Stantec

Memo

To:	Nat Tupper Town of Yarmouth	From:	Gordon E Clark Northampton MA
File:	195602899	Date:	January 3, 2024

Reference: Summary Memo - Royal River Sediment Probing, Yarmouth, Maine

INTRODUCTION

Stantec Consulting Services Inc. (Stantec) contracted with the Town of Yarmouth (Town) to collect data on sediment depth and characterization in the Royal River upstream from the Elm Street and Bridge Street dams. Stantec understands that these data will be used to support the U.S. Army Corps of Engineers analysis for estimating sediment transport volumes if the dams are altered. Note that the analysis approach presented in this memo is similar to the sediment depth and characterization analysis approach performed by Stantec in 2014 as presented in the "Estimated Volume of Accumulated Sediment Bridge Street Dam Impoundment" report dated June 19, 2015.

This memo presents a summary of the data collection methodology, including an overview of the approach and post-processing, and a summary of the sediment probing and characterization data.

OBJECTIVES

The objectives of the data collection effort presented herein included:

1. Estimate the depth of accumulated sediment along transects upstream of the Elm Street and Bridge Street dams.
2. Characterize the sediment along the transects by general substrate type.
3. Prepare figures and a summary table of the sediment depth and characterization data.

METHODOLOGY

The following sections present the methodology for the sediment depth and characterization data collection effort including an overview of the field-based data collection approach as well as the post-processing of the data.

FIELD-BASED DATA COLLECTION APPROACH

Two Stantec staff performed a site visit to the Royal River study reaches on December 15, 2023. The study reaches included an approximately 1,800 ft section of the Royal River upstream from Bridge Street Dam (downstream reach) and an approximately 500 ft section upstream of Elm Street Dam (upstream reach). Stantec accessed the downstream reach via the Town access road off Bridge Street to the right[1] of the dam and accessed the upstream reach via the public boat launch off East Elm Street approximately 500 ft upstream from Elm Street Dam.

[1] The directionals "right" and "left" reference an observer facing downstream.

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The weather was mostly sunny with low and high temperatures of about 30°F to 55°F. Flows in the river were estimated at between 344 cubic feet per second (cfs) to 366 cfs during the time of the data collection based on the U.S. Geological Survey (USGS) streamgage "Royal River at Yarmouth, Maine – 01060000" (Figure 1), which is located approximately 1,000 feet (ft) downstream of Bridge Street and likely provides a reasonably close approximation of flow within the study reaches.

A canoe was used to traverse within the study reaches to collect the data. Stantec used a fiberglass graduated survey rod and a steel t-handle probe to estimate the approximate top-of-sediment, bottom-of-sediment, and sediment type. In locations where the probe depth exceeded 9 ft, the fiberglass graduated survey rod was used since the maximum probing depth of the steel t-handle rod was 9 ft.

Data were collected at each probe location using a GNSS-enabled GPS receiver. For each probe location, the first measurement recorded was the distance from the water surface elevation to the top of the sediment or apparent hard channel bottom. The second measurement recorded was the distance from the water surface elevation to the point of probing refusal, which represented the approximate bottom-of-sediment. The total depth of accumulated sediment at each probe location was calculated as the absolute value of the bottom-of-sediment depth minus the top-of-sediment depth. In addition, at each probe location the sediment type was characterized according to several broad substrate type or channel bottom categories, including rock (i.e., either bedrock or large rocks), cobble, gravel, sand, fine sand, or muck (i.e., fine organics). The sediment characterization portion of the data collection was based on professional experience using manual probing tools and provides a qualitative, category-based estimate for the type of accumulated material. Hard refusals (e.g., rock or cobble) were explicitly noted as part of the field data collection as well as locations representing "softer" refusals (e.g., firm sand).

Water surface elevations in the study reaches may be assumed to be equal to other water surface elevations in the same study reach due to an approximate "level-pool" condition from the backwater effects of the dams. Flow speeds were very low (<1 fps) within the impounded reaches. Therefore, a level-pool assumption could be used to rectify the depth measurements to a known vertical datum (e.g., the North American Vertical Datum of 1988 [NAVD88]). Distances were measured between the water surface elevation and the top of the fishway concrete training walls. For the downstream reach, the water surface elevation was approximately 2.20 ft below the top of the upstream right fishway concrete training wall. For the upstream reach, the water surface elevation was approximately 2.05 ft below the top of the upstream left fishway concrete training wall. Figure 2 presents the locations of these measurement points.

Due to high flows on the day of the site visit, flows over the spillways at both dams precluded data collection near the spillways. Collecting data near the spillways was not considered safe and was therefore not included as part of this analysis. The photos in Figure 3 present an overview of the spillways during the site visit.

There was skim ice adjacent to the shores in the downstream reach which was considered navigable. However, there was some thicker ice in some portions of the downstream reach in areas that may experience increased backwater effects and slower flow speeds, especially in the areas along the left shore from approximately 1,200 ft to 1500 ft upstream of Bridge Street Dam. This ice was more difficult to navigate and collection of data along the transect in this area needed to accommodate these ice conditions.

Reference: **Summary Memo - Royal River Sediment Probing, Yarmouth, Maine**

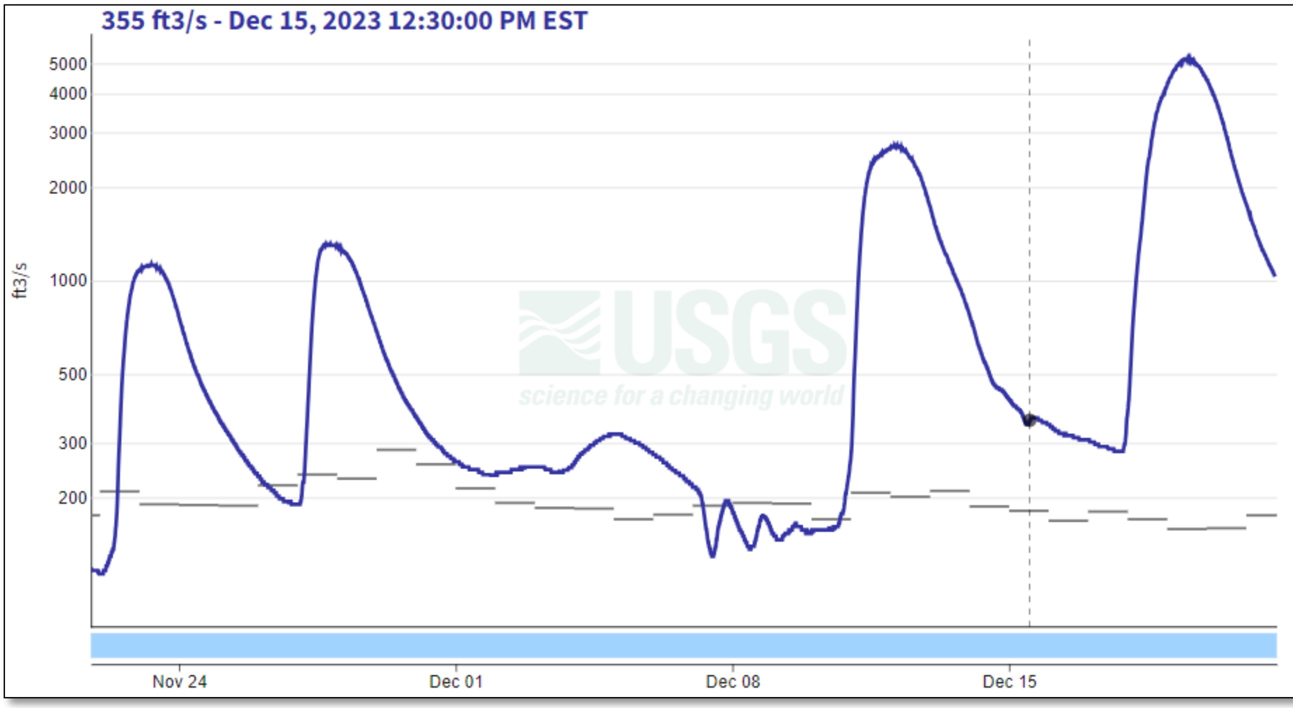

Figure 1. Discharge data from USGS streamgage "Royal River at Yarmouth, Maine – 01060000" from the period of November 21, 2023, to December 21, 2023; note grey horizontal lines represent approximately the historic median flow

Figure 2. Locations of water surface elevation measurements for the downstream reach at Bridge Street Dam (left photo) and the upstream reach at Elm Street Dam (right photo)

Reference: Summary Memo - Royal River Sediment Probing, Yarmouth, Maine

Figure 3. Overview of the Bridge Street Dam spillway (left) and the Elm Street Dam spillway (right)

POST-PROCESSING

Post-processing included applying a differential correction to the GPS data, calculating northing and easting location data using GIS software, and integrating the data into AutoCAD Civil3D (ver. 2019). Northing and easting horizontal positions from the GPS were calculated using ESRI ArcGIS Desktop (ver. 10.8.1) and were based on the North American Datum of 1983 (NAD83) Maine West State Plane Coordinate System in feet. The differentially corrected GPS data with northing and easting data were then loaded into AutoCAD Civil3D in two groups with the first group representing the top-of-sediment elevation and the second group representing the bottom-of-sediment elevation. The elevations contained in these GPS point data represent the depth measurements as described in the previous section with elevations relative to the water surface elevation.

Following importing of points into AutoCAD Civil3D, two sets of Civil3D feature lines were created representing the top- and bottom-of-sediment along the transects based on the point data. Straight Civil3D alignments were created for each transect, and these alignments were used to create vertical profiles for each transect. The profiles were numbered from downstream to upstream. The feature lines containing the top- and bottom-of-sediment elevation data were then projected on to the transect Civil3D profiles to create a representative cross-section depicting the collected data. This approach was used to manage and best represent the planform “drift” of the sediment probe locations at each location, which is primarily due to managing varying flow speeds in the canoe while collecting the data and the horizontal accuracy of the GPS (i.e., approximately 1-meter accuracy according to the GPS differential correction post-processing).

Figures were developed that present the transect locations and cross-section profiles. Note that a one-to-ten (1:10) vertical exaggeration was used in the profiles to exaggerate the vertical scale. The locations of the GPS points were plotted on aerial imagery for reference. The most proximal data location points to the transects were selected for use in projecting onto the cross-section profiles and were considered to be the most representative data for the transects. Although not all the data location points were incorporated into the cross-section profiles at the transects, the raw data of these points presented in the summary table (Attachment B) can help augment the information presented in the profiles, if warranted.

Reference: **Summary Memo - Royal River Sediment Probing, Yarmouth, Maine**

RESULTS

The results from the sediment probing and characterization data collection efforts are presented in the representative cross-sections in Figures 1 and 2 in Attachment A to this memo. In addition, a summary table with the GPS location data and sediment depth and characterization information is presented in Attachment B to this memo. Point ID numbers for each probe location are provided in the plan views in Attachment A and can be cross-referenced to the summary table in Attachment B.

SUMMARY

Stantec performed sediment probing and characterization in the reaches of the Royal River upstream of Bridge Street Dam and Elm Street Dam on December 15, 2023. Although the field data collection efforts were overall successful at meeting the sediment probing and characterization objectives, due to the higher-than-normal flows and safety concerns, data were unable to be collected in close proximity to the dam spillways. Data were post-processed following the data collection efforts and were used to developed figures and a summary table representing the sediment probing and characterization efforts.

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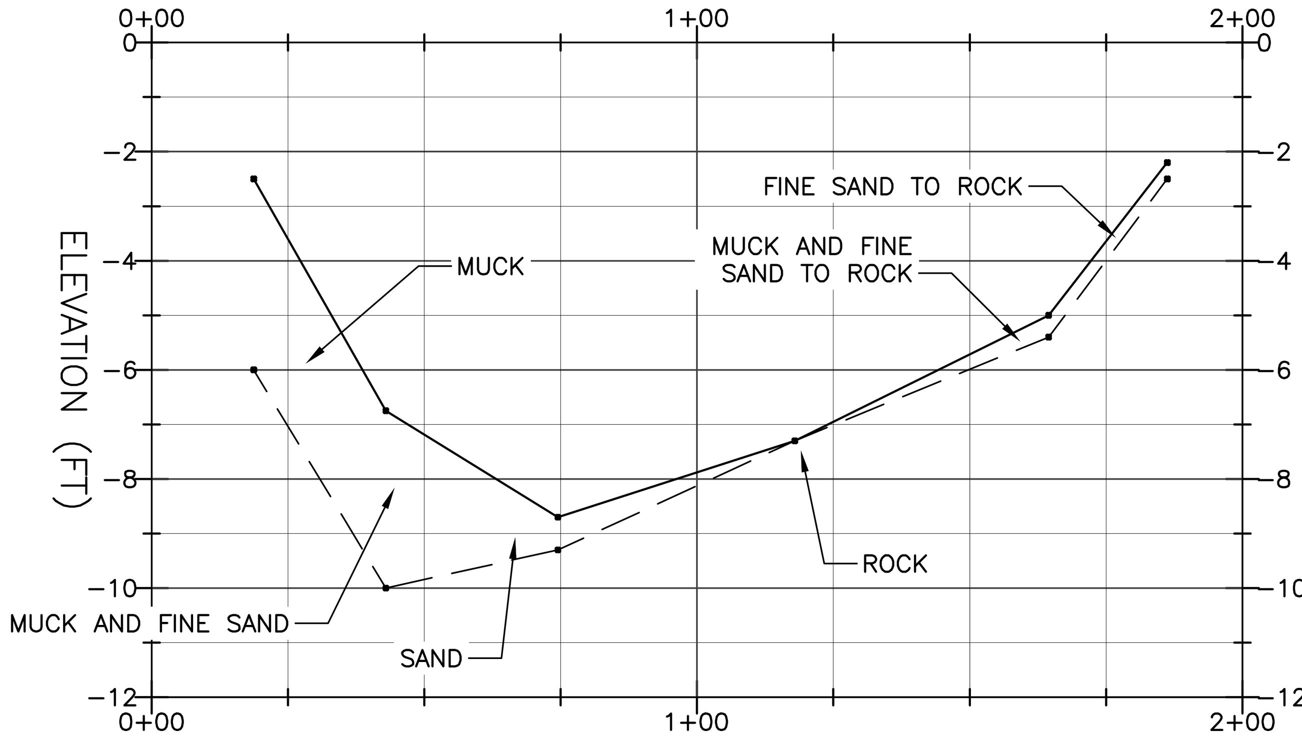
Attachment: Attachment A - Figures
Attachment B – Summary Table

c. Michael Chelminski, P.E.

ATTACHMENT A

Figures



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CROSS-SECTION 01
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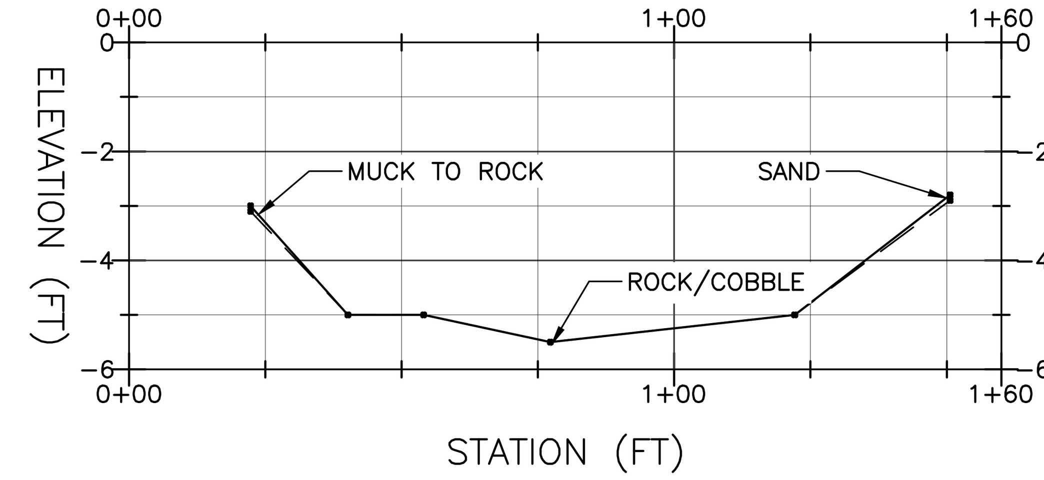

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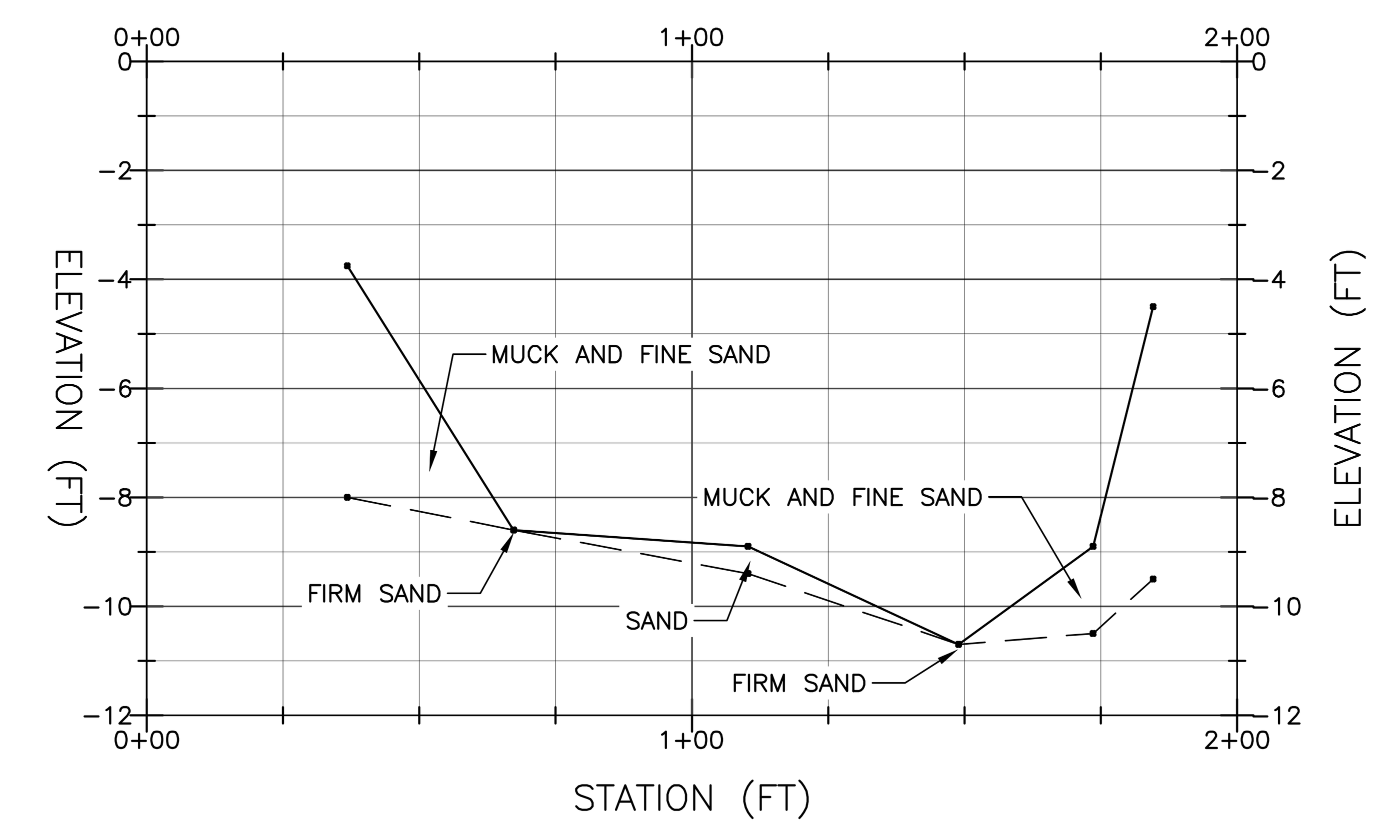

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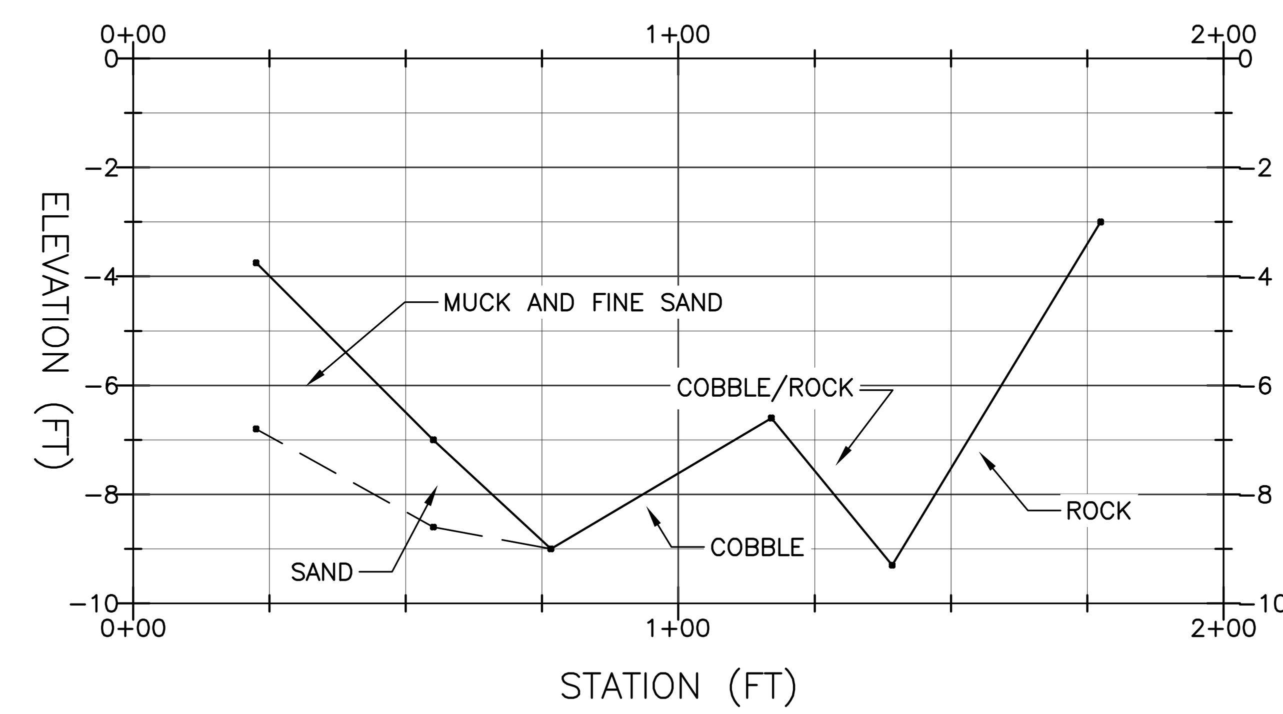

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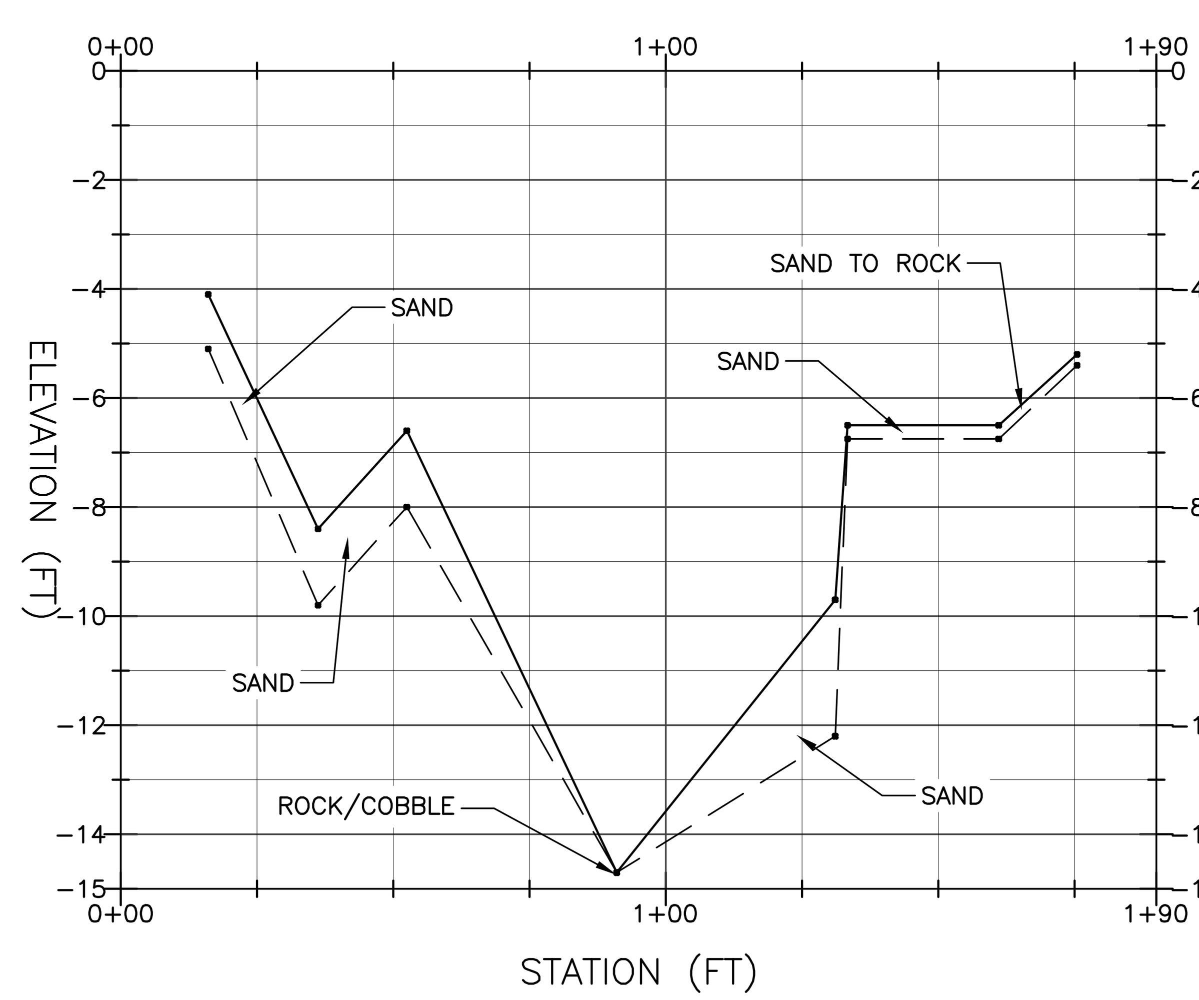

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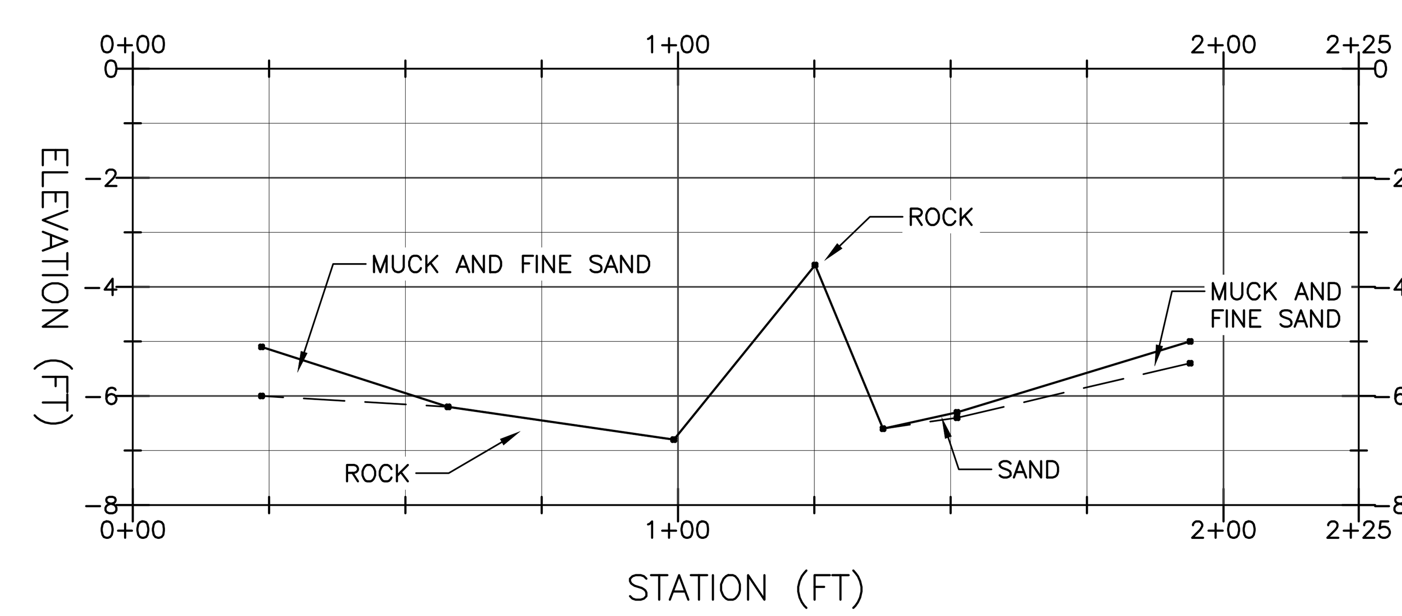

CS-06 --
CROSS-SECTION 06
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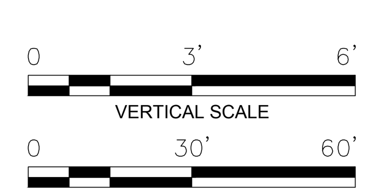

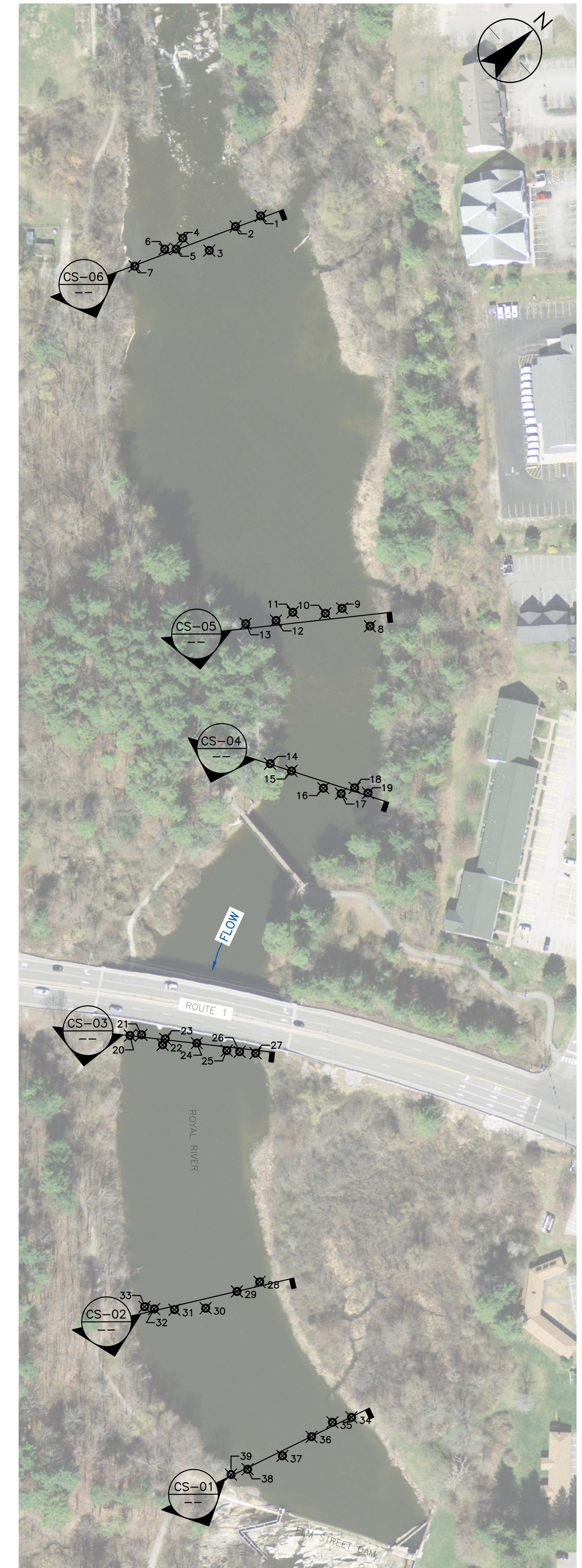

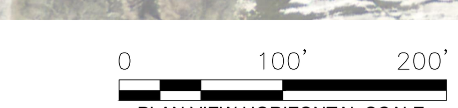

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Legend

- TOP OF SEDIMENT (solid line)
- BOTTOM OF SEDIMENT (dashed line)
- PROBE LOCATION (PLAN)
- PROBE LOCATION (CROSS-SECTION)

Notes

1. CROSS-SECTION DATA WAS DEVELOPED FROM MANUAL PROBING COLLECTED BY GPS AND PERFORMED BY STANTEC ON DECEMBER 15, 2023. REFER TO THE ACCOMPANYING STANTEC MEMO FOR DETAILS RELATED TO THE DATA COLLECTION METHODS AND THE SEDIMENT PROBE SUMMARY DATA TABLE.
2. AERIAL PHOTOGRAPHY IS MAINE 2012 ORTHO IMAGERY ACCESSED VIA THE NATIONAL MAP ONLINE DATA PORTAL.
3. ORIENTATION OF CROSS-SECTIONS ARE BASED ON AN OBSERVER FACING DOWNSTREAM.
4. TOP AND BOTTOM OF SEDIMENT PROBES WERE BASED ON DEPTHS MEASURED IN REFERENCE TO THE WATER SURFACE ELEVATION (ELEVATION = 0 FT).
5. SEDIMENT PROBING DATA PRESENTED HEREIN WERE DEVELOPED BY PROJECTING THE ELEVATION DATA ONTO THE CROSS-SECTIONS DEPICTED IN THE PLAN VIEW.

Revision	By	Appd	YYYY.MM.DD
0 ORIGINAL	GEC	MRC	2024.01.30

Issued	By	Appd	YYYY.MM.DD

File Name: 02899_SEDPROBINGDATA	Dwn.	Dsgn.	Chkd.	YYYY.MM.DD
	GEC	GEC	MRC	2024.01.30

Permit/Seal

Client/Project Logo

Client/Project
Town of Yarmouth

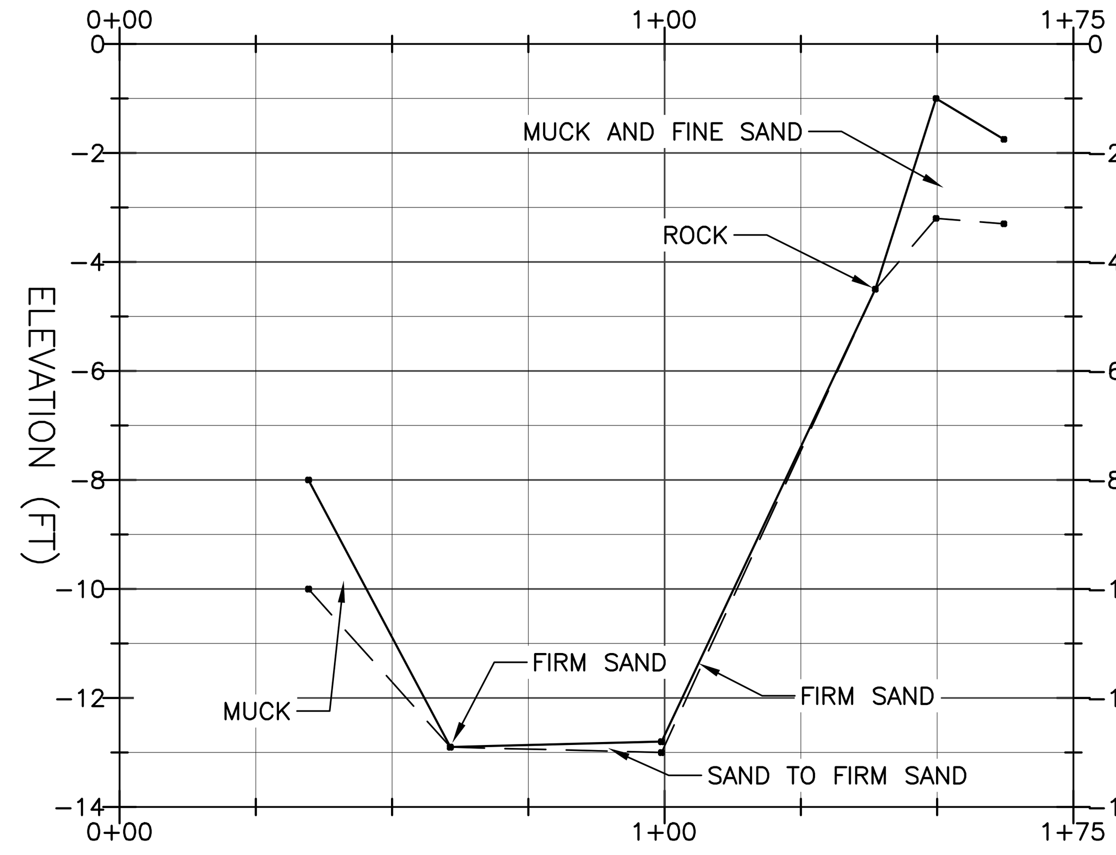
Royal River Sediment Probing

Royal River, Yarmouth, ME

Title
Royal River Sediment Probing - Downstream Reach

Project No. 195602899
Scale AS SHOWN
Revision 0
Sheet 1 of 2
Drawing No. **FIG-01**

ORIGINAL SHEET - ANSI D



CS-07 CROSS-SECTION 07
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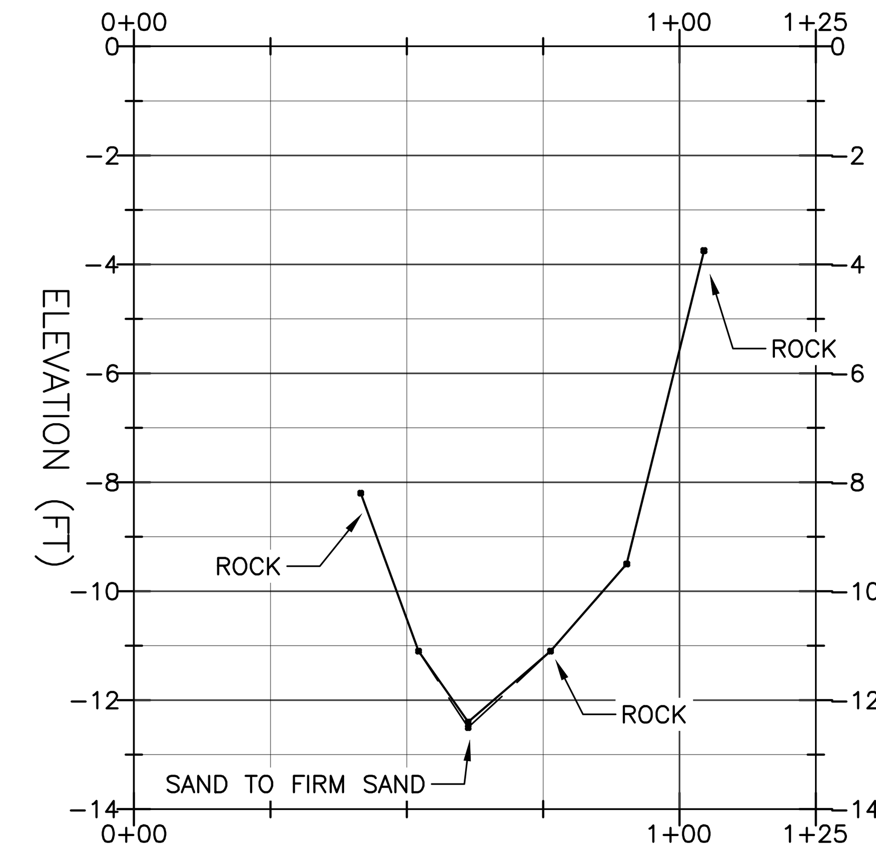

CS-10 CROSS-SECTION 10
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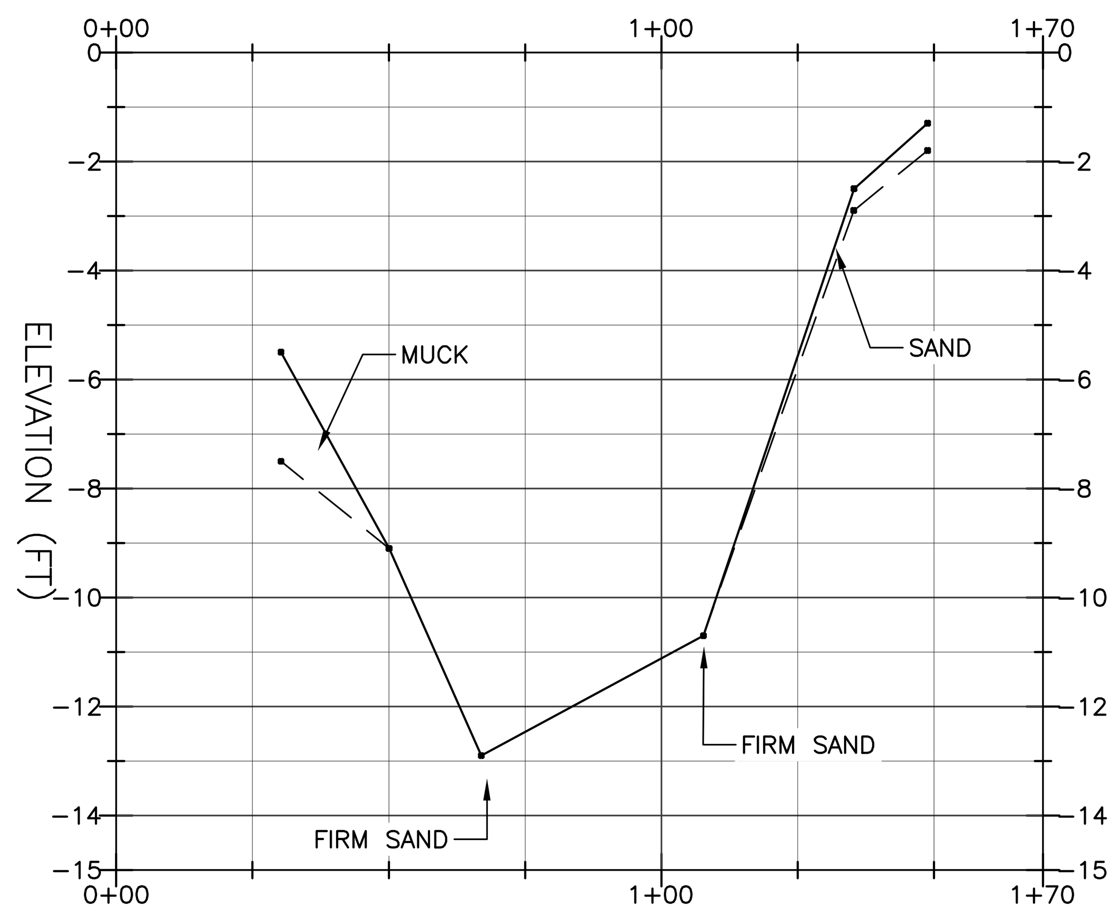

CS-08 CROSS-SECTION 08
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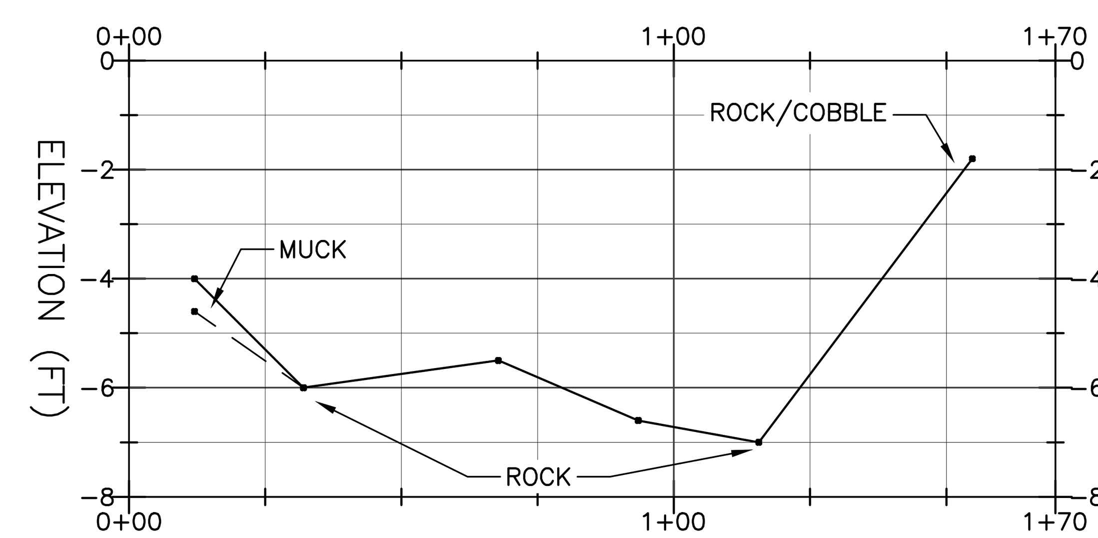

CS-11 CROSS-SECTION 11
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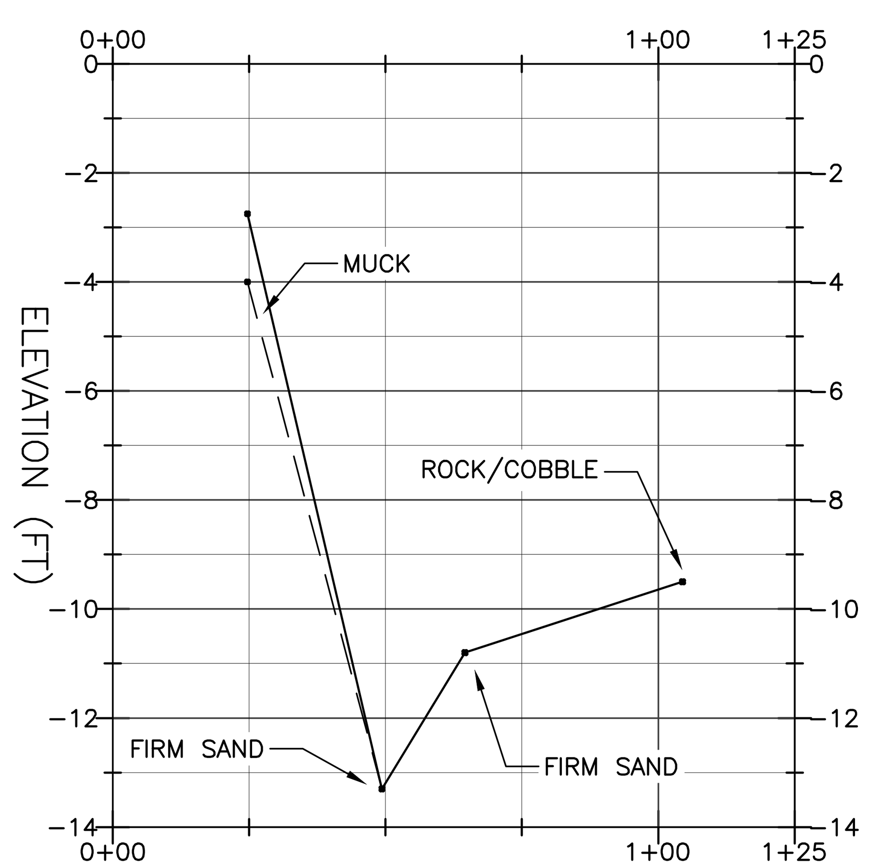

CS-09 CROSS-SECTION 09
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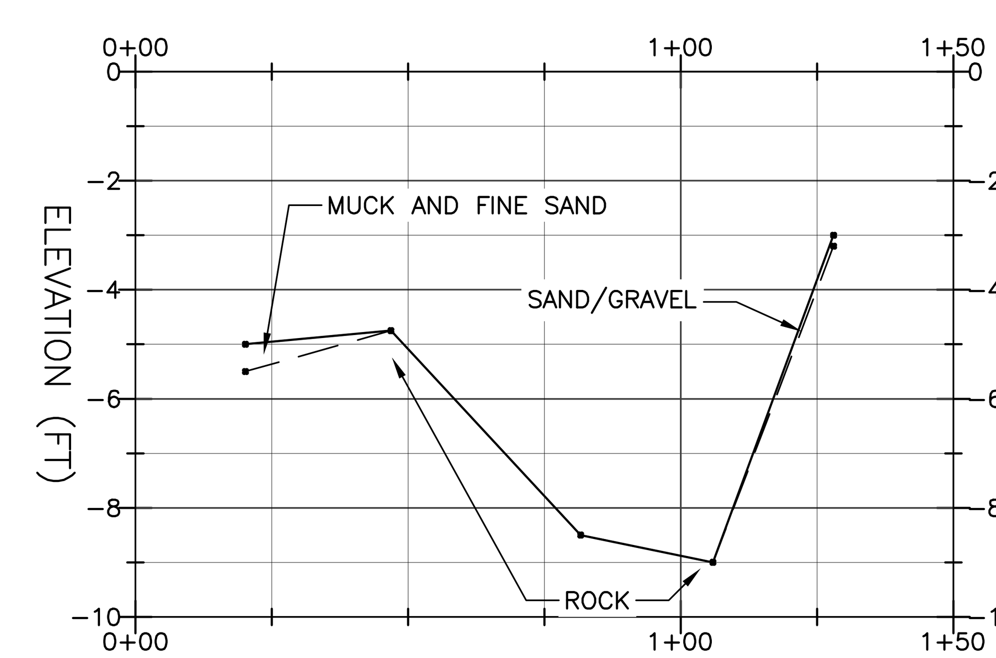
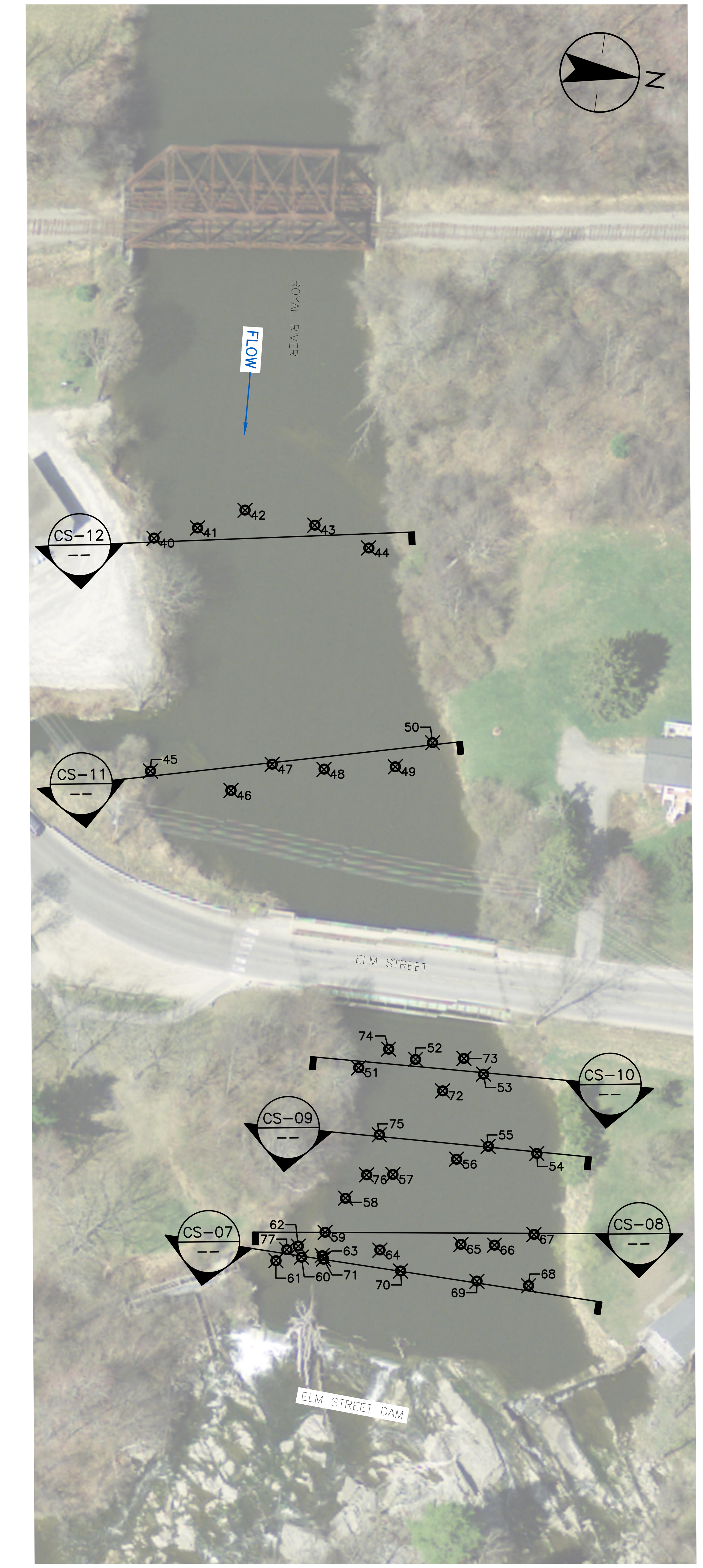


CS-12 CROSS-SECTION 12
SCALE: AS SHOWN

VERTICAL SCALE (0, 3', 6')
HORIZONTAL SCALE (0, 30', 60')



PLAN VIEW HORIZONTAL SCALE (0, 50', 100')

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Legend

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Issued — By / Appd / YYYY.MM.DD

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	Dwn.	Dsgn.	Chkd.	YYYY.MM.DD

Permit/Seal

Client/Project Logo

Client/Project
Town of Yarmouth

Royal River Sediment Probing

Royal River, Yarmouth, ME

Title
Royal River Sediment Probing - Upstream Reach

Project No. 195602899
Scale AS SHOWN
Revision 0
Sheet 2 of 2
Drawing No. FIG-02

ORIGINAL SHEET - ANSI D

ATTACHMENT B

Summary Table

US/ DS	ID	Northing (ft)	Easting (ft)	Top of Sediment (ft)	Bottom of Sediment (ft)	Sediment Thickness (ft)	Sediment Characterization
Downstream Reach	1	353986.7	2947407.0	-5.1	-6	0.9	muck and fine sand
	2	353954.5	2947395.4	-6.2	-6.2	0	rock (hard bottom)
	3	353909.8	2947395.2	-6.8	-6.8	0	rock (hard bottom)
	4	353895.8	2947361.1	-3.6	-3.6	0	rock (hard bottom)
	5	353880.5	2947365.5	-6.6	-6.6	0	rock (hard bottom)
	6	353869.8	2947355.8	-6.3	-6.4	0.1	sand
	7	353827.7	2947345.9	-5	-5.4	0.4	muck and fine sand
	8	353737.7	2947878.7	-3.75	-6.8	3.05	muck and fine sand
	9	353727.1	2947838.4	-7	-8.6	1.6	sand
	10	353707.4	2947828.8	-9	-9	0	cobble
	11	353678.3	2947800.0	-6.6	-6.6	0	cobble/rock
	12	353655.8	2947793.3	-9.3	-9.3	0	rock (hard bottom)
	13	353625.1	2947770.4	-3	-3	0	rock (hard bottom)
	14	353528.3	2947920.3	-2.8	-2.9	0.1	sand
	15	353541.9	2947945.3	-5	-5	0	rock (hard bottom)
	16	353556.5	2947988.4	-5.5	-5.5	0	rock (hard bottom)
	17	353568.2	2948008.4	-5	-5	0	rock (hard bottom)
	18	353585.7	2948014.7	-5	-5	0	rock (hard bottom)
	19	353593.5	2948030.8	-3	-3.1	0.1	muck to rock
	20	353167.1	2948051.6	-5.2	-5.4	0.2	sand to rock
	21	353178.5	2948060.8	-6.5	-6.75	0.25	sand to firm
	22	353189.3	2948088.0	-6.5	-6.75	0.25	sand to firm
	23	353196.9	2948084.6	-9.7	-12.2	2.5	sand to firm
	24	353222.4	2948115.5	-14.7	-14.7	0	rock/cobble (hard bottom)
	25	353243.6	2948147.9	-6.6	-8	1.4	sand to firm
	26	353254.5	2948160.0	-8.4	-9.8	1.4	sand to firm
	27	353268.1	2948174.9	-4.1	-5.1	1	sand to firm
	28	353076.7	2948389.3	-3.75	-8	4.25	muck and fine sand
	29	353047.6	2948378.8	-8.6	-8.6	0	firm sand
	30	353004.5	2948367.5	-8.9	-9.4	0.5	sand to firm
	31	352974.4	2948342.4	-10.7	-10.7	0	firm sand
	32	352956.3	2948324.4	-8.9	-10.5	1.6	muck and fine sand
	33	352949.4	2948314.2	-4.5	-9.5	5	muck and fine sand
	34	353045.9	2948592.5	-2.5	-6	3.5	muck
	35	353024.1	2948580.9	-6.75	-10	3.25	muck and fine sand
	36	352992.5	2948576.5	-8.7	-9.3	0.6	sand
	37	352949.3	2948569.2	-7.3	-7.3	0	rock (hard bottom)
	38	352905.9	2948551.9	-5	-5.4	0.4	muck and fine sand to rock
	39	352886.0	2948542.6	-2.2	-2.5	0.3	fine sand to rock
Upstream Reach	40	354996.0	2946382.0	-3	-3.2	0.2	sand/gravel
	41	355017.0	2946374.0	-9	-9	0	rock (hard bottom)
	42	355039.5	2946362.0	-8.5	-8.5	0	rock (hard bottom)
	43	355075.4	2946364.8	-4.75	-4.75	0	rock (hard bottom)
	44	355103.8	2946372.7	-5	-5.5	0.5	muck and fine sand
	45	355009.7	2946498.5	-1.8	-1.8	0	rock/cobble (hard bottom)
	46	355051.2	2946502.9	-7	-7	0	rock (hard bottom)
	47	355070.0	2946487.0	-6.6	-6.6	0	rock (hard bottom)
	48	355096.2	2946486.0	-5.5	-5.5	0	rock (hard bottom)
	49	355131.6	2946480.1	-6	-6	0	rock (hard bottom)
	50	355148.6	2946465.6	-4	-4.6	0.6	muck to rock
	51	355133.3	2946632.7	-3.75	-3.75	0	rock (hard bottom)
	52	355161.1	2946624.8	-11.1	-11.1	0	rock (hard bottom)
	53	355196.1	2946627.6	-8.2	-8.2	0	rock (hard bottom)
	54	355227.9	2946663.6	-2.75	-4	1.25	muck
	55	355203.2	2946663.3	-13.3	-13.3	0	firm sand
	56	355188.3	2946671.9	-10.8	-10.8	0	firm sand
	57	355157.5	2946683.7	-8.7	-8.7	0	rock/cobble (hard bottom)
	58	355135.5	2946698.7	-6.1	-8	1.9	muck
	59	355127.5	2946717.1	-2.5	-2.9	0.4	sand
	60	355117.4	2946731.1	-1	-3.2	2.2	sand
	61	355104.9	2946734.5	-1.75	-3.3	1.55	sand
	62	355115.1	2946725.7	-1.3	-1.8	0.5	sand
	63	355127.7	2946728.9	-3	-3.1	0.1	sand to rock
	64	355156.1	2946722.3	-10.7	-10.7	0	firm sand

US/ DS	ID	Northing (ft)	Easting (ft)	Top of Sediment (ft)	Bottom of Sediment (ft)	Sediment Thickness (ft)	Sediment Characterization
	65	355196.1	2946714.1	-12.9	-12.9	0	firm sand
	66	355212.9	2946712.3	-9.1	-9.1	0	firm sand
	67	355231.9	2946704.2	-5.5	-7.5	2	muck
	68	355232.6	2946730.1	-8	-10	2	muck
	69	355206.5	2946731.4	-12.9	-12.9	0	firm sand
	70	355167.8	2946731.4	-12.8	-13	0.2	firm sand
	71	355128.6	2946730.6	-4.5	-4.5	0	rock (hard bottom)
	72	355176.8	2946638.7	-12.4	-12.5	0.1	firm sand
	73	355185.2	2946621.1	-11.1	-11.1	0	firm sand
	74	355147.1	2946621.5	-9.5	-9.5	0	rock (hard bottom)
	75	355148.1	2946664.8	-9.5	-9.5	0	rock/cobble (hard bottom)
	76	355144.4	2946685.6	-9.2	-9.3	0.1	gravel
	77	355109.6	2946728.3	-1.75	-4.5	2.75	muck