



Marine Geophysical and Geological Investigation For Improvement Dredging of Boston Harbor:

Subsurface Mapping with Full Coverage of Reflection Seismic

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William F. Murphy IV
Ian M. Nesbitt
David C. Herron
Lonia R. Friedlander



William Francis Murphy III
June 29, 1951 – October 18, 2017

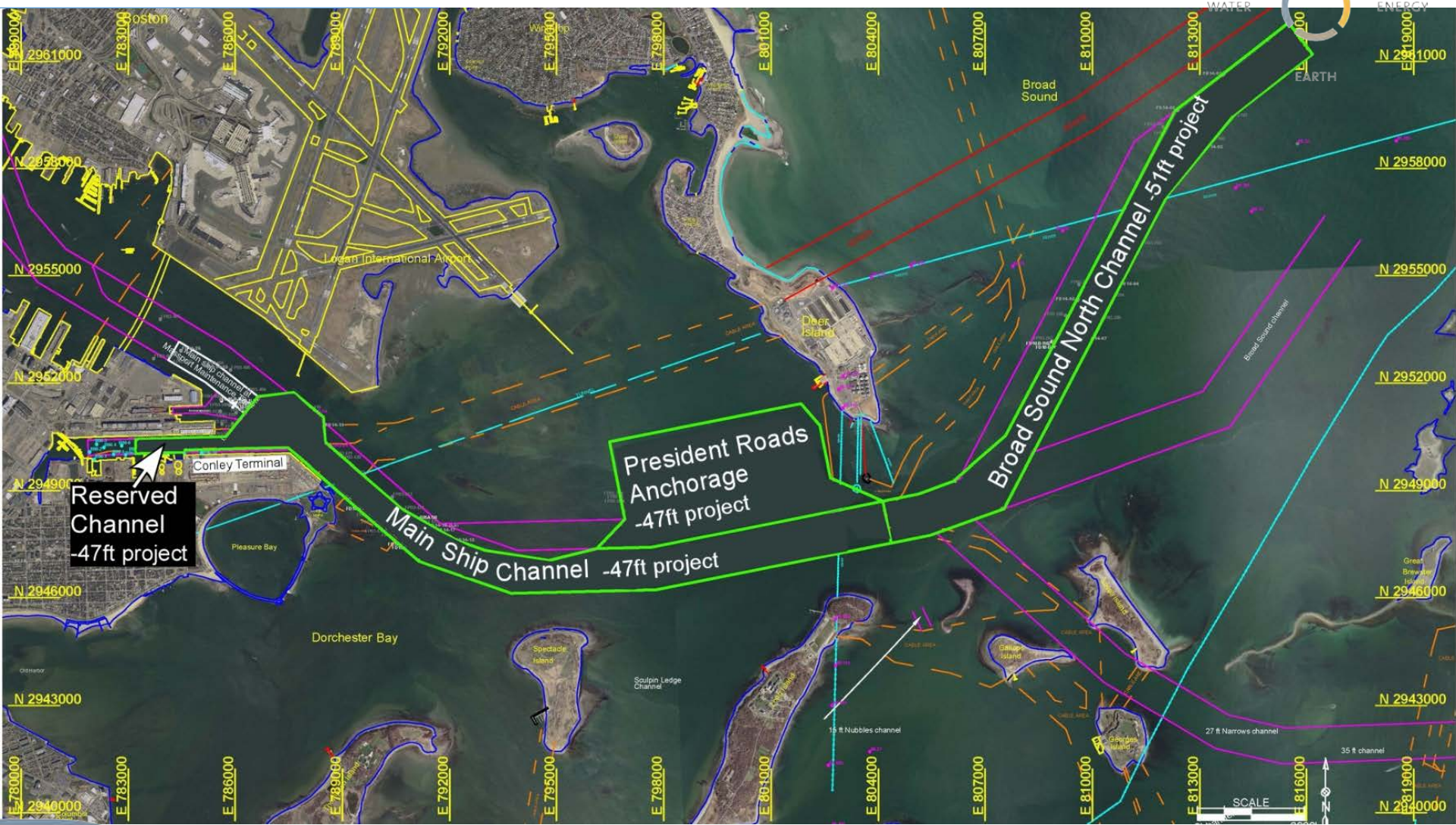


Thanks to our client
U.S. Army Corps of Engineers
New England District

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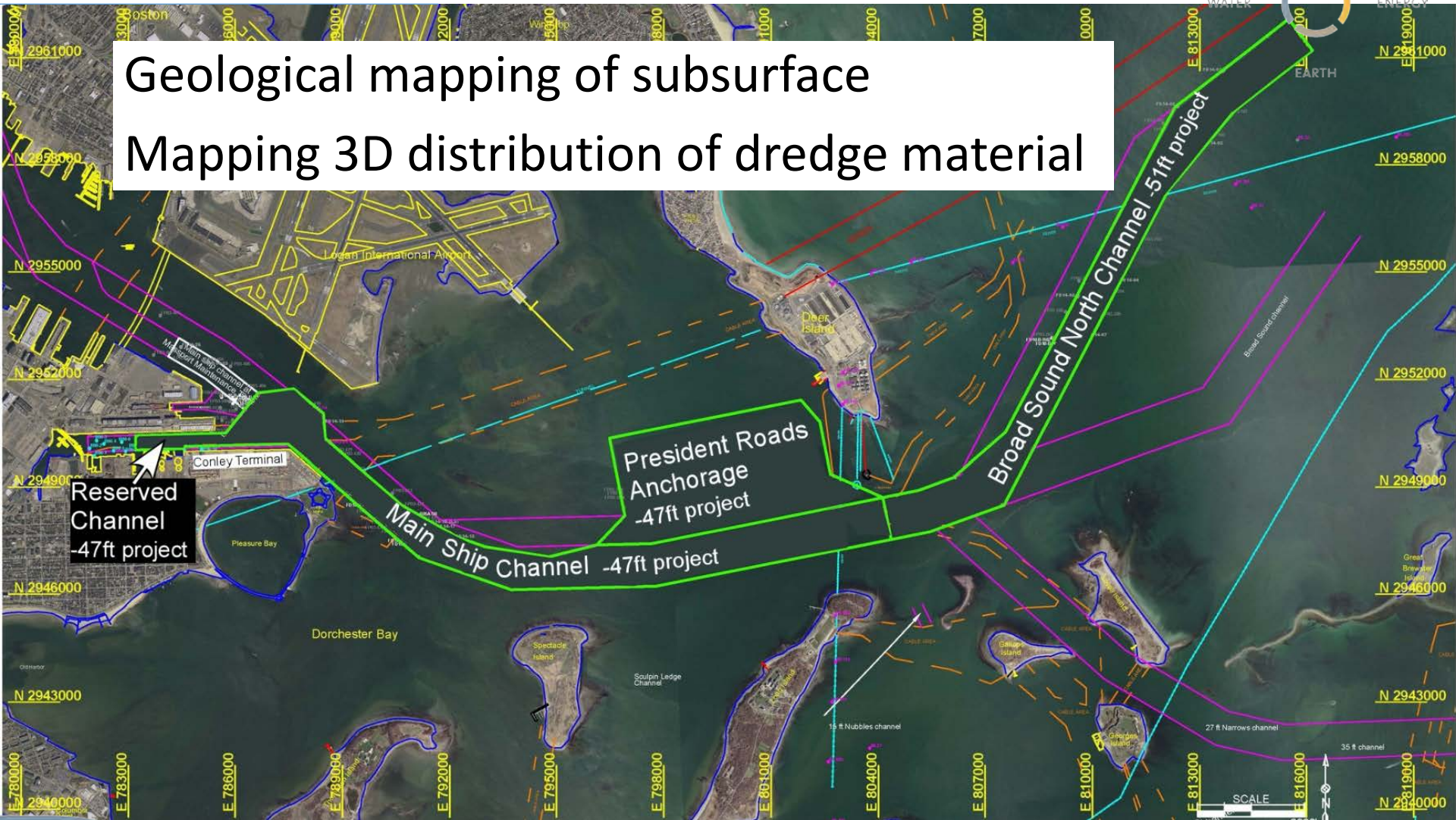
Boston Harbor Improvement Project

LIFE



Boston Harbor Improvement Project

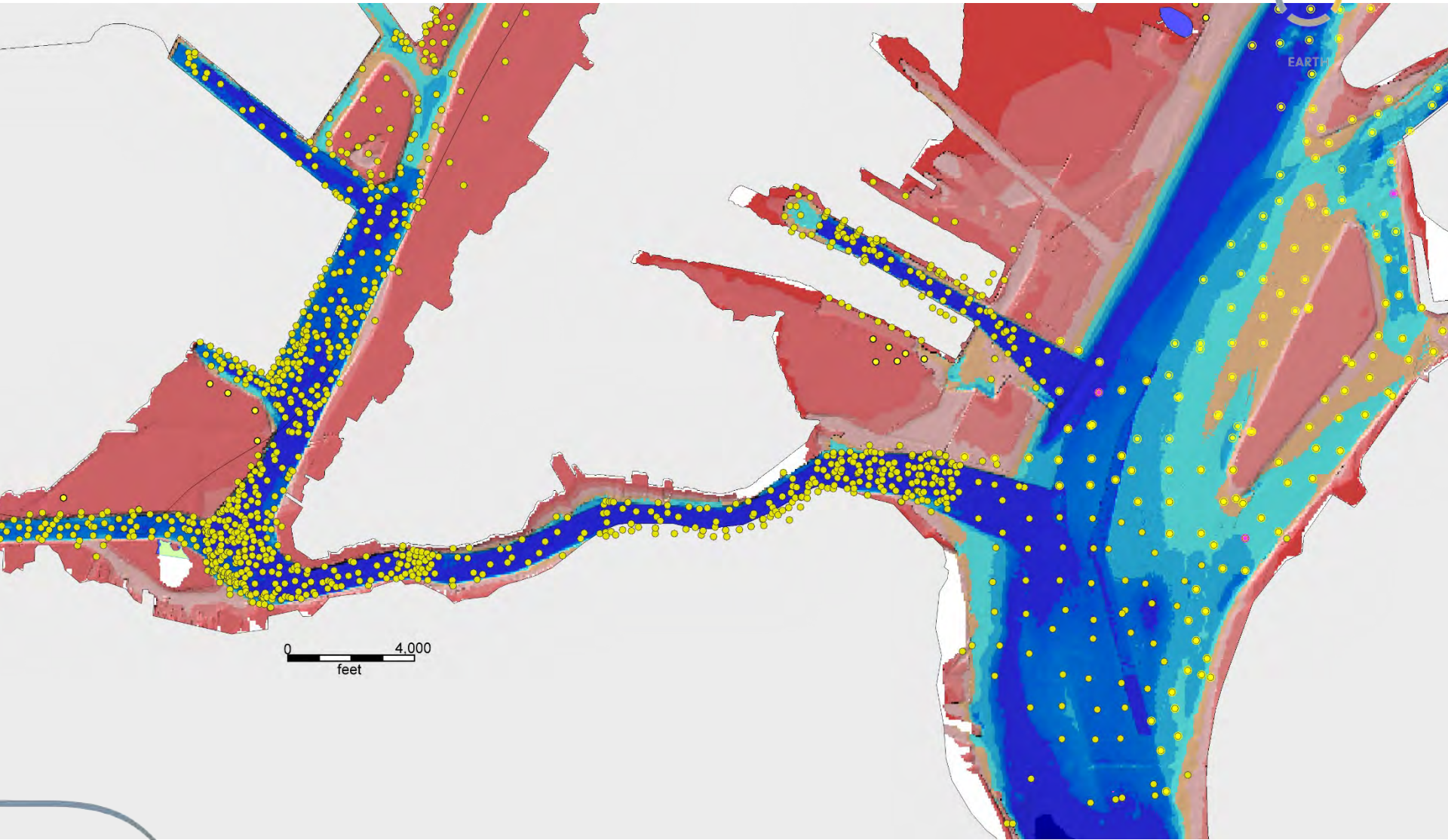
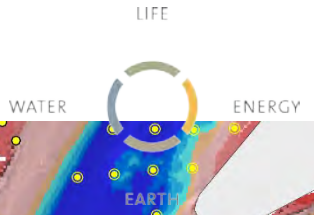
Geological mapping of subsurface
Mapping 3D distribution of dredge material



Historically done with borings

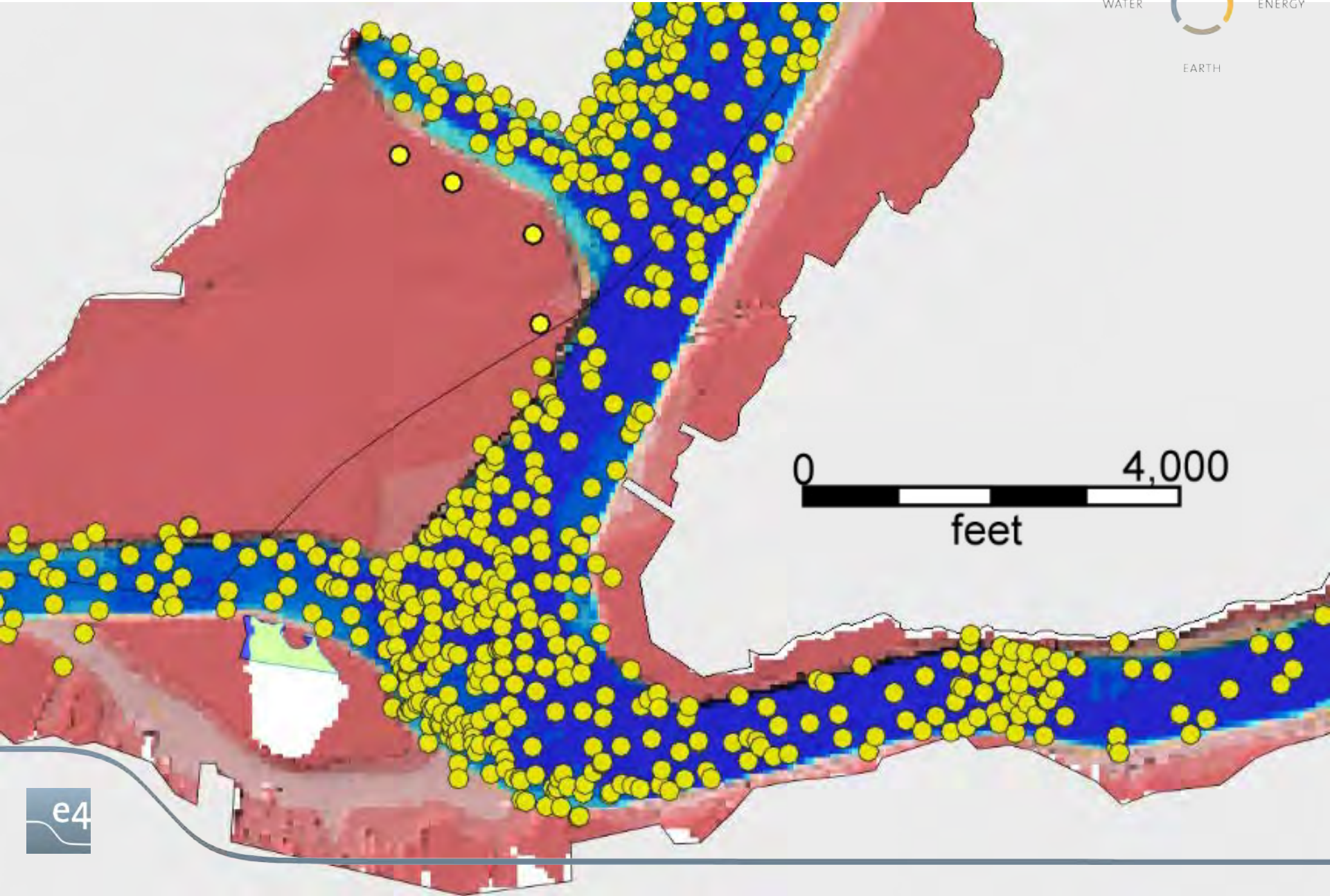
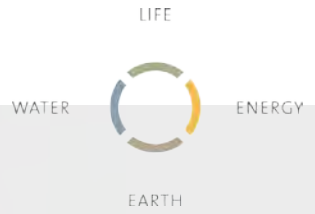
New York New Jersey Harbor

>2,000 borings



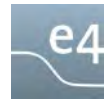
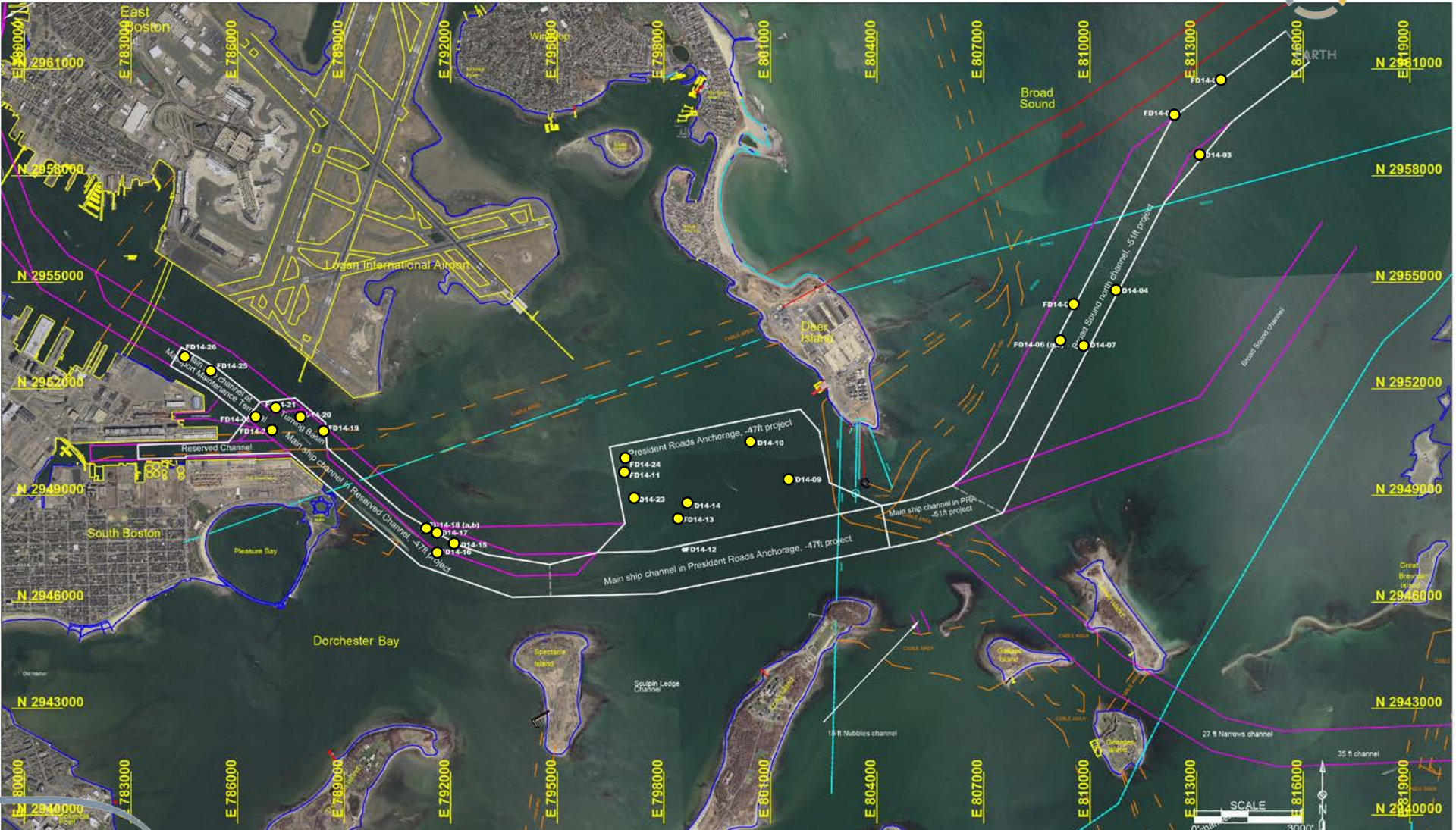
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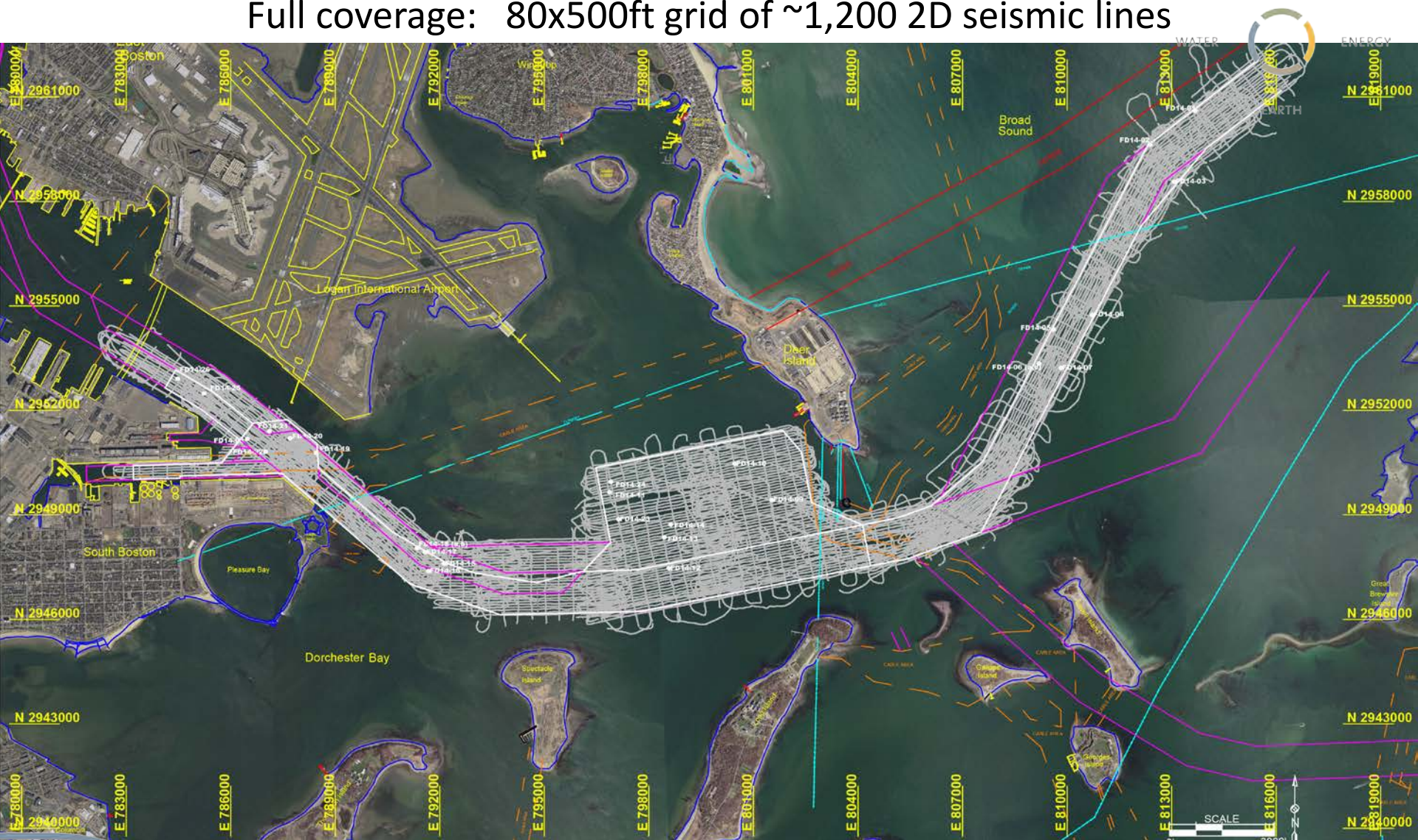
Boston Harbor

Borings



Reflection seismic tracklines

Full coverage: 80x500ft grid of ~1,200 2D seismic lines



Geological mapping of subsurface

Mapping 3D distribution of dredge material



Harbor geology

Mapping the harbor floor

Mapping the subsurface

borings

reflection seismic

example

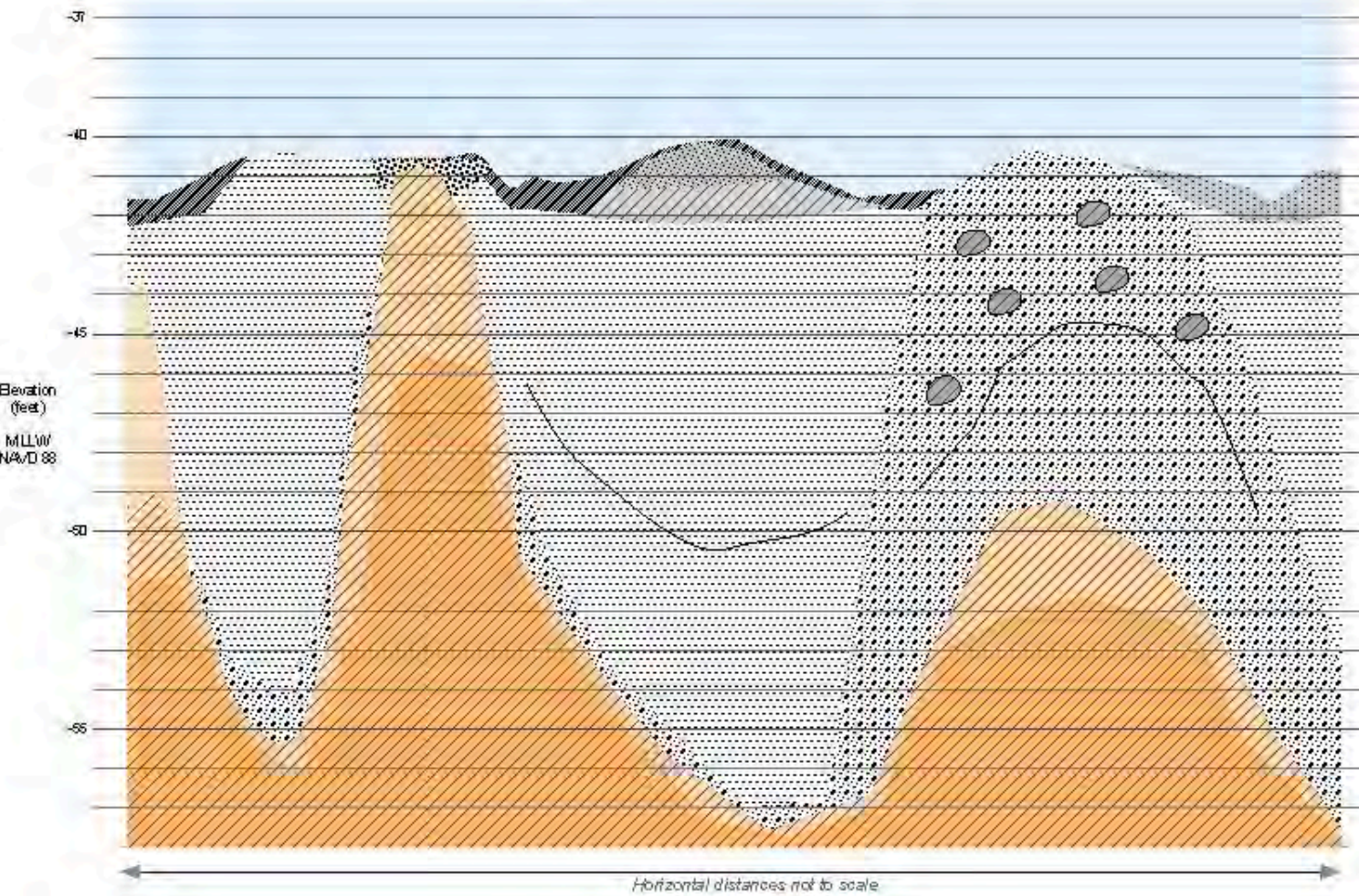
geological principles

geology is predictive

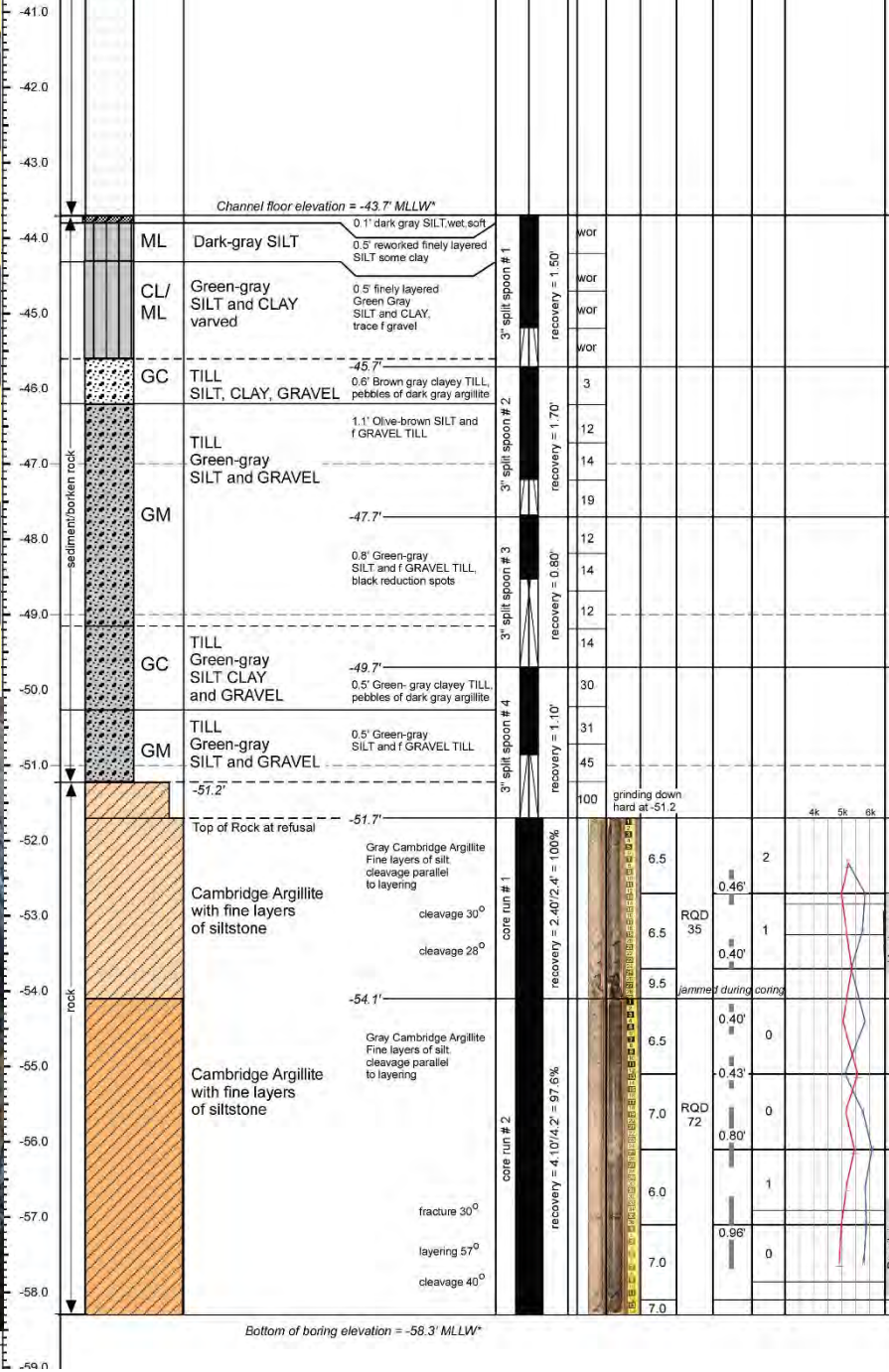
borings test hypotheses from seismic

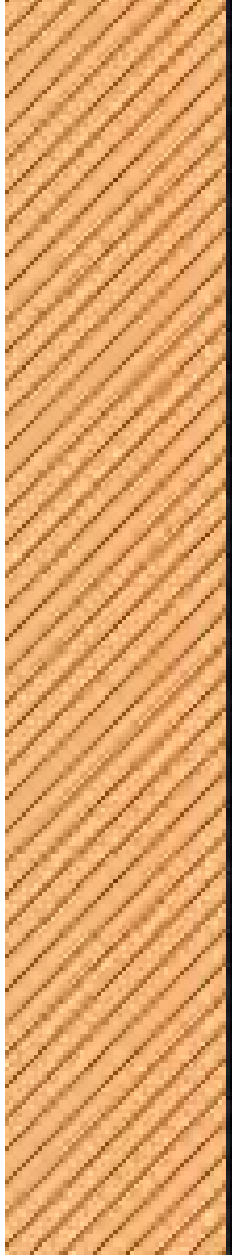
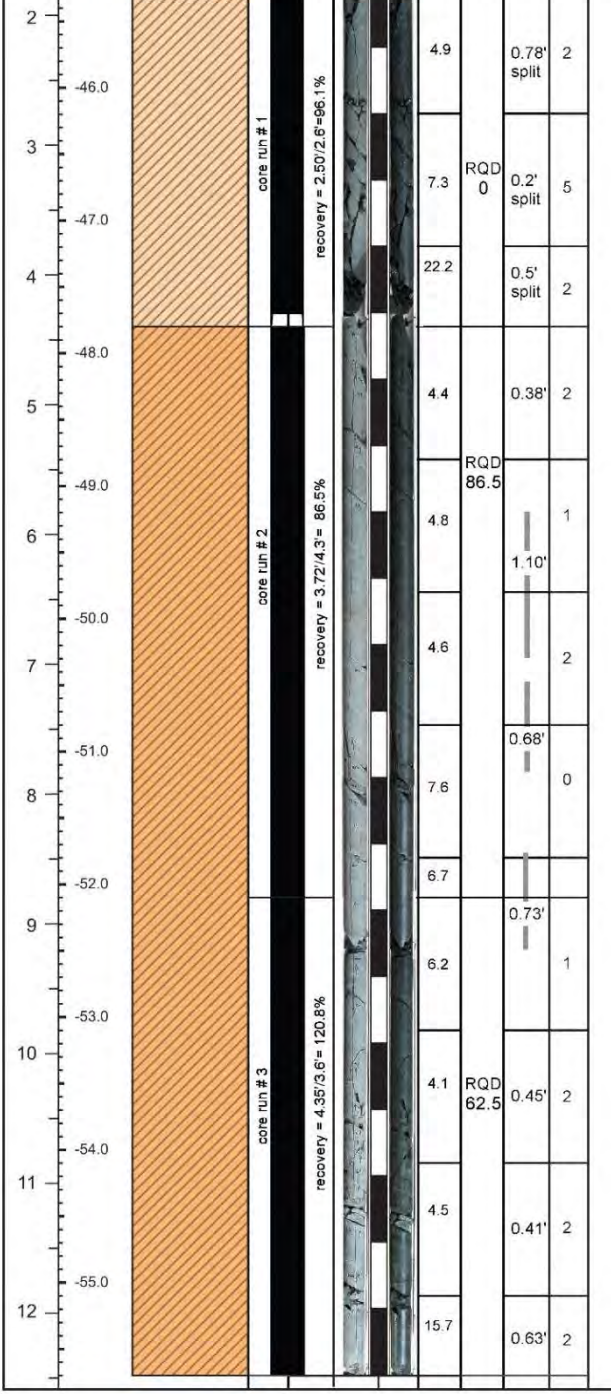
seismic test hypotheses from borings

Boston Harbor Stratigraphy

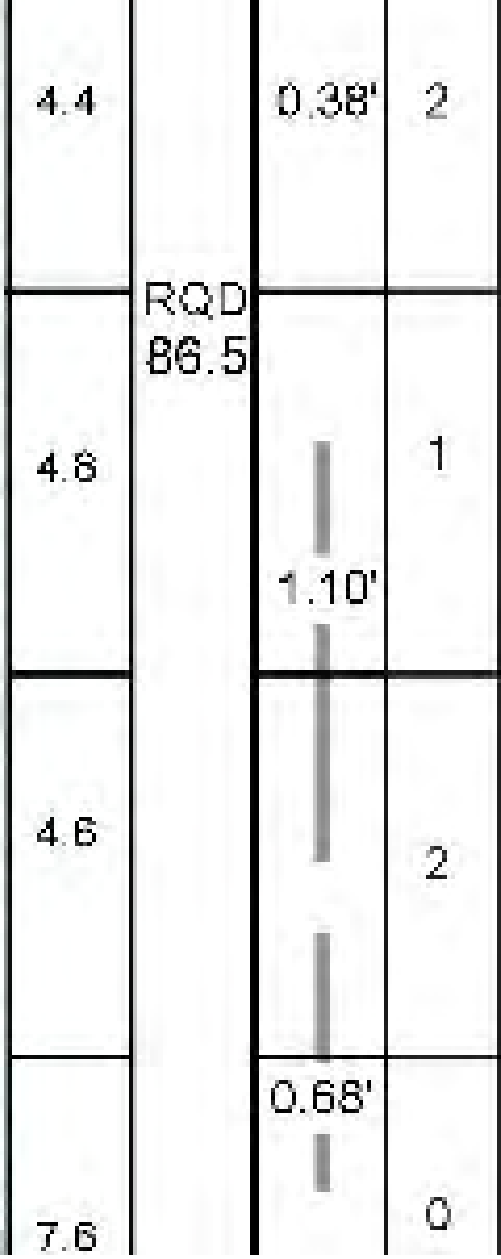
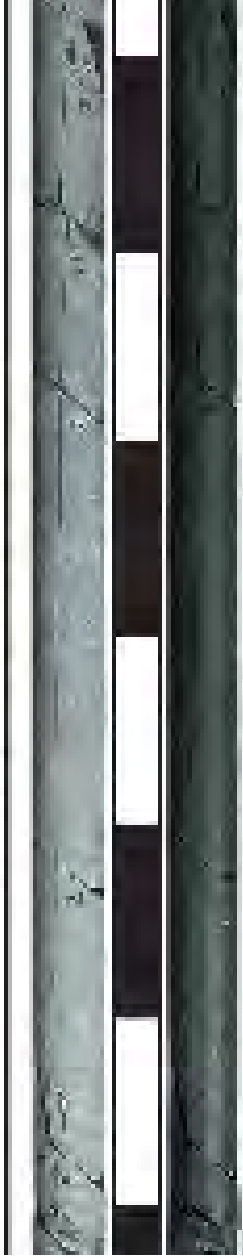


Key to geological units	
Holocene sediment	Recent black silt
	Recent/Holocene sand
	Recent gravel
	Holocene clay and silt
	Holocene peat
Pleistocene sediment	Boston Blue Clay Pleistocene glacial marine clay
	Pleistocene glacial till 2
	Pleistocene glacial till 1
Bedrock	Decomposed to highly weathered Cambridge Argillite
	Cambridge Argillite with RQD < 50
	Cambridge Argillite with RQD > 50





recovery = $3.72 / 4.3 = 86.5\%$



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example

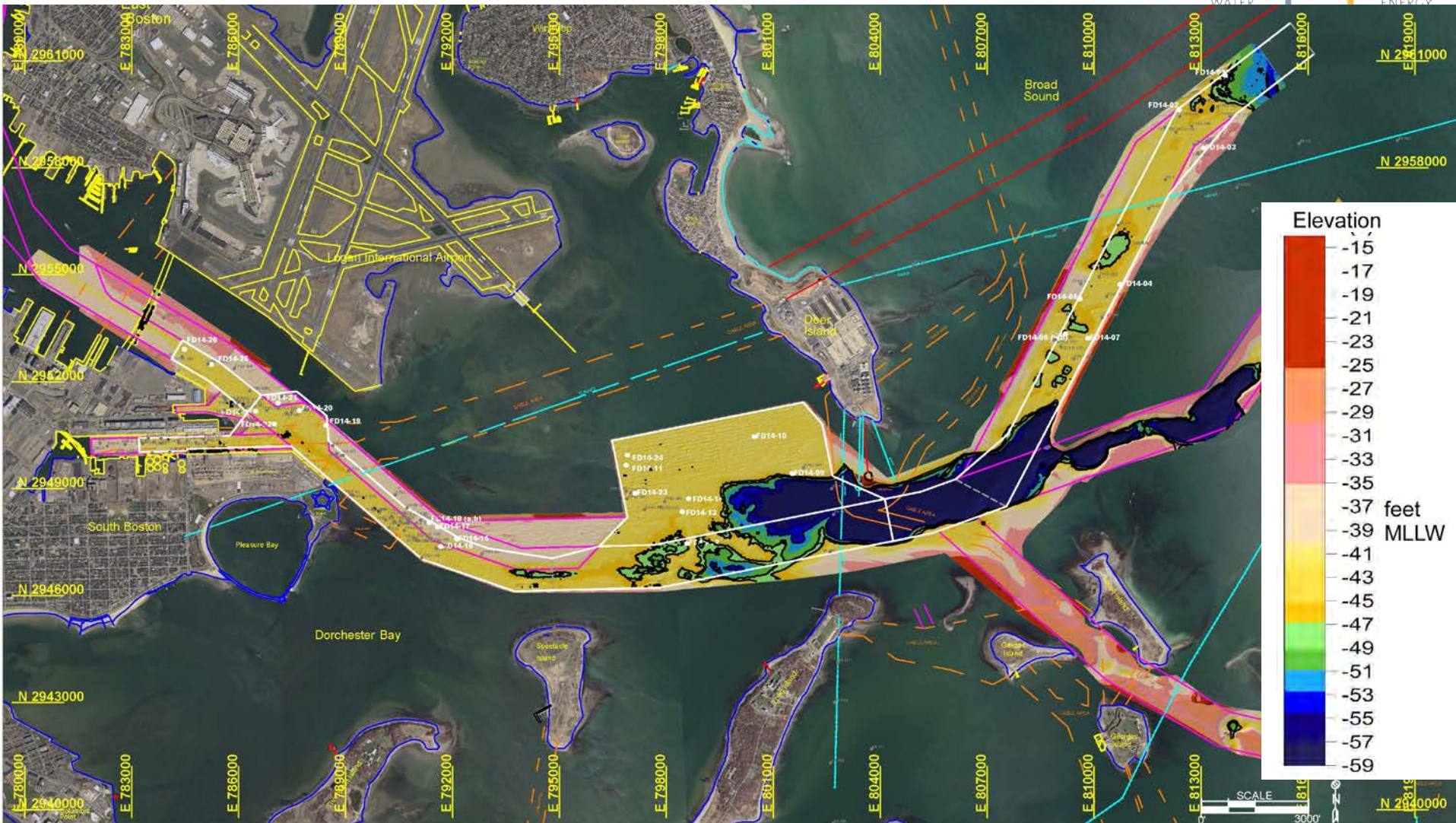
geological principles

predictive of geology

borings as tests of hypothesis

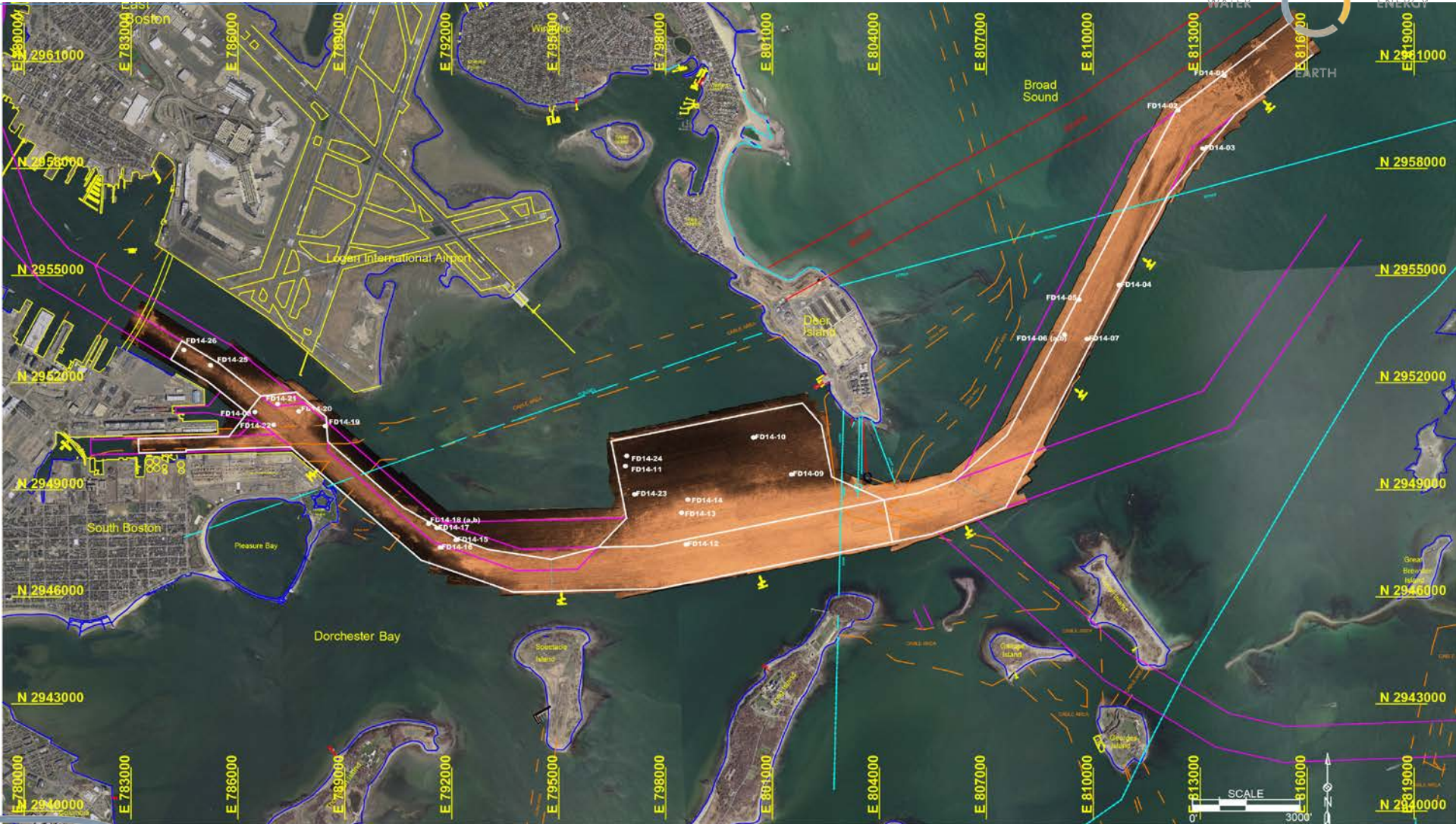
USACE Bathymetry

full coverage of harbor floor: 3x3ft grid

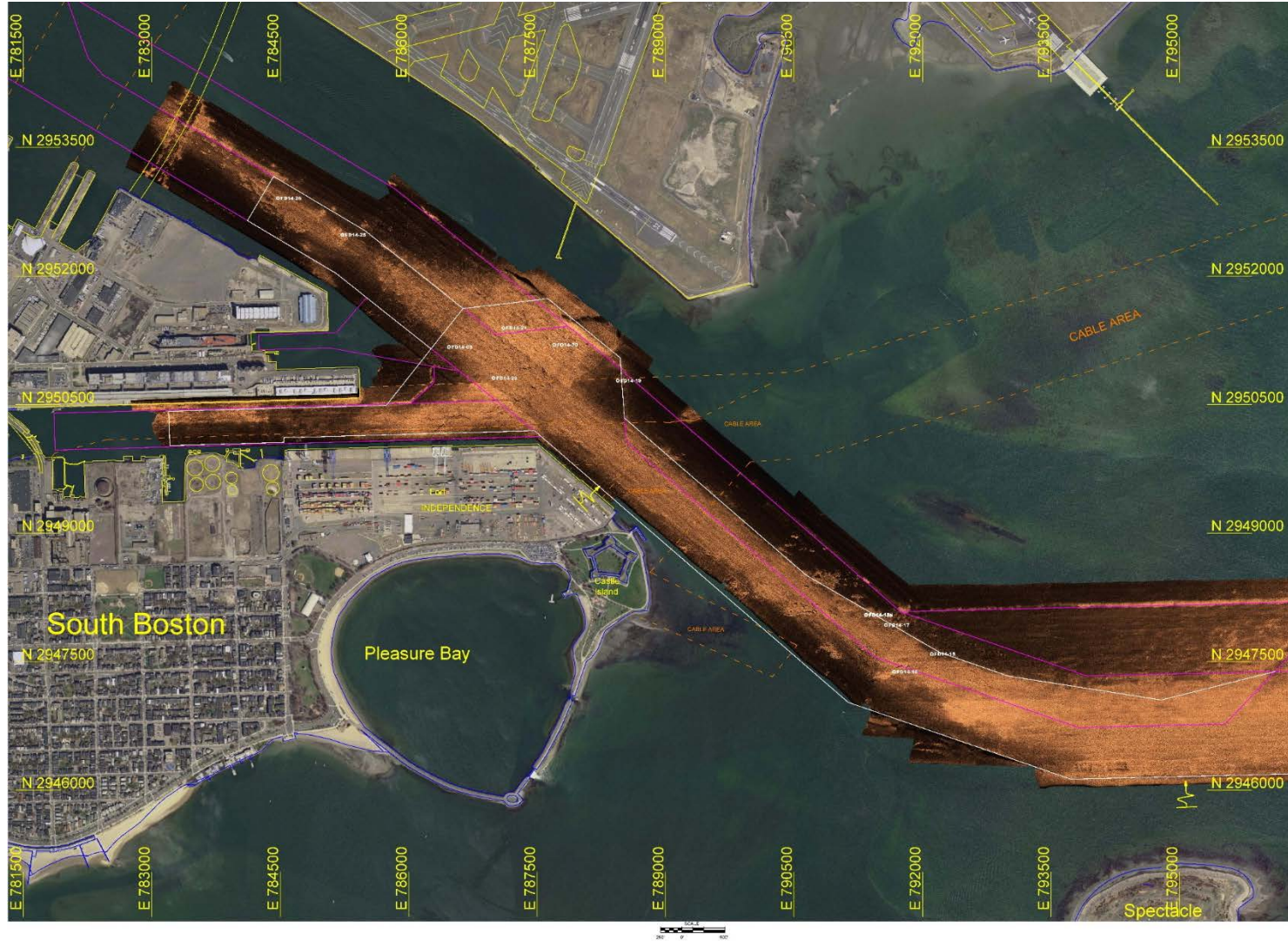


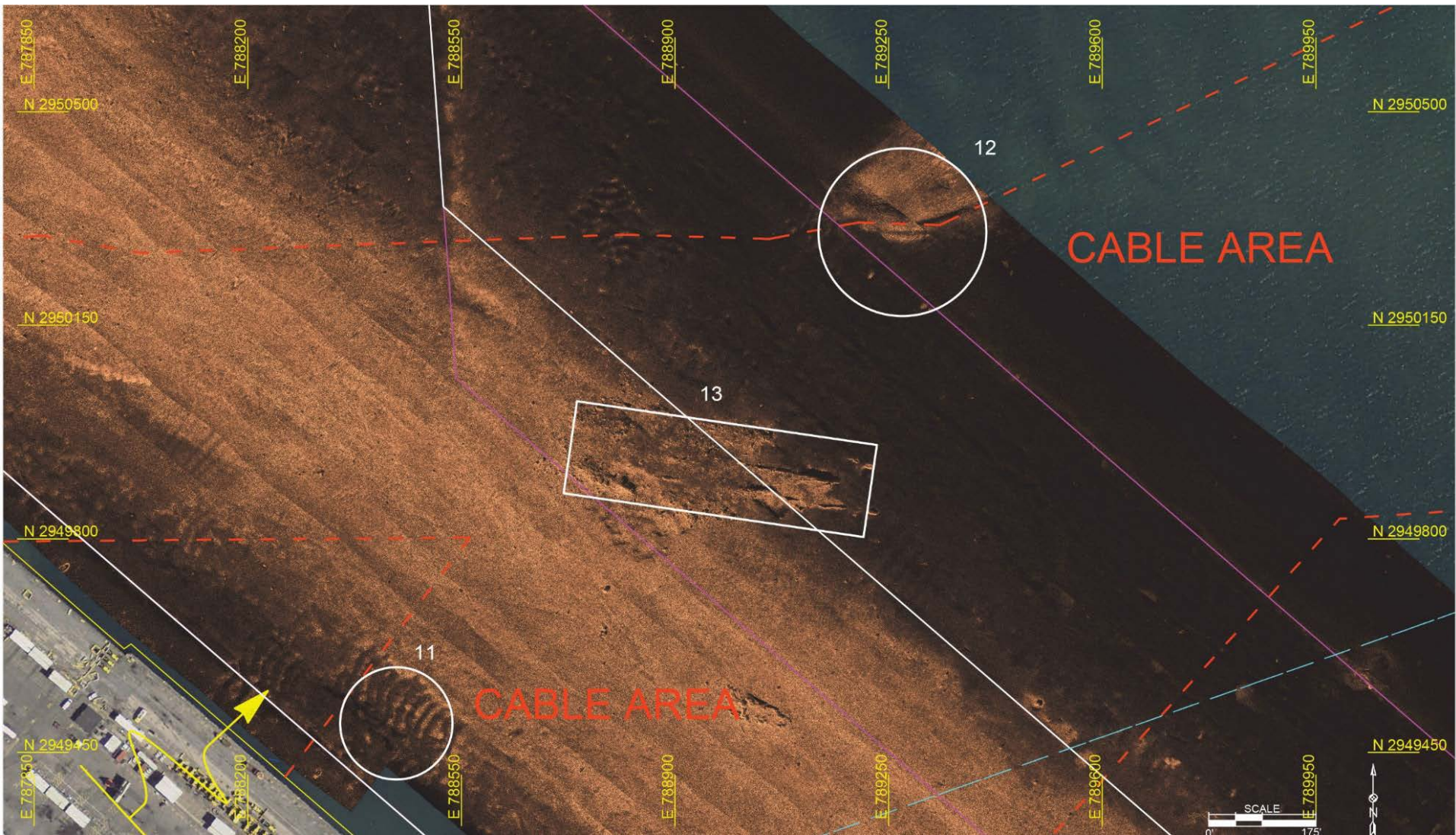
Orthosonographs

continuous coverage image of harbor floor: 1 pixel < 10x10cm



Boston Harbor





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example

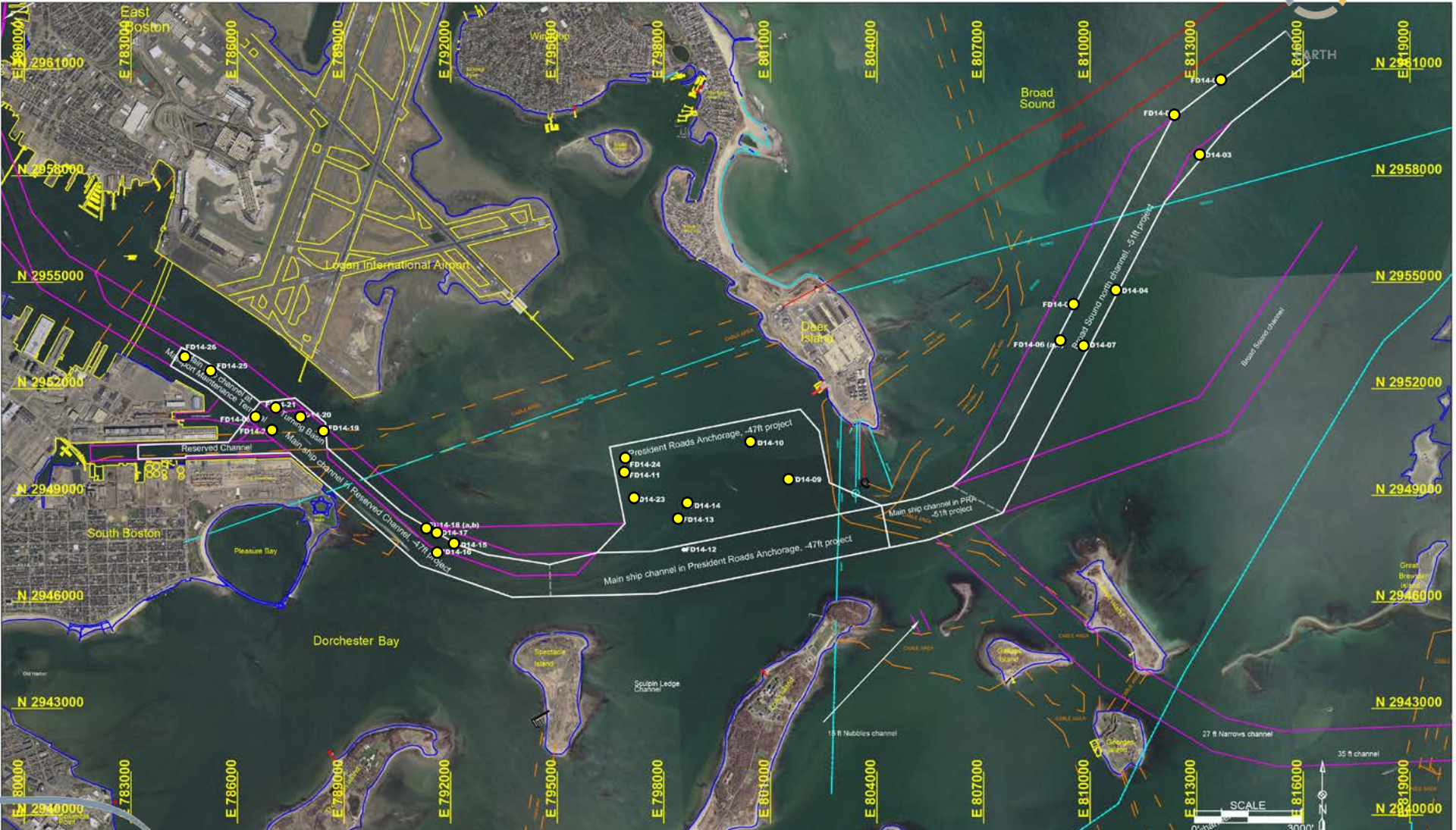
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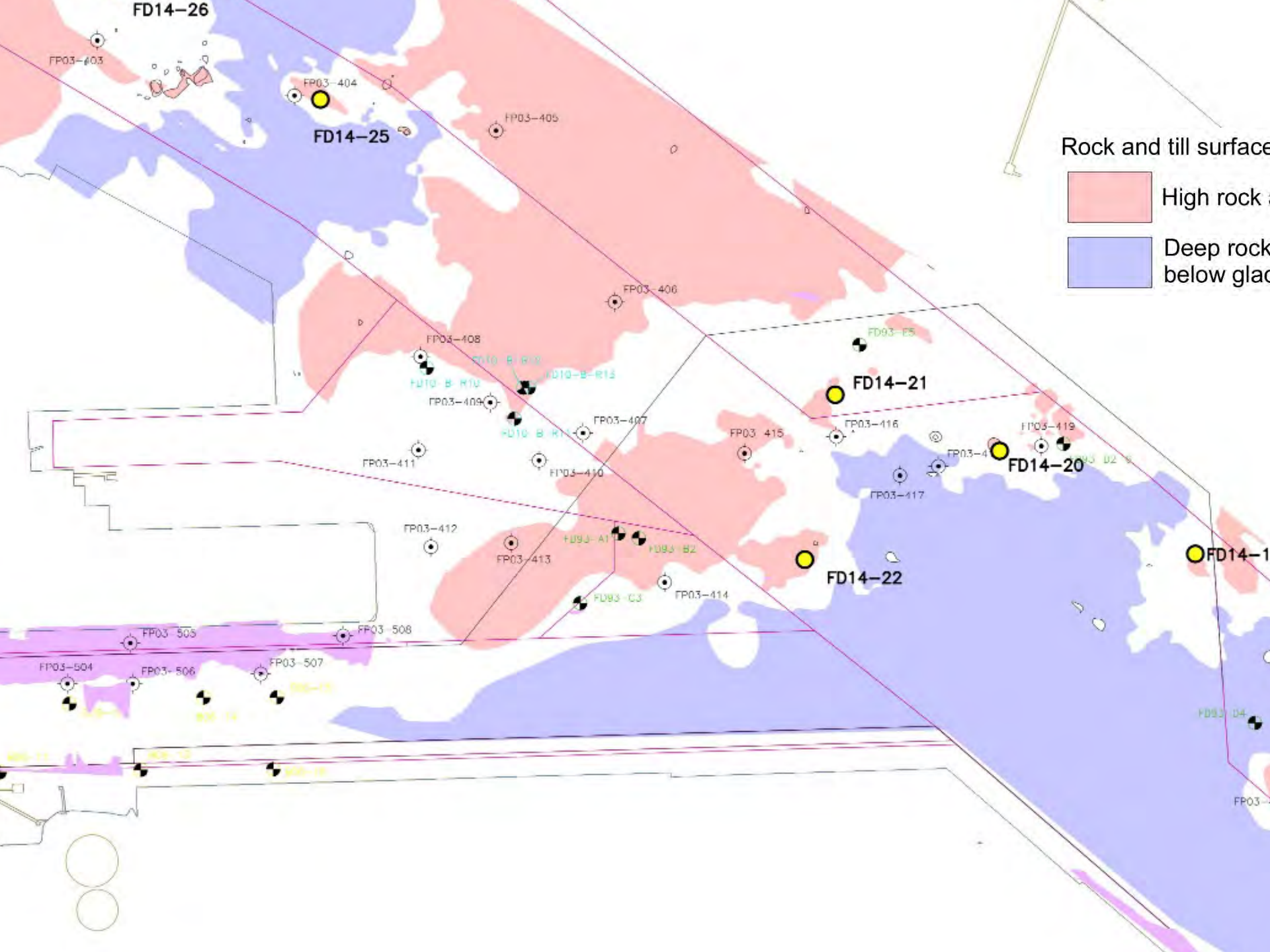
Boston Harbor

Borings





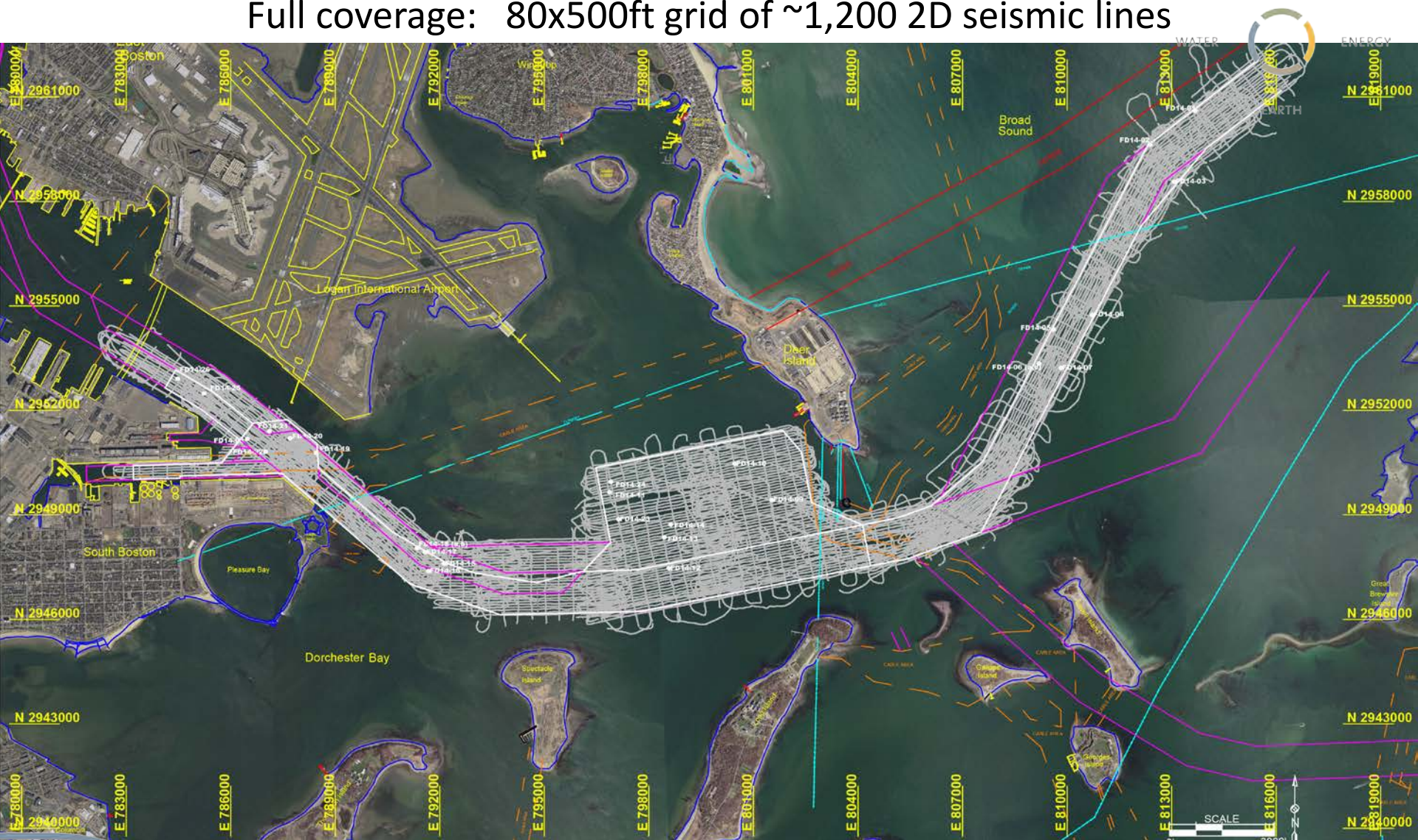




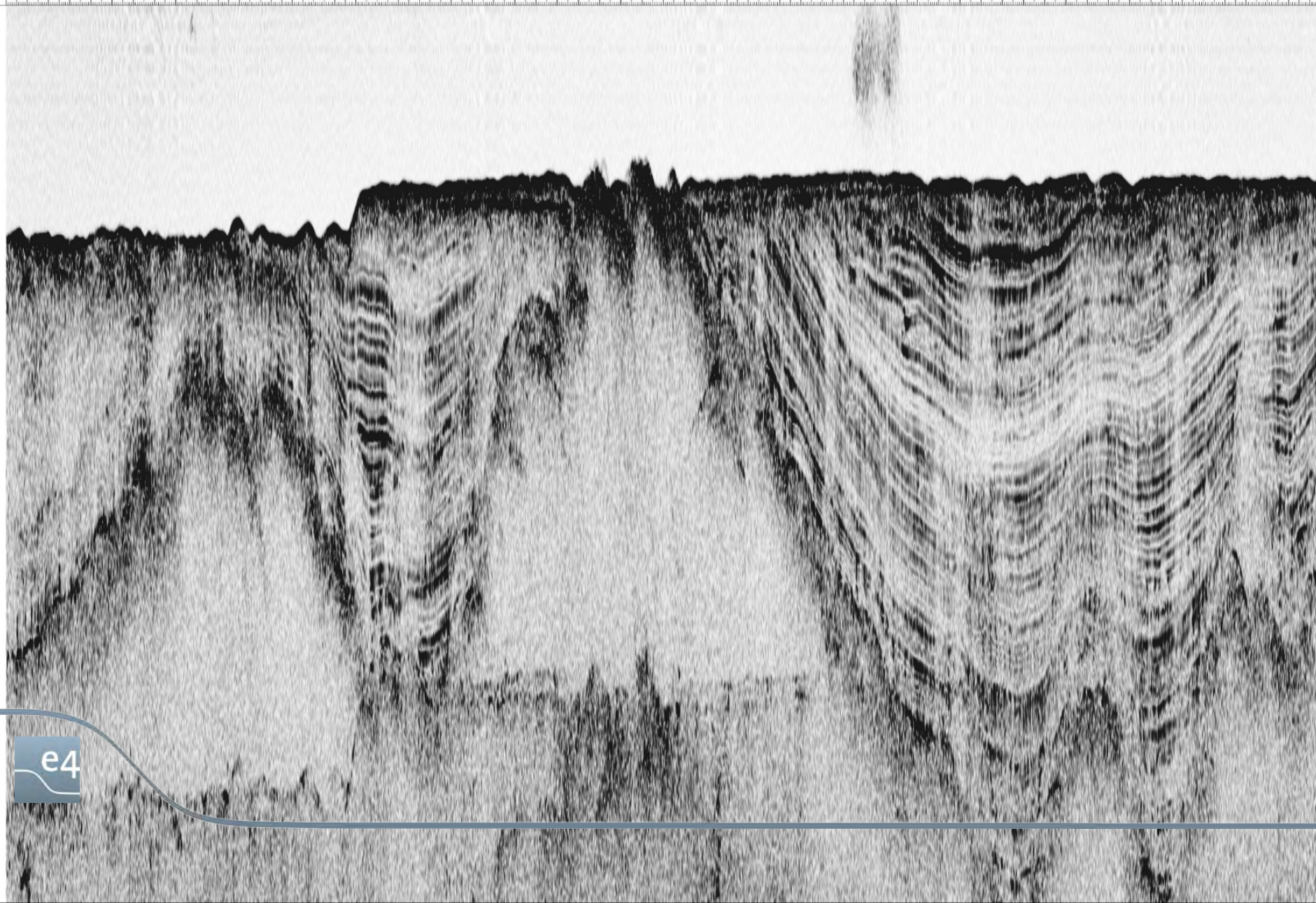


Reflection seismic tracklines

Full coverage: 80x500ft grid of ~1,200 2D seismic lines

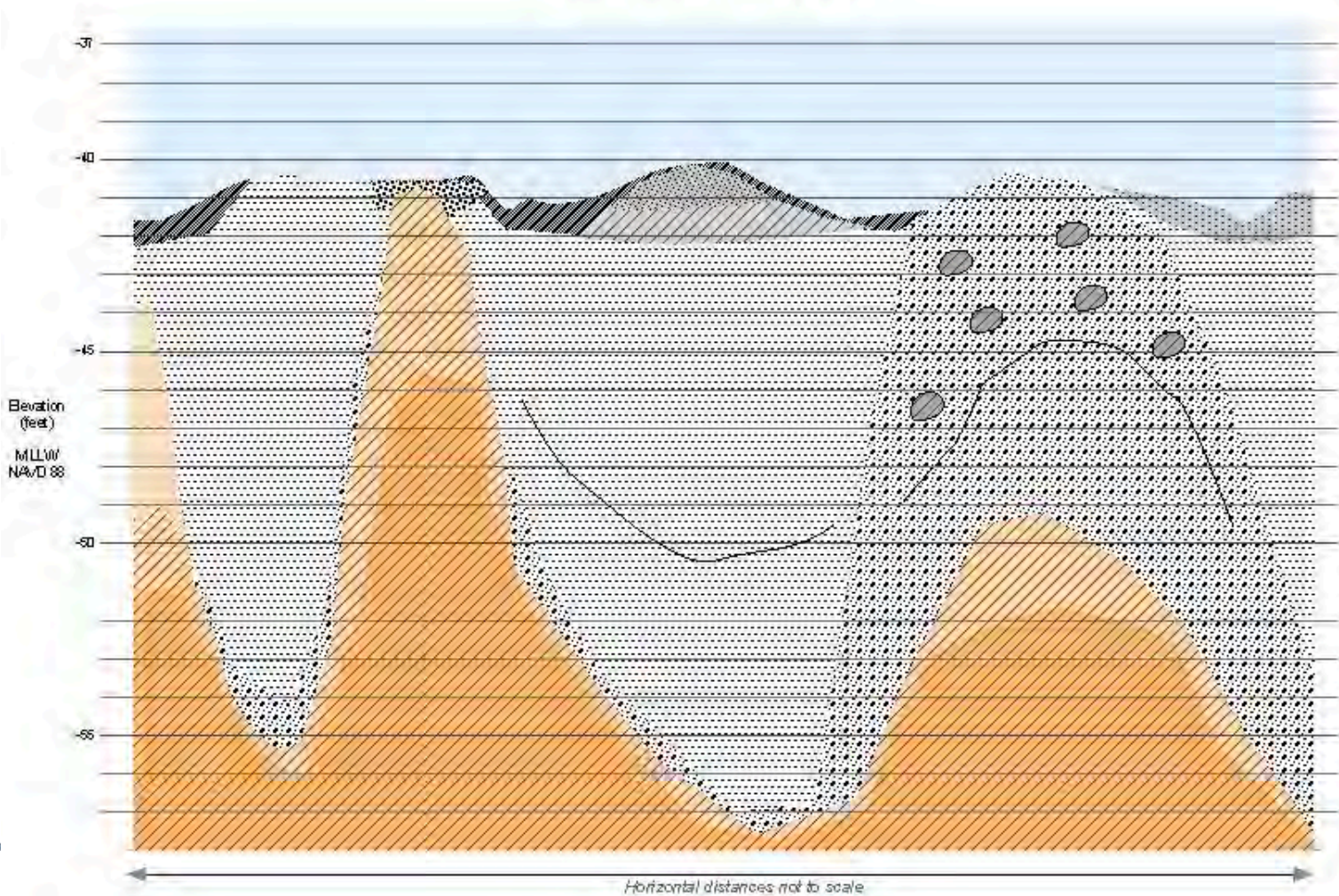


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0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 501 001 502 002 503 003 504 004 505 005 506 006 507 007 508 008 509 009 5010 0010 5011 0011 5012 0012 5013 0013 5014 0014 5015 0015 5016 0016 5017 0017 5018 0018 5019 0019 5020 0020 5021 0021 5022 0022 5023 0023 5024 0024 5025 0025 5026 0026 5027 0027 5028 0028 5029 0029 5030 0030 5031



e4

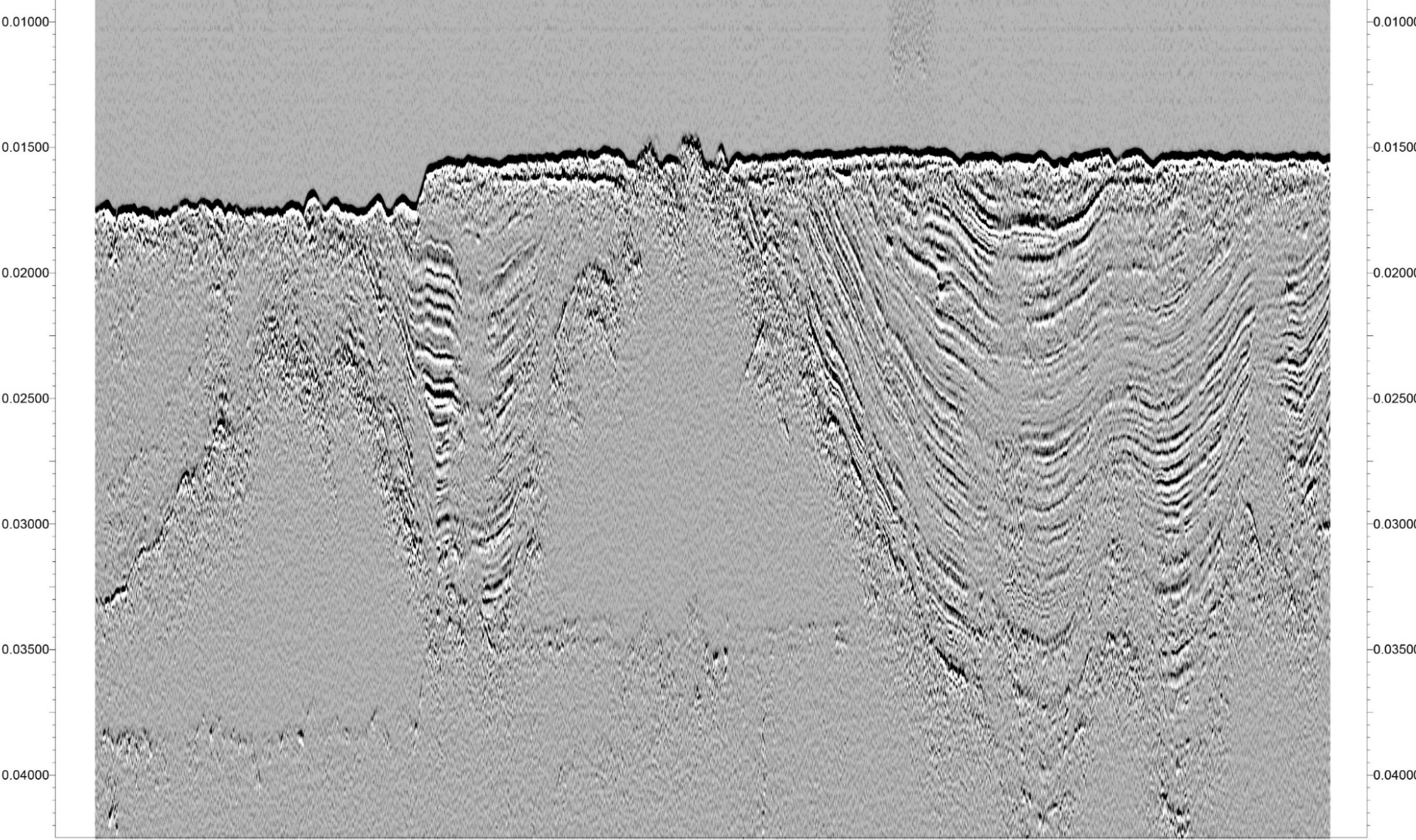
Boston Harbor Stratigraphy



Key to geological units

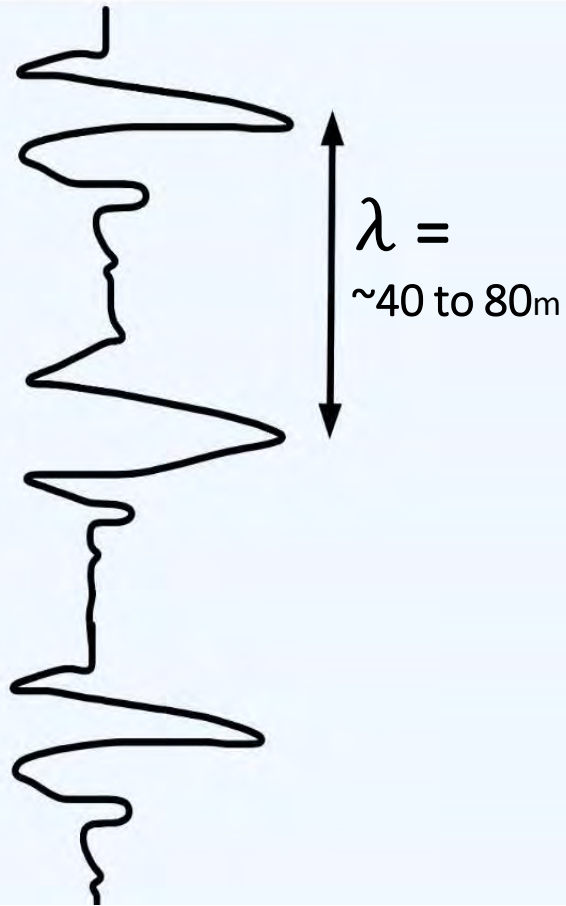
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		Cambridge Argillite with RQ
		Cambridge Argillite with RQ

SP: 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0 1100.0 1200.0 1300.0 1400.0 1500.0 1600.0 1700.0 1800.0 1900.0 2000.0 2100.0 2200.0 2300.0 2400.0 2500.0 2600.0 2700.0 2800.0
Offset: 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 501 1001 502 1002 503 1003 504 1004 505 1005 506 1006 507 1007 508 1008 509 1009 520 1020 521 1021 522 1022 523 1023 524 1024 525 1025 526 1026 527 1027 528 1028 529 1029 530 1030 53103



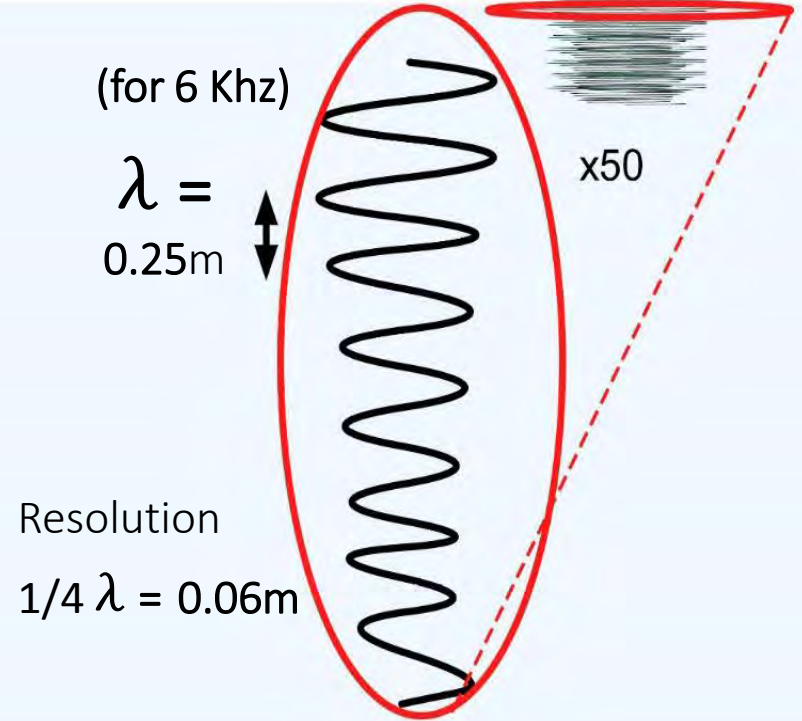
Conventional Seismic

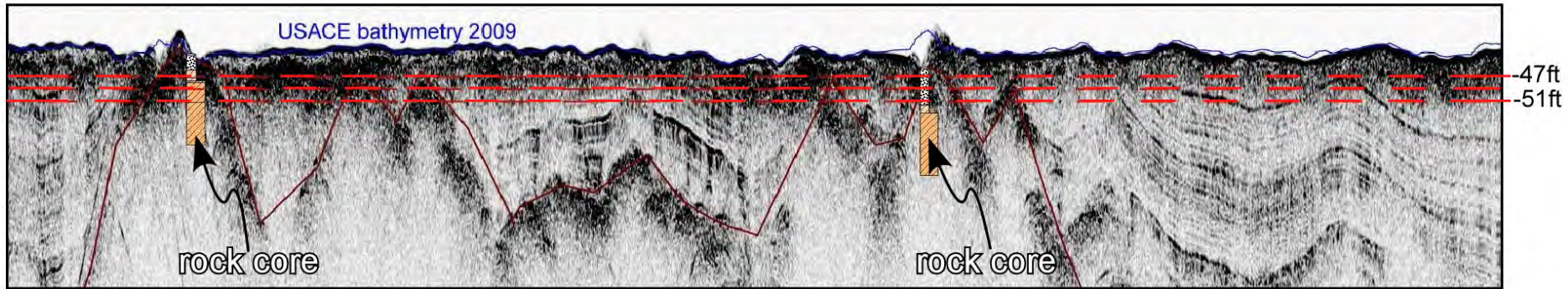
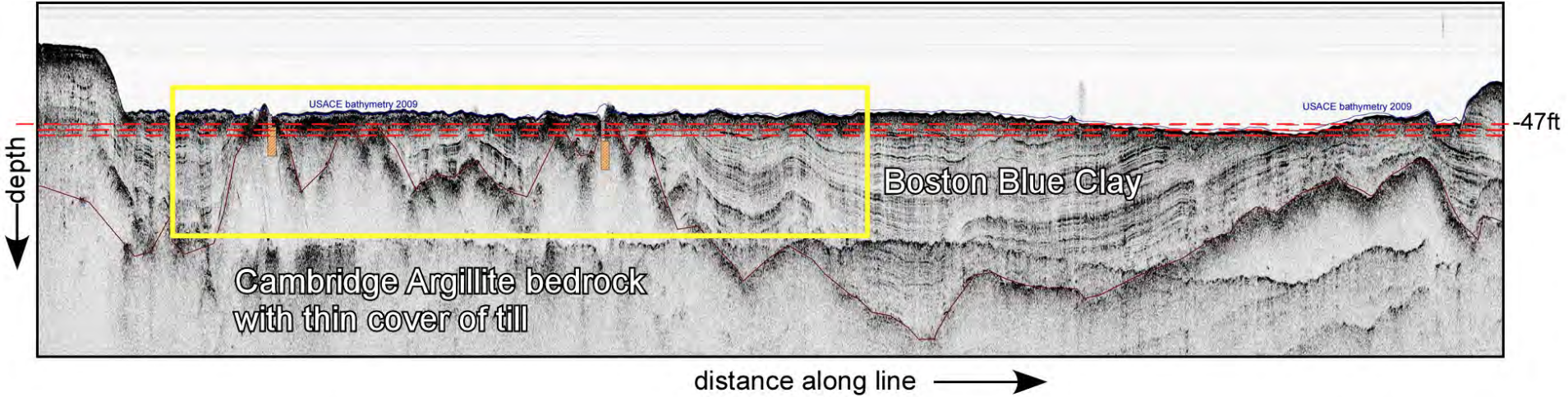
20-50 hertz
(high-res 100 hertz)

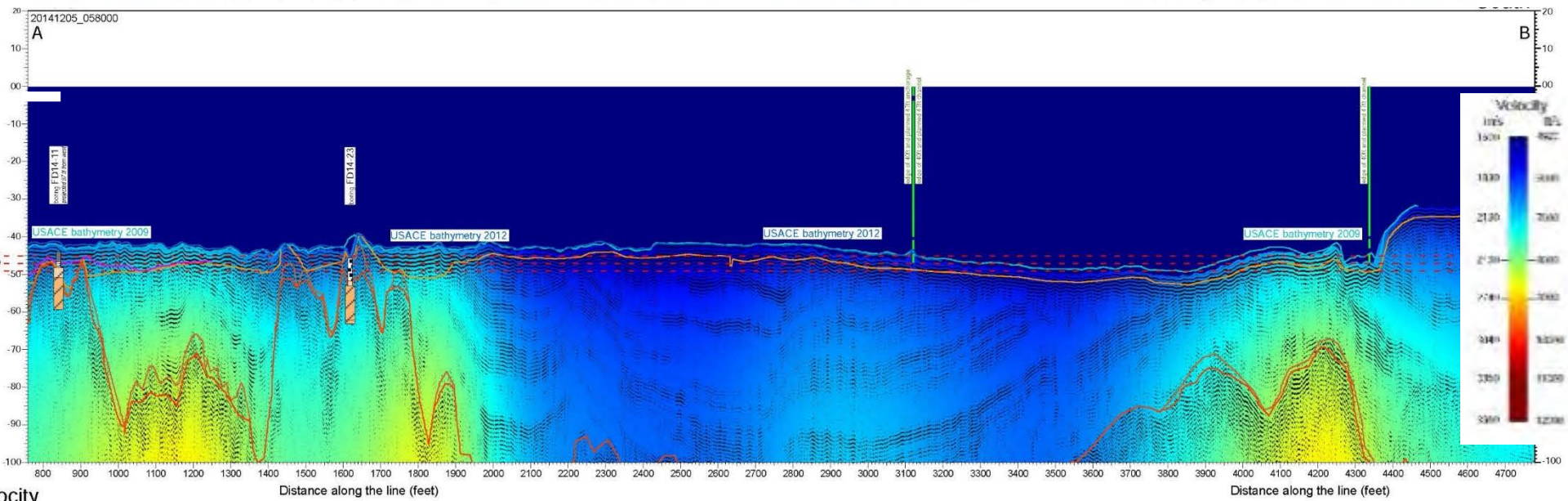
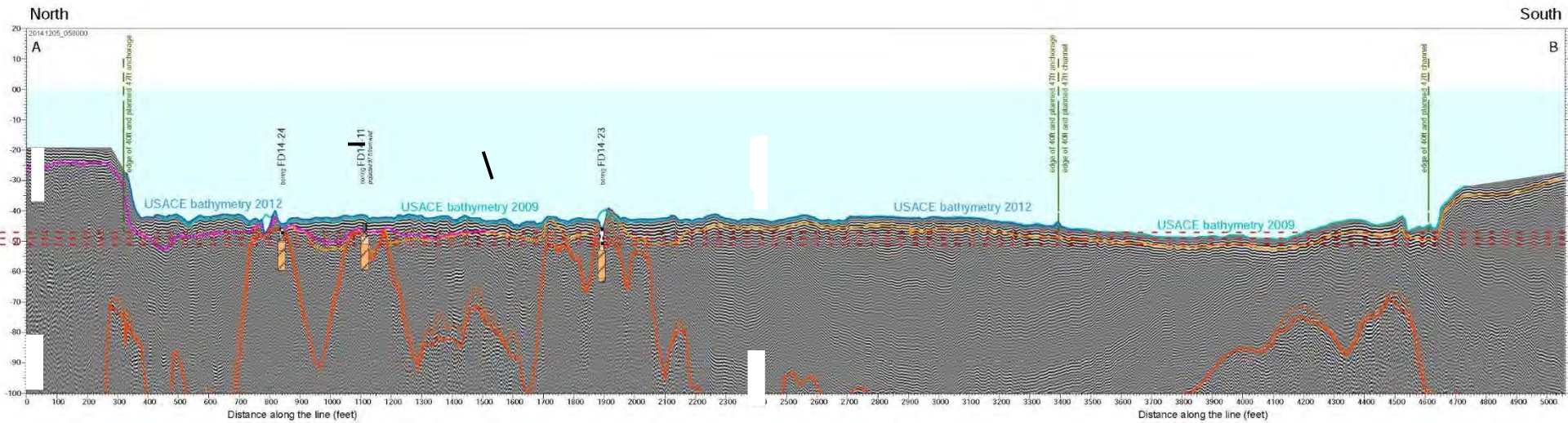


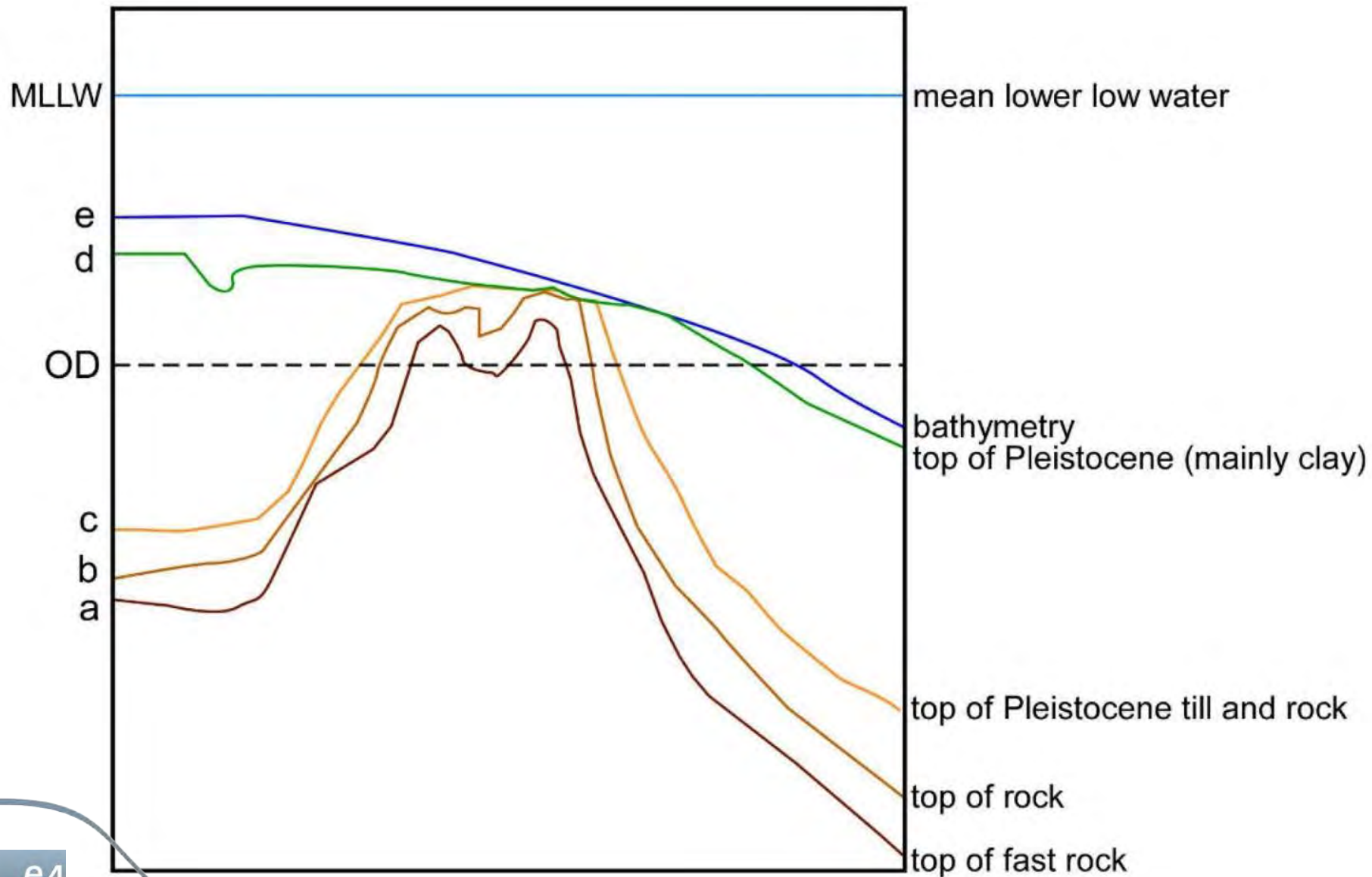
High-resolution Seismic

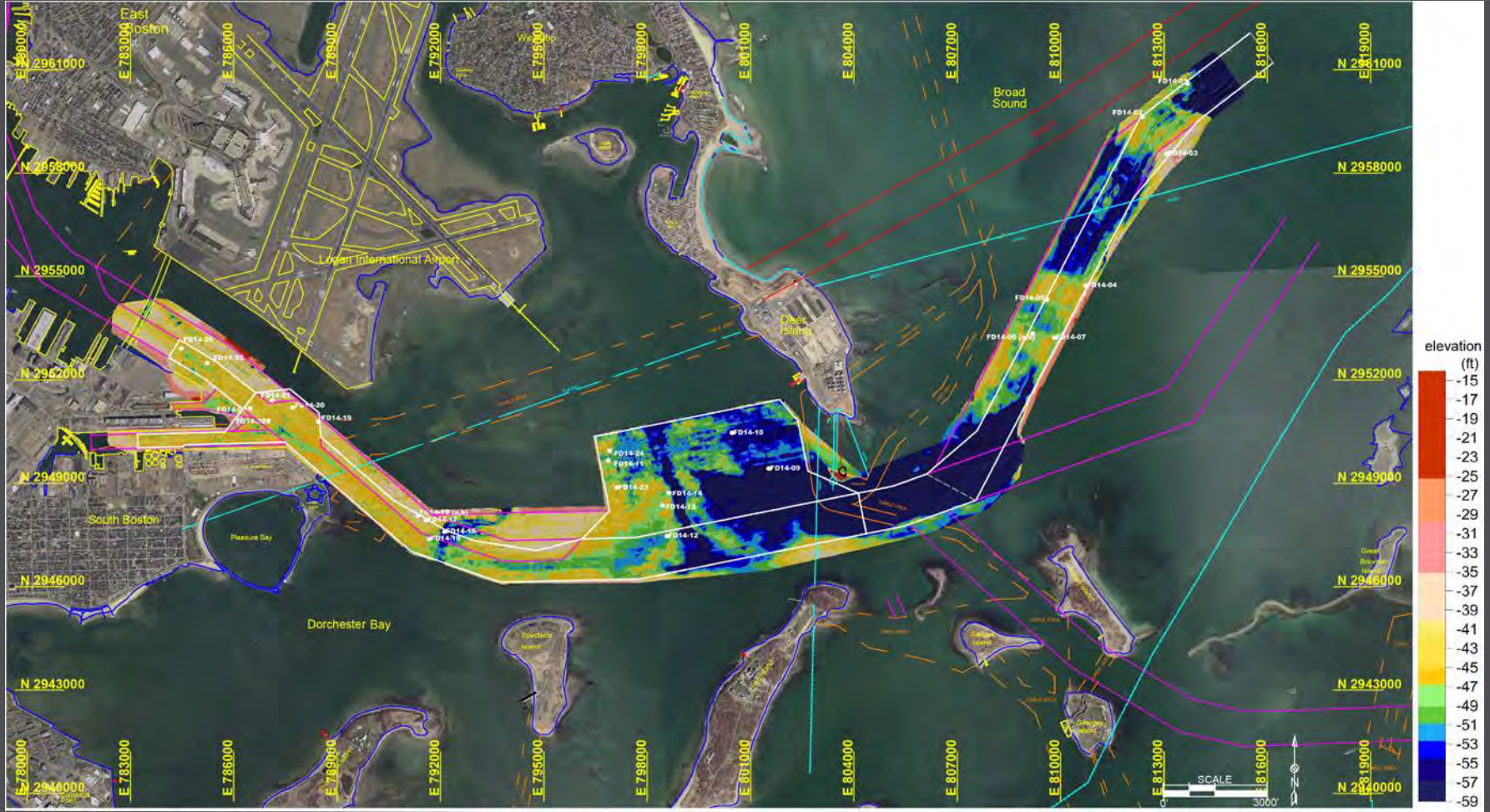
5,000-12,000 hertz
(6,000 hertz)











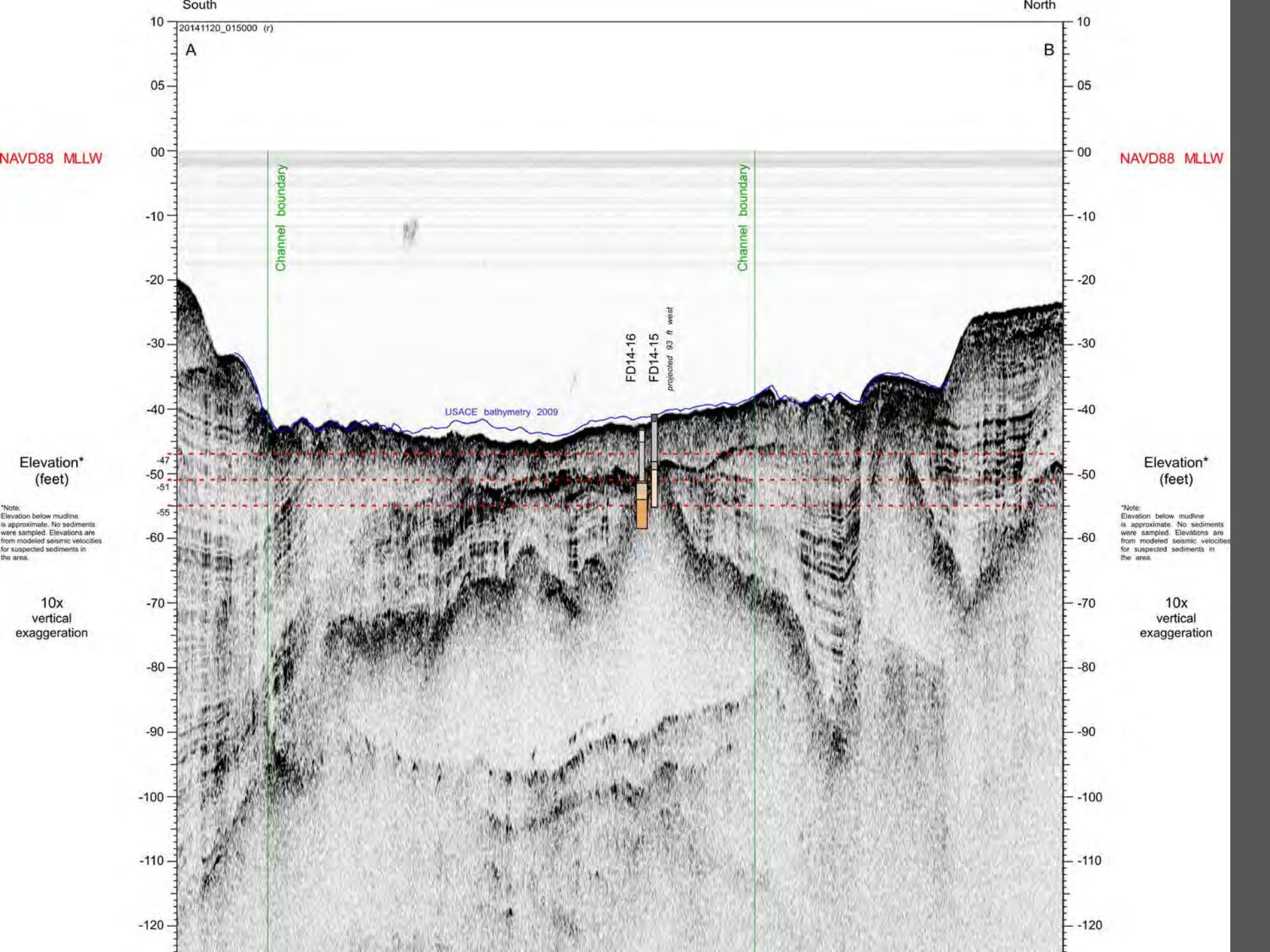
Planimetrics provided by USACE-NAE, New England District

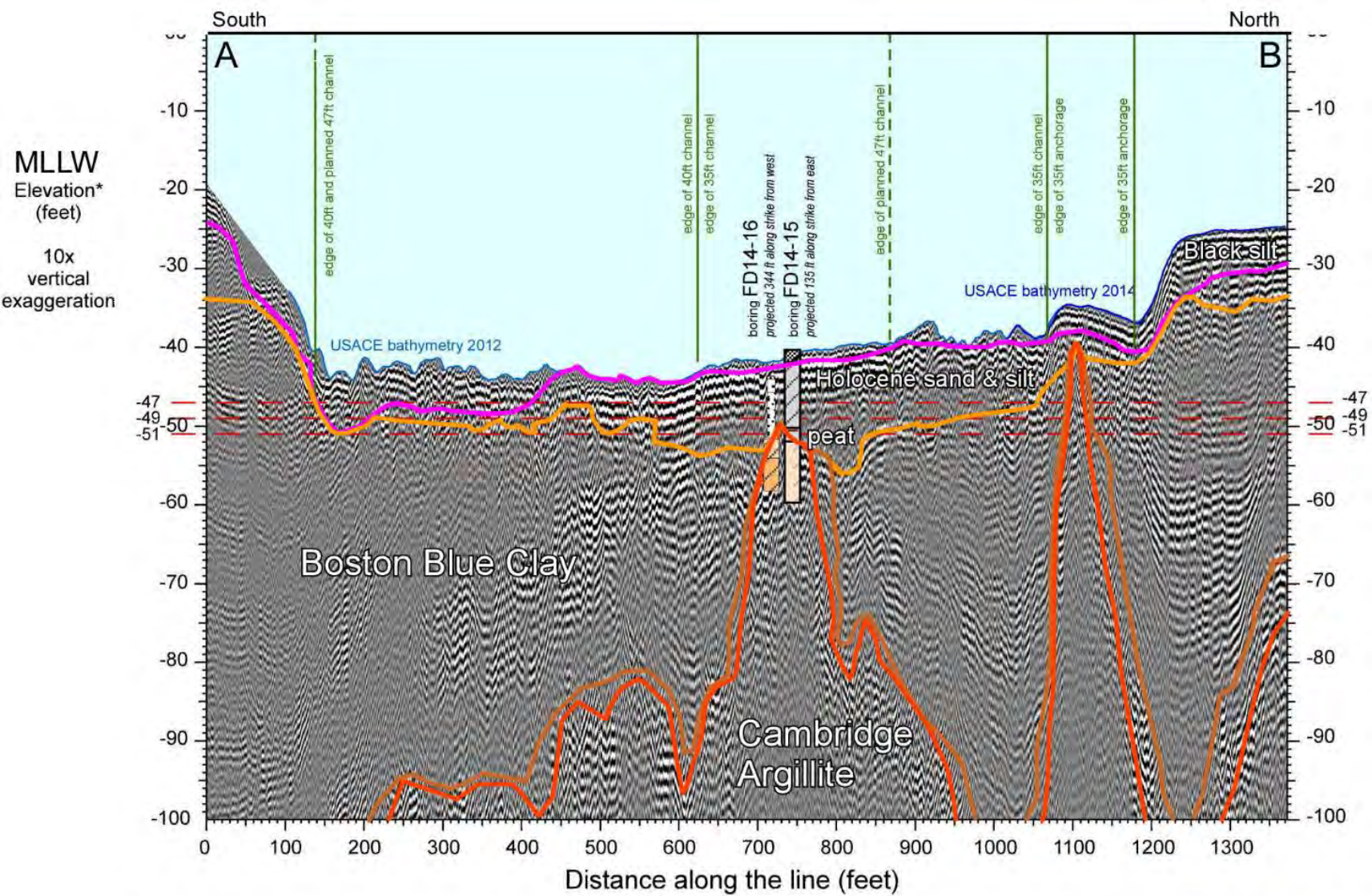
Proposed channel	Sewer area	Channel outline, 2010
e4sciences area divisions	Sewer and tunnel area	Shoreline and dock
	Cable area	Land planimetrics

As drilled boring locations

Massachusetts Mainland State Plane Feet Coordinate System
 North American Datum of 1983 (NAD83)
 Vertical datum: MLLW (NAVD 1988)
 2013 Orthophotos: USGS and Massachusetts



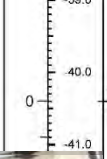




KEY

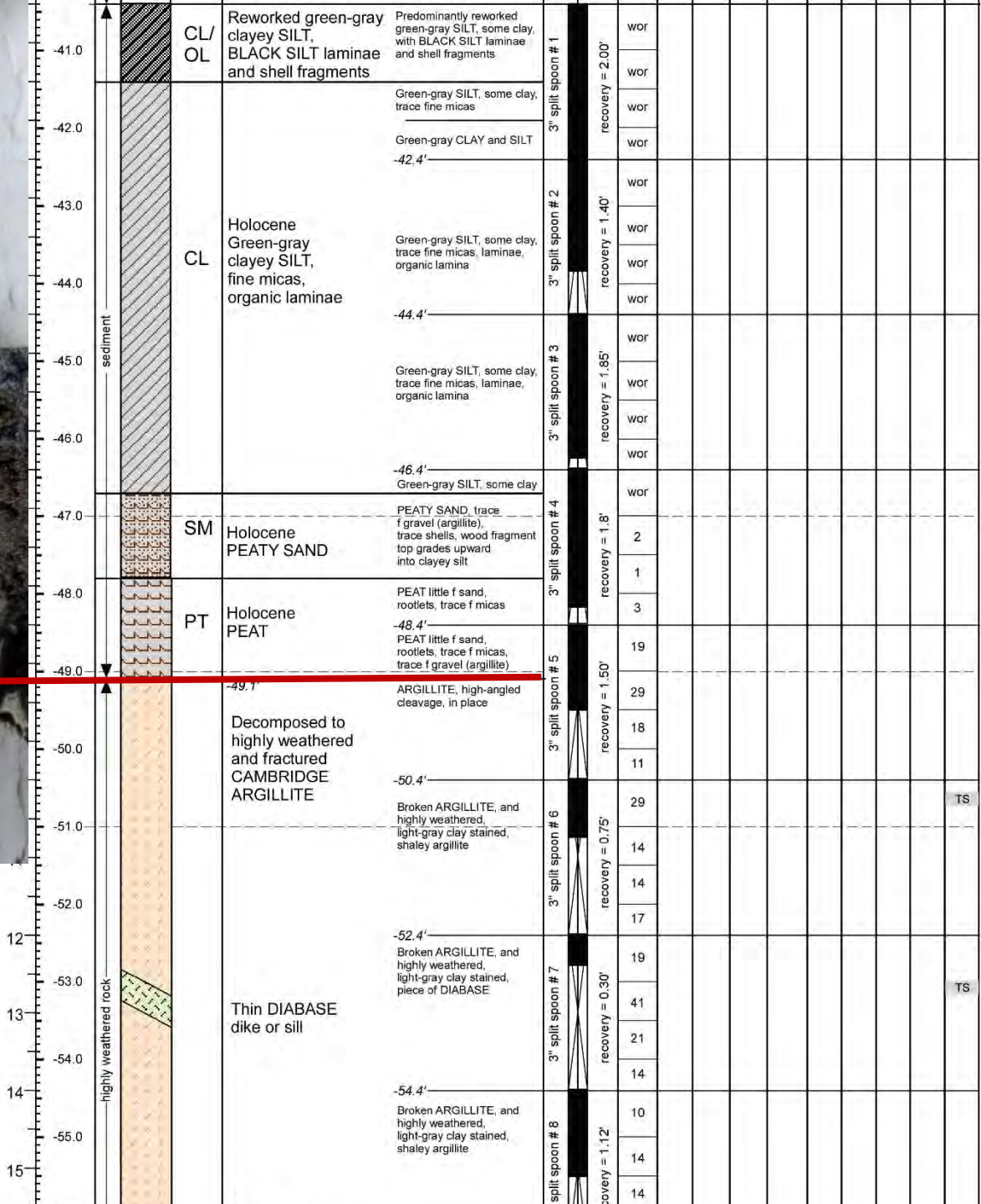
--- Improvement Dredge Depth	— USACE bathymetry 2014
— Bottom of Black Silt	— USACE bathymetry 2012
— Top of Pleistocene	— USACE bathymetry 2009
— Top of Till and Rock	
— Top of Rock (Cambridge Argillite)	

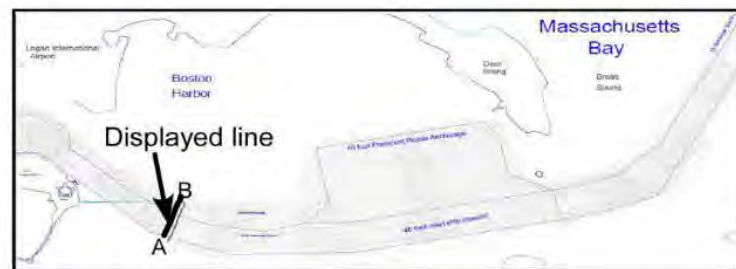
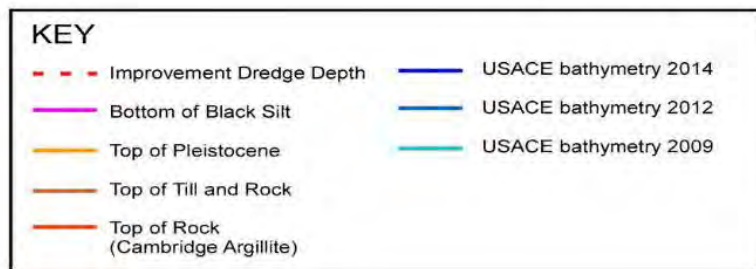
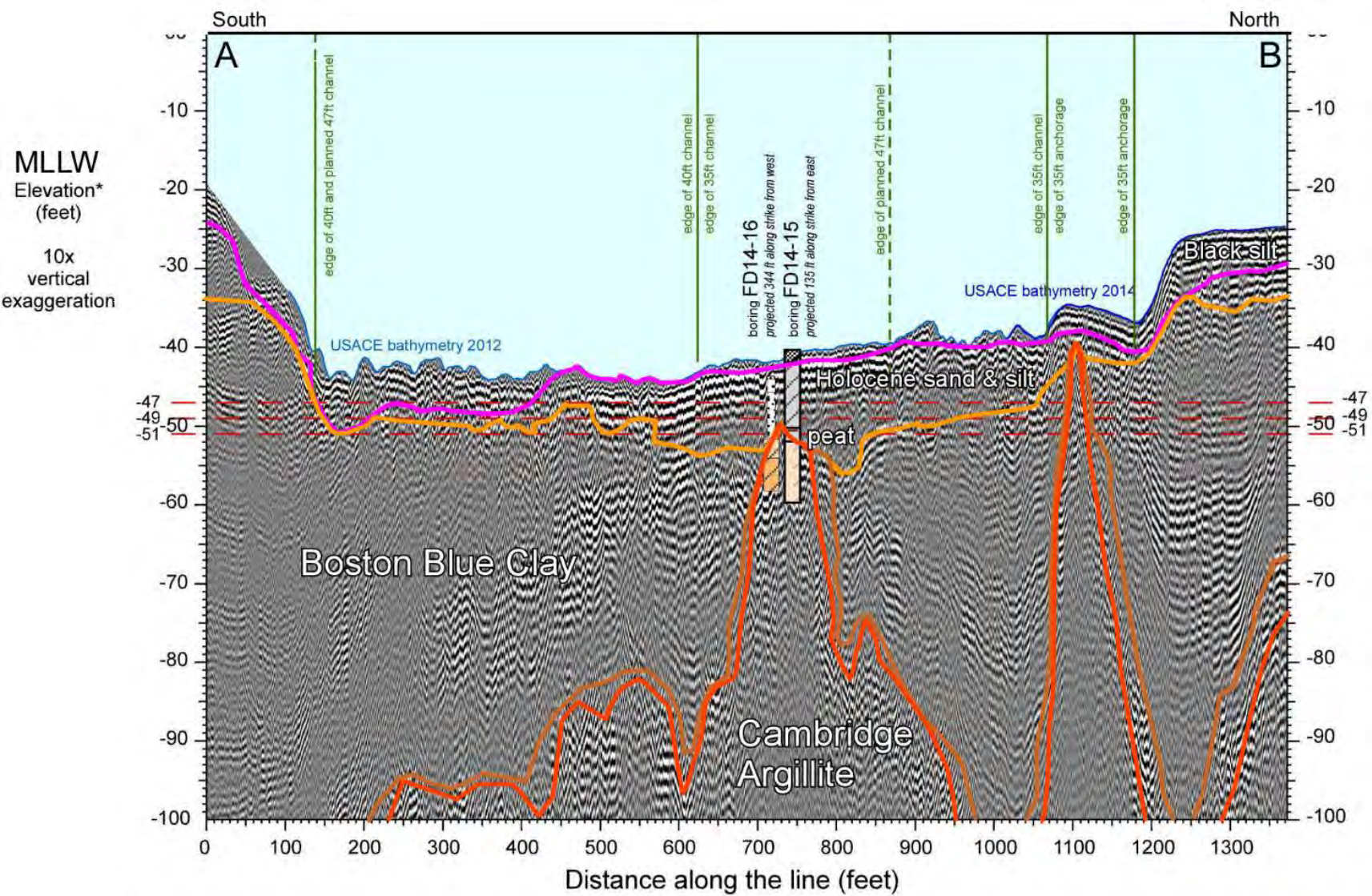




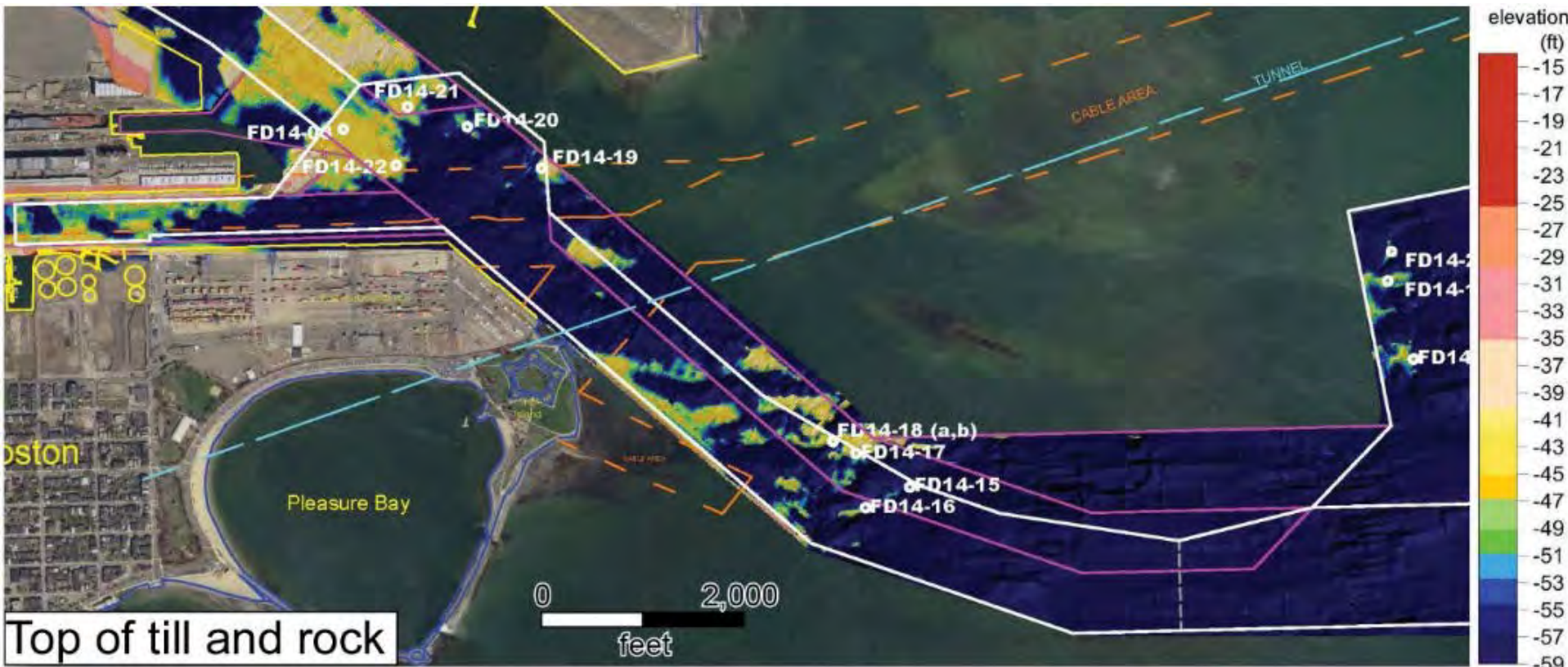
Soil Code	Description	Notes	Spill Spoon #	Recovery %	Other
CL/OL	Reworked green-gray clayey SILT, BLACK SILT laminae and shell fragments	Channel floor elevation = -40.4' MLLW* Predominantly reworked green-gray SILT, some clay with BLACK SILT laminae and shell fragments	1	2.00	wor
CL	Holocene Green-gray clayey SILT, fine micaceous, organic laminae	Green-gray SILT, some clay, trace fine micaceous	2	1.40	wor
		Green-gray CLAY and SILT	3	1.85	wor
		-42.4'	4	1.85	wor
SM	Holocene PEATY SAND	PEATY SAND, trace f gravel (argillite), trace shells, wood fragment top grades upward into clayey silt	5	1.8	2
		PEAT little f sand, rootlets, trace f micaceous	6	1.50	3
PT	Holocene PEAT	PEAT little f sand, rootlets, trace f micaceous, trace f gravel (argillite)	7	1.50	19
	Decomposed to highly weathered and fractured CAMBRIDGE ARGILLITE	ARGILLITE, high-angled cleavage, in place	8	1.50	29
		-49.7'	9	1.50	18
	Thin DIABASE dike or sill	Broken ARGILLITE and highly weathered, light-gray clay stained, shaley argillite	10	0.75	11
		-50.4'	11	0.75	29
	Broken highly weathered Cambridge Argillite	Broken ARGILLITE and highly weathered, light-gray clay stained, piece of DIABASE	12	0.30	14
		-52.4'	13	0.30	14
	Broken highly weathered Cambridge Argillite	Broken ARGILLITE and highly weathered, light-gray clay stained, shaley argillite	14	1.12	19
		-54.4'	15	1.12	10
	Broken highly weathered Cambridge Argillite	Broken ARGILLITE and highly weathered, light-gray clay stained, shaley argillite	16	1.00	14
		-56.4'	17	1.00	14
			18	1.00	17
			19	1.00	11

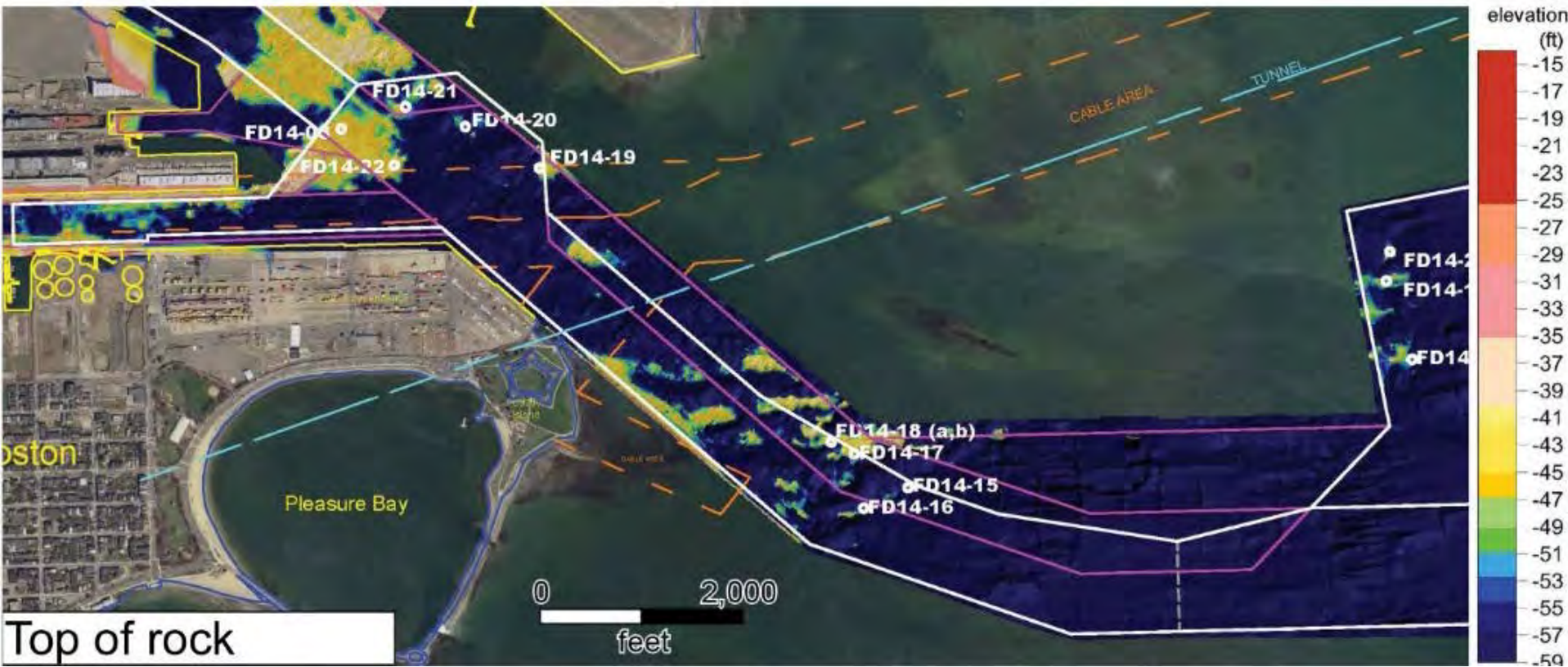
Bottom of boring elevation = -58.4' MLLW*

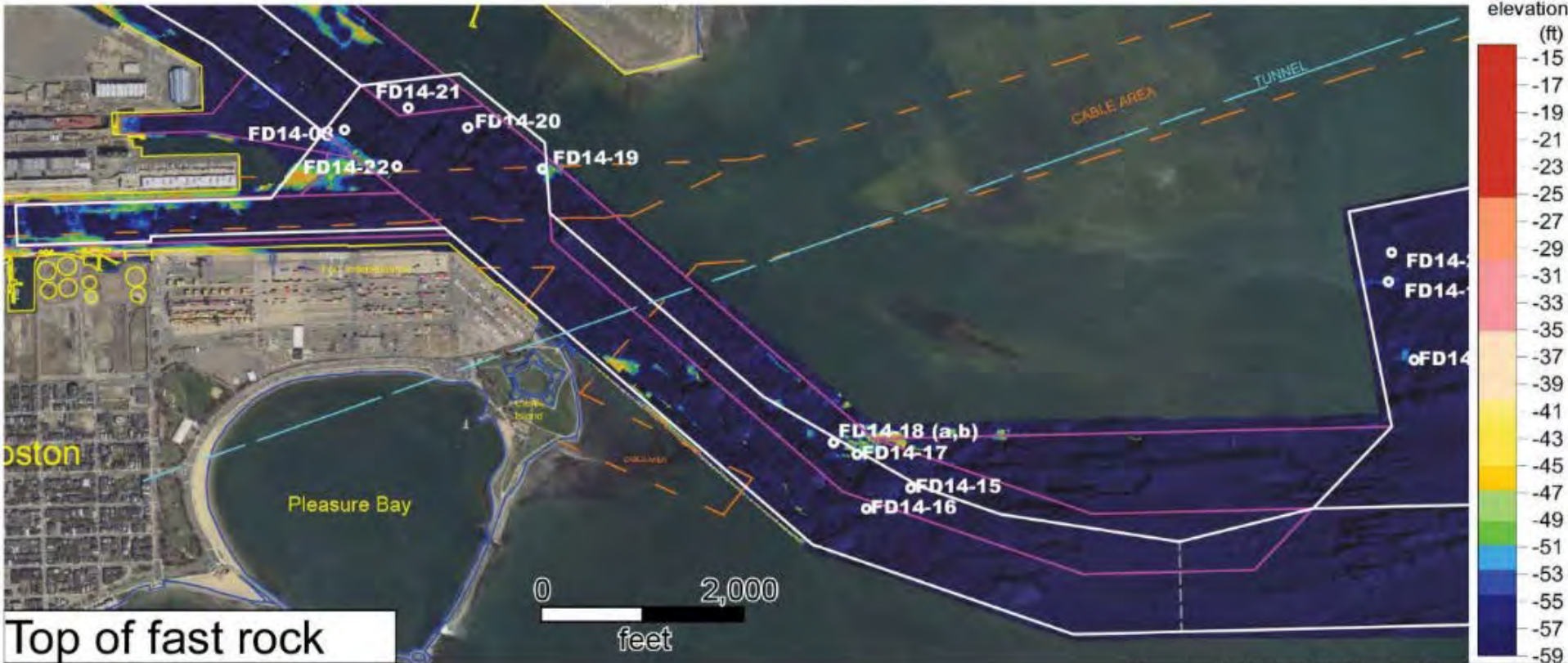


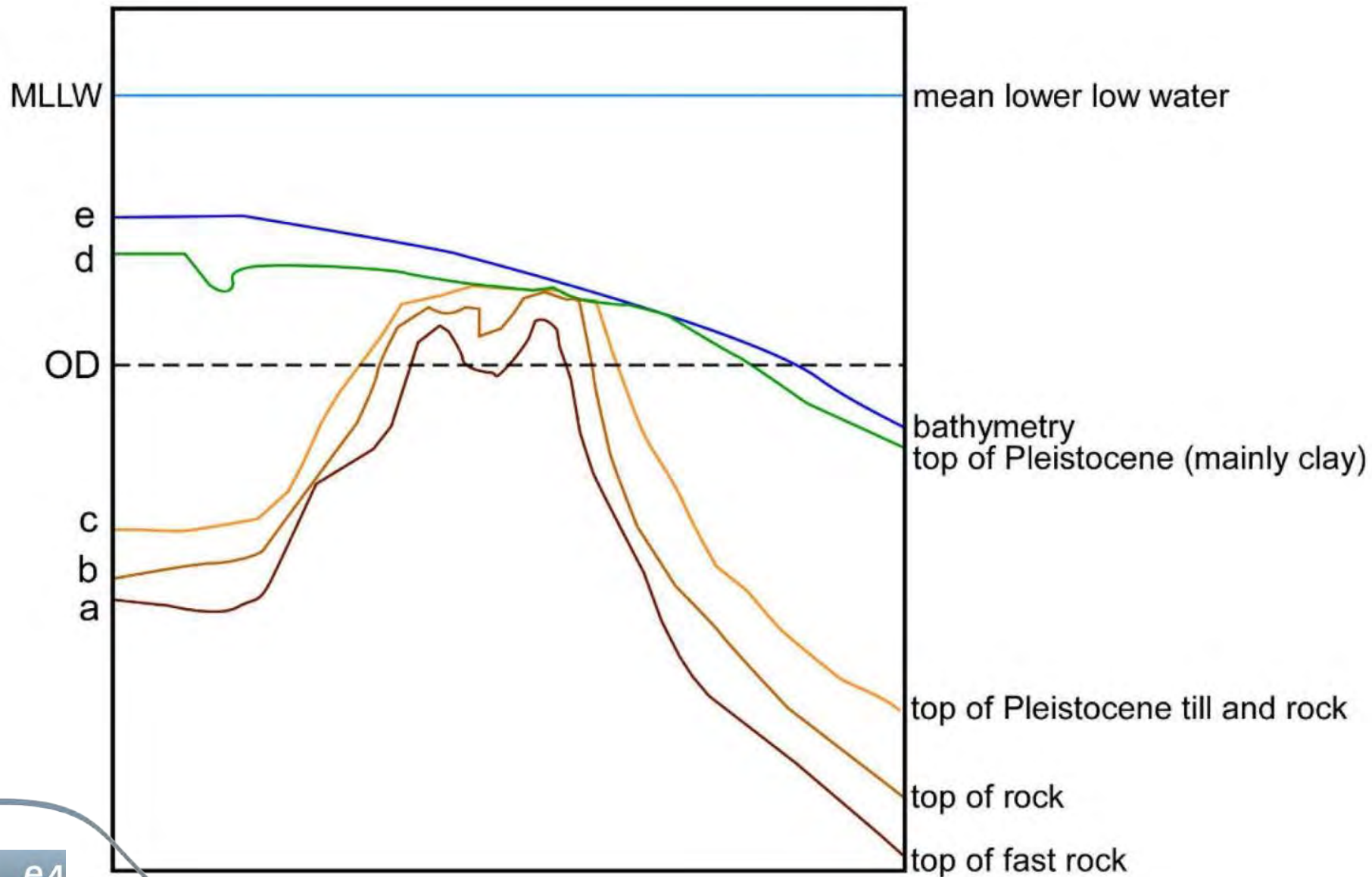






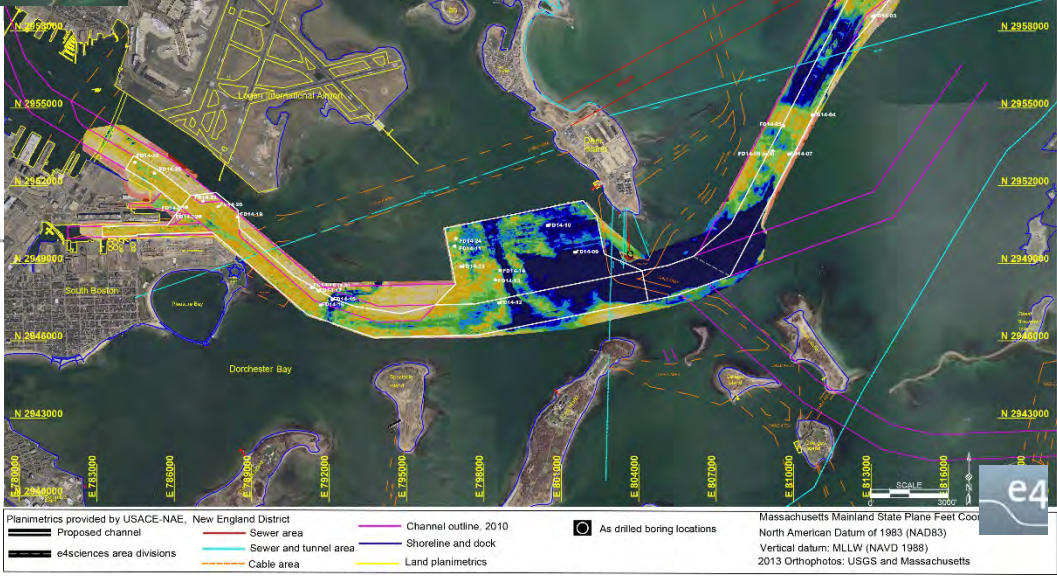
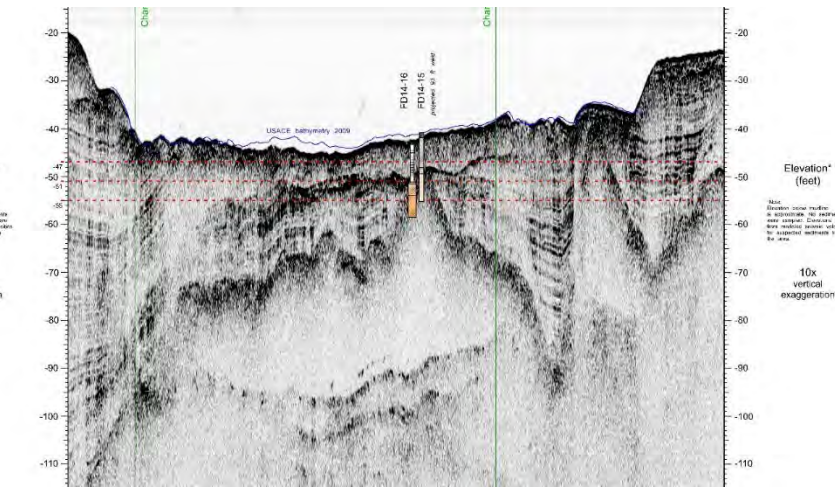
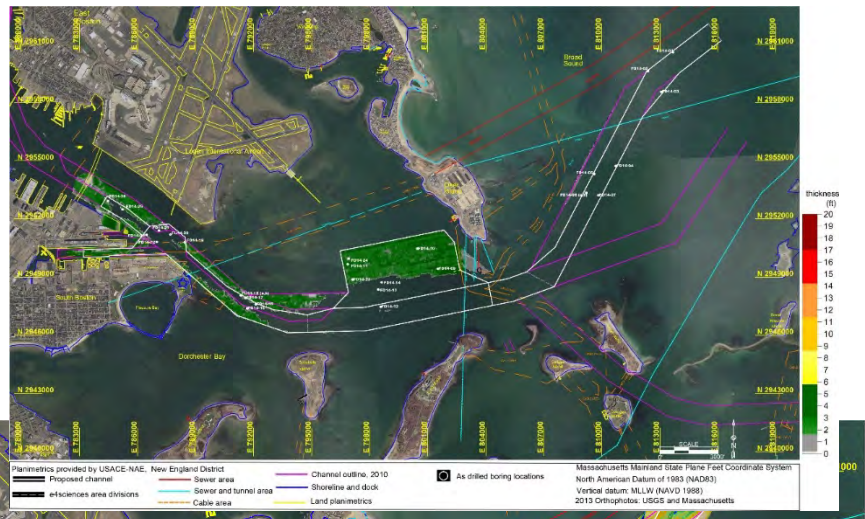






Mapping

fully integrated interpretation of an area and volume of interest



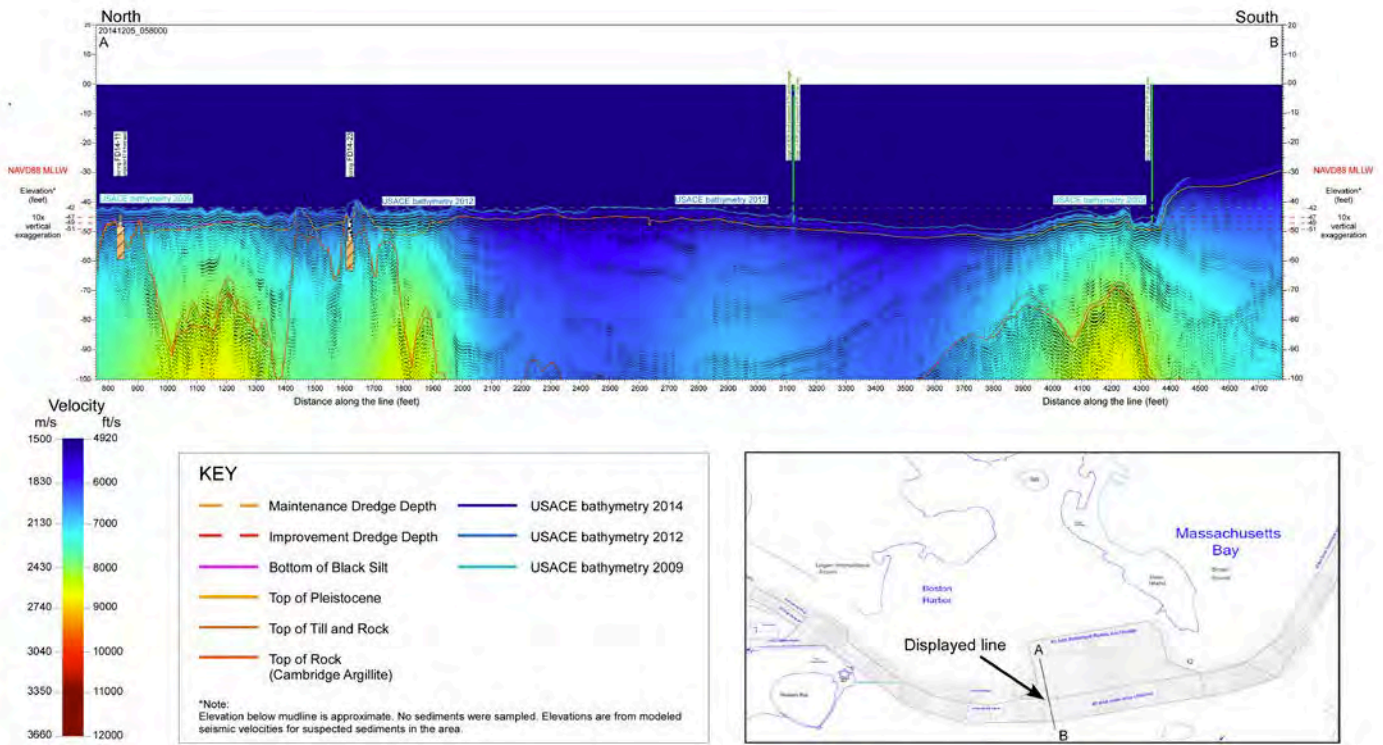
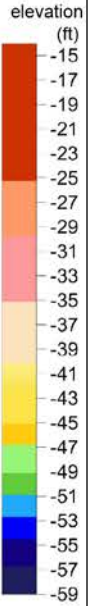
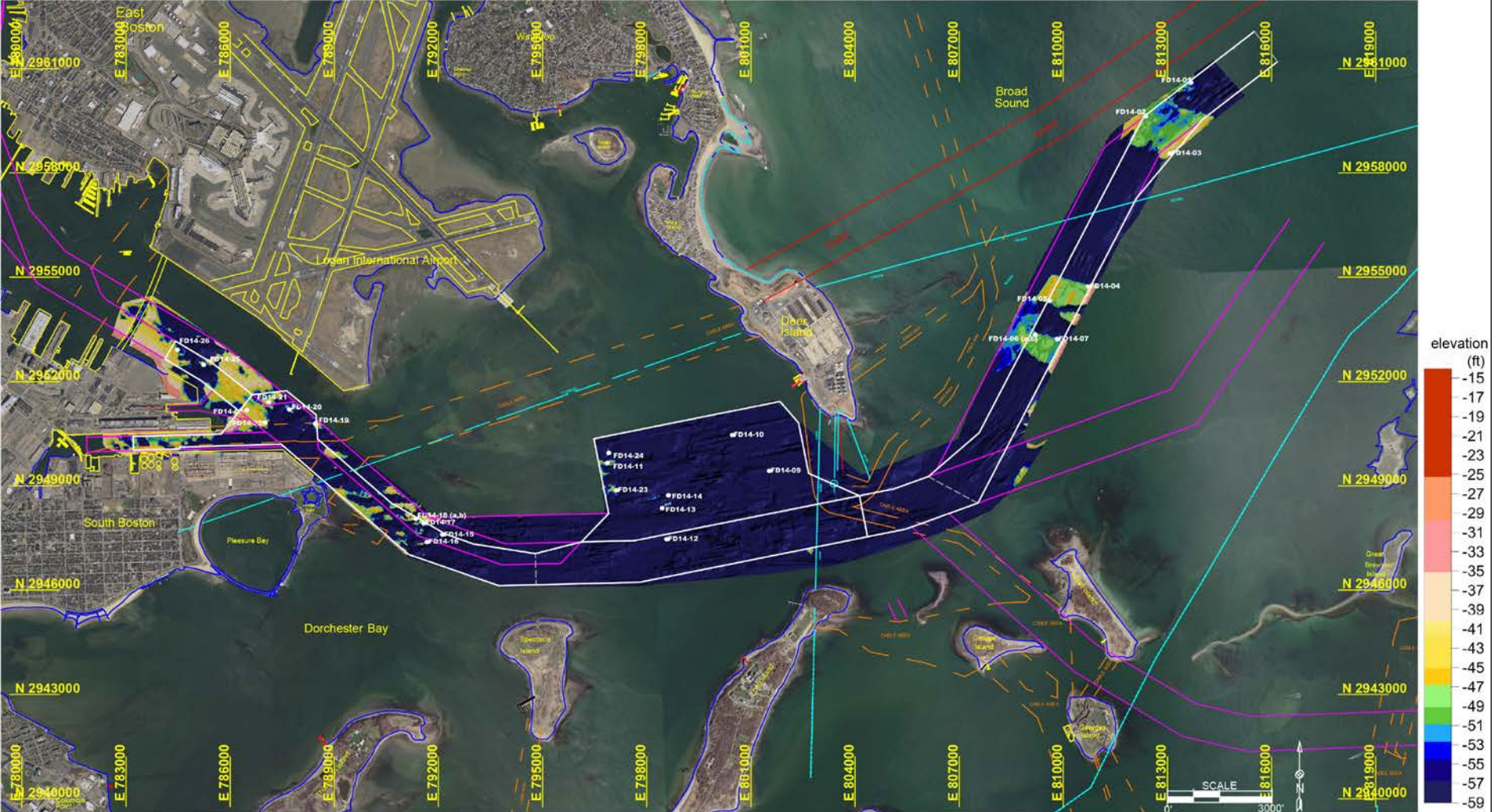


Figure 70. Seismic-velocity cross section in President Roads Anchorage Area.



Planimetrics provided by USACE-NAE, New England District

Proposed channel	Sewer area	Channel outline, 2010	As drilled boring locations
e4sciences area divisions	Sewer and tunnel area	Shoreline and dock	
Cable area	Land planimetrics		

Massachusetts Mainland State Plane Feet Coordinate System
 North American Datum of 1983 (NAD83)
 Vertical datum: MLLW (NAVD 1988)
 2013 Orthophotos: USGS and Massachusetts