17r2bk
Boring: FD14-17 core run 2 piece bk

1" x 2" thin section
elevation: -53.73 to -53.89ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
thinly layered shale-dominated argillite

Sedimentary textures:

thinly layered
silt laminae

graded layers

Deformation features:

steeply dipping lithologic layers

crenulation
anastomosing pressure-solution seams parallel and at high-angle to layering
cleavage at high angle.

calcite-filled fractures brecciated wall rock

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques - secondary

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-17	1	i	-49.26 to -49.55				M		2.5										
FD14-17	1	i	-49.3 to -49.4	0.13	166.2	166.0	B-1	A							1318				
FD14-17	1	i	-49.3 to -49.4	0.12	168.2	168.0	B-2	B							1190				
FD14-17	1	k	-49.84 to -49.95				PL	Axial					1.9	6273					
FD14-17	1	l	-49.84 to -49.95	0.12			PL	Axial					3.5	10527					
FD14-17	3	ca2	-55.8 to -56.5				M		3.5										
FD14-17	3	ca2	-55.8 to -56.1	0.12	168.9	168.7	B-1	A							1315				
FD14-17	3	ca2	-55.8 to -56.1	0.10	167.7	167.6	B-2	B							1235				
FD14-17	3	ca2	-56.1 to -56.5	0.13	169.5	169.3	UCmod									6350	0.06	9.3E+06	0.14
FD14-17	3	ca3	-56.5 to -57.0				M		3.5										
FD14-17	3	ca3	-56.5 to -57.0				TH			39.4	0.7	34.1							

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-17
Sample: Run 3 - piece ca3
Elevation: -56.5 to -57.0
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	**Anvil Calibration Readings**	Specimen Readings	D >7?
1	**72.0**	**37.0**	
2	**72.0**	**40.0**	
3	**72.0**	**41.0**	
4	**70.0**	**40.0**	
5	**71.0**	**39.0**	
6	**70.0**	**40.0**	
7	**70.0**	**37.0**	
8	**70.0**	**42.0**	
9	**70.0**	**42.0**	
10	**71.0**	**40.0**	
average	70.8	39.8	
theoretical reading on anvil	**70.0**		
correction factor	0.989		

Corrected Average corrected reading, Hr **39.4**

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	**27.78**	**29.21**
Specimen Mass after 400 revolutions (grams)	**27.16**	**28.52**
Specimen Mass after 800 revolutions (grams)	**26.55**	**27.77**
dM after 400 revolutions (grams)	0.62	0.69
dM after 800 revolutions (grams)	1.23	1.44
Average ΔM (800 revolutions)	1.335	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	0.749	

Total Hardness, $H_T = H_R*(H_A)^{0.5}$ = 34.06

Boston Harbor

e4sciences

TerraSense, LLC 7803-15001

DATA SHEET
TOTAL HARDNESS TEST
Boring: FD14-17 Sample: Run 3 - piece ca3
Elevation: -56.5 to -57.0 ft

Data Sheet

Depth:				
Load Orientation:			Axial	
Length to nearest free end, L (mm)			24.8	
Specimen Width, W (mm)			49.7	
D (mm)			26.0	
D' (mm)			26.0	
D_e (mm)			40.5	
Failure Load, P (lb)			1411	
Point Load (N)			**6276**	
Point Load (Mpa)			**3.47**	
Index, Is50 (psi)			**500**	
Unconfined Compressive Strength (psi)			**10527**	
Specimen /Failure Sketch				
Tare No.			M-4	
Wet + Tare (gm)			215.58	
Dry + Tare (gm)			215.38	
Tare (gm)			51.13	
Water Content%			**0.12**	
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-17 Run: 1 - piece l
Elevation: -49.84 to -49.95 ft.

Analysis File: PLV4 (9/09)

4/22/2015
PL14-17-run1l.xlsx

Depth:				
Load Orientation:			Axial	
Length to nearest free end, L (mm)			31.6	
Specimen Width, W (mm)			50.3	
D (mm)			35.0	
D' (mm)			34.0	
D_e (mm)			46.6	
Failure Load, P (lb)			967	
Point Load (N)			**4301**	
Point Load (Mpa)			**1.92**	
Index, Is50 (psi)			**280**	
Unconfined Compressive Strength (psi)			**6273**	
Specimen /Failure Sketch				
Tare No.				
Wet + Tare (gm)				
Dry + Tare (gm)				
Tare (gm)				
Water Content%				
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-17 Run: 1 - piece k
Elevation: -49.84 to -49.95 ft.

TerraSense, LLC

7803-15001

SPLITTING TENSILE (Brazilian) TEST
ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-17
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 3 - piece ca2

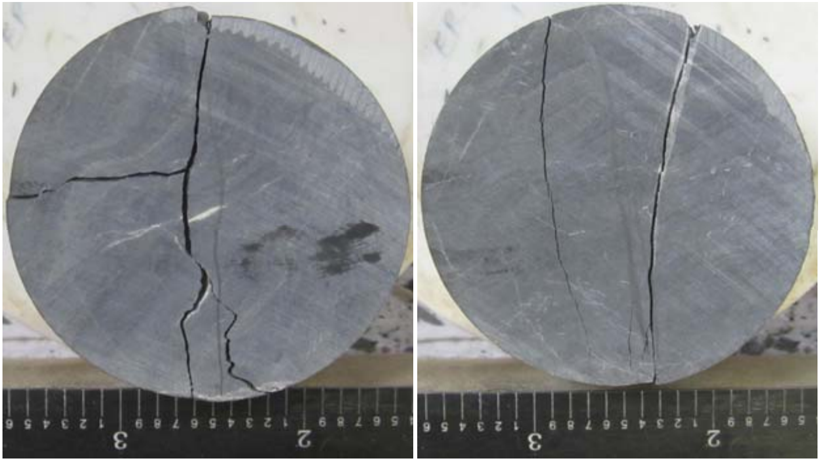
SPECIMEN READINGS

Test Number: B-1
Elevation: -55.8 to -56.1
Specimen mass(gm): 111.60

	Thickness (inch)	Diameter (inch)
	0.822	1.977
	0.817	1.979
	0.819	1.978
Average	0.819	1.978

Thickness / Diameter, (t/d): 0.41
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.
Data Acquisition File B14-17R3A
Maximum Load 3348 lb

	After Test
Container No.:	LA-207
Initial Mass + cont. (g):	144.29
Dry Mass + cont. (g):	144.16
Mass of cont. (g):	32.76
Water content (%):	**0.12**
Total unit weight (pcf):	168.93
Dry unit weight (pcf):	168.73
Splitting Tensile Strength (psi)	1315.38



Failure Photo

Test Number: B-2
Elevation: -55.8 to -56.1
Specimen mass(gm): 114.48

	Thickness (inch)	Diameter (inch)
	0.843	1.981
	0.845	1.981
	0.844	1.981
Average	0.844	1.981

Thickness / Diameter, (t/d): 0.43
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
Data Acquisition File B14-17R3B
Maximum Load 3242 lb

	After Test
Container No.:	LB-35
Initial Mass + cont. (g):	147.62
Dry Mass + cont. (g):	147.5
Mass of cont. (g):	33.1
Water content (%):	**0.10**
Total unit weight (pcf):	167.75
Dry unit weight (pcf):	167.57
Splitting Tensile Strength (psi)	1234.88

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-17** **Run: 3 - piece ca2 Elevation: -55.8 to -56.1 ft.**
TerraSense, LLC	7803-15001		

SPLITTING TENSILE (Brazilian) TEST
ASTM D 3967

Project Number: 7803-15001 **Test by:** GT **Sta:** FD14-17
Project Name: Boston Harbor **Test Date:** 4/20/15 **Run:** 1 - piece i

SPECIMEN READINGS

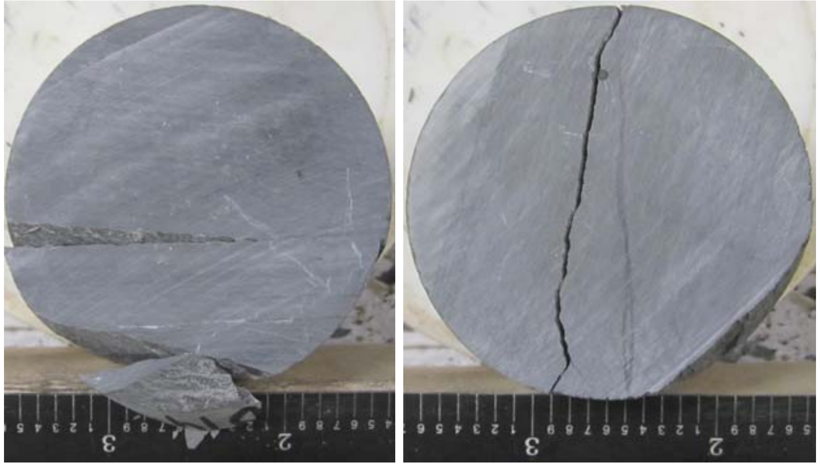
Test Number: B-1
Elevation: -49.3 to -49.4
Specimen mass(gm): 119.01

	Thickness (inch)	Diameter (inch)
	0.892	1.978
	0.878	1.974
	0.897	1.979
Average	0.889	1.977

Thickness / Diameter, (t/d): 0.45
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.

Data Acquisition File B14-17R1A
Maximum Load 3638 lb

	After Test
Container No.:	LA-201
Initial Mass + cont. (g):	151.31
Dry Mass + cont. (g):	151.16
Mass of cont. (g):	32.91
Water content (%):	**0.13**
Total unit weight (pcf):	166.23
Dry unit weight (pcf):	166.02
Splitting Tensile Strength (psi)	1318.36



Failure Photo

Test Number: B-2
Elevation: -49.3 to -49.4
Specimen mass(gm): 116.28

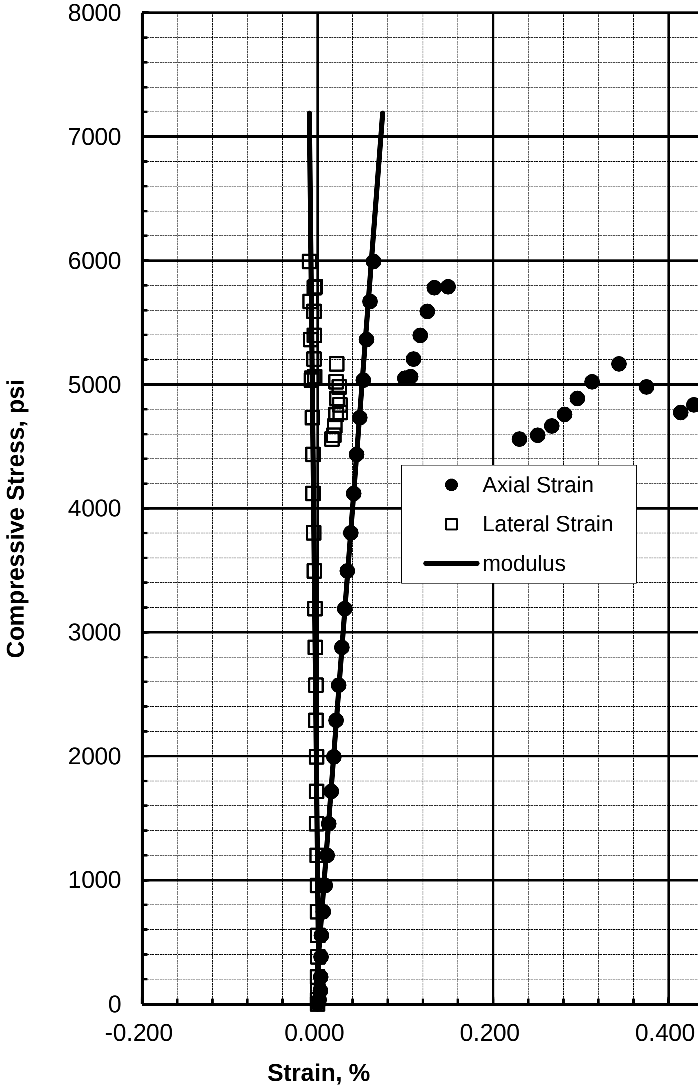
	Thickness (inch)	Diameter (inch)
	0.859	1.979
	0.857	1.976
	0.856	1.979
Average	0.857	1.978

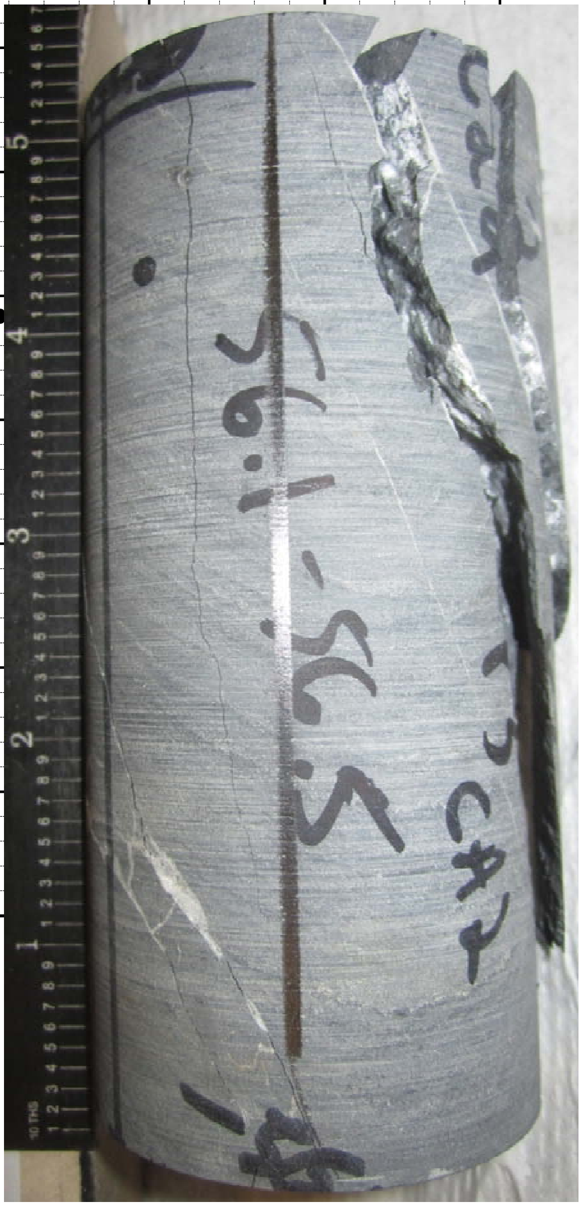
Thickness / Diameter, (t/d): 0.43
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch

Data Acquisition File B14-17R1B
Maximum Load 3169 lb

	After Test
Container No.:	LC-6
Initial Mass + cont. (g):	149.91
Dry Mass + cont. (g):	149.77
Mass of cont. (g):	33.55
Water content (%):	**0.12**
Total unit weight (pcf):	168.24
Dry unit weight (pcf):	168.04
Splitting Tensile Strength (psi)	1190.10

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-17** **Run: 1 - piece i Elevation: -49.3 to -49.4 ft.**
TerraSense, LLC	7803-15001		





Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.13	170	169	4.819	1.980

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.14	0.06	6350	9.27E+06	0.14

FAILURE PHOTO

Tested by: GT Test Date: Apr-11-15

e4sciences	**Boston Harbor**	**COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST**
TerraSense, LLC Project # 7803-15001		**Boring: FD14-17 Run: 3 ca2 Elevation -56.1 to -56.5 ft.**

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]	
FD14-17	1	-48.9	llfrac	5,563.3	18,252.2	
FD14-17	1	-48.9	xfrac	4,804.2	15,761.7	
FD14-17	1	-49.4	llbed	5,657.8	18,562.3	
FD14-17	1	-49.4	xbed	4,450.6	14,601.8	
FD14-17	1	-49.9	llfrac	5,650.6	18,538.9	
FD14-17	1	-49.9	xfrac	4,904.4	16,090.4	
FD14-17	1	-50.4	llbed	5,322.2	17,461.2	
FD14-17	1	-50.4	xbed	4,544.7	14,910.5	
FD14-17	1	-51.0	llbed	5,654.9	18,552.9	
FD14-17	1	-51.0	xbed	4,734.9	15,534.6	
FD14-17	2	-52.0	llbed	5,396.1	17,703.9	
FD14-17	2	-52.0	xbed	4,404.9	14,451.8	
FD14-17	2	-52.4	llbed	5,690.6	18,669.9	
FD14-17	2	-52.4	xbed	4,860.2	15,945.5	
FD14-17	2	-52.9	llbed	5,580.1	18,307.5	
FD14-17	2	-52.9	xbed	4,751.8	15,589.8	
FD14-17	2	-53.4	llbed	5,478.6	17,974.4	
FD14-17	2	-53.4	xbed	4,795.1	15,731.9	
FD14-17	2	-54.0	llfrac	5,575.9	18,293.7	
FD14-17	2	-54.0	xfrac	4,572.3	15,001.0	
FD14-17	2	-54.7	llfrac	5,407.0	17,739.6	
FD14-17	2	-54.7	xfrac	4,602.6	15,100.4	
FD14-17	2	-55.1	llfrac	5,108.4	16,759.8	
FD14-17	2	-55.1	xfrac	4,768.5	15,644.7	
FD14-17	3	-55.9	llbed	5,382.5	17,659.2	
FD14-17	3	-55.9	xbed	4,569.7	14,992.4	
FD14-17	3	-56.2	llbed	5,323.5	17,465.6	through calcium vein
FD14-17	3	-56.2	xbed	4,436.0	14,553.9	
FD14-17	3	-56.7	llbed	5,240.1	17,191.8	
FD14-17	3	-56.7	xbed	4,967.1	16,296.1	
FD14-17	3	-57.2	llbed	5,328.9	17,483.2	
FD14-17	3	-57.2	xbed	5,118.7	16,793.7	
FD14-17	3	-57.8	llbed	5,156.8	16,918.5	
FD14-17	3	-57.8	xbed	4,943.8	16,219.7	
FD14-17	3	-58.2	llbed	5,116.1	16,785.2	
FD14-17	3	-58.2	xbed	4,790.4	15,716.4	
FD14-17	3	-58.7	llbed	5,217.0	17,116.2	
FD14-17	3	-58.7	xbed	4,865.9	15,964.1	
FD14-17	3	-59.2	llbed	5,321.1	17,457.8	
FD14-17	3	-59.2	xbed	5,020.3	16,470.8	

US Army Corps
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Boston Harbor

boring **FD14-18b** *(no log for FD14-18a abandoned after 1 spoon)*

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page 1 of 1

Easting 791,341.2
Northing 2,948,043.0
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 07:00 am December 10, 2014
boring completed at 01:00 pm December 10, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -37.0 MLLW
Boring bottom elevation = -55.3 MLLW
Total depth below channel floor = 18.3'

Top of all rock elevation = -37.8' MLLW
Rock refusal elevation = -38.0' MLLW
Number of rock core runs = 4

Rock encountered: Cambridge Argillite
Thickness of sediment = 0.8'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)

- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ⁘ Sand
- ▦ Gravel
- ▦ Sand & gravel
- ▦ Silt, sand & gravel
- ▨ Clay & gravel

Rock (Rock)

- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

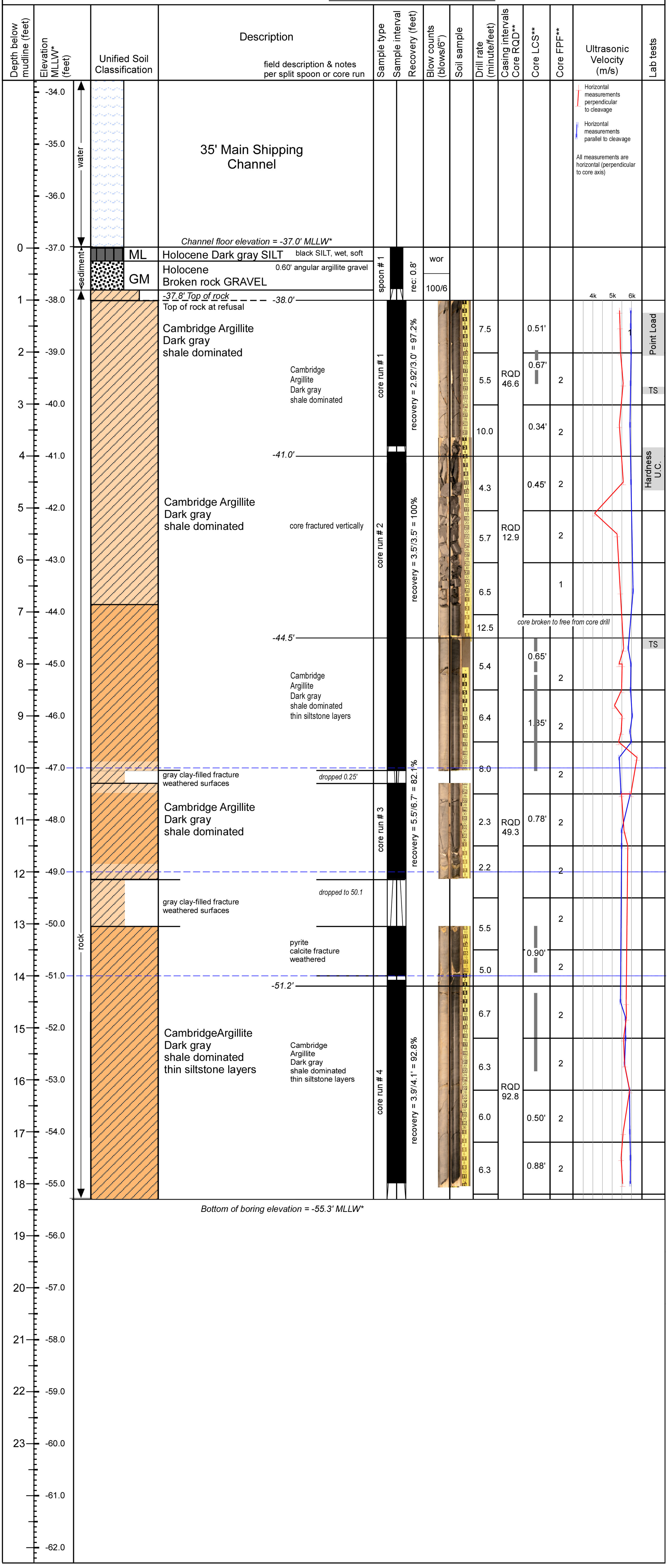
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

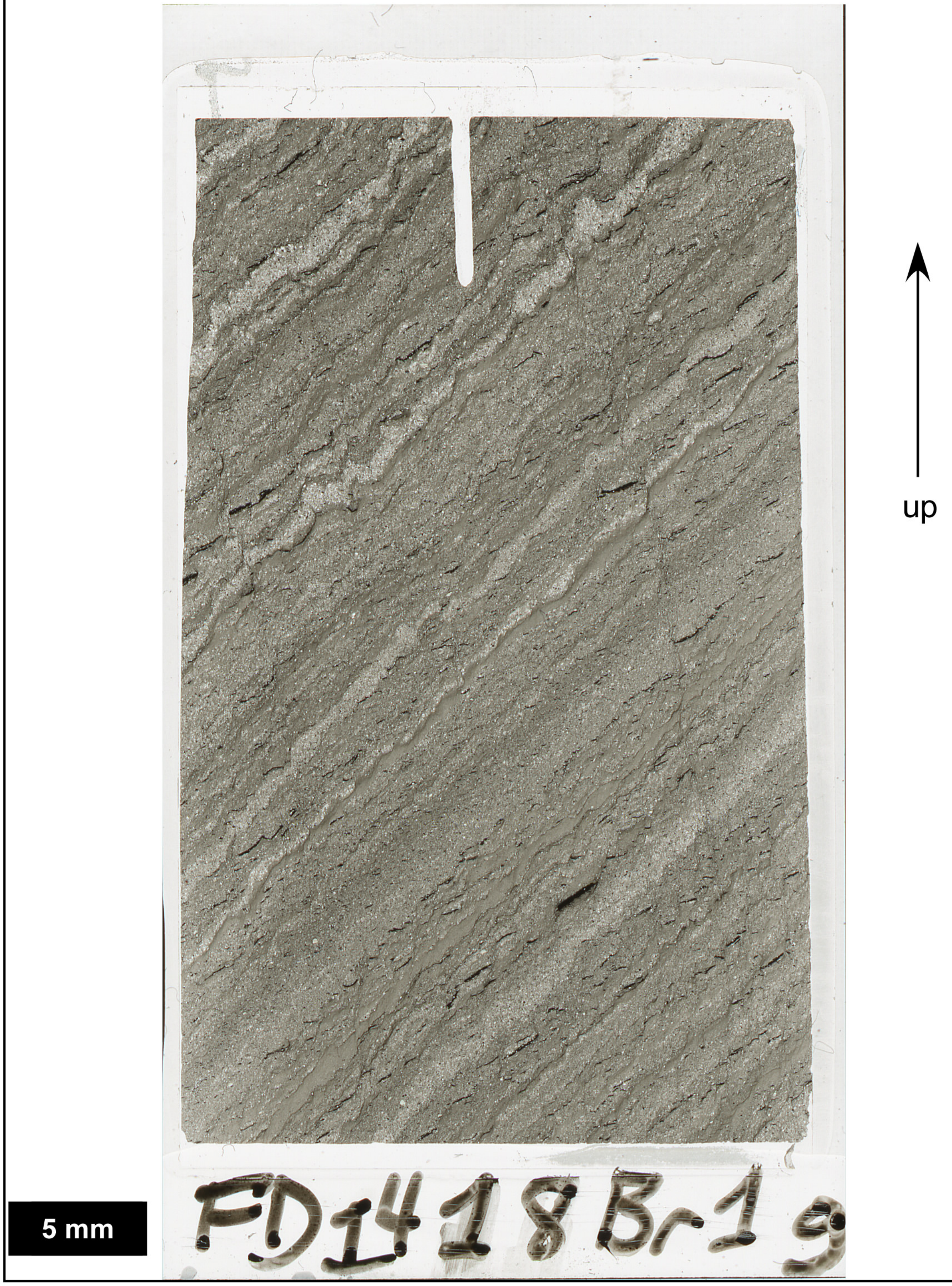
Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-18B core run 1 piece g

Thin section of Cambridge Argillite.

Transmitted-light image.



Petrographic summary

Sample: FD14-18Br1g
1" x 2" thin section
Boring: FD14-18B core run 1 piece g
elevation: -39.58 to -39.72ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
laminated shale-dominated argillite

Sedimentary textures:

thinly layered
silt laminae

cross-lamination
graded layers
slump fold

Deformation features:

steeply dipping lithologic layers and cleavage

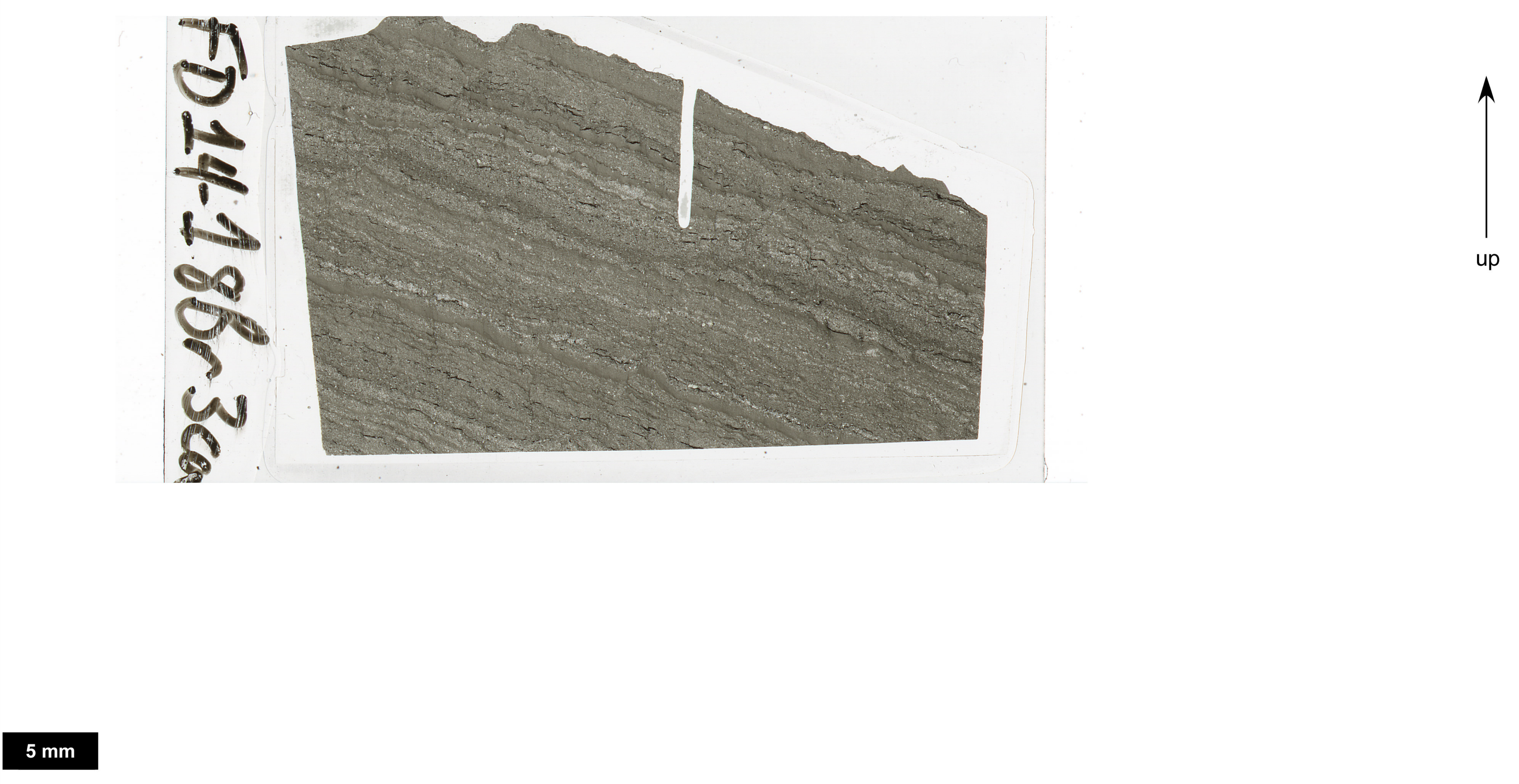
pressure-solution seams
pressure solution cleavage
stylolites

fractures calcite-filled

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
pyrite
opaques

Boring FD-14-18B core run 3 piece ca
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-18Br3ca

1" x 2" thin section

Boring: FD14-18B core run 3 piece ca

Formation: Cambridge Argillite.

Lithology: argillite
thinly layered shale-dominated argillite with silt-rich layers

Sedimentary textures:

thinly layered
silt laminae

graded layers

Deformation features:

steeply dipping lithologic layers

crenulation
anastomosing pressure-solution seams parallel
near-vertical pressure-solution cleavage disrupting layers

Dominant minerals:

quartz - detrital coarse silt-sized grains sub rounded to angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques - secondary

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SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-18B	1	d	-38.29 to -38.8				M		3.5										
FD14-18B	1	d	-38.4 to -38.75	0.06	171.4	171.3	UCmod									16820	0.19	9.2E+06	0.17
FD14-18B	1	e	-38.8 to -38.89	0.04			PL	Axial					7.0	20444					
FD14-18B	1	m	-40.91 to -41.5				M		3.5										

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:			Axial	
Length to nearest free end, L (mm)			21.7	
Specimen Width, W (mm)			43.4	
D (mm)			23.0	
D' (mm)			23.0	
D_e (mm)			35.7	
Failure Load, P (lb)			2344	
Point Load (N)			**10427**	
Point Load (Mpa)			**7.04**	
Index, Is50 (psi)			**1020**	
Unconfined Compressive Strength (psi)			**20444**	
Specimen /Failure Sketch				
Tare No.			M-36	
Wet + Tare (gm)			210.76	
Dry + Tare (gm)			210.70	
Tare (gm)			49.46	
Water Content%			**0.04**	
Comments				

Test by: RAT Test Date: 3/30/2015 Reviewed by: GET

Boston Harbor

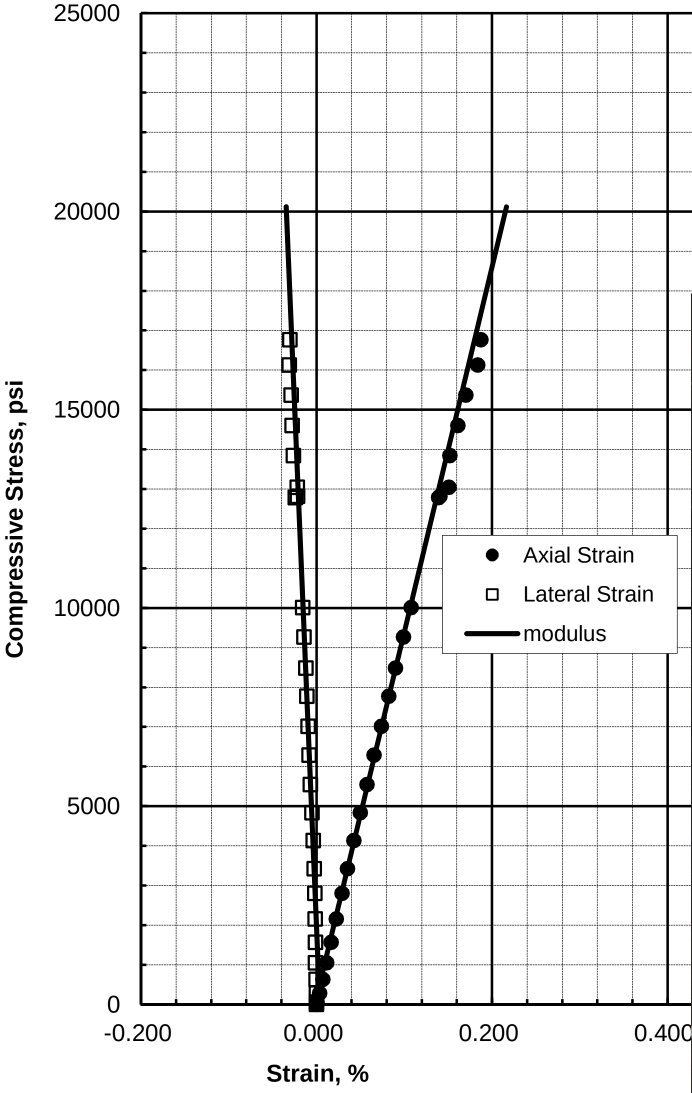
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-18B Run: 1 - piece e
Elevation: -38.8 to -38.89 ft.



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.06	171	171	4.111	1.972

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.33	0.19	16820	9.21E+06	0.17

FAILURE PHOTO

Tested by: GT Test Date: Apr-08-15

e4sciences	**Boston Harbor**	**COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST**
TerraSense, LLC **Project # 7803-15001**		**Boring: FD14-18B Run: 1 d** **Elevation -38.4 to -38.75 ft.**

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-18B	1	-38.2	llfrac	5,959.6	19,552.4
FD14-18B	1	-38.2	xfrac	5,375.7	17,636.7
FD14-18B	1	-38.5	llfrac	5,955.4	19,538.7
FD14-18B	1	-38.5	xfrac	5,398.9	17,712.8
FD14-18B	1	-39.0	llfrac	5,976.6	19,608.1
FD14-18B	1	-39.0	xfrac	5,423.6	17,794.0
FD14-18B	1	-39.6	llfrac	5,948.2	19,515.2
FD14-18B	1	-39.6	xfrac	5,563.7	18,253.7
FD14-18B	1	-40.4	llbed	5,916.2	19,410.2
FD14-18B	1	-40.4	xbed	5,364.9	17,601.5
FD14-18B	1	-41.5	llbed	5,969.3	19,584.3
FD14-18B	1	-41.5	xbed	5,568.9	18,270.6
FD14-18B	1	-42.1	xfrac	4,087.8	13,411.5
FD14-18B	1	-42.5	xfrac	5,246.3	17,212.3
FD14-18B	1	-43.6	llfrac	6,075.7	19,933.3
FD14-18B	1	-43.6	xfrac	5,414.5	17,764.0
FD14-18B	1	-45.0	xfrac	5,349.9	17,552.1
FD14-18B	1	-45.8	xfrac	5,113.9	16,777.8
FD14-18B	1	-46.5	llfrac	5,985.6	19,637.9
FD14-18B	1	-46.5	xfrac	5,326.9	17,476.9
FD14-18B	1	-47.5	llbed	5,935.2	19,472.3
FD14-18B	1	-47.5	xbed	5,472.0	17,952.9
FD14-18B	3	-44.7	llbed	5,825.2	19,111.7
FD14-18B	3	-44.7	xbed	5,586.6	18,328.7
FD14-18B	3	-45.0	llbed	5,964.8	19,569.5
FD14-18B	3	-45.0	xbed	5,508.9	18,073.8
FD14-18B	3	-45.5	llbed	5,945.6	19,506.7
FD14-18B	3	-45.5	xbed	5,482.1	17,985.8
FD14-18B	3	-46.0	llbed	6,031.0	19,786.7
FD14-18B	3	-46.0	xbed	5,505.6	18,063.1
FD14-18B	3	-46.3	llbed	5,916.2	19,410.2
FD14-18B	3	-46.3	xbed	5,460.7	17,915.8
FD14-18B	3	-46.8	llfrac	5,358.3	17,579.8
FD14-18B	3	-46.8	xfrac	6,282.9	20,613.1
FD14-18B	3	-47.5	llfrac	5,451.1	17,884.2
FD14-18B	3	-47.5	xfrac	5,963.0	19,563.6
FD14-18B	3	-48.2	llbed	5,484.8	17,994.9
FD14-18B	3	-48.2	xbed	5,603.9	18,385.7
FD14-18B	3	-48.5	llbed	5,482.1	17,985.8
FD14-18B	3	-48.5	xbed	5,801.7	19,034.5
FD14-18B	4	-51.5	llbed	5,420.8	17,784.7
FD14-18B	4	-51.5	xbed	5,717.9	18,759.4
FD14-18B	4	-51.8	llbed	5,686.3	18,655.7
FD14-18B	4	-51.8	xbed	5,732.4	18,807.1
FD14-18B	4	-52.2	llbed	5,687.7	18,660.4
FD14-18B	4	-52.2	xbed	5,585.2	18,324.1
FD14-18B	4	-52.7	llbed	5,633.8	18,483.7
FD14-18B	4	-52.7	xbed	5,632.4	18,479.1
FD14-18B	4	-53.2	llbed	5,893.9	19,336.9
FD14-18B	4	-53.2	xbed	5,899.8	19,356.4
FD14-18B	4	-54.0	llbed	5,910.3	19,390.6
FD14-18B	4	-54.0	xbed	5,565.3	18,259.0
FD14-18B	4	-54.5	llbed	5,938.1	19,482.1
FD14-18B	4	-54.5	xbed	5,455.2	17,897.7
FD14-18B	4	-55.0	llbed	5,930.7	19,457.5
FD14-18B	4	-55.0	xbed	5,536.8	18,165.2

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-19**

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page 1 of 1

Easting 788,441.3
Northing 2,950,781.9
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Reserved Turning Basin

boring started at 07:40 am November 24, 2014
boring completed at 06:15 pm November 24, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.4 MLLW
Boring bottom elevation = -61.1 MLLW
Total depth below channel floor = 18.7'

Top of all rock elevation = -43.2' MLLW
Rock refusal elevation = -44.4' MLLW
Number of rock core runs = 7

Rock encountered: Cambridge Argillite
Thickness of sediment = 0.8'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils

- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▓ Gravel
- ▒ Sand & gravel
- ▚ Silt, sand & gravel
- ▞ Clay & gravel

Rock

- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

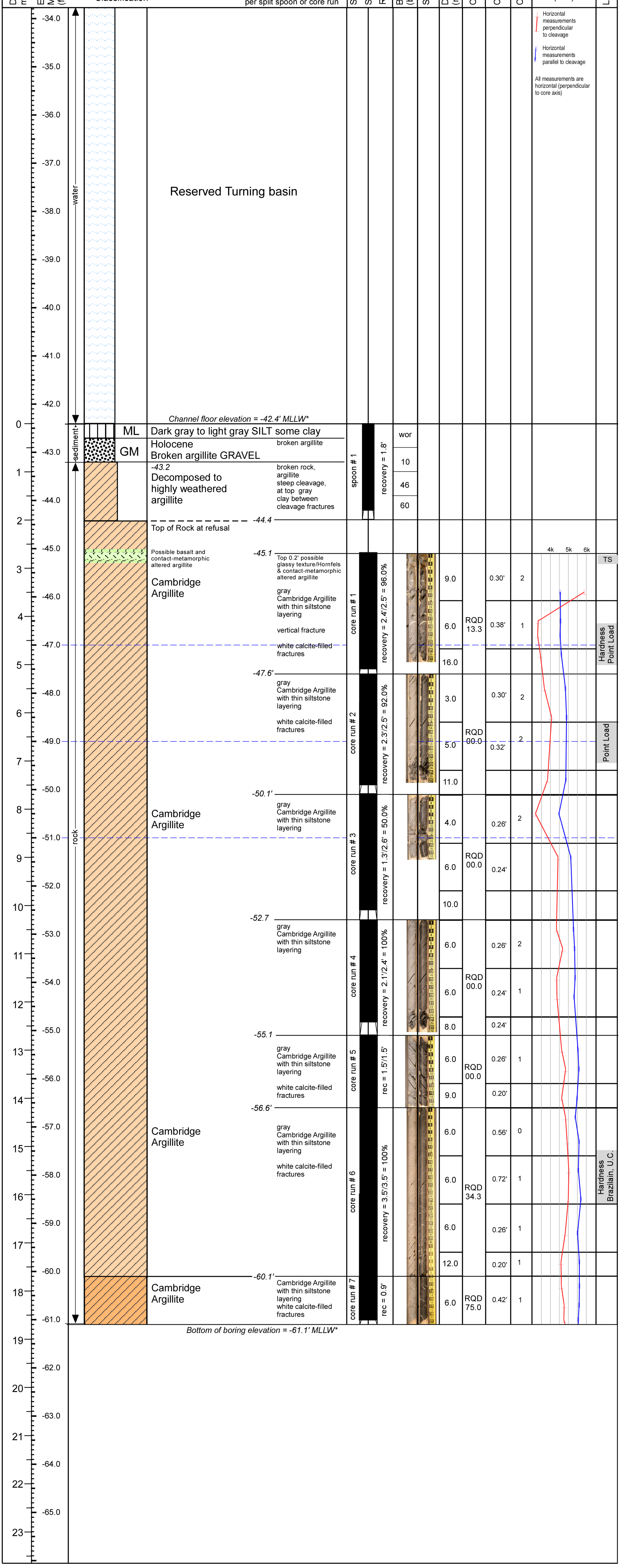
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Horizontal measurements perpendicular to cleavage

Horizontal measurements parallel to cleavage

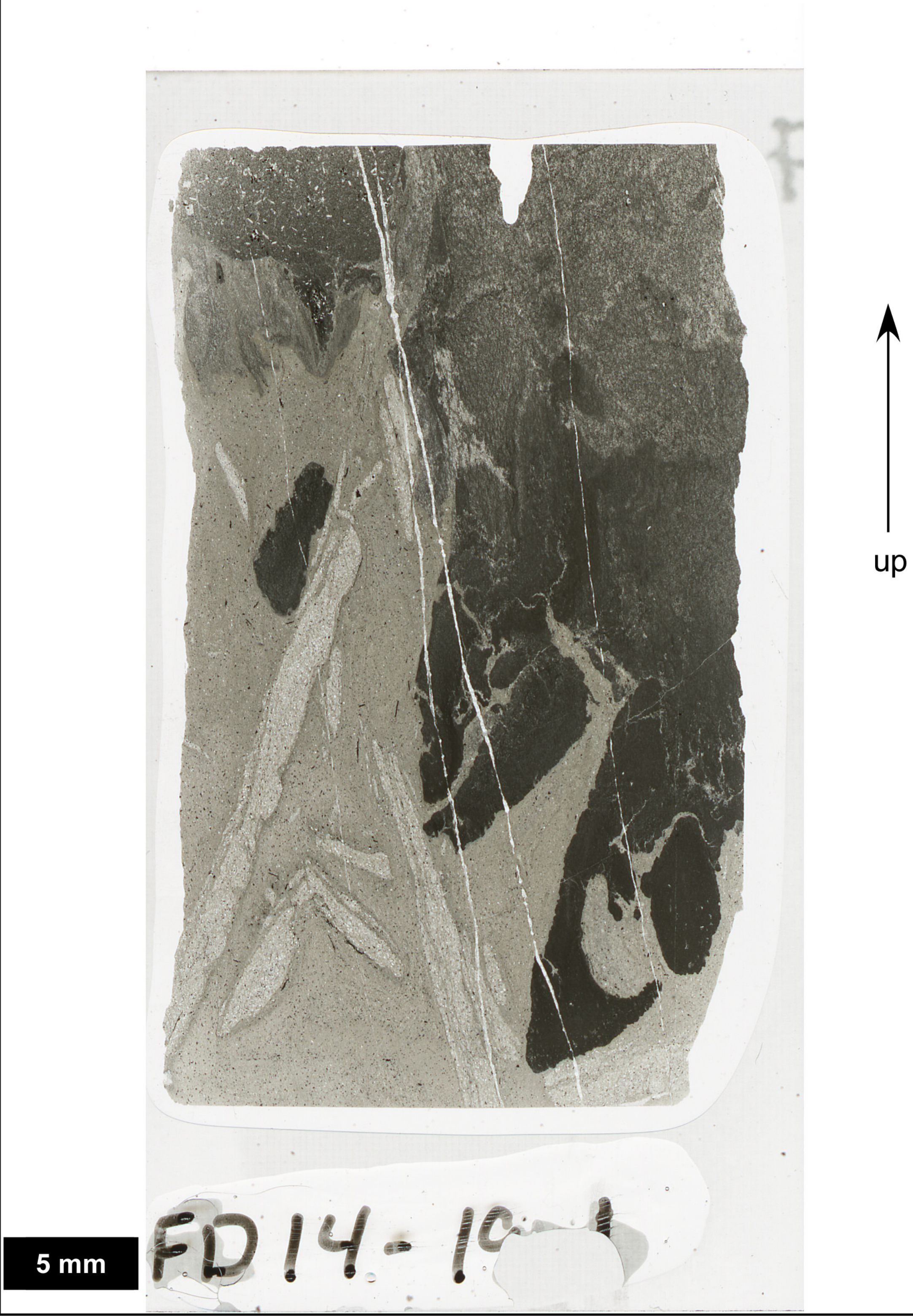
All measurements are horizontal (perpendicular to core axis)

*Channel floor elevation = -42.4' MLLW**

Elevation MLLW* (feet)	Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**	Lab tests
	ML	Dark gray to light gray SILT some clay		spoon # 1	recovery = 1.8'	wor					
	GM	Holocene Broken argillite GRAVEL	broken argillite			10					
-43.2		Decomposed to highly weathered argillite	broken rock, argillite steep cleavage, at top gray clay between cleavage fractures			46 60					
-44.4		Top of Rock at refusal									
-45.1		Possible basalt and contact-metamorphic altered argillite Cambridge Argillite	Top 0.2' possible glassy texture/Hornfels & contact-metamorphic altered argillite gray Cambridge Argillite with thin siltstone layering vertical fracture white calcite-filled fractures	core run # 1	recovery = 2.4'/2.5' = 96.0%		9.0 6.0 16.0	RQD 13.3	0.30' 0.38'	2 1	TS Hardness Point Load
-47.6'			gray Cambridge Argillite with thin siltstone layering white calcite-filled fractures	core run # 2	recovery = 2.3'/2.5' = 92.0%		3.0 5.0 11.0	RQD 00.0	0.30' 0.32'	2 2	Point Load
-50.1'		Cambridge Argillite	gray Cambridge Argillite with thin siltstone layering	core run # 3	recovery = 1.3'/2.6' = 50.0%		4.0 6.0 10.0	RQD 00.0	0.26' 0.24'	2	
-52.7			gray Cambridge Argillite with thin siltstone layering	core run # 4	recovery = 2.1'/2.4' = 100%		6.0 6.0 8.0	RQD 00.0	0.26' 0.24' 0.24'	2 1	
-55.1			gray Cambridge Argillite with thin siltstone layering white calcite-filled fractures	core run # 5	rec = 1.5'/1.5'		6.0 9.0	RQD 00.0	0.26' 0.20'	1	
-56.6'		Cambridge Argillite	gray Cambridge Argillite with thin siltstone layering white calcite-filled fractures	core run # 6	recovery = 3.5'/3.5' = 100%		6.0 6.0 6.0 12.0	RQD 34.3	0.56' 0.72' 0.26' 0.20'	0 1 1 1	Hardness Brazilain, U.C.
-60.1'		Cambridge Argillite	Cambridge Argillite with thin siltstone layering white calcite-filled fractures	core run # 7	rec = 0.9'		6.0	RQD 75.0	0.42'	1	

*Bottom of boring elevation = -61.1' MLLW**

Boring FD-14-19 core run 1 piece a
Thin section of Altered Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample:FD14-19r1 1" x 2" thin section
Boring:FD14-19 core run 1 piece a elevation: -45.12 to -45.21ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
shale-dominated argillite with alteration from from top (hornfels?)

Sedimentary textures:

thin layering
silt-rich layers folded/ alteration or slumping?

Deformation features:

steeply dipping lithologic layers

alteration lobes extend down vertically
subtle sub-vetrical pressure-solution seams

calcite-filled fractures cross-cutting all

Key minerals:

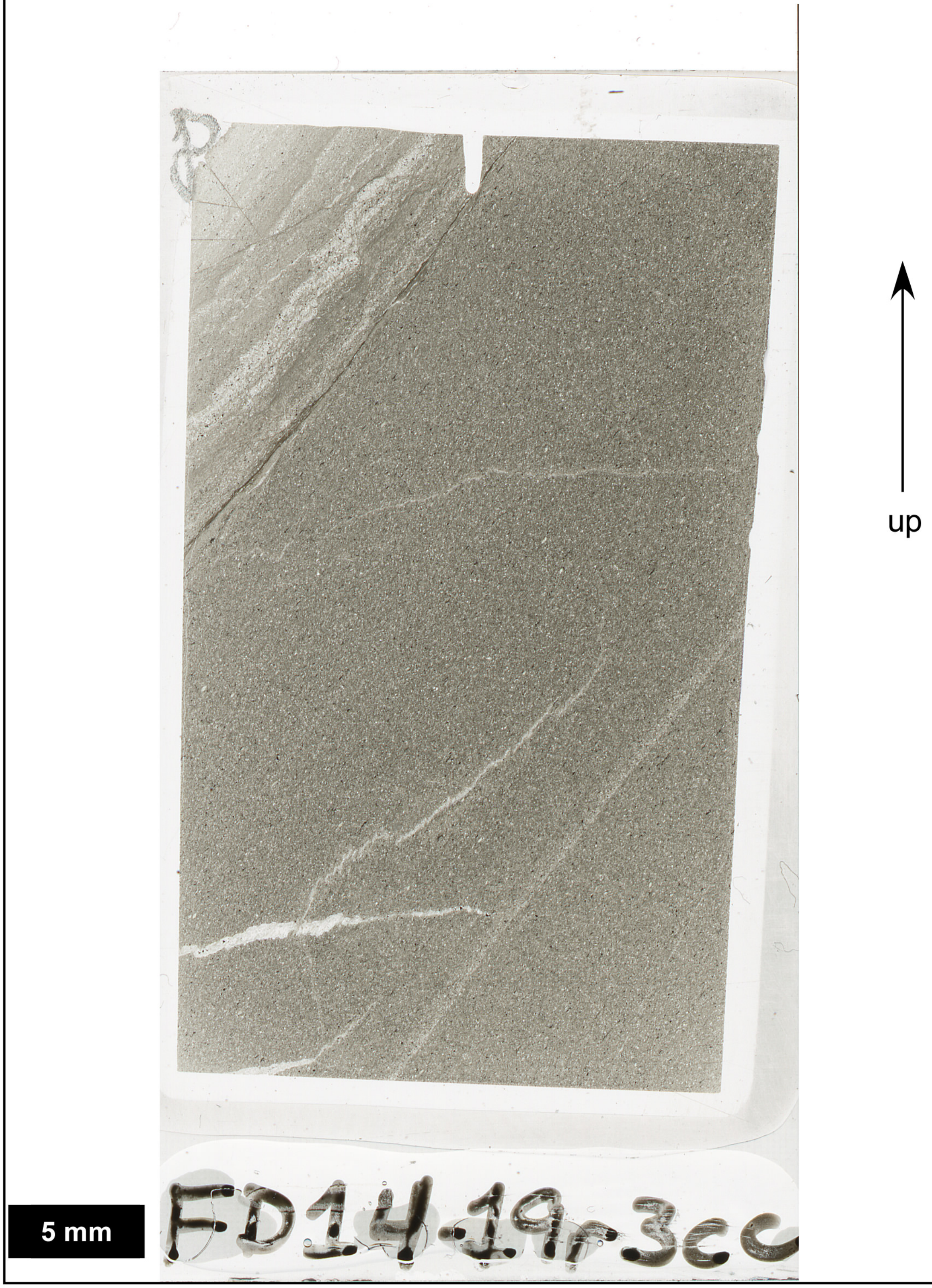
quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary
opaques - secondary

glass

Boring FD-14-19 core run 3 piece cc

Thin section of Cambridge Argillite.

Transmitted-light image.



Petrographic summary

Sample:FD14-19r3cc 1" x 2" thin section
Boring: FD14-19 core run 3 piece cc elevation:-50.46 to -50.62ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
thinly layered

Sedimentary textures:

thin layering of silt-rich mudstone
silt laminae
graded laminae at base of thin layers

Deformation features:

steeply dipping lithologic layers and cleavage

pressure-solution seams paarallel and at high angle to lithological layering
pressure solution cleavage

multidirectional fractures filled with calcite
fractures quartz-filled

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

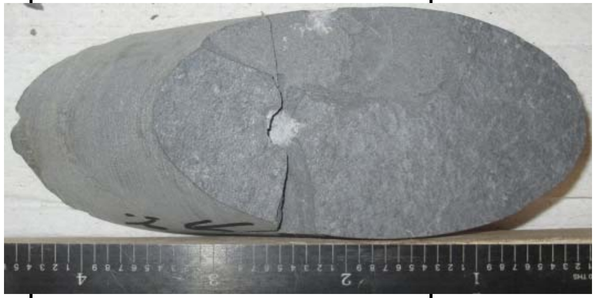
e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
									Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-19	2	bc	-47.71 to -47.97				M		3.5										
FD14-19	2	bc	-47.71 to -47.97	0.13			PL	Diametral					0.5	1632					
FD14-19	2	bc	-47.71 to -47.97				PL	Axial					4.2	12767					
FD14-19	4	di	-53.86 to -54.03	0.08			PL	Diametral					2.1	7229					
FD14-19	4	di	-53.86 to -54.03				PL	Axial					7.2	21498					
FD14-19	6	fc	-57.46 to -58.18				M		2.5										
FD14-19	6	fc	-57.5 to -57.9	0.09	170.0	169.9	UCmod									9490	0.12	8.6E+06	0.18
FD14-19	6	fc	-57.9 to -58.1	0.06	167.0	166.9	B-1	A							1430				
FD14-19	6	fc	-57.9 to -58.1		164.6	164.6	B-2	B							1199				

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	19.1		21.9	
Specimen Width, W (mm)	50.2		43.7	
D (mm)	51.0		27.0	
D' (mm)	51.0		27.0	
D_e (mm)	51.0		38.8	
Failure Load, P (lb)	1233		2713	
Point Load (N)	**5485**		**12068**	
Point Load (Mpa)	**2.13**		**7.16**	
Index, Is50 (psi)	**310**		**1040**	
Unconfined Compressive Strength (psi)	**7229**		**21498**	
Specimen /Failure Sketch				
Tare No.	M-9			
Wet + Tare (gm)	274.68			
Dry + Tare (gm)	274.5			
Tare (gm)	50.13			
Water Content%	**0.08**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

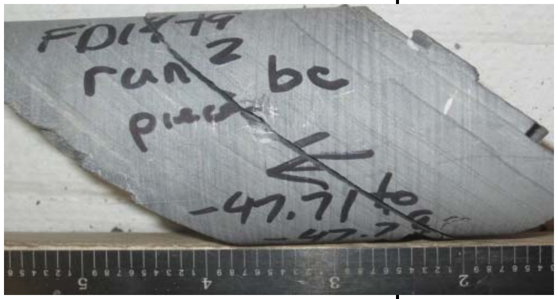
TerraSense, LLC

7803-15001

Boring: FD14-19 Run: 4 - piece di
Elevation: -53.86 to -54.03 ft.

Analysis File: PLV4 (9/09)

4/22/2015
PL14-19-run4di.xlsx

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	28.8		25.9	
Specimen Width, W (mm)	50.3		50.3	
D (mm)	51.0		27.0	
D' (mm)	51.0		27.0	
D_e (mm)	51.0		41.6	
Failure Load, P (lb)	265		1755	
Point Load (N)	**1179**		**7807**	
Point Load (Mpa)	**0.46**		**4.16**	
Index, Is50 (psi)	**70**		**600**	
Unconfined Compressive Strength (psi)	**1632**		**12767**	
Specimen /Failure Sketch				
Tare No.	M-22			
Wet + Tare (gm)	250.25			
Dry + Tare (gm)	249.99			
Tare (gm)	50.58			
Water Content%	**0.13**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

E4science

TerraSense, LLC

7803-15001

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

Boring: FD14-19 Run: 2 - piece bc
Elevation: -47.71 to -47.97 ft.

SPLITTING TENSILE (Brazilian) TEST
ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-19
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 6 - piece fc

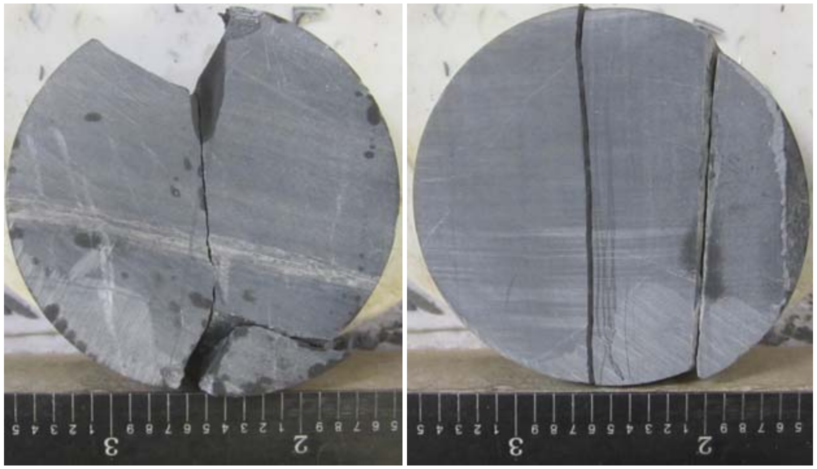
SPECIMEN READINGS

Test Number: B-1
Elevation: -57.9 to -58.1
Specimen mass(gm): 85.35

Thickness (inch)	Diameter (inch)
0.629	1.979
0.645	1.977
0.627	1.978
Average 0.634	1.978

Thickness / Diameter, (t/d): 0.32
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.
Data Acquisition File B14-19R6A
Maximum Load 2814 lb

	After Test
Container No.:	LB-14
Initial Mass + cont. (g):	110.55
Dry Mass + cont. (g):	110.50
Mass of cont. (g):	32.49
Water content (%):	**0.06**
Total unit weight (pcf):	167.03
Dry unit weight (pcf):	166.93
Splitting Tensile Strength (psi)	1429.66



Failure Photo

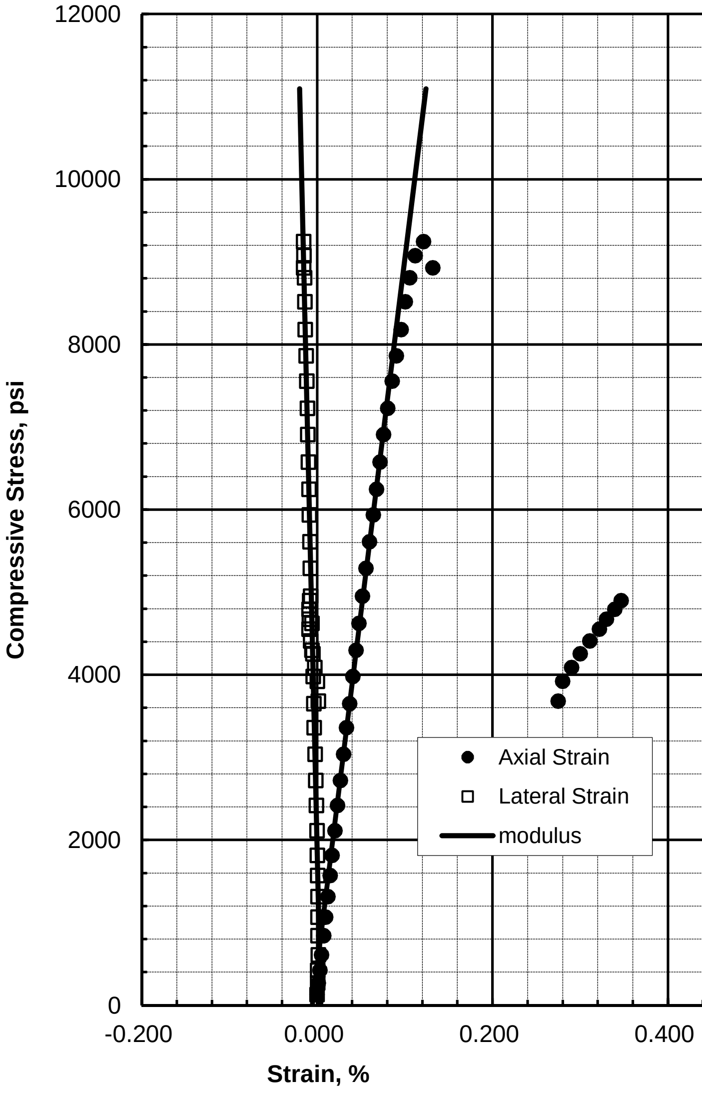
Test Number: B-2
Elevation: -57.9 to -58.1
Specimen mass(gm): 75.15

Thickness (inch)	Diameter (inch)
0.587	1.981
0.545	1.985
0.560	1.981
Average 0.564	1.982

Thickness / Diameter, (t/d): 0.28
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
Data Acquisition File B14-19R6B
Maximum Load 2105 lb

	After Test
Container No.:	LA-208
Initial Mass + cont. (g):	108.59
Dry Mass + cont. (g):	108.59
Mass of cont. (g):	33.39
Water content (%):	**0.00**
Total unit weight (pcf):	164.61
Dry unit weight (pcf):	164.61
Splitting Tensile Strength (psi)	1199.26

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-19** **Run: 6 - piece fc Elevation: -57.9 to -58.1 ft.**
TerraSense, LLC	7803-15001		



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.09	170	170	4.794	1.977

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.17	0.12	9490	8.55E+06	0.18

FAILURE PHOTO

Tested by: GT Test Date: Apr-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-19 Run: 6 fc
Elevation -57.5 to -57.9 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-19	1	-45.9	llfrac	4,540.1	14,895.5
FD14-19	1	-45.9	xfrac	5,880.9	19,294.4
FD14-19	1	-46.5	llfrac	4,558.1	14,954.5
FD14-19	1	-46.5	xfrac	3,307.1	10,849.9
FD14-19	1	-46.8	llbed	4,534.7	14,877.7
FD14-19	1	-46.8	xbed	3,278.1	10,754.8
FD14-19	1	-47.2	llfrac	4,602.0	15,098.4
FD14-19	1	-47.2	xfrac	3,430.5	11,254.8
FD14-19	2	-47.9	llfrac	4,829.4	15,844.5
FD14-19	2	-47.9	xfrac	3,654.5	11,989.7
FD14-19	2	-48.5	llfrac	4,891.0	16,046.5
FD14-19	2	-48.5	xfrac	4,058.9	13,316.6
FD14-19	2	-49.8	llbed	4,852.0	15,918.6
FD14-19	2	-49.8	xbed	3,831.4	12,570.1
FD14-19	3	-50.5	llbed	4,469.9	14,664.9
FD14-19	3	-50.5	xbed	3,158.9	10,363.9
FD14-19	3	-51.4	llfrac	5,127.0	16,821.0
FD14-19	3	-51.4	xfrac	4,415.6	14,486.7
FD14-19	4	-52.9	llfrac	5,280.6	17,324.8
FD14-19	4	-52.9	xfrac	4,327.2	14,196.8
FD14-19	4	-53.3	llfrac	5,340.8	17,522.2
FD14-19	4	-53.3	xfrac	4,678.7	15,349.9
FD14-19	4	-53.9	llfrac	5,370.4	17,619.3
FD14-19	4	-53.9	xfrac	4,343.8	14,251.5
FD14-19	4	-54.3	llfrac	5,314.1	17,434.7
FD14-19	4	-54.3	xfrac	4,354.8	14,287.6
FD14-19	5	-55.4	llfrac	5,528.7	18,138.9
FD14-19	5	-55.4	xfrac	4,617.7	15,149.9
FD14-19	5	-55.8	llfrac	5,578.1	18,300.9
FD14-19	5	-55.8	xfrac	4,842.2	15,886.4
FD14-19	5	-56.4	llfrac	5,479.3	17,976.7
FD14-19	5	-56.4	xfrac	4,620.3	15,158.4
FD14-19	6	-56.8	llbed	5,381.1	17,654.5
FD14-19	6	-56.8	xbed	4,834.4	15,861.0
FD14-19	6	-57.3	llbed	5,590.8	18,342.6
FD14-19	6	-57.3	xbed	4,923.1	16,152.0
FD14-19	6	-57.9	llbed	5,552.0	18,215.3
FD14-19	6	-57.9	xbed	5,019.0	16,466.7
FD14-19	6	-58.5	llbed	5,693.5	18,679.3
FD14-19	6	-58.5	xbed	4,989.3	16,369.0
FD14-19	6	-59.2	llbed	5,507.5	18,069.3
FD14-19	6	-59.2	xbed	4,821.1	15,817.3
FD14-19	6	-59.8	llfrac	5,607.8	18,398.1
FD14-19	6	-59.8	xfrac	4,581.1	15,029.8
FD14-19	7	-60.3	llfrac	5,610.1	18,405.9
FD14-19	7	-60.3	xfrac	4,602.1	15,098.7
FD14-19	7	-60.7	llbed	5,593.1	18,350.1
FD14-19	7	-60.7	xbed	4,761.3	15,621.0
FD14-19	7	-61.0	llbed	5,547.8	18,201.5
FD14-19	7	-61.0	xbed	4,739.8	15,550.6
FD14-19	7	-61.4	llbed	5,563.9	18,254.4
FD14-19	7	-61.4	xbed	5,049.6	16,567.1

US Army Corps
of Engineers®
New England District

e4sciences | Earthworks, LLC

Boston Harbor

boring **FD14-20**

page 1 of

Easting 787,700.7
Northing 2,951,198.4
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Reserved Turning Basin

boring started at 07:05 am December 02, 2014
boring completed at 02:38 pm December 02, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -44.3 MLLW	Top of all rock elevation = -52.7' MLLW	Rock encountered: Cambridge Argillite
Boring bottom elevation = -63.4 MLLW	Rock refusal elevation = -53.4' MLLW	Thickness of sediment = 8.4'
Total depth below channel floor = 19.1'	Number of rock core runs = 4	

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils

Sediment
- ▥ Black silt
- ▨ Clay
- ▯ Silt
- ░ Sand
- ▦ Gravel
- ▦ Sand & gravel
- ▦ Silt, sand & gravel
- ▦ Clay & gravel

Rock

Rock
- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations

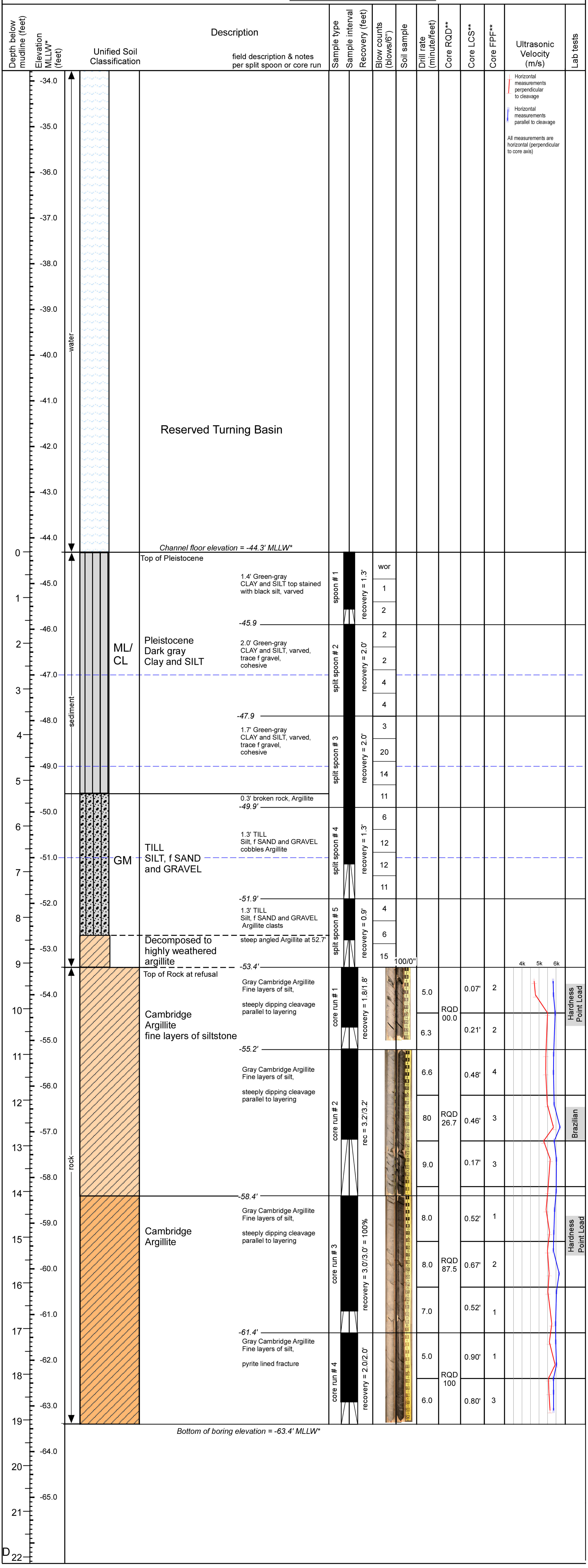
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations

wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Horizontal measurements perpendicular to cleavage

Horizontal measurements parallel to cleavage

All measurements are horizontal (perpendicular to core axis)

Reserved Turning Basin

*Channel floor elevation = -44.3' MLLW**

Top of Pleistocene

Pleistocene
Dark gray
Clay and SILT

1.4' Green-gray
CLAY and SILT top stained
with black silt, varved

-45.9

2.0' Green-gray
CLAY and SILT, varved,
trace f gravel,
cohesive

-47.9

1.7' Green-gray
CLAY and SILT, varved,
trace f gravel,
cohesive

0.3' broken rock, Argillite
-49.9'

TILL
SILT, f SAND
and GRAVEL

1.3' TILL
Silt, f SAND and GRAVEL
cobbles Argillite

-51.9'

1.3' TILL
Silt, f SAND and GRAVEL
Argillite clasts

Decomposed to
highly weathered
argillite

steep angled Argillite at 52.7'

-53.4'

Top of Rock at refusal

Cambridge
Argillite
fine layers of siltstone

Gray Cambridge Argillite
Fine layers of silt,

steeply dipping cleavage
parallel to layering

-55.2'

Gray Cambridge Argillite
Fine layers of silt,

steeply dipping cleavage
parallel to layering

-58.4'

Cambridge
Argillite

Gray Cambridge Argillite
Fine layers of silt,

steeply dipping cleavage
parallel to layering

-61.4'

Gray Cambridge Argillite
Fine layers of silt,

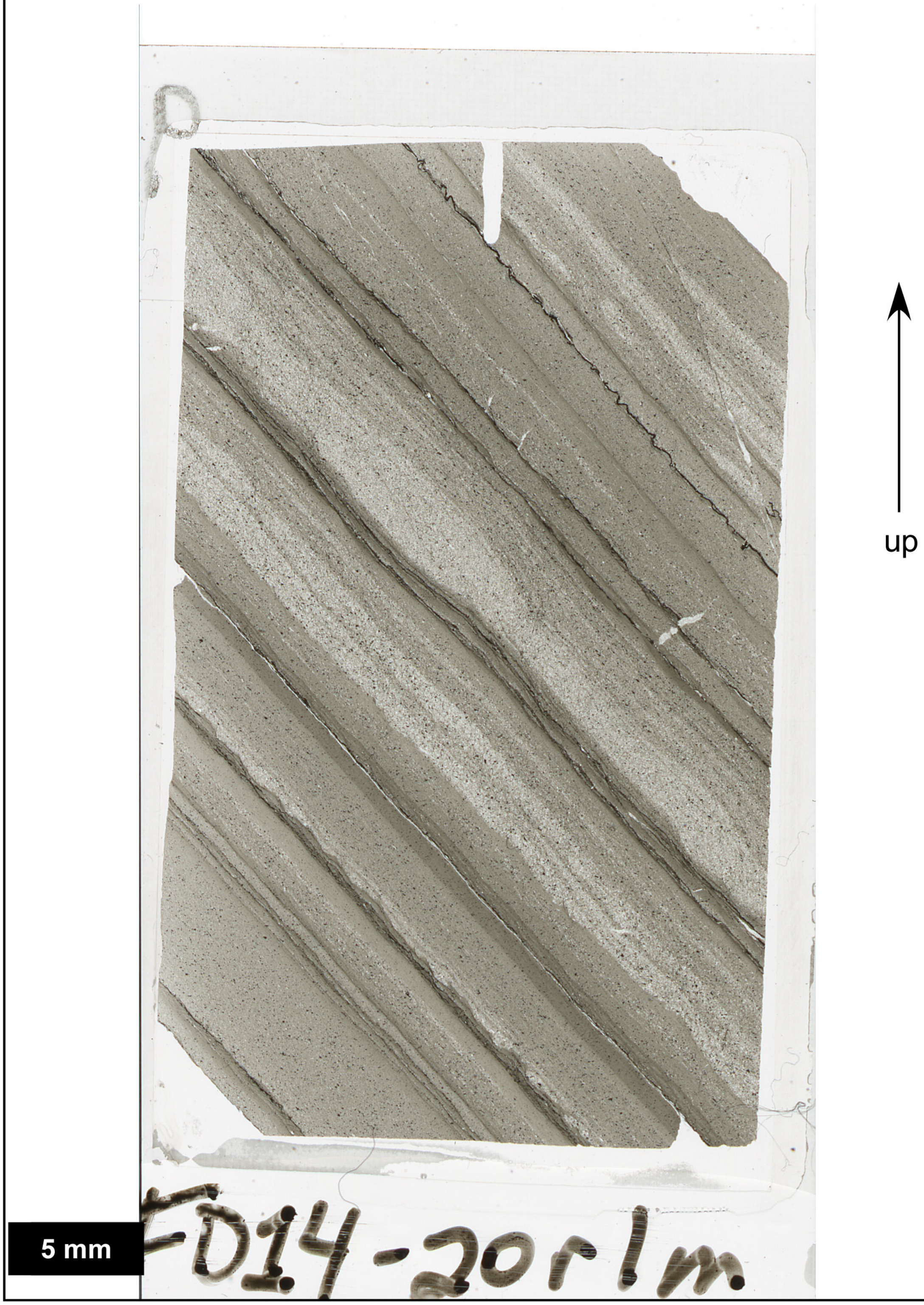
pyrite lined fracture

*Bottom of boring elevation = -63.4' MLLW**

Sample type	Recovery (feet)	Blow counts (blows/6")
spoon # 1	recovery = 1.3'	wor 1 2
split spoon # 2	recovery = 2.0'	2 2 4 4
split spoon # 3	recovery = 2.0'	3 20 14 11
split spoon # 4	recovery = 1.3'	6 12 12 11
split spoon # 5	recovery = 0.9'	4 6 15 100/0"

Sample type	Recovery (feet)	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**
core run # 1	recovery = 1.8/1.8'	5.0 6.3	RQD 00.0	0.07' 0.21'	2 2
core run # 2	rec = 3.2'/3.2'	6.6 80 9.0	RQD 26.7	0.48' 0.46' 0.17'	4 3 3
core run # 3	recovery = 3.0'/3.0' = 100%	8.0 8.0 7.0	RQD 87.5	0.52' 0.67' 0.52'	1 2 1
core run # 4	recovery = 2.0/2.0'	5.0 6.0	RQD 100	0.90' 0.80'	1 3

Boring FD-14-20 core run 1 piece m
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-20r1m
Boring: FD14-20 core run 1 piece lm

1" x 2" thin section
elevation: -54.19 to -54.34ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
siltstone laminated argillite

Sedimentary textures:

thin layers of siltstone and clay-rich mudstone
silt laminae
some graded layers

Deformation features:

steeply dipping lithologic layers and cleavage

pressure-solution seams parallel to lithological layering
pressure solution cleavage
stylolites

tension gashes perpendicular to layering filled with calcite
fracture at angle to layering off set layering

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
white mica - secondary
opaques - secondary

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Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-20	1	j	-53.8 to -54.06				M		3.5										
FD14-20	1	j	-53.8 to -54.06	0.08			PL	Axial					9.7	28637					
FD14-20	1	k	-54.06 to -54.2	0.09			PL	Axial					7.7	24351					
FD14-20	2	bf	-55.76 to -56.22				M		3.5										
FD14-20	2	bh	-56.4 to -56.5	0.03	164.5	164.5	B-1	A							1760				
FD14-20	2	bh	-56.4 to -56.5	0.03	171.1	171.1	B-2	B							2047				
FD14-20	3	cd	-58.62 to -59.29				M		3.5										
FD14-20	3	cd	-58.62 to -59.29				TH			40.0	0.9	38.9							
FD14-20	3	cd	-58.9 to -59.2	0.09			PL	Diametral					1.9	6530					
FD14-20	3	cd	-58.9 to -59.2				PL	Axial					10.5	32521					

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-20
Sample: Run 3 - piece cd
Elevation: -58.62 to -59.29
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	Anvil Calibration Readings	Specimen Readings	D >7?
1	**72.0**	**40.0**	
2	**72.0**	**41.0**	
3	**72.0**		
4	**70.0**		
5	**71.0**		
6	**70.0**		
7	**70.0**		
8	**70.0**		
9	**70.0**		
10	**71.0**		
average	70.8	40.5	
theoretical reading on anvil	**70.0**		
correction factor	0.989		

Corrected Average corrected reading, Hr **40.0**

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	**34.74**	**37.22**
Specimen Mass after 400 revolutions (grams)	**34.24**	**36.73**
Specimen Mass after 800 revolutions (grams)	**33.69**	**36.15**
dM after 400 revolutions (grams)	0.5	0.49
dM after 800 revolutions (grams)	1.05	1.07
Average ΔM (800 revolutions)	1.06	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	0.943	

Total Hardness, $H_T = H_R*(H_A)^{0.5}$ = 38.89

Boston Harbor

e4sciences

TerraSense, LLC

7803-15001

DATA SHEET
TOTAL HARDNESS TEST
Boring: FD14-20 Sample: Run 3 - piece cd
Elevation: -58.62 to -59.29 ft

Data Sheet

Depth:				
Load Orientation:			Axial	
Length to nearest free end, L (mm)			24.3	
Specimen Width, W (mm)			48.6	
D (mm)			25.0	
D' (mm)			23.0	
D_e (mm)			37.7	
Failure Load, P (lb)			3515	
Point Load (N)			**15636**	
Point Load (Mpa)			**9.68**	
Index, Is50 (psi)			**1400**	
Unconfined Compressive Strength (psi)			**28637**	
Specimen /Failure Sketch				
Tare No.			M-11	
Wet + Tare (gm)			242.84	
Dry + Tare (gm)			242.69	
Tare (gm)			50.66	
Water Content%			**0.08**	
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-20 Run: 1 - piece j
Depth: -53.8 to -54.06 ft.

TerraSense, LLC

7803-15001

Analysis File: PLV4 (9/09)

4/22/2015
PL14-20-run1j.xlsx

Depth:				
Load Orientation:			Axial	
Length to nearest free end, L (mm)			31.0	
Specimen Width, W (mm)			50.3	
D (mm)			33.0	
D' (mm)			31.0	
D_e (mm)			44.5	
Failure Load, P (lb)			3602	
Point Load (N)			**16022**	
Point Load (Mpa)			**7.67**	
Index, Is50 (psi)			**1110**	
Unconfined Compressive Strength (psi)			**24351**	
Specimen /Failure Sketch				
Tare No.			M-28	
Wet + Tare (gm)			294.94	
Dry + Tare (gm)			294.71	
Tare (gm)			49.26	
Water Content%			**0.09**	
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

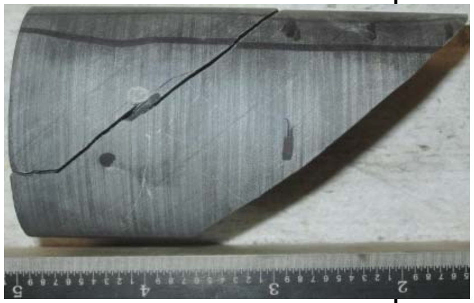
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-20 Run: 1 - piece k
Elevation: -54.06 to -54.2 ft.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	26.4		25.8	
Specimen Width, W (mm)	50.4		51.6	
D (mm)	51.0		27.0	
D' (mm)	51.0		27.0	
D_e (mm)	51.0		42.1	
Failure Load, P (lb)	1124		4518	
Point Load (N)	**5000**		**20097**	
Point Load (Mpa)	**1.94**		**10.49**	
Index, Is50 (psi)	**280**		**1520**	
Unconfined Compressive Strength (psi)	**6530**		**32521**	
Specimen /Failure Sketch				
Tare No.	M-16			
Wet + Tare (gm)	257.98			
Dry + Tare (gm)	257.79			
Tare (gm)	50.56			
Water Content%	**0.09**			
Comments				

Test by: RAT Test Date: 4/17/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

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TerraSense, LLC

7803-15001

Boring: FD14-20 Run: 3 - piece cd
Elevation: -58.9 to -59.2 ft.

Analysis File: PLV4 (9/09)

4/22/2015
PL14-20-run3cd.xlsx

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-20
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 2 - piece bh

SPECIMEN READINGS

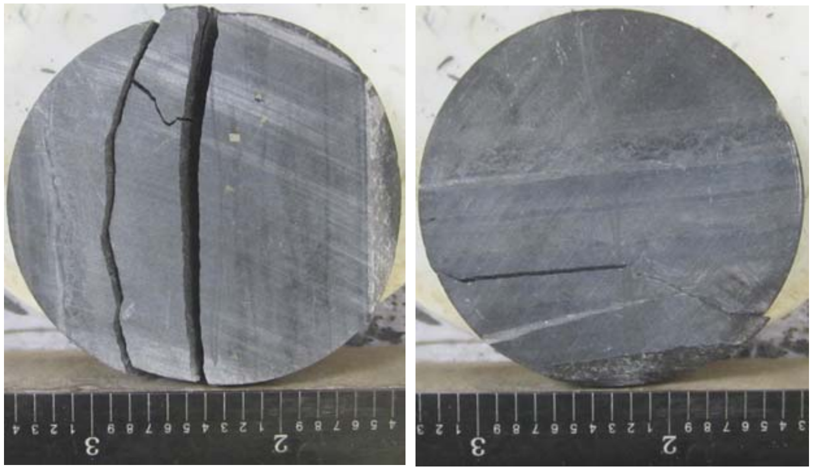
Test Number: B-1
Elevation: -56.4 to -56.5
Specimen mass(gm): 68.39

Thickness (inch)	Diameter (inch)
0.484	1.981
0.518	1.981
0.541	1.981
Average 0.514	1.981

Thickness / Diameter, (t/d): 0.26
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.

Data Acquisition File B14-20R2A
Maximum Load 2814 lb

	After Test
Container No.:	LA-133
Initial Mass + cont. (g):	102.44
Dry Mass + cont. (g):	102.42
Mass of cont. (g):	34.00
Water content (%):	**0.03**
Total unit weight (pcf):	164.52
Dry unit weight (pcf):	164.47
Splitting Tensile Strength (psi)	1759.66



Failure Photo

Test Number: B-2
Elevation: -56.4 to -56.5
Specimen mass(gm): 70.81

Thickness (inch)	Diameter (inch)
0.510	1.980
0.510	1.980
0.517	1.981
Average 0.512	1.980

Thickness / Diameter, (t/d): 0.26
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch

Data Acquisition File B14-20R2B
Maximum Load 3259 lb

	After Test
Container No.:	LC-2
Initial Mass + cont. (g):	103.14
Dry Mass + cont. (g):	103.12
Mass of cont. (g):	33.34
Water content (%):	**0.03**
Total unit weight (pcf):	171.12
Dry unit weight (pcf):	171.07
Splitting Tensile Strength (psi)	2046.58

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-20** **Run: 2 - piece bh Elevation: -56.4 to -56.5 ft**
TerraSense, LLC	7803-15001		

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-20	1	-53.7	llfrac	5,822.3	19,102.0
FD14-20	1	-53.7	xfrac	4,706.5	15,441.2
FD14-20	1	-54.0	llfrac	5,845.0	19,176.4
FD14-20	1	-54.0	xfrac	4,779.8	15,681.8
FD14-20	1	-54.4	llfrac	5,941.6	19,493.3
FD14-20	1	-54.4	xfrac	5,496.5	18,033.1
FD14-20	2	-55.3	llbed	5,854.5	19,207.6
FD14-20	2	-55.3	xbed	5,397.5	17,708.3
FD14-20	2	-55.7	llbed	5,845.0	19,176.4
FD14-20	2	-55.7	xbed	5,388.0	17,677.3
FD14-20	2	-56.4	llbed	5,882.7	19,300.0
FD14-20	2	-56.4	xbed	5,480.3	17,980.1
FD14-20	2	-56.9	llbed	6,227.4	20,431.1
FD14-20	2	-56.9	xbed	5,840.8	19,162.8
FD14-20	2	-57.2	llfrac	5,888.6	19,319.5
FD14-20	2	-57.2	xfrac	5,265.7	17,275.9
FD14-20	2	-57.6	llfrac	6,017.4	19,742.1
FD14-20	2	-57.6	xfrac	5,650.7	18,538.9
FD14-20	2	-58.3	llfrac	6,003.8	19,697.4
FD14-20	2	-58.3	xfrac	5,511.4	18,082.1
FD14-20	3	-58.7	llbed	5,911.8	19,395.5
FD14-20	3	-58.7	xbed	5,408.4	17,744.1
FD14-20	3	-59.2	llbed	5,865.6	19,244.2
FD14-20	3	-59.2	xbed	5,614.4	18,419.8
FD14-20	3	-59.6	llbed	5,839.9	19,159.9
FD14-20	3	-59.6	xbed	5,487.6	18,004.0
FD14-20	3	-60.1	llbed	6,176.5	20,264.2
FD14-20	3	-60.1	xbed	5,586.6	18,328.7
FD14-20	3	-60.5	llbed	6,018.8	19,746.8
FD14-20	3	-60.5	xbed	5,514.5	18,092.1
FD14-20	3	-61.2	llbed	5,967.8	19,579.4
FD14-20	3	-61.2	xbed	5,744.0	18,845.1
FD14-20	4	-61.6	llbed	5,976.6	19,608.1
FD14-20	4	-61.6	xbed	5,601.2	18,376.7
FD14-20	4	-62.1	llfrac	6,018.8	19,746.8
FD14-20	4	-62.1	xfrac	5,939.8	19,487.5
FD14-20	4	-62.4	llbed	5,845.0	19,176.4
FD14-20	4	-62.4	xbed	5,550.0	18,208.5
FD14-20	4	-62.7	llbed	5,849.4	19,190.9
FD14-20	4	-62.7	xbed	5,575.9	18,293.7
FD14-20	4	-63.1	llbed	5,849.4	19,190.9
FD14-20	4	-63.1	xbed	5,641.3	18,508.2

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-21**

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page 1 of 1

Easting 787,106.4
Northing 2,951,198.4
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Reserved Turning Basn

boring started at 06:23 am December 05, 2014
boring completed at 03:45 pm December 05, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -40.0 MLLW
Boring bottom elevation = -63.9 MLLW
Total depth below channel floor = 23.9'

Top of all rock elevation = -57.0' MLLW
Rock refusal elevation = -60.3' MLLW
Number of rock core runs = 0

Rock encountered: Cambridge Argillite
Thickness of sediment = 17.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils

Sediment
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock

Rock
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations

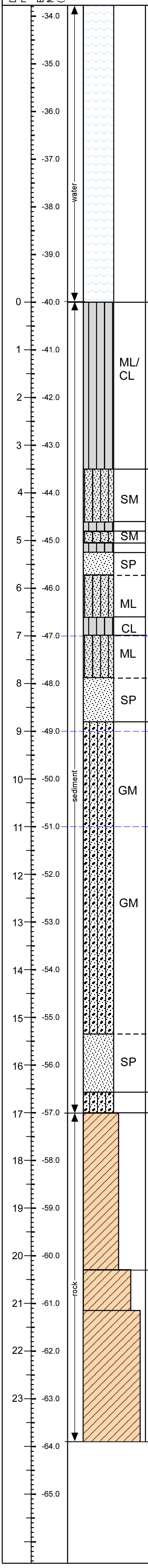
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations

wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Description

Reserved Turning Basin

*Channel floor elevation = -40.0' MLLW**

Top of Pleistocene

Green-Gray Clay and SIlt, varved

Glacial Outwash SANDS and SILTS with interbeds of Green-Gray Clay and SIlt, varved

TILL
f-m SAND and GRAVEL

TILL
SILT, f SAND and GRAVEL

f SAND and SILT

f SAND and GRAVEL

-57.0'

Decomposed to highly weathered Cambridge Argillite

Top of rock at refusal

Cambridge Argillite

Elevation MLLW* (feet)	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")
-40.0 to *-42.0'*	2.0 Green-gray CLAY and SILT varved, trace m sand laminae, cohesive, black laminae	3" split spoon #1	recovery = 2.0'	1 1 2 2
-42.0' to *-44.0'*	1.5' Green-gray CLAY and SILT, varved, cohesive, trace f sand 0.2' f SAND, some silt	3" split spoon # 2	recovery = 1.7'	2 4 4 5
-44.0' to *-46.0'*	0.6' f SAND and SILT 0.2' CLAY and SILT, varved 0.25' f SAND and SILT 0.2' CLAY and SILT, varved 0.25' f SAND	split spoon # 3	recovery = 1.5'	3 20 14 11
-46.0' to *-48.0'*	0.6' SILT, trace f sand 0.4' CLAY and SILT, varved, 0.6' SILT, trace f sand, cross lamination	3" split spoon # 4	recovery = 1.1'	10 4 4 10
-48.0' to *-50.0'*	0.8' f SAND, trace silt 0.4' f-m SAND and GRAVEL argillite clasts	3" split spoon # 5	recovery = 1.2'	12 14 7 5
-50.0' to *-52.0'*	1.3' f-m SAND and GRAVEL argillite clasts	3" split spoon # 6	recovery = 1.3'	6 2 10 12
-52.0' to *-54.0'*	0.5' TILL Silt, f SAND and GRAVEL pebbles argillite & pink granite	3" split spoon #7	recovery = 0.5'	60 24 20 44
-54.0' to *-56.0'*	attempted to resample	3" split spoon # 8	recovery = 0.0'	1 6 5 7
-56.0' to *-58.0'*	0.6' f SAND and SILT 0.4' TILL f SAND GRAVEL cobbles argillite Decomposed rock, steeply dipping cleavage	3" split spoon # 9	recovery = 1.3'	4 5 4 13
-58.0' to *-60.0'*	Broken argillite high angled, in place	3" split spoon # 10	recovery = 1.3'	13 11 16 44
-60.0' to *-60.3'*	Refusal	# 11		100/4"
below *-60.3'*	Drilled down to confirm rock smooth drilling, broken rock to 61.2' smooth drilling below that			

*Bottom of boring elevation = -63.9' MLLW**

Sample interval
Soil sample
Drill rate (minute/feet)
Core RQD**
Core LCS**
Core FPF**

Ultrasonic Velocity (m/s)

Horizontal measurements perpendicular to cleavage

Horizontal measurements parallel to cleavage

All measurements are horizontal (perpendicular to core axis)

Lab tests

Boring FD-14-21 spoon 10

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-21s10a
Boring: FD14-21 spoon 20 piece a

1" x 2" thin section
elevation: -44.51 to -44.60ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
shale-dominated argillite with insitu pyrite crystals

Sedimentary textures:

fine laminae of quartz silt
subtle cross lamination

Deformation features:

unoriented sample from split spoon

few fine pressure-solution seams parallel to lithological layering

no fractures apparent

Key minerals:

quartz - detrital silt-sized grains sub angular
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary
pyrite crystals-secondary replacing mudstone
opaques

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-22**

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page 1 of 1

Easting 786,993.2
Northing 2,950,809.5
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 03:00 pm December 03, 2014
boring completed at 07:00 pm December 03, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -42.5 MLLW
Boring bottom elevation = -56.6 MLLW
Total depth below channel floor = 14.1'

Top of all rock elevation = -45.1'MLLW
Rock refusal elevation = -45.6'MLLW
Number of rock core runs = 3

Rock encountered: Cambridge Argillite
Thickness of sediment = 2.6'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)

- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)

- 🟩 Mafic igneous rock with RQD < 50
- 🟩 Mafic igneous rock with RQD >50
- 🟩 Hornfels & contact-metamorphic altered argillite with RQD < 50
- 🟩 Hornfels & contact-metamorphic altered argillite RQD >50
- 🟧 Argillite with RQD < 50
- 🟧 Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations

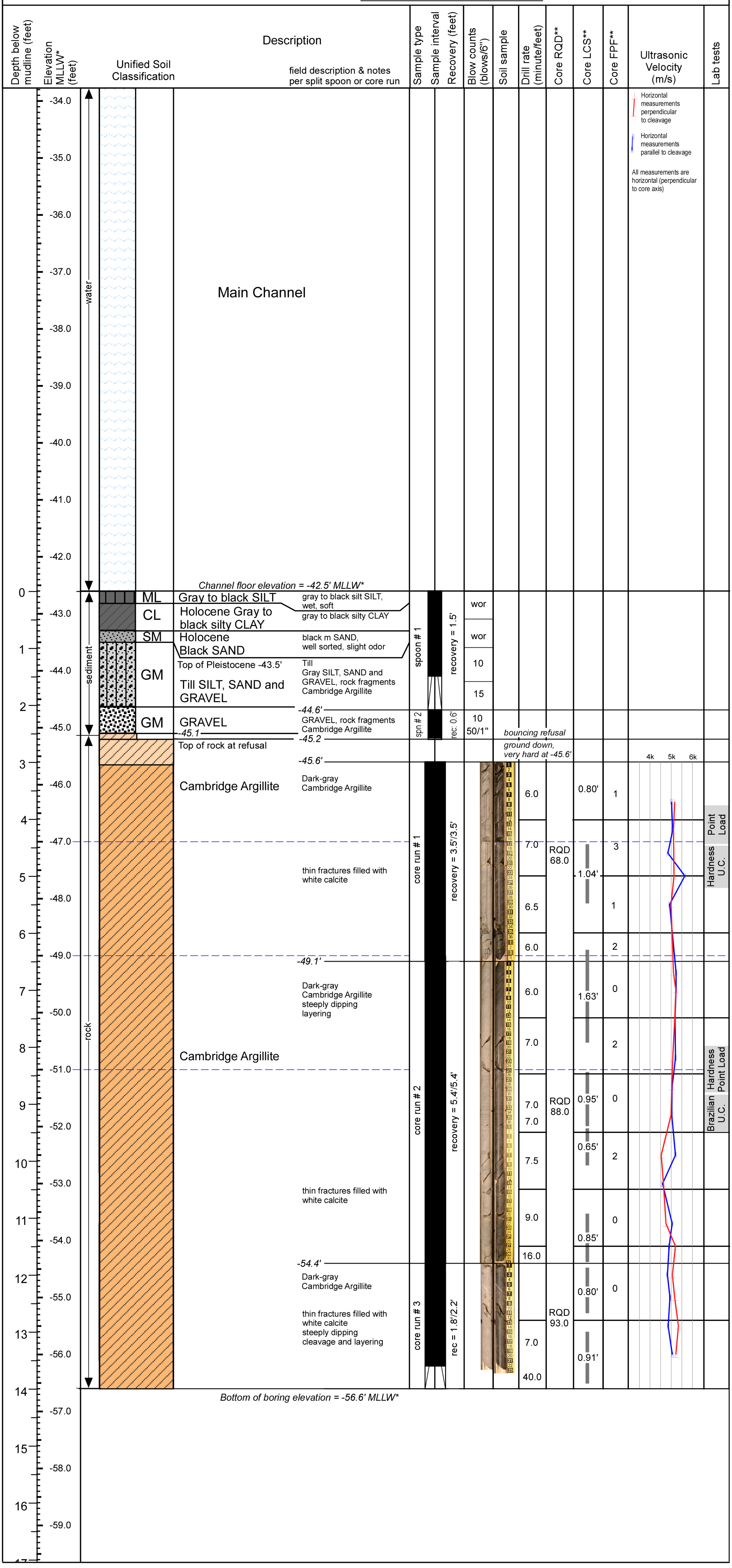
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations

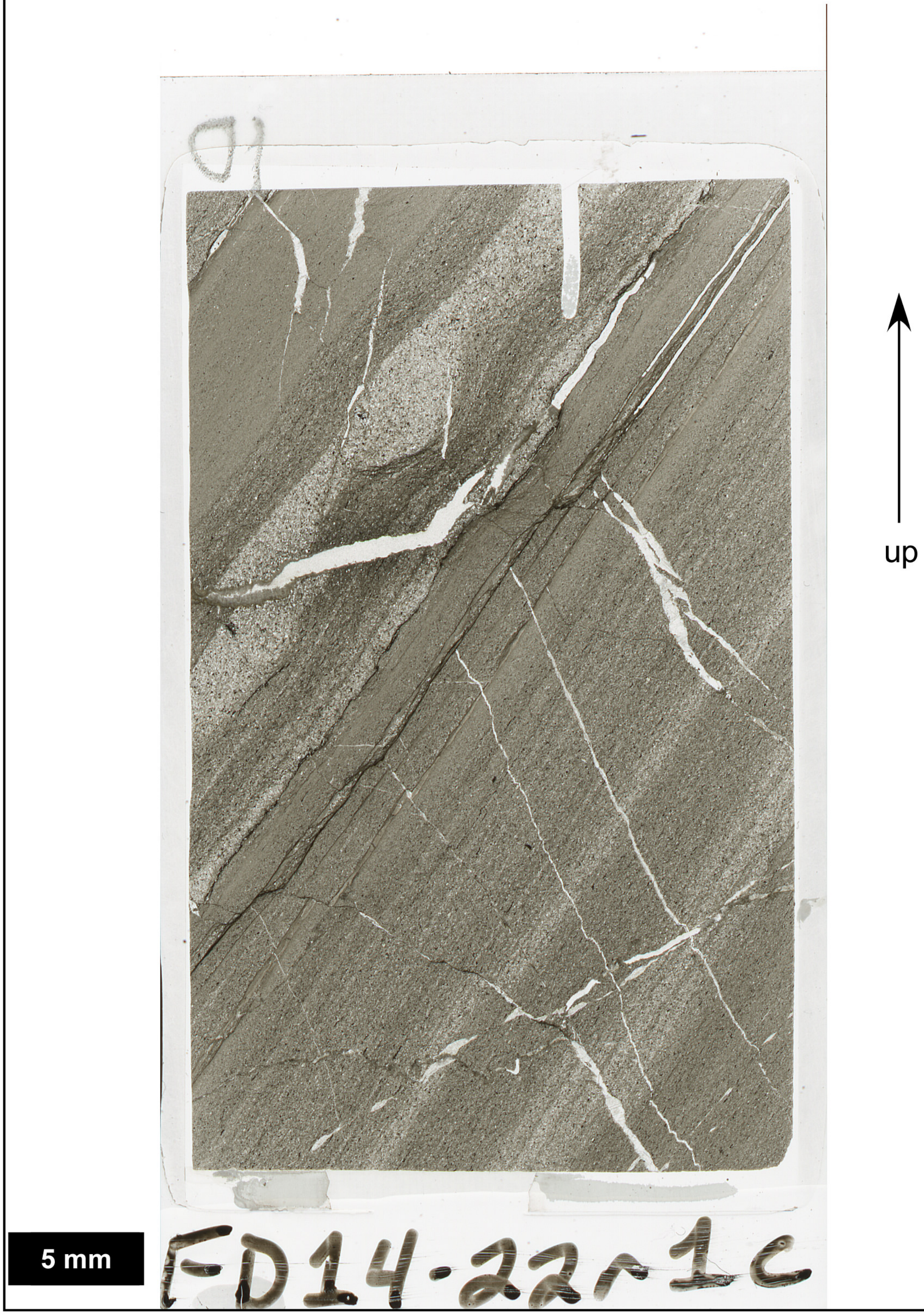
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-22 core run 1 piece c
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-22r1c
Boring: FD14-22 run 1 piece c

1" x 2" thin section
elevation: -43.30 to -44.43ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
laminated shale-dominated argillite

Sedimentary textures:

thinly layered
fine laminae of silt

subtle low-angle cross-lamination
graded layers

Deformation features:

steeply dipping lithologic layers and cleavage

pressure-solution seams subparallel to lithological layering
lensing/augen? of siltstone layer

multiple fracture orientations, calcite-filled fractures:
- 1 vertical
- 2 at high angle conjugates locally with minor offset of layers
- 2 at lower angle conjugates with minor offset of layers

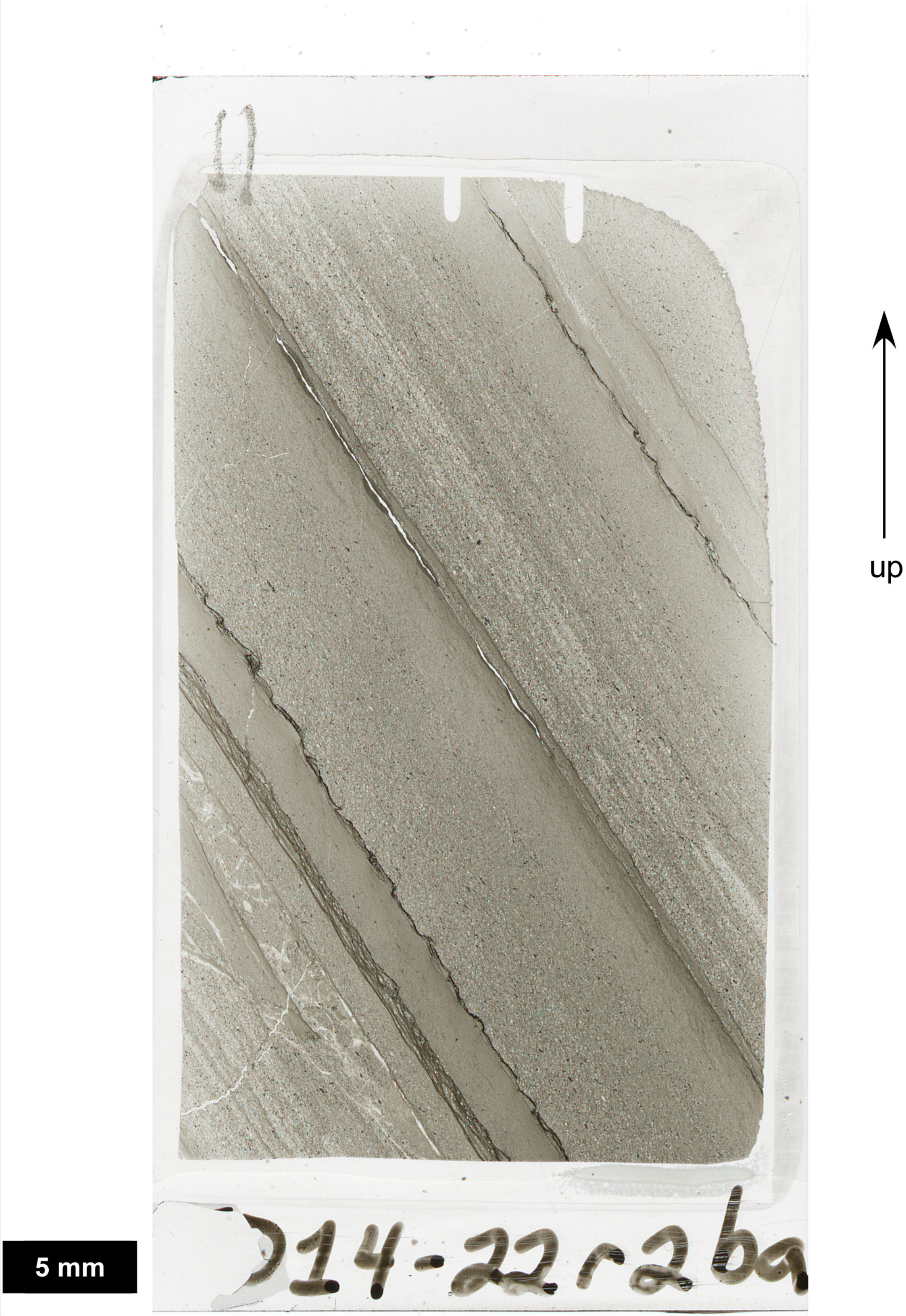
Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

grains replaced by calcite

Boring FD-14-22 core run 2 piece ba

Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-22r2ba 1" x 2" thin section

Boring: FD14-22 core run 2 piece ba elevation: --48.22 to -48.37ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
laminated shale-dominated argillite with siltstone laminae

Sedimentary textures:

thin layering
silt laminae

cross-lamination
graded layers

Deformation features:

steeply dipping lithologic layers

crenulation along layers
pressure-solution seams parallel to lithologic layering

fine calcite-filled fractures high-angle to lithologic layering

highly fractured cemented layer

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

grains replaced by calcite
grains replaced by chlorite

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-22	1	d	-44.61 to -44.85	0.15			PL	Diametral					0.8	2798					
FD14-22	1	d	-44.61 to -44.85				PL	Axial					5.2	15862					
FD14-22	1	f	-45.27 to -46.31				M		2.5										
FD14-22	1	f	-45.35 to -45.75	0.16	167.3	167.0	UCmod									8940	0.16	6.3E+06	0.22
FD14-22	1	f	- 45.75 to -46.31				TH			37.4	0.7	30.9							
FD14-22	2	bc	-48.93 to -49.9				M		3.5										
FD14-22	2	bc	-48.9 to -49.2	0.18			PL	Diametral					0.9	3056					
FD14-22	2	bc	-48.9 to -49.2				PL	Diametral					1.9	6295					
FD14-22	2	bc	-48.9 to -49.2				PL	Axial					2.2	6968					
FD14-22	2	bc	-49.2 to -49.45	0.17	166.4	166.1	B-1	A							608				
FD14-22	2	bc	-49.2 to -49.45	0.17	164.2	164.0	B-2	B							484				
FD14-22	2	bc	-49.45 to -49.85	0.18	167.7	167.4	UCmod									6310	0.12	6.1E+06	0.18

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-22
Sample: Run 1 - piece f
Elevation: - 45.75 to -46.31
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	**Anvil Calibration Readings**	Specimen Readings	D >7?
1	**72.0**	**38.0**	
2	**72.0**	**40.0**	
3	**72.0**	**36.0**	
4	**70.0**	**35.0**	
5	**71.0**	**37.0**	
6	**70.0**	**36.0**	
7	**70.0**	**41.0**	
8	**70.0**	**40.0**	
9	**70.0**	**38.0**	
10	**71.0**	**37.0**	
average	70.8	37.8	
theoretical reading on anvil	**70.0**		
correction factor	0.989		

Corrected Average corrected reading, Hr **37.4**

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	**42.33**	**39.94**
Specimen Mass after 400 revolutions (grams)	**41.52**	**39.2**
Specimen Mass after 800 revolutions (grams)	**40.88**	**38.47**
dM after 400 revolutions (grams)	0.81	0.74
dM after 800 revolutions (grams)	1.45	1.47
Average ΔM (800 revolutions)	1.46	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	0.685	

Total Hardness, $H_T = H_R*(H_A)^{0.5} =$ 30.93

Boston Harbor

e4sciences

TerraSense, LLC 7803-15001

DATA SHEET

TOTAL HARDNESS TEST

Boring: FD14-22 Sample: Run 1 - piece f

Elevation: - 45.75 to -46.31 ft

Data Sheet

Depth:				
Load Orientation:	Diametral	Diametral	Axial	
Length to nearest free end, L (mm)	31.9	29.1	31.5	
Specimen Width, W (mm)	50.3	50.3	52.0	
D (mm)	52.0	51.0	30.0	
D' (mm)	52.0	47.0	29.0	
D_e (mm)	52.0	47.0	43.8	
Failure Load, P (lb)	517	973	1001	
Point Load (N)	**2300**	**4328**	**4453**	
Point Load (Mpa)	**0.87**	**1.91**	**2.19**	
Index, Is50 (psi)	**130**	**280**	**320**	
Unconfined Compressive Strength (psi)	**3056**	**6295**	**6968**	
Specimen /Failure Sketch				
Tare No.	M-25			
Wet + Tare (gm)	171.86			
Dry + Tare (gm)	171.64			
Tare (gm)	51.09			
Water Content%	**0.18**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

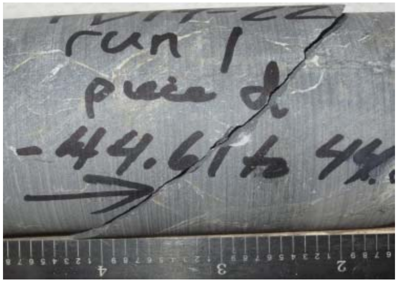
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC

7803-15001

Boring: FD14-22 Run: 2 - piece bc
Elevation: -48.9 to -49.2 ft.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	28.1		23.6	
Specimen Width, W (mm)	50.3		47.1	
D (mm)	51.0		29.0	
D' (mm)	51.0		28.0	
D_e (mm)	51.0		41.0	
Failure Load, P (lb)	489		2144	
Point Load (N)	**2175**		**9537**	
Point Load (Mpa)	**0.84**		**5.19**	
Index, Is50 (psi)	**120**		**750**	
Unconfined Compressive Strength (psi)	**2798**		**15862**	
Specimen /Failure Sketch				
Tare No.	M-18			
Wet + Tare (gm)	295.32			
Dry + Tare (gm)	294.94			
Tare (gm)	49.58			
Water Content%	**0.15**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-22 Run: 1 - piece d
Elevation: -44.61 to -44.85 ft.

TerraSense, LLC

7803-15001

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001 **Test by:** GT **Sta:** FD14-22

Project Name: Boston Harbor **Test Date:** 4/20/15 **Run:** 2 - piece bc

SPECIMEN READINGS

Test Number: B-1

Depth: -49.2 to -49.45

Specimen mass(gm): 110.27

Thickness (inch)	Diameter (inch)
0.819	1.979
0.824	1.980
0.821	1.979
Average 0.821	1.979

Thickness / Diameter, (t/d): 0.41

t/D ratio between 0.2 and 0.75 yes

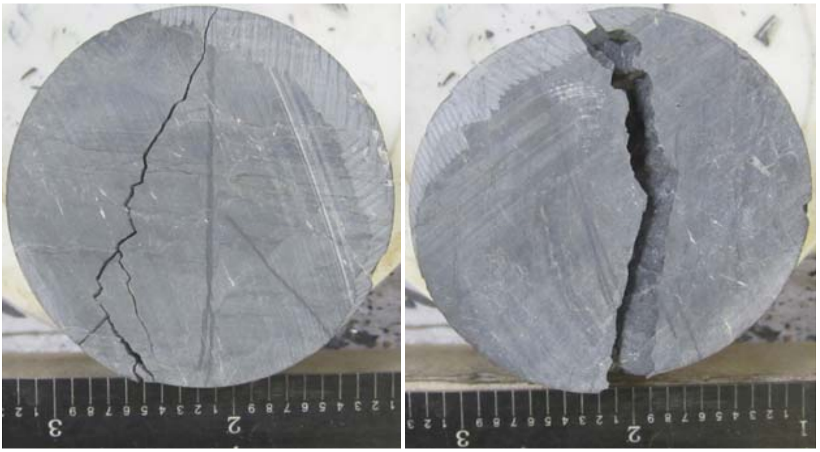
Largest Grain Diameter 0.010 inch

meets mineral size spec.

Data Acquisition File B14-22R2A

Maximum Load 1551 lb

	After Test
Container No.:	LB-22
Initial Mass + cont. (g):	143.94
Dry Mass + cont. (g):	143.75
Mass of cont. (g):	33.90
Water content (%):	**0.17**
Total unit weight (pcf):	166.38
Dry unit weight (pcf):	166.10
Splitting Tensile Strength (psi)	607.84



Failure Photo

Test Number: B-2

Depth: -49.2 to -49.45

Specimen mass(gm): 111.58

Thickness (inch)	Diameter (inch)
0.839	1.981
0.859	1.978
0.826	1.980
Average 0.841	1.979

Thickness / Diameter, (t/d): 0.42

t/D ratio between 0.2 and 0.75 yes

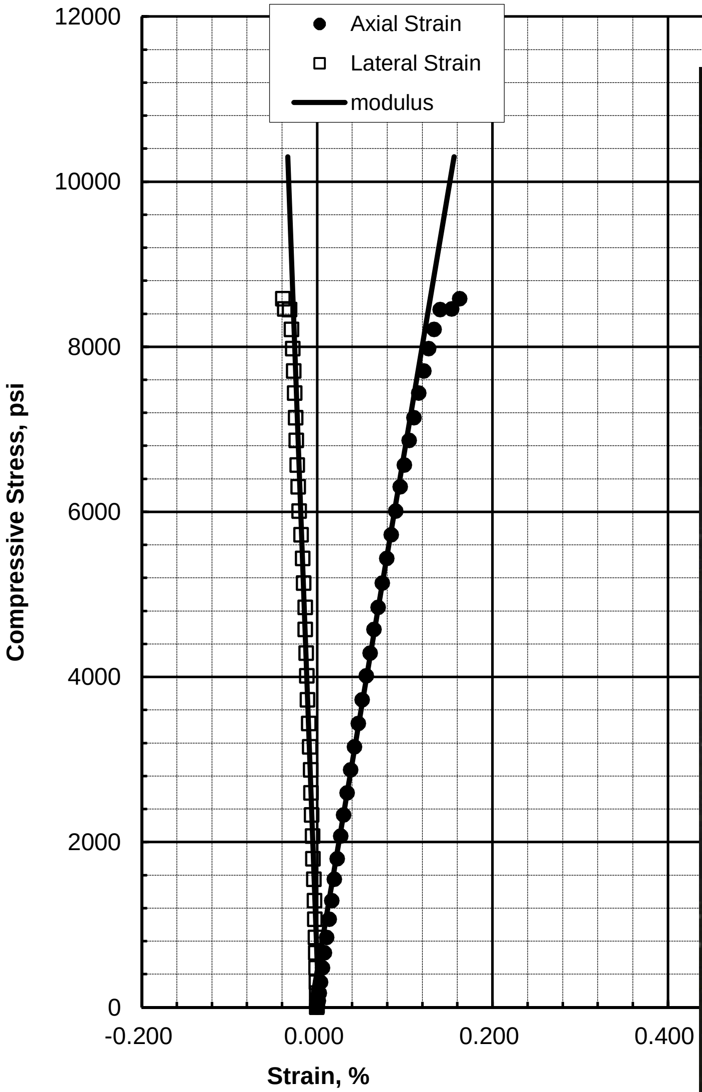
Largest Grain Diameter 0.010 inch

Data Acquisition File B14-22R2B

Maximum Load 1267 lb

	After Test
Container No.:	LB-9
Initial Mass + cont. (g):	145.55
Dry Mass + cont. (g):	145.36
Mass of cont. (g):	34.11
Water content (%):	**0.17**
Total unit weight (pcf):	164.24
Dry unit weight (pcf):	163.96
Splitting Tensile Strength (psi)	484.46

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-22** **Run: 2 - piece bc Depth: -49.2 to -49.45 ft.**
TerraSense, LLC	7803-15001		



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.16	167	167	4.785	1.977

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.13	0.16	8940	6.31E+06	0.22

FAILURE PHOTO

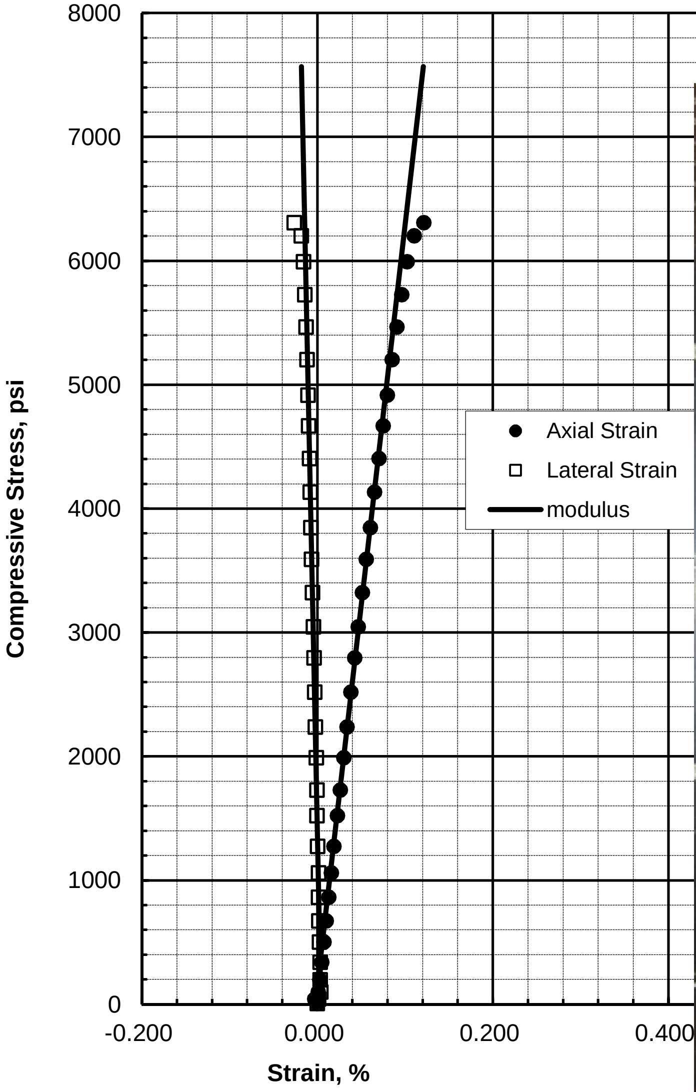
Tested by: GT Test Date: Apr-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-22 Run: 1 f
Elevation -45.35 to -45.75 ft.



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.18	168	167	4.774	1.979

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.13	0.12	6310	6.15E+06	0.18

FAILURE PHOTO

Tested by: GT Test Date: Apr-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-22 Run: 2 bc
Elevation -49.45 to -49.85 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-22	1	-44.3	llfrac	5,007.7	16,429.5
FD14-22	1	-44.3	xfrac	5,155.8	16,915.3
FD14-22	1	-44.8	llbed	5,060.8	16,603.7
FD14-22	1	-44.8	xbed	5,099.4	16,730.2
FD14-22	1	-45.2	llfrac	4,837.0	15,869.4
FD14-22	1	-45.6	llbed	5,633.8	18,483.7
FD14-22	1	-45.6	xbed	5,125.2	16,814.9
FD14-22	1	-46.1	llbed	4,918.1	16,135.6
FD14-22	1	-46.1	xbed	4,984.6	16,353.8
FD14-22	2	-47.3	llbed	5,222.9	17,135.4
FD14-22	2	-47.3	xbed	5,099.4	16,730.2
FD14-22	2	-47.6	llbed	5,221.0	17,129.1
FD14-22	2	-47.6	xbed	5,211.7	17,098.9
FD14-22	2	-48.1	llbed	5,172.8	16,971.0
FD14-22	2	-48.1	xbed	5,160.3	16,930.3
FD14-22	2	-48.8	llbed	5,195.5	17,045.5
FD14-22	2	-48.8	xbed	5,064.6	16,616.3
FD14-22	2	-49.3	llbed	5,035.6	16,520.8
FD14-22	2	-49.3	xbed	5,021.6	16,475.0
FD14-22	2	-49.8	llbed	5,019.5	16,468.3
FD14-22	2	-49.8	xbed	4,983.0	16,348.4
FD14-22	2	-50.5	llbed	5,194.1	17,041.2
FD14-22	2	-50.5	xbed	4,519.2	14,826.9
FD14-22	2	-51.0	llbed	4,584.7	15,041.7
FD14-22	2	-51.0	xbed	4,626.4	15,178.6
FD14-22	2	-51.7	llbed	5,036.8	16,525.0
FD14-22	2	-51.7	xbed	4,744.5	15,566.0
FD14-22	2	-52.1	llbed	4,894.7	16,058.7
FD14-22	2	-52.1	xbed	5,194.1	17,041.2
FD14-22	3	-52.6	llbed	4,813.6	15,792.6
FD14-22	3	-52.6	xbed	5,048.1	16,562.1
FD14-22	3	-53.0	llbed	4,933.1	16,184.6
FD14-22	3	-53.0	xbed	5,155.5	16,914.3
FD14-22	3	-53.5	llbed	4,848.3	15,906.5
FD14-22	3	-53.5	xbed	5,332.9	17,496.5
FD14-22	3	-54.0	llbed	5,044.3	16,549.5
FD14-22	3	-54.0	xbed	5,210.4	17,094.6

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-23**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 797,123.1
Northing 2,948,871.3
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 06:18 am December 16, 2014
boring completed at 01:26 pm December 16, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -45.6 MLLW
Boring bottom elevation = -63.2 MLLW
Total depth below channel floor = 17.6'

Top of all rock elevation = -50.5'MLLW
Rock refusal elevation = -53.0'MLLW
Number of rock core runs = 3

Rock encountered: Cambridge Argillite
Thickness of sediment = 7.4'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

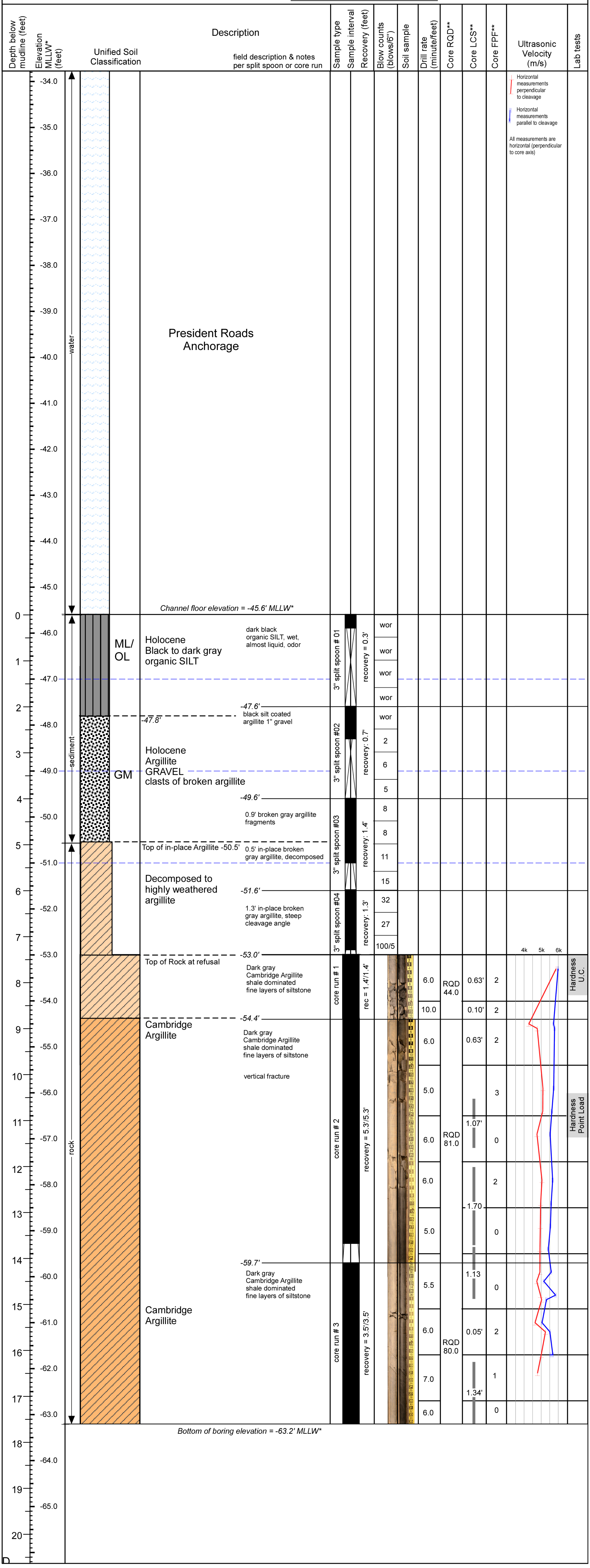
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

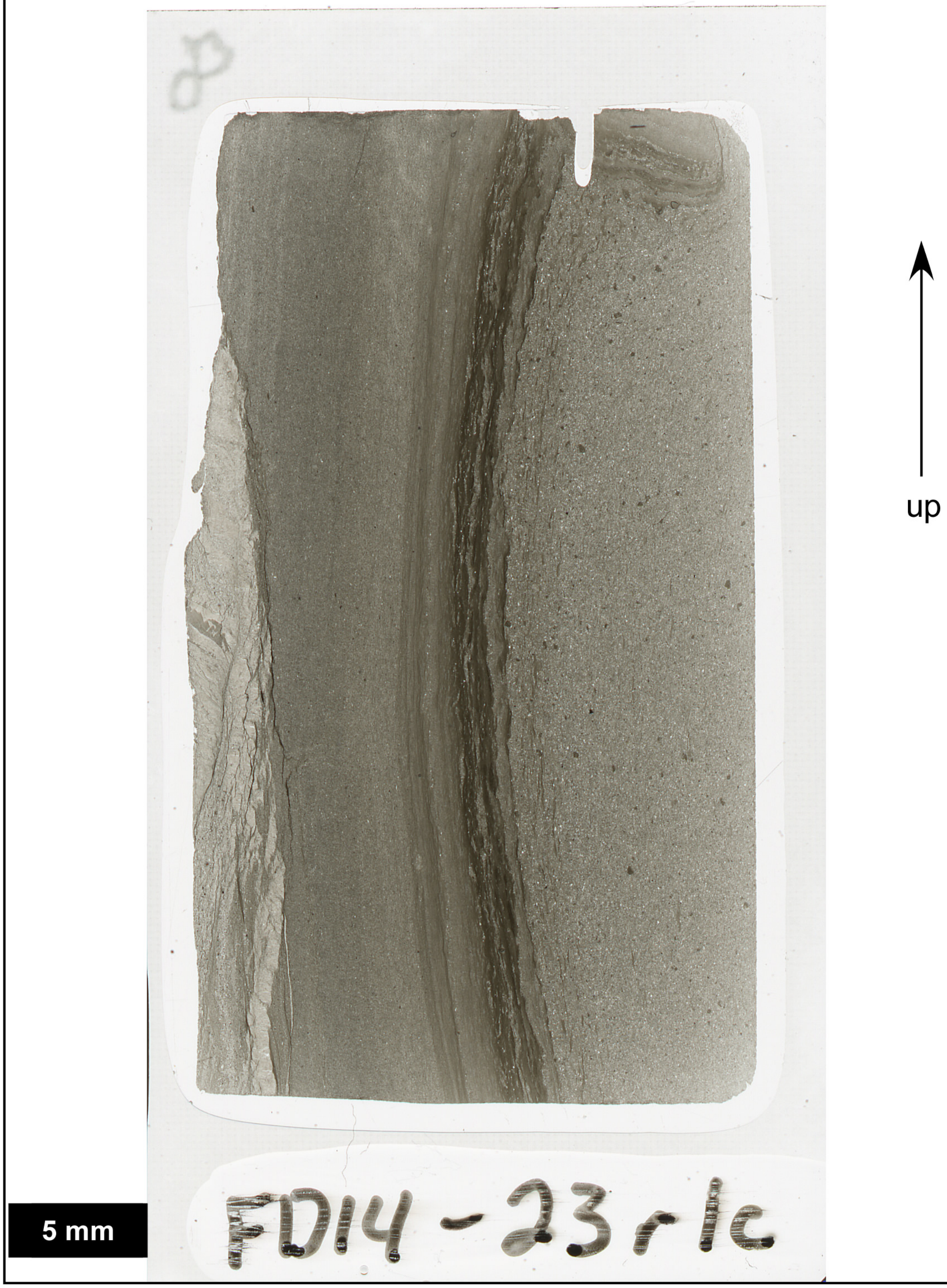
Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-23 core run 1 piece c

Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-23r1c
Boring: FD14-23 core run 1 piece ca

1" x 2" thin section
elevation: -53.54 to -53.69ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
laminated shale-dominated argillite

Sedimentary textures:

thin layering

subtle cross-lamination

Deformation features:

near-vertical lithological layering

pressure-solution seams parallel to lithological layering
pressure solution cleavage

thin calcite-filled fractures subparallel to layering
small tension gashes perpendicular to layering

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

grains replaced by calcite

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-23	1	a	-53.0 to -53.6				M		3.5										
FD14-23	1	a	-53.1 to -53.5	0.05	172.8	172.7	UCmod									17320	0.15	1.2E+07	0.20
FD14-23	1	bk	-56.03 to -57.14				M		4.5										
FD14-23	1	bk	-56.03 to -57.14				TH			41.6	0.9	39.0							
FD14-23	1	bk	-56 to -57	0.12			PL	Diametral					2.7	9095					
FD14-23	1	bk	-56 to -57				PL	Diametral					2.8	9561					
FD14-23	1	bk	-56 to -57				PL	Diametral					3.4	11660					
FD14-23	1	bk	-56 to -57				PL	Axial					4.9	12995					

Notes: (1) Water contents determined after trimming and shearing.
(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination
(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-23
Sample: Run 1 - piece bk
Elevation: -56.03 to -57.14
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	**Anvil Calibration Readings**	Specimen Readings	D >7?
1	**72.0**	**40.0**	
2	**72.0**	**40.0**	
3	**72.0**	**40.0**	
4	**70.0**	**44.0**	
5	**71.0**	**41.0**	
6	**70.0**	**42.0**	
7	**70.0**	**46.0**	
8	**70.0**	**42.0**	
9	**70.0**	**45.0**	
10	**71.0**	**41.0**	
average	70.8	42.1	
theoretical reading on anvil	**70.0**		
correction factor	0.989		

Corrected Average corrected reading, Hr **41.6**

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	**39.75**	**39.18**
Specimen Mass after 400 revolutions (grams)	**39.24**	**38.57**
Specimen Mass after 800 revolutions (grams)	**38.63**	**38.02**
dM after 400 revolutions (grams)	0.51	0.61
dM after 800 revolutions (grams)	1.12	1.16
Average ΔM (800 revolutions)	1.14	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	0.877	

Total Hardness, $H_T = H_R*(H_A)^{0.5} =$ 38.98

Boston Harbor

e4sciences

TerraSense, LLC 7803-15001

DATA SHEET
TOTAL HARDNESS TEST
Boring: FD14-23 Sample: Run 1 - piece bk
Elevation: -56.03 to -57.14 ft

Data Sheet

Depth:				
Load Orientation:	Diametral	Diametral	Diametral	Axial
Length to nearest free end, L (mm)	31.8	77.8	28.9	17.0
Specimen Width, W (mm)	50.2	50.2	50.2	34.0
D (mm)	51.0	51.0	51.0	17.0
D' (mm)	51.0	51.0	51.0	17.0
D_e (mm)	51.0	51.0	51.0	27.1
Failure Load, P (lb)	1547	1644	1990	1058
Point Load (N)	**6881**	**7313**	**8852**	**4706**
Point Load (Mpa)	**2.67**	**2.84**	**3.43**	**4.85**
Index, Is50 (psi)	**390**	**410**	**500**	**700**
Unconfined Compressive Strength (psi)	**9095**	**9561**	**11660**	**12995**
Specimen /Failure Sketch				
Tare No.	M-18			
Wet + Tare (gm)	253.34			
Dry + Tare (gm)	253.09			
Tare (gm)	49.6			
Water Content%	**0.12**			
Comments				

Test by: RAT Test Date: 4/17/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

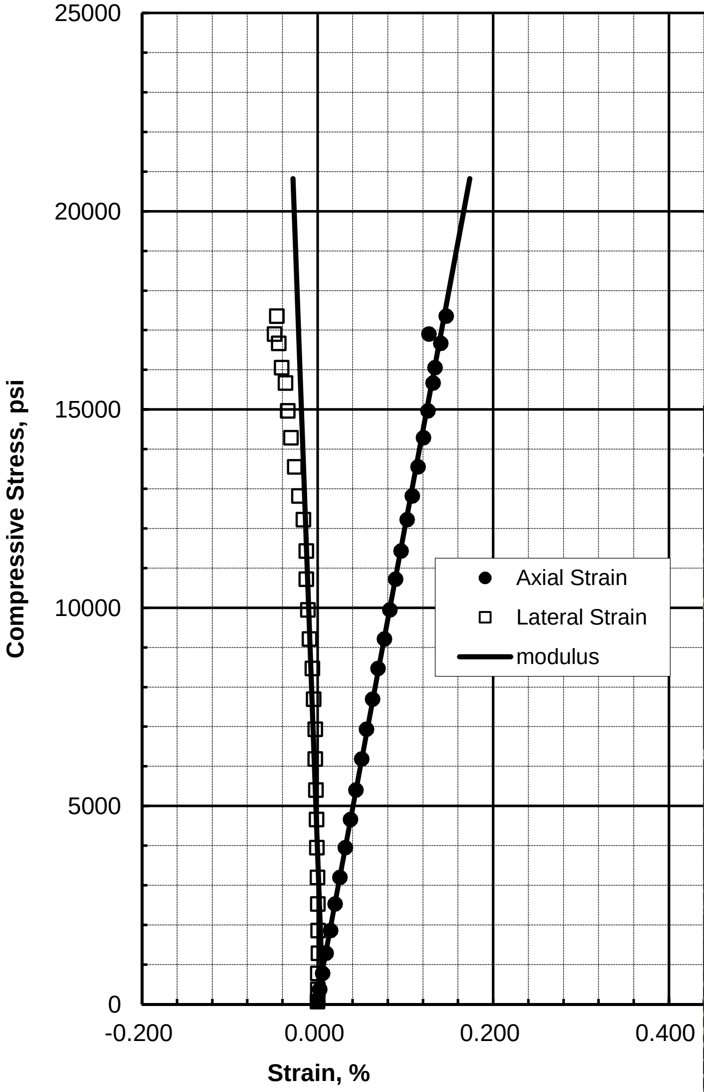
TerraSense, LLC

7803-15001

Boring: FD14-23 Run: 1 - piece bk
Elevation: -56 to -57 ft.

Analysis File: PLV4 (9/09)

4/22/2015
PL14-23-run1bk.xlsx



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.05	173	173	4.759	1.976

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.19	0.15	17320	1.19E+07	0.20

FAILURE PHOTO

Tested by: GT Test Date: Apr-08-15

e4sciences	Boston Harbor	COMPRESSIVE STRESS VS STRAIN UNCONFINED COMPRESSIVE STRENGTH AND AND ELASTIC MODULUS TEST Boring: FD14-23 Run: 1 a Elevation -53.1 to -53.5 ft.
TerraSense, LLC Project # 7803-15001		

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-23	1	-53.3	llbed	5,982.6	19,628.0
FD14-23	1	-53.3	xbed	5,870.8	19,261.1
FD14-23	1	-54.5	llbed	5,719.3	18,764.1
FD14-23	1	-54.5	xbed	4,269.8	14,008.6
FD14-23	2	-54.6	llbed	5,776.5	18,951.6
FD14-23	2	-54.6	xbed	4,762.5	15,625.0
FD14-23	2	-55.9	llbed	5,726.5	18,787.9
FD14-23	2	-55.9	xbed	5,095.4	16,717.3
FD14-23	2	-56.4	llbed	5,618.6	18,433.8
FD14-23	2	-56.4	xbed	5,086.4	16,687.8
FD14-23	2	-56.9	llbed	5,520.0	18,110.4
FD14-23	2	-56.9	xbed	4,745.7	15,570.0
FD14-23	2	-57.9	llfrac	5,664.1	18,583.1
FD14-23	2	-57.9	xfrac	5,039.4	16,533.5
FD14-23	2	-58.4	llbed	5,580.9	18,310.2
FD14-23	2	-58.4	xbed	4,960.8	16,275.5
FD14-23	2	-58.9	llbed	5,533.2	18,153.5
FD14-23	2	-58.9	xbed	4,943.8	16,219.7
FD14-23	2	-59.4	llbed	5,412.5	17,757.5
FD14-23	2	-59.4	xbed	4,921.3	16,145.8
FD14-23	2	-59.9	llbed	5,580.9	18,310.2
FD14-23	2	-59.9	xbed	4,916.9	16,131.5
FD14-23	2	-60.4	llbed	5,834.6	19,142.4
FD14-23	2	-60.4	xbed	4,952.0	16,246.7
FD14-23	2	-61.2	llbed	5,504.3	18,058.6
FD14-23	2	-61.2	xbed	5,243.4	17,202.8
FD14-23	2	-61.7	llbed	5,526.2	18,130.5
FD14-23	2	-61.7	llbed	5,676.2	18,622.7
FD14-23	2	-61.7	xbed	4,995.2	16,388.6
FD14-23	2	-62.1	xbed	4,775.7	15,668.2
FD14-23	3	-60.1	llbed	5,150.3	16,897.2
FD14-23	3	-60.1	xbed	4,734.9	15,534.6
FD14-23	3	-60.5	llbed	5,301.0	17,391.9
FD14-23	3	-60.5	xbed	5,020.3	16,470.8
FD14-23	3	-61.0	llbed	5,045.6	16,553.7
FD14-23	3	-61.0	xbed	4,633.6	15,202.2

US Army Corps
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New England District

Boston Harbor

boring **FD14-24**

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page 1 of 1

Easting 796,901.2
Northing 2,949,945.9
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

President Roads Anchorage

boring started at 1:32 pm December 16, 2014
boring completed at 06:15 pm December 16, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -44.0 MLLW
Boring bottom elevation = -58.1 MLLW
Total depth below channel floor = 14.1'

Top of all rock elevation = -48.0'MLLW
Rock refusal elevation = -48.5'MLLW
Number of rock core runs = 2

Rock encountered: Cambridge Argillite
Thickness of sediment = 4.0'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

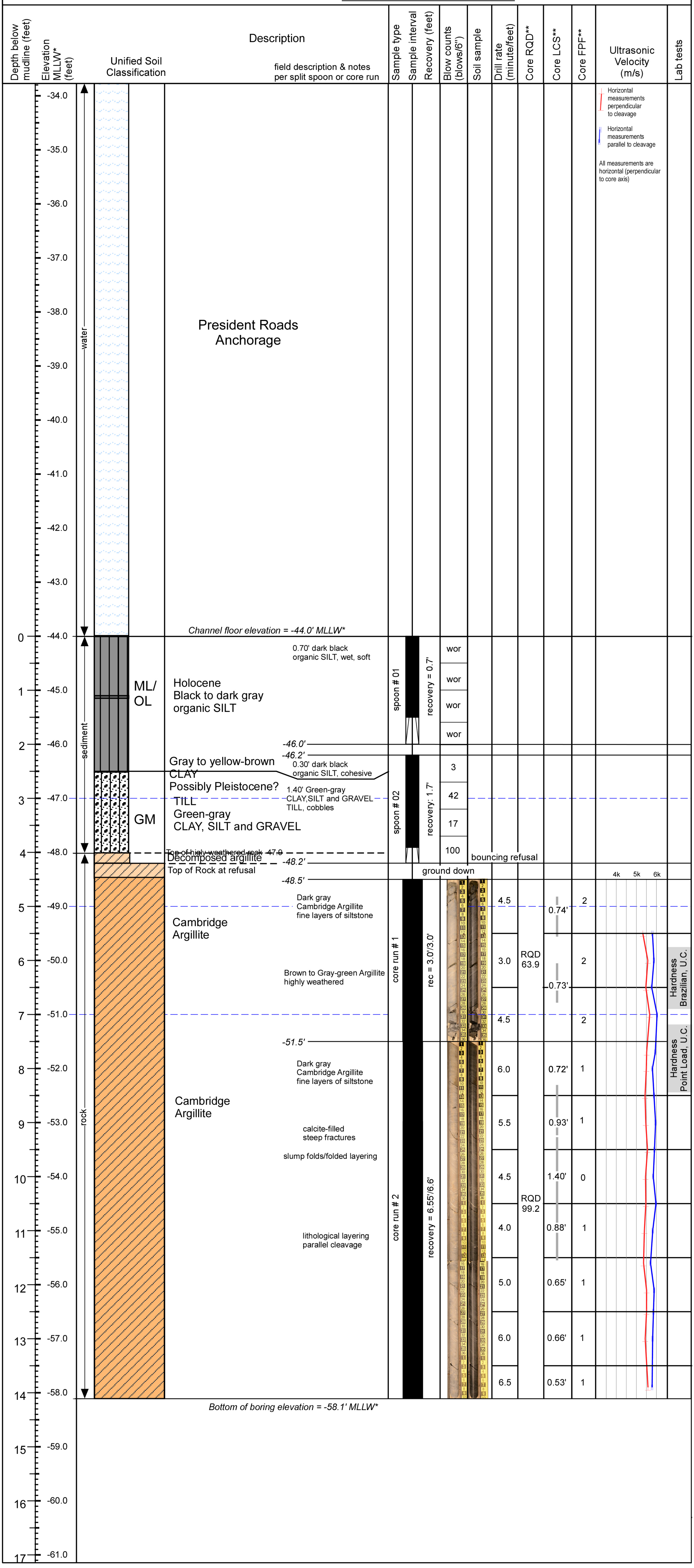
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

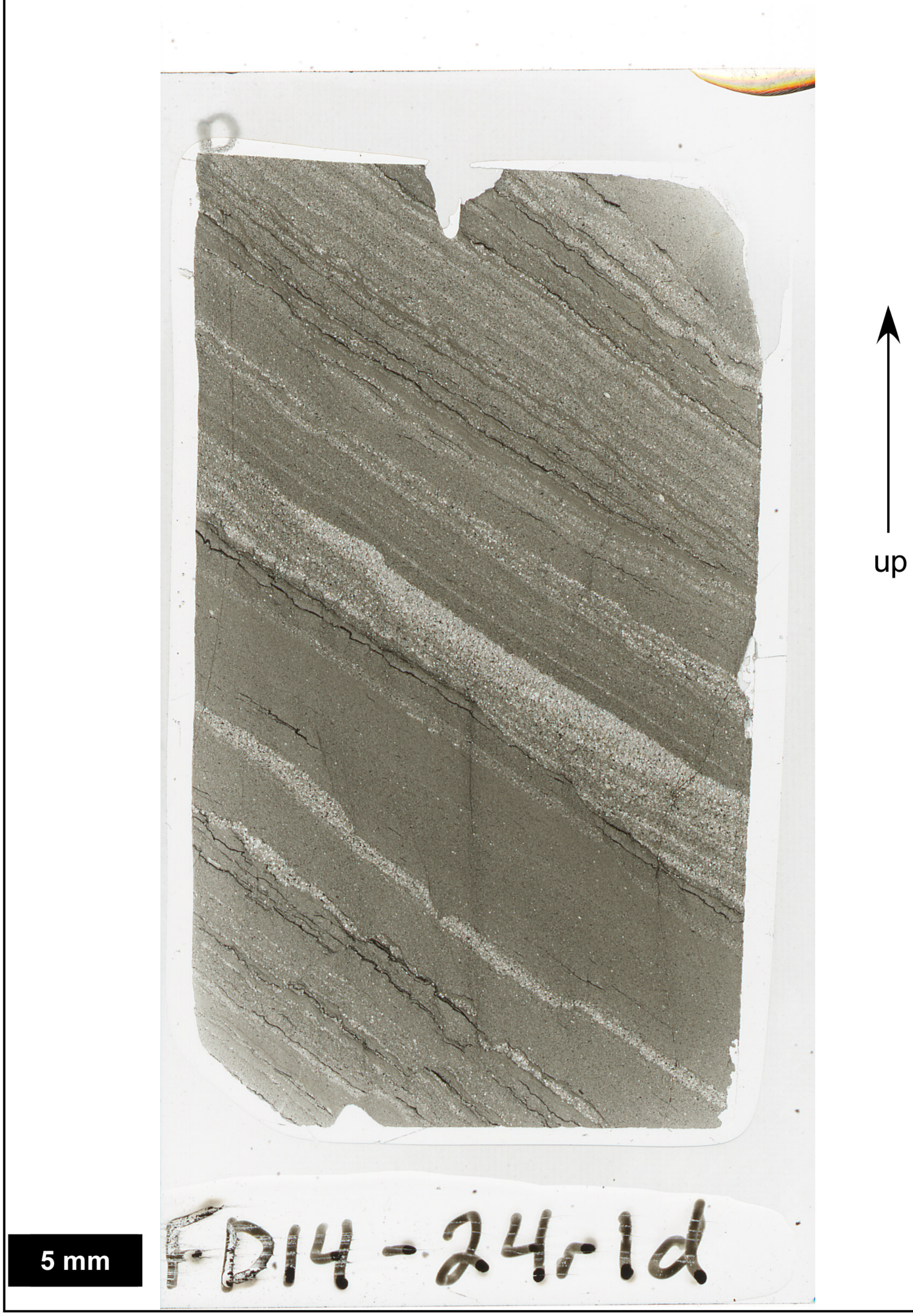
Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Boring FD-14-24 core run 1 piece d
Thin section of Cambridge Argillite.
Transmitted-light image.



Petrographic summary

Sample: FD14-24r1d
Boring: FD14-24 core run 1 piece d

1" x 2" thin section
elevation: -48.73 to -48.89ft MLLW

Formation: Cambridge Argillite.

Lithology: argillite
thinly laminated shale-dominated argillite with siltstone layering

Sedimentary textures:

thinly laminated
silt laminae

cross-lamination
graded layers

Deformation features:

steeply dipping lithologic layers

pressure-solution seams parallel to lithological layering and subvertical
weathered alteration zone along vertical seams

few fine fractures

Key minerals:

quartz - detrital silt-sized grains sub angular
clays - detrital
chlorite - secondary/metamorphic
white mica - secondary
calcite - secondary in fractures
opaques

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIENTATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COMPRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-24	1	g	-50.02 to -50.75				M		2.5										
FD14-24	1	g	-50.1 to -50.3	0.07	169.0	168.9	B-1	B							2460				
FD14-24	1	g	-50.1 to -50.3	0.08	169.0	168.9	B-2	A							1620				
FD14-24	1	g	-50.3 to -50.7	0.10	171.5	171.3	UCmod									27130	0.31	8.6E+06	0.11
FD14-24	2	ba	-51.49 to -52.2				M		2.5										
FD14-24	2	ba	-51.55 to -51.95	0.11	171.6	171.4	UCmod									27290	0.33	8.5E+06	0.30
FD14-24	2	ba	-52.0 to -52.2	0.09			PL	Diametral					5.7	18841					
FD14-24	2	ba	-52.0 to -52.2				PL	Axial					3.5	10821					

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	31.0		25.8	
Specimen Width, W (mm)	49.7		51.5	
D (mm)	51.0		26.0	
D' (mm)	48.0		26.0	
D_e (mm)	48.0		41.3	
Failure Load, P (lb)	3013		1457	
Point Load (N)	**13402**		**6481**	
Point Load Index, Is50 (Mpa)	**5.71**		**3.49**	
(psi)	**830**		**510**	
Unconfined Compressive Strength (psi)	**18841**		**10821**	
Specimen /Failure Sketch				
Tare No.	M-16			
Wet + Tare (gm)	191.76			
Dry + Tare (gm)	191.63			
Tare (gm)	50.56			
Water Content%	**0.09**			
Comments				

Test by: RAT Test Date: 3/28/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-24 Run: 2 - piece ba
Elevation: -52.0 to -52.2 ft.

TerraSense, LLC

7803-15001

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-24
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 1 - piece g

SPECIMEN READINGS

Test Number: B-1
Elevation: -50.1 to -50.3
Specimen mass(gm): 120.85

Thickness (inch)	Diameter (inch)
0.906	1.967
0.883	1.966
0.902	1.968
Average 0.897	1.967

Thickness / Diameter, (t/d): 0.46
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.
Data Acquisition File B14-24R1A
Maximum Load 6814 lb

	After Test
Container No.:	LA-5
Initial Mass + cont. (g):	102.38
Dry Mass + cont. (g):	102.33
Mass of cont. (g):	26.50
Water content (%):	**0.07**
Total unit weight (pcf):	169.03
Dry unit weight (pcf):	168.92
Splitting Tensile Strength (psi)	2459.92

Failure Photo

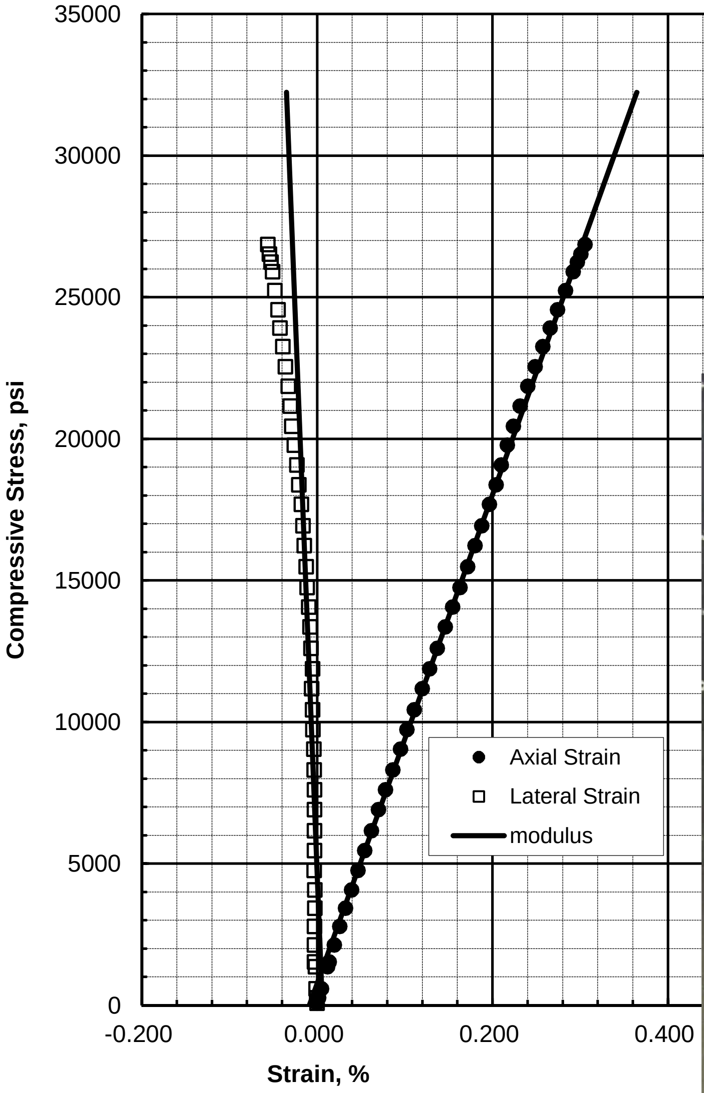
Test Number: B-2
Elevation: -50.1 to -50.3
Specimen mass(gm): 111.82

Thickness (inch)	Diameter (inch)
0.822	1.968
0.851	1.968
0.815	1.967
Average 0.829	1.967

Thickness / Diameter, (t/d): 0.42
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
Data Acquisition File B14-24R1B
Maximum Load 4151 lb

	After Test
Container No.:	LB-26
Initial Mass + cont. (g):	144.47
Dry Mass + cont. (g):	144.38
Mass of cont. (g):	32.65
Water content (%):	**0.08**
Total unit weight (pcf):	169.01
Dry unit weight (pcf):	168.88
Splitting Tensile Strength (psi)	1619.99

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-24** **Run: 1 - piece g Elevation: -50.1 to -50.3 ft.**
TerraSense, LLC	7803-15001		



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.10	172	171	4.715	1.962

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.11	0.31	27130	8.63E+06	0.11

FAILURE PHOTO

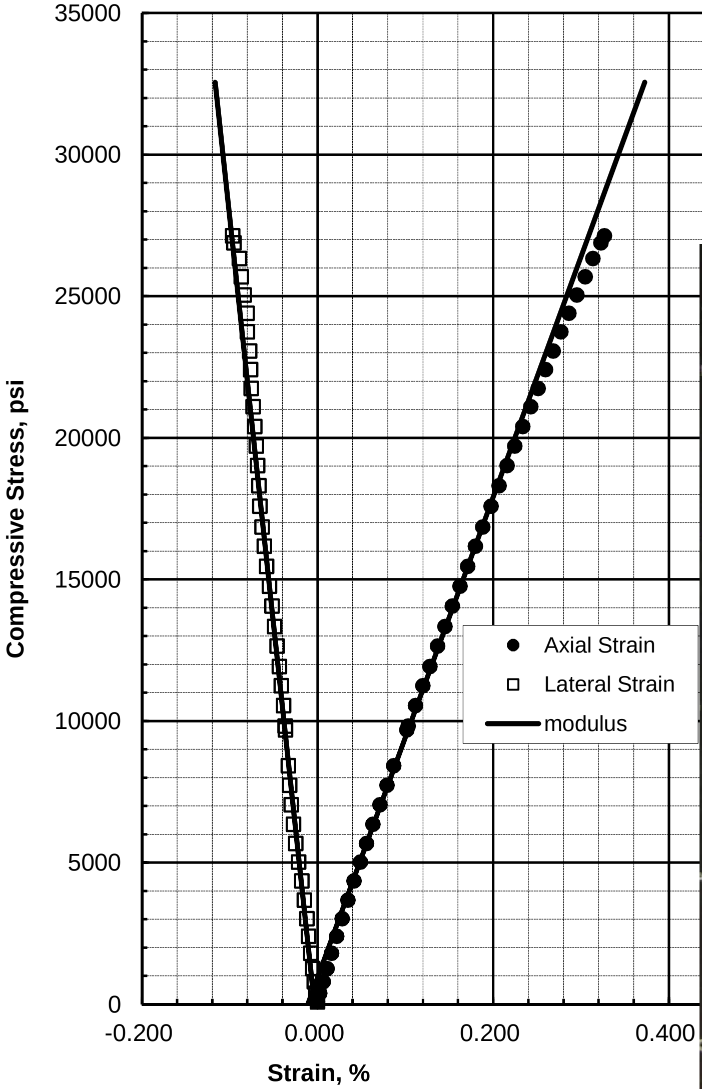
Tested by: GT Test Date: Apr-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-24 Run: 1 g
Elevation -50.3 to -50.7 ft.



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.11	172	171	4.843	1.960

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.10	0.33	27290	8.49E+06	0.30

FAILURE PHOTO

Tested by: GT Test Date: Apr-11-15

e4sciences

TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-24 Run: 2 ba
Elevation -51.55 to -51.95 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-24	1	-49.5	llbed	5,795.8	19,015.2
FD14-24	1	-49.5	xbed	5,313.7	17,433.5
FD14-24	1	-50.0	llbed	5,867.8	19,251.2
FD14-24	1	-50.0	xbed	5,563.3	18,252.4
FD14-24	1	-50.5	llbed	5,758.9	18,894.0
FD14-24	1	-50.5	xbed	5,465.1	17,930.3
FD14-24	1	-51.0	llbed	6,024.8	19,766.5
FD14-24	1	-51.0	xbed	5,655.8	18,555.9
FD14-24	2	-51.7	llbed	5,935.7	19,474.2
FD14-24	2	-51.7	xbed	5,504.3	18,058.6
FD14-24	2	-52.0	llbed	5,793.3	19,006.8
FD14-24	2	-52.0	xbed	5,489.4	18,009.9
FD14-24	2	-52.5	llbed	5,870.8	19,261.0
FD14-24	2	-52.5	xbed	5,425.2	17,799.3
FD14-24	2	-53.0	llbed	5,949.3	19,518.8
FD14-24	2	-53.0	xbed	5,461.3	17,917.6
FD14-24	2	-53.5	llbed	5,894.7	19,339.6
FD14-24	2	-53.5	xbed	5,547.1	18,199.1
FD14-24	2	-54.0	llbed	5,835.2	19,144.3
FD14-24	2	-54.0	xbed	5,448.8	17,876.6
FD14-24	2	-54.5	llbed	5,968.7	19,582.3
FD14-24	2	-54.5	xbed	5,464.3	17,927.6
FD14-24	2	-55.0	llbed	5,808.2	19,055.7
FD14-24	2	-55.0	xbed	5,392.0	17,690.3
FD14-24	2	-55.6	llbed	5,699.1	18,697.7
FD14-24	2	-55.6	xbed	5,349.8	17,551.9
FD14-24	2	-56.1	llbed	5,879.0	19,287.9
FD14-24	2	-56.1	xbed	5,500.5	18,046.4
FD14-24	2	-56.5	llbed	5,844.1	19,173.5
FD14-24	2	-56.5	xbed	5,499.2	18,041.8
FD14-24	2	-57.0	llbed	5,803.6	19,040.7
FD14-24	2	-57.0	xbed	5,432.2	17,822.1
FD14-24	2	-57.9	llbed	5,776.7	18,952.5
FD14-24	2	-57.9	xbed	5,572.5	18,282.4

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-25**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 785,226.9
Northing 2,952,481.6
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 09:58 am December 01, 2014
boring completed at 05:00 pm December 01, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -43.4 MLLW
Boring bottom elevation = -59.7 MLLW
Total depth below channel floor = 16.3'

Top of all rock elevation = -47.1'MLLW
Rock refusal elevation = -47.6'MLLW
Number of rock core runs = 3

Rock encountered: Cambridge Argillite
Thickness of sediment = 3.7'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)
- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)
- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

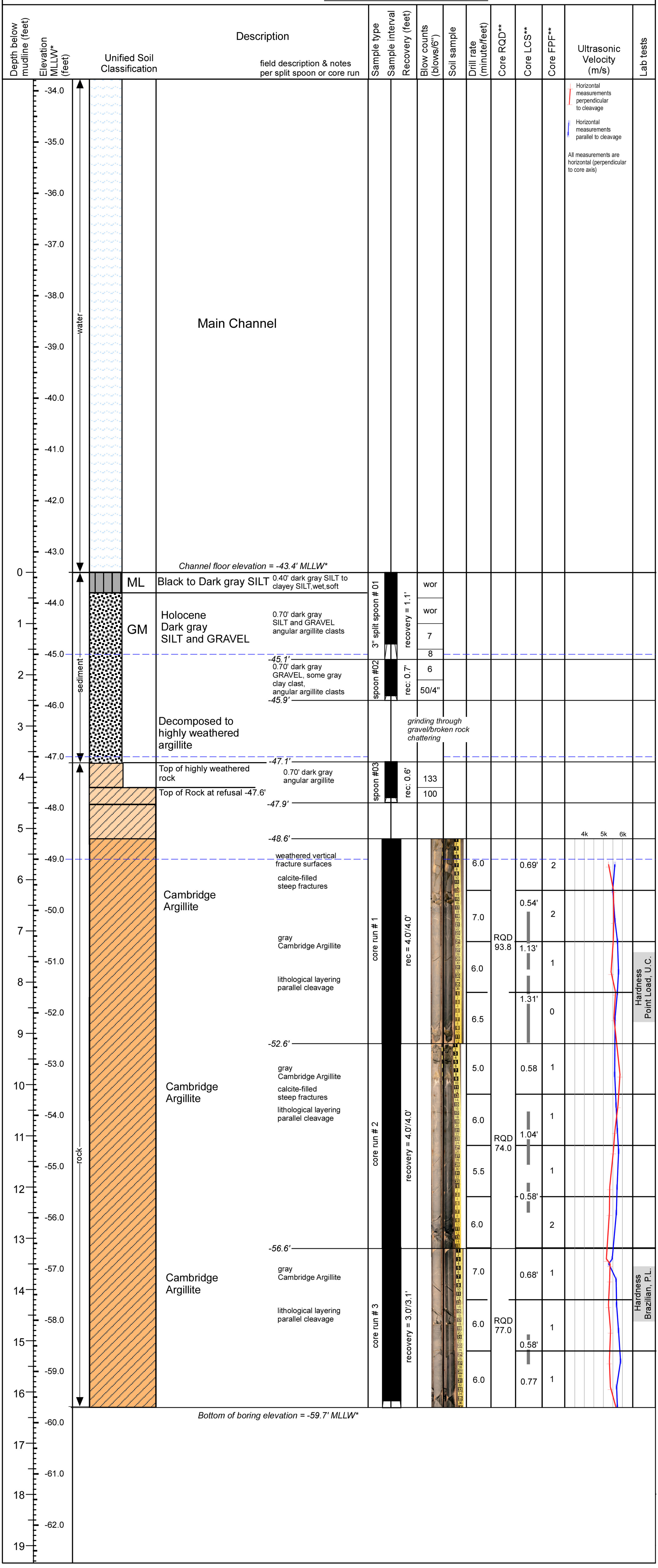
Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations
wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description
**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Bottom of boring elevation = -59.7' MLLW*

Boring FD-14-25 core run 1 piece a

Thin section of Cambridge Argillite.
Transmitted-light image.

Petrographic summary

Sample: FD14-25r1a
Boring: FD14-25 core run 1 piece a

1" x 2" thin section
elevation: -49.14 to -49.28ft MLLW

Formation: Cambridge Argillite.

Lithology: siltstone

Sedimentary textures:

no laminae apparent on thin section

Deformation features:

intergranular pressure-solution seams
no well-developed seams or cleavage

near vertical and high angle fratures filled with cslcite
subtle fractures with calcite and opaques

Key minerals:

quartz - detrital coarse silt to very fine sand-sized grains sub-rounded to sub-angular
clays - detrital
chlorite - secondary/metamorphic
calcite - secondary fracture fill and replacement
opaques including oxides

grains replaced by chlorite and calcite

e4sciences
Boston Harbor
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-25	1	d1	-51.0 to -51.6				M		4.5										
FD14-25	1	d1	-51.0 to -51.6				TH			44.3	1.6	55.6							
FD14-25	1	d1	-51.0 to -51.6	0.15			PL	Diametral					2.1	7229					
FD14-25	1	d1	-51.0 to -51.6				PL	Axial					5.5	15686					
FD14-25	1	d2	-51.6 to -52.0	0.08	170.4	170.3	UCmod									12380	0.16	9.5E+06	0.02
FD14-25	3	cc	-57.36 to -57.79				M		3.5										
FD14-25	3	cc	-57.4 to -57.5	0.08	170.0	169.9	B-1	B							1667				
FD14-25	3	cc	-57.4 to -57.5	0.07	170.3	170.2	B-2	A							1851				
FD14-25	3	cc	-57.5 to -57.8	0.12			PL	Diametral					3.6	12127					
FD14-25	3	cc	-57.5 to -57.8				PL	Axial					6.6	20673					

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

ROCK HARDNESS TEST

Project Number: TS
Project Name: 7803-15001
e4sciences

Boring: FD14-25
Sample: Run 1 - piece d1
Elevation: -51.0 to -51.6
Lithology:

Test by: RT

Rebound Hardness Test
ASTM D5873

Reading	Anvil Calibration Readings	Specimen Readings	D >7?
1	72.0	48.0	
2	72.0	45.0	
3	72.0	43.0	
4	70.0	40.0	
5	71.0	42.0	
6	70.0	48.0	
7	70.0	46.0	
8	70.0	47.0	
9	70.0	45.0	
10	71.0	44.0	
average	70.8	44.8	
theoretical reading on anvil	70.0		
correction factor	0.989		

Corrected Average corrected reading, Hr 44.3

Modified Abrasion Hardness

	Specimen 1	Specimen 2
Initial Specimen Mass (grams)	28.50	33.84
Specimen Mass after 400 revolutions (grams)	28.19	33.46
Specimen Mass after 800 revolutions (grams)	27.89	33.18
dM after 400 revolutions (grams)	0.31	0.38
dM after 800 revolutions (grams)	0.61	0.66
Average ΔM (800 revolutions)	0.635	
Abrasion Hardness, $H_A = 1/\Delta M_{800}$	1.575	

Total Hardness, $H_T = H_R*(H_A)^{0.5}$ = 55.58

Boston Harbor		**DATA SHEET** **TOTAL HARDNESS TEST** **Boring: FD14-25 Sample: Run 1 - piece d1** **Elevation: -51.0 to -51.6 ft**	Data Sheet
e4sciences			
TerraSense, LLC	7803-15001		

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	26.2		24.7	
Specimen Width, W (mm)	50.2		49.5	
D (mm)	51.0		29.0	
D' (mm)	51.0		29.0	
D_e (mm)	51.0		42.7	
Failure Load, P (lb)	2088		2906	
Point Load (N)	**9288**		**12927**	
Point Load (Mpa)	**3.60**		**6.60**	
Index, Is50 (psi)	**520**		**960**	
Unconfined Compressive Strength (psi)	**12127**		**20673**	
Specimen /Failure Sketch				
Tare No.	M-7			
Wet + Tare (gm)	247.58			
Dry + Tare (gm)	247.34			
Tare (gm)	51.28			
Water Content%	**0.12**			
Comments				

Test by: RAT Test Date: 4/3/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-25 Run: 3 - piece cc
Elevation: -57.5 to -57.8 ft.

TerraSense, LLC

7803-15001

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	26.9		22.5	
Specimen Width, W (mm)	50.2		45.0	
D (mm)	51.0		21.0	
D' (mm)	51.0		21.0	
D_e (mm)	51.0		34.7	
Failure Load, P (lb)	1226		1743	
Point Load (N)	**5454**		**7753**	
Point Load (Mpa)	**2.12**		**5.46**	
Index, Is50 (psi)	**310**		**790**	
Unconfined Compressive Strength (psi)	**7229**		**15686**	
Specimen /Failure Sketch				
Tare No.	M-11			
Wet + Tare (gm)	194.93			
Dry + Tare (gm)	194.72			
Tare (gm)	50.68			
Water Content%	**0.15**			
Comments				

Test by: RAT Test Date: 4/17/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-25 Run: 1 - piece d1
Elevation: -51.0 to -51.6 ft.

TerraSense, LLC

7803-15001

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001 **Test by:** GT **Sta:** FD14-25

Project Name: Boston Harbor **Test Date:** 4/20/15 **Run:** 3 - piece cc

SPECIMEN READINGS

Test Number: B-1

Elevation: -57.4 to -57.5

Specimen mass(gm): 110.71

Thickness (inch)	Diameter (inch)
0.809	1.979
0.807	1.980
0.804	1.980
Average 0.806	1.980

Thickness / Diameter, (t/d): 0.41

t/D ratio between 0.2 and 0.75 yes

Largest Grain Diameter 0.010 inch

meets mineral size spec.

Data Acquisition File B14-25R3A

Maximum Load 4178 lb

	After Test
Container No.:	LA-120
Initial Mass + cont. (g):	145.26
Dry Mass + cont. (g):	145.17
Mass of cont. (g):	34.50
Water content (%):	**0.08**
Total unit weight (pcf):	170.00
Dry unit weight (pcf):	169.86
Splitting Tensile Strength (psi)	1666.74

Test Number: B-2

Elevation: -57.4 to -57.5

Specimen mass(gm): 107.43

Thickness (inch)	Diameter (inch)
0.775	1.977
0.780	1.976
0.795	1.978
Average 0.783	1.977

Thickness / Diameter, (t/d): 0.40

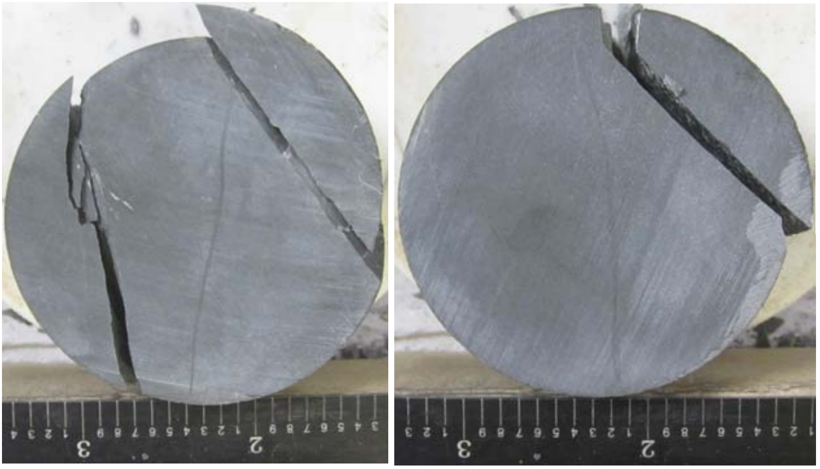
t/D ratio between 0.2 and 0.75 yes

Largest Grain Diameter 0.010 inch

Data Acquisition File B14-25R3B

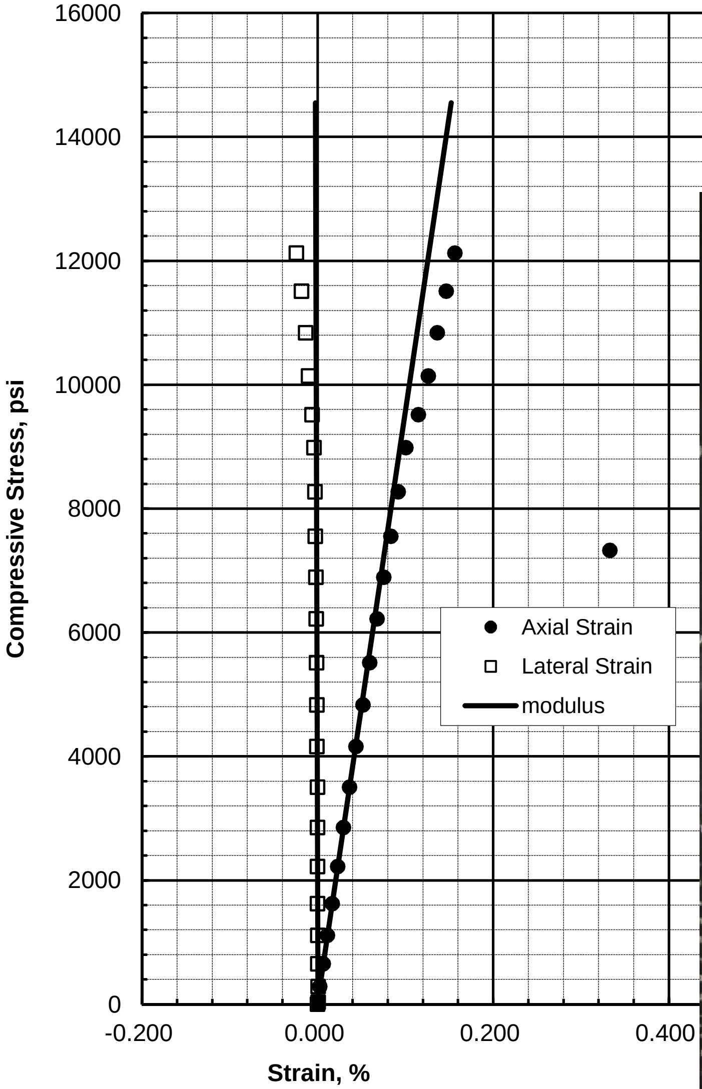
Maximum Load 4502 lb

	After Test
Container No.:	LA-113
Initial Mass + cont. (g):	141
Dry Mass + cont. (g):	140.93
Mass of cont. (g):	33.71
Water content (%):	**0.07**
Total unit weight (pcf):	170.27
Dry unit weight (pcf):	170.16
Splitting Tensile Strength (psi)	1851.23



Failure Photo

e4sciences		**Boston Harbor**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST** **Sta: FD14-25** **Run: 3 - piece cc Elevation: -57.4 to -57.5 ft.**
TerraSense, LLC	7803-15001		



FAILURE PHOTO

Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.08	170	170	4.746	1.980

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.30	0.16	12380	9.53E+06	0.02

Tested by: GT Test Date: Jan-00-00

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TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-25 Run: 1 d2
Elevation -51.6 to -52.0 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-25	1	-49.1	llfrac	5,597.9	18,365.7
FD14-25	1	-49.1	xfrac	5,263.7	17,269.4
FD14-25	1	-49.6	llfrac	5,487.6	18,004.0
FD14-25	1	-49.6	xfrac	5,522.5	18,118.5
FD14-25	1	-50.2	llbed	5,601.6	18,378.0
FD14-25	1	-50.2	xbed	5,542.2	18,183.1
FD14-25	1	-50.6	llbed	5,735.3	18,816.6
FD14-25	1	-50.6	xbed	5,511.7	18,083.0
FD14-25	1	-51.2	llbed	5,789.6	18,994.8
FD14-25	1	-51.2	xbed	5,397.5	17,708.3
FD14-25	1	-51.6	llbed	5,729.5	18,797.6
FD14-25	1	-51.6	xbed	5,632.4	18,479.1
FD14-25	1	-52.1	llbed	5,607.8	18,398.1
FD14-25	1	-52.1	xbed	5,548.6	18,203.9
FD14-25	2	-53.2	llbed	5,588.0	18,333.3
FD14-25	2	-53.2	xbed	5,865.6	19,244.2
FD14-25	2	-53.8	llbed	5,662.1	18,576.4
FD14-25	2	-53.8	xbed	5,763.1	18,907.7
FD14-25	2	-54.3	llbed	5,728.0	18,792.6
FD14-25	2	-54.3	xbed	5,599.3	18,370.4
FD14-25	2	-54.7	llbed	5,794.0	19,009.2
FD14-25	2	-54.7	xbed	5,518.7	18,105.8
FD14-25	2	-55.4	llbed	5,715.0	18,750.0
FD14-25	2	-55.4	xbed	5,326.2	17,474.4
FD14-25	2	-55.9	llbed	5,676.4	18,623.3
FD14-25	2	-55.9	xbed	5,309.1	17,418.2
FD14-25	2	-56.8	llbed	5,458.2	17,907.6
FD14-25	2	-56.8	xbed	5,150.3	16,897.2
FD14-25	3	-56.9	llbed	5,281.4	17,327.6
FD14-25	3	-56.9	xbed	5,347.5	17,544.3
FD14-25	3	-57.2	llbed	5,663.5	18,581.1
FD14-25	3	-57.2	xbed	5,323.5	17,465.6
FD14-25	3	-57.7	llbed	5,689.1	18,665.2
FD14-25	3	-57.7	xbed	5,260.7	17,259.4
FD14-25	3	-58.2	llbed	5,789.6	18,994.8
FD14-25	3	-58.2	xbed	5,370.4	17,619.3
FD14-25	3	-58.8	llbed	5,896.0	19,343.8
FD14-25	3	-58.8	xbed	5,309.1	17,418.2
FD14-25	3	-59.3	llbed	5,690.6	18,669.9
FD14-25	3	-59.3	xbed	5,361.0	17,588.7
FD14-25	3	-59.7	llfrac	5,729.5	18,797.6
FD14-25	3	-59.7	xfrac	5,654.9	18,552.9

US Army Corps
of Engineers®
New England District

Boston Harbor

boring **FD14-26**

e4sciences | Earthworks, LLC

page 1 of 1

Easting 784,474.2
Northing 2,952,908.4
NAD83 Massachusetts State Plane feet
Boring location and elevation by post-processed dGPS

Main Channel

boring started at 01:20 pm December 03, 2014
boring completed at 06:03 pm December 03, 2014

*Elevations relative to Mean Lower Low Water (MLLW) NAVD88; Tidal epoch 1983-2001

Channel floor elevation = -43.6 MLLW
Boring bottom elevation = -59.8 MLLW
Total depth below channel floor = 14.2'

Top of all rock elevation = -48.1' MLLW
Rock refusal elevation = -48.8' MLLW
Number of rock core runs = 3

Rock encountered: Cambridge Argillite
Thickness of sediment = 4.5'

drilled by G. Suri w/ M. T., Aquifer Drilling and Testing,
drilled from liftboat Vision, Northstar Marine

GME55LC/300 track mount drill rig, rotary drill
SPT with 3" split spoon, 300lb hammer using 18" drop
NQ-size wireline core barrel,

described by W.B.Ward and J.Trotta, e4sciences|Earthworks

Key

Sediment/soils (Sediment)

- Black silt
- Clay
- Silt
- Sand
- Gravel
- Sand & gravel
- Silt, sand & gravel
- Clay & gravel

Rock (Rock)

- Mafic igneous rock with RQD < 50
- Mafic igneous rock with RQD >50
- Hornfels & contact-metamorphic altered argillite with RQD < 50
- Hornfels & contact-metamorphic altered argillite RQD >50
- Argillite with RQD < 50
- Argillite with RQD >50

Geological Formations

Holocene	Black organic silt Marine silt Marine sands and gravels Estaurine silt and sands Estaurine Peat
Pleistocene	Boston Blue clay: Glacial marine clays & silts Glacial till silt sand & gravels
Paleozoic/Jurassic	Mafic igneous dikes & sills
Paleozoic	Felsic igneous dikes & sills
Neoproterozoic to Cambrian	Cambridge Argillite

Sand and gravel modifiers abbreviations

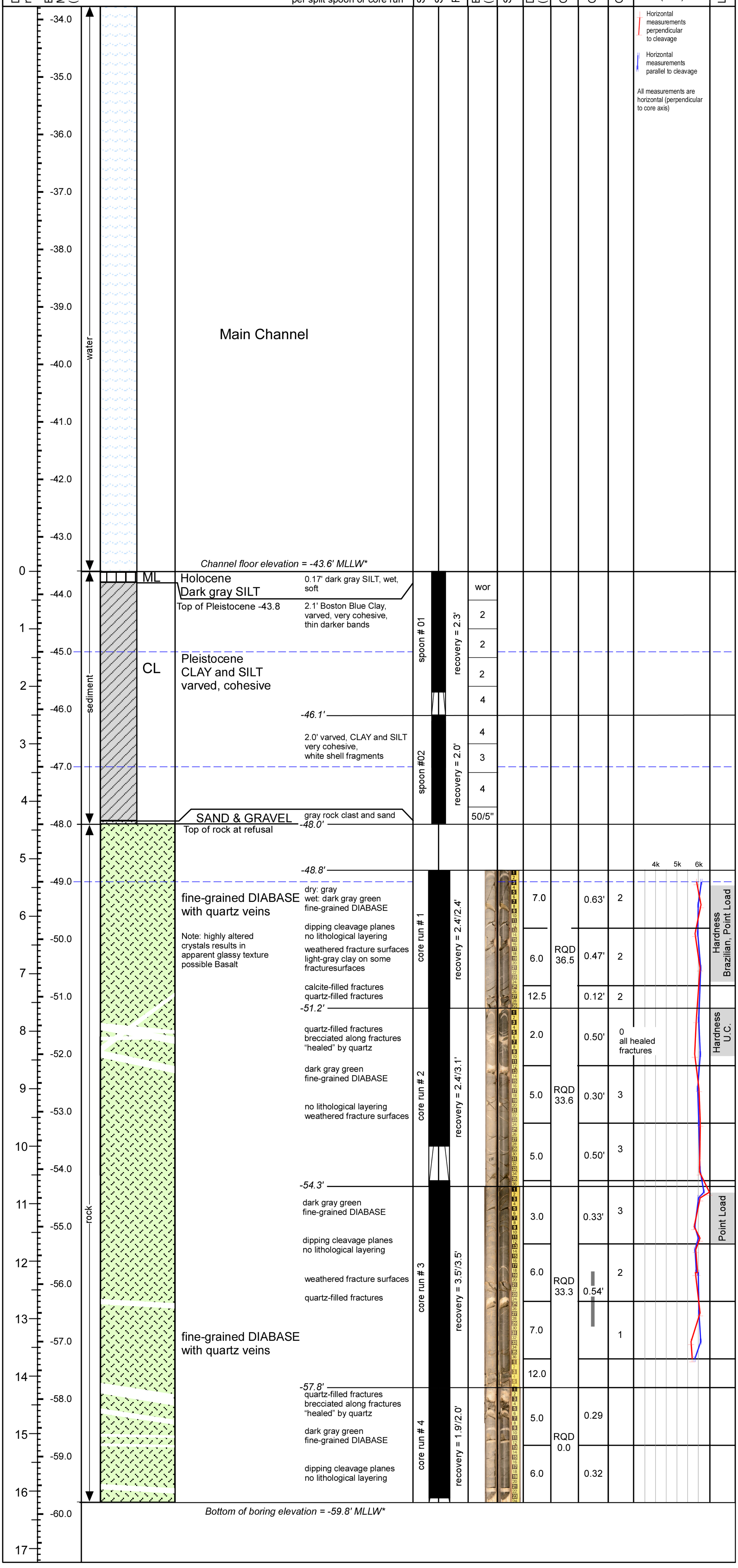
f = fine-graind
m = medium-grain
c = coarse grained

Blow-count abbreviations

wor = weight of rod
woh = weight of hammer
woc = weight of casing

Rock-core description

**RQD = Rock Quality Designation
**LCS = Longest Core Segment within foot interval
**FPF = Fractures Per Foot



Main Channel

Channel floor elevation = -43.6' MLLW*

Elevation	Unified Soil Classification	Description	field description & notes per split spoon or core run	Sample type	Recovery (feet)	Blow counts (blows/6")	Drill rate (minute/feet)	Core RQD**	Core LCS**	Core FPF**	Lab tests
	ML	Holocene Dark gray SILT	0.17' dark gray SILT, wet, soft	spoon # 01	recovery = 2.3'	wor					
	CL	Top of Pleistocene -43.8 Pleistocene CLAY and SILT varved, cohesive	2.1' Boston Blue Clay, varved, very cohesive, thin darker bands			2 2 2 4					
-46.1'			2.0' varved, CLAY and SILT very cohesive, white shell fragments	spoon #02	recovery = 2.0'	4 3 4					
		SAND & GRAVEL	gray rock clast and sand			50/5"					
-48.0'		Top of rock at refusal									
-48.8'		fine-grained DIABASE with quartz veins Note: highly altered crystals results in apparent glassy texture possible Basalt	dry: gray wet: dark gray green fine-grained DIABASE dipping cleavage planes no lithological layering weathered fracture surfaces light-gray clay on some fracturesurfaces calcite-filled fractures quartz-filled fractures	core run # 1	recovery = 2.4'/2.4'		7.0 6.0 12.5	RQD 36.5	0.63' 0.47' 0.12'	2 2 2	Hardness Brazilian, Point Load
-51.2'			quartz-filled fractures brecciated along fractures "healed" by quartz dark gray green fine-grained DIABASE no lithological layering weathered fracture surfaces	core run # 2	recovery = 2.4'/3.1'		2.0 5.0 5.0	RQD 33.6	0.50' 0.30' 0.50'	0 all healed fractures 3 3	Hardness U.C.
-54.3'		fine-grained DIABASE with quartz veins	dark gray green fine-grained DIABASE dipping cleavage planes no lithological layering weathered fracture surfaces quartz-filled fractures	core run # 3	recovery = 3.5'/3.5'		3.0 6.0 7.0 12.0	RQD 33.3	0.33' 0.54'	3 2 1	Point Load
-57.8'			quartz-filled fractures brecciated along fractures "healed" by quartz dark gray green fine-grained DIABASE dipping cleavage planes no lithological layering	core run # 4	recovery = 1.9'/2.0'		5.0 6.0	RQD 0.0	0.29 0.32		

Bottom of boring elevation = -59.8' MLLW*

Boring FD-14-26 core run 1 piece d

Thin section of Cambridge Argillite.

Transmitted-light image.

Boring FD-14-26 core run 1 piece d

Thin section of Diabase

Transmitted-light crossed-polarized light image.

Petrographic summary

Sample: FD14-26r1d
Boring: FD14-26 core run 1 piece d

1" x 2" thin section
elevation: -49.54 to -49.69ft MLLW

Formation: Diabase intruding Cambridge Argillite.

Lithology: fine-grained Diabase

Sedimentary textures:

no laminae
no lithological layering

crystalline igneous texture
subophitic texture

Deformation features:

no cleavage apparent in thin section
no pressure-solution seams apparent

Key minerals:

plagioclase
olivine
augite
opaques primary and secondary
olivine pseudomorphs
plagioclase pseudomorphs
chlorite - secondary/metamorphic
white mica/sericite - secondary
carbonate - secondary

white mica/sericite replaced crystals
chlorite replaced crystals
carbonate replaced crystals

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SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION				STATE PROPERTIES			ENGINEERING PROPERTY TESTS												
									HARDNESS TESTS				POINT LOAD TEST (ASTM D5731)		Brazilian (ASTM D3967)	UNCONFIND COMPRESSION TESTS (ASTM D7012)			
Boring No.	Run	Piece	Elevation	WATER CONTENT (1) (%)	TOTAL UNIT WGT. (pcf)	DRY UNIT WGT. (pcf)	TEST TYPE (2)	ORIEN-TATION (3)	Mohs HARDNESS (-)	REBOUND HARDNESS H_R (-)	ABRASION HARDNESS H_A (-)	TOTAL HARDNESS H_T (-)	STRENGTH INDEX Is(50) (MPa)	COM-PRESSIVE STRENGTH (psi)	SPLITTING TENSILE STRENGTH (psi)	COM-PRESSIVE STRENGTH (psi)	AXIAL STRAIN @ FAILURE (%)	ELASTIC MODULUS (psi)	POISSON'S RATIO (-)
FD14-26	1	k	-50.22 to -50.69				M		3.5										
FD14-26	1	k	-50.22 to -50.5	0.08			PL	Diametral					0.7	2332					
FD14-26	1	k	-50.22 to -50.5				PL	Axial					7.1	21154					
FD14-26	1	k	-50.5 to -50.6	0.04	177.7	177.6	B-1	B							3161				
FD14-26	1	k	-50.5 to -50.6	0.05	176.6	176.6	B-2	A							1823				
FD14-26	2	ba	-51.14 to -51.63				M		3.5										
FD14-26	2	ba	-51.2 to -51.57	0.04	175.5	175.4	UCmod									7370	0.11	7.8E+06	0.07
FD14-26	3	ci	-54.85 to -55.18	0.09			PL	Diametral					0.6	1866					
FD14-26	3	ci	-54.85 to -55.18				PL	Axial					6.1	17135					

Notes: (1) Water contents determined after trimming and shearing.

(2) Test Type Abbreviations: M: Mohs Hardness,TH: Total Hardness, PL: Point Load, B: Brasilian Splitting Tensile, UCmod: UC Compression test with moduli determination

(3) A and B orientations approximately perpendicular to other orientation. Diametral orientation across core, axial perpendicular to structure.

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	30.0		20.3	
Specimen Width, W (mm)	50.3		40.7	
D (mm)	51.0		24.0	
D' (mm)	51.0		19.0	
D_e (mm)	51.0		31.4	
Failure Load, P (lb)	321		1668	
Point Load (N)	**1428**		**7420**	
Point Load (Mpa)	**0.55**		**6.11**	
Index, Is50 (psi)	**80**		**890**	
Unconfined Compressive Strength (psi)	**1866**		**17135**	
Specimen /Failure Sketch				
Tare No.	M-26			
Wet + Tare (gm)	190.22			
Dry + Tare (gm)	190.1			
Tare (gm)	51.52			
Water Content%	**0.09**			
Comments				

Test by: RAT Test Date: 3/30/2015 Reviewed by: GET

Boston Harbor

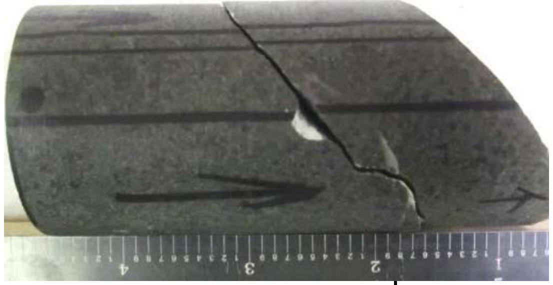
POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

Boring: FD14-26 Run: 3 - piece ci
Elevation: -54.85 to -55.18 ft.

TerraSense, LLC

7803-15001

Depth:				
Load Orientation:	Diametral		Axial	
Length to nearest free end, L (mm)	24.7		25.0	
Specimen Width, W (mm)	50.2		50.0	
D (mm)	51.0		28.0	
D' (mm)	51.0		24.0	
D_e (mm)	51.0		39.1	
Failure Load, P (lb)	408		2708	
Point Load (N)	**1815**		**12046**	
Point Load (Mpa)	**0.70**		**7.06**	
Index, Is50 (psi)	**100**		**1020**	
Unconfined Compressive Strength (psi)	**2332**		**21154**	
Specimen /Failure Sketch				
Tare No.	M-26			
Wet + Tare (gm)	217.84			
Dry + Tare (gm)	217.71			
Tare (gm)	51.52			
Water Content%	**0.08**			
Comments				

Test by: RAT Test Date: 4/3/2015 Reviewed by: GET

Boston Harbor

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

E4science

TerraSense, LLC 7803-15001

Boring: FD14-26 Run: 1 - piece k
Elevation: -50.22 to -50.5 ft.

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7803-15001
Test by: GT
Sta: FD14-26
Project Name: Boston Harbor
Test Date: 4/20/15
Run: 1 - piece k

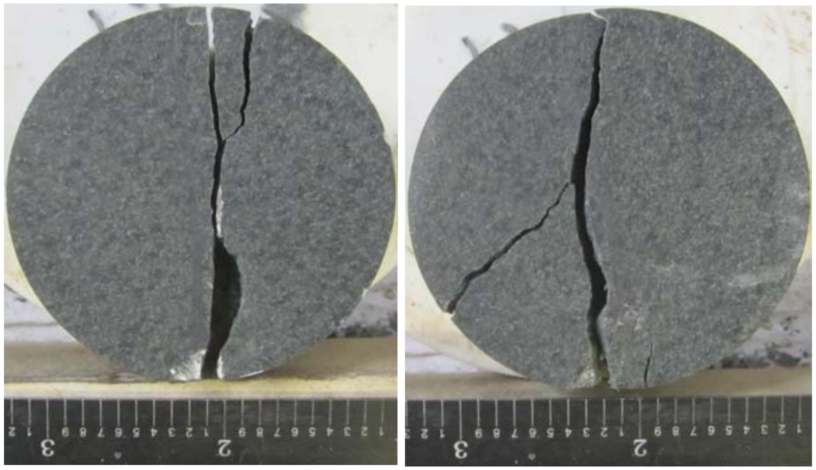
SPECIMEN READINGS

Test Number: B-1
Depth: -50.5 to -50.6
Specimen mass(gm): 115.35

Thickness (inch)	Diameter (inch)
0.797	1.981
0.814	1.978
0.800	1.980
Average 0.803	1.980

Thickness / Diameter, (t/d): 0.41
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
meets mineral size spec.
Data Acquisition File B14-26R1A
Maximum Load 7897 lb

	After Test
Container No.:	LB-27
Initial Mass + cont. (g):	147.89
Dry Mass + cont. (g):	147.84
Mass of cont. (g):	32.81
Water content (%):	**0.04**
Total unit weight (pcf):	177.72
Dry unit weight (pcf):	177.64
Splitting Tensile Strength (psi)	3161.22



Failure Photo

Test Number: B-2
Depth: -50.5 to -50.6
Specimen mass(gm): 110.87

Thickness (inch)	Diameter (inch)
0.781	1.977
0.772	1.980
0.779	1.982
Average 0.777	1.980

Thickness / Diameter, (t/d): 0.39
t/D ratio between 0.2 and 0.75 yes
Largest Grain Diameter 0.010 inch
Data Acquisition File B14-26R1B
Maximum Load 4405 lb

	After Test
Container No.:	LB-24
Initial Mass + cont. (g):	144.15
Dry Mass + cont. (g):	144.1
Mass of cont. (g):	33.4
Water content (%):	**0.05**
Total unit weight (pcf):	176.64
Dry unit weight (pcf):	176.56
Splitting Tensile Strength (psi)	1823.26

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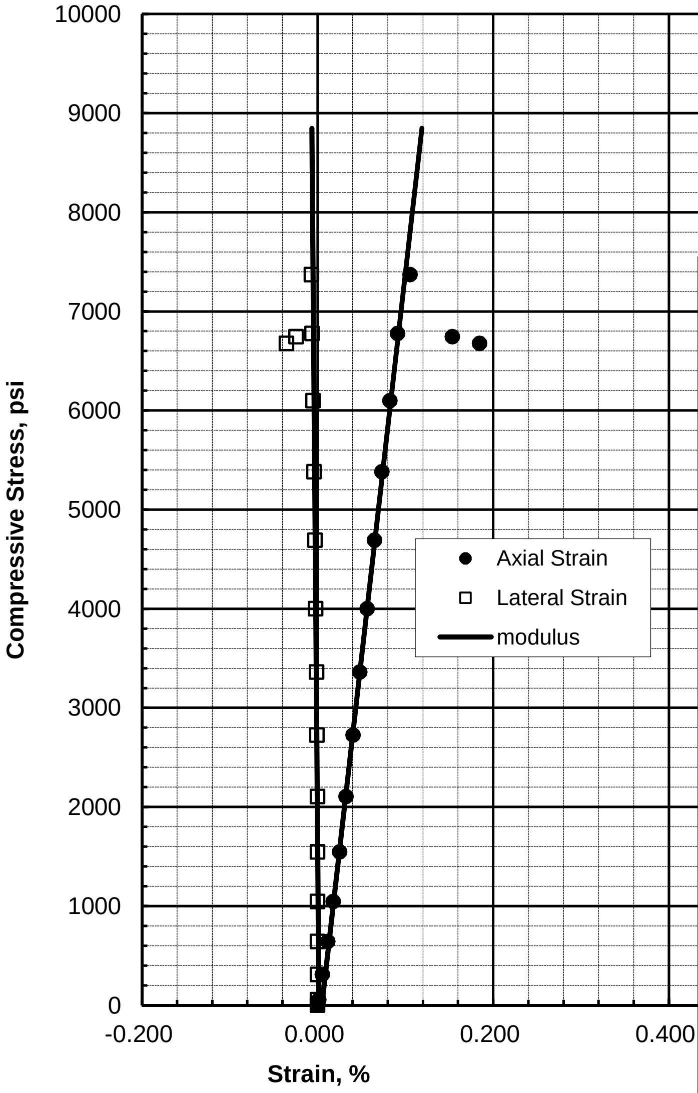
Boston Harbor

DATA SHEET
SPLITTING TENSILE STRENGTH TEST
Sta: FD14-26
Run: 1 - piece k Depth: -50.5 to -50.6 ft.



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.04	175	175	4.326	1.978

Specimen meets ASTM D4543 shape tolerances for side straightness

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.25	0.11	7370	7.76E+06	0.07

FAILURE PHOTO

Tested by: GT Test Date: Apr-08-15

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TerraSense, LLC
Project # 7803-15001

Boston Harbor

COMPRESSIVE STRESS VS STRAIN
UNCONFINED COMPRESSIVE
STRENGTH AND
AND ELASTIC MODULUS TEST
Boring: FD14-26 Run: 2 ba
Elevation -51.2 to -51.57 ft.

Boring	Run	Elevation (ft)	Orientation	P Velocity [m/s]	P Velocity [ft/s]
FD14-26	1	-49.0	xbed	5,912.7	19,398.6
FD14-26	1	-49.4	llfrac	5,990.2	19,652.8
FD14-26	1	-49.4	xrac	6,121.4	20,083.3
FD14-26	1	-49.9	llbed	5,969.3	19,584.3
FD14-26	1	-49.9	xbed	5,842.0	19,166.7
FD14-26	1	-50.5	llbed	6,106.5	20,034.4
FD14-26	1	-50.5	xbed	6,073.9	19,927.5
FD14-26	2	-51.4	llbed	6,017.3	19,741.8
FD14-26	2	-51.4	xbed	5,899.8	19,356.4
FD14-26	2	-52.0	llbed	6,086.2	19,967.8
FD14-26	2	-52.0	xbed	5,823.8	19,106.9
FD14-26	2	-52.6	llbed	5,964.8	19,569.5
FD14-26	2	-52.6	xbed	6,026.4	19,771.7
FD14-26	2	-53.2	llbed	6,018.8	19,746.8
FD14-26	2	-53.2	xbed	6,087.7	19,972.8
FD14-26	2	-54.0	llbed	6,070.8	19,917.5
FD14-26	2	-54.1	xbed	6,052.3	19,856.8
FD14-26	3	-54.5	llbed	6,003.8	19,697.4
FD14-26	3	-54.5	xbed	6,081.3	19,951.9
FD14-26	3	-55.2	llbed	5,994.7	19,667.7
FD14-26	3	-55.2	xbed	6,073.7	19,926.9
FD14-26	3	-55.8	llbed	5,991.7	19,657.7
FD14-26	3	-55.8	xbed	5,858.2	19,220.0
FD14-26	3	-56.5	llbed	6,026.4	19,771.7
FD14-26	3	-56.5	xbed	6,077.0	19,937.6
FD14-26	3	-57.0	llfrac	6,109.6	20,044.5
FD14-26	3	-57.0	xfrac	5,655.1	18,553.4
FD14-26	3	-57.3	llfrac	5,830.7	19,129.7
FD14-26	3	-57.3	xfrac	5,709.2	18,730.9
FD14-26	4	-57.9	llbed	6,258.4	20,532.8
FD14-26	4	-57.9	xbed	6,514.5	21,373.1
FD14-26	4	-58.5	llfrac	5,831.3	19,131.5
FD14-26	4	-58.5	xfrac	5,799.7	19,027.8
FD14-26	4	-58.9	llbed	5,842.0	19,166.7
FD14-26	4	-58.9	xbed	5,873.8	19,270.8
FD14-26	4	-59.3	llbed	5,905.8	19,376.0
FD14-26	4	-59.3	xbed	5,955.8	19,539.9