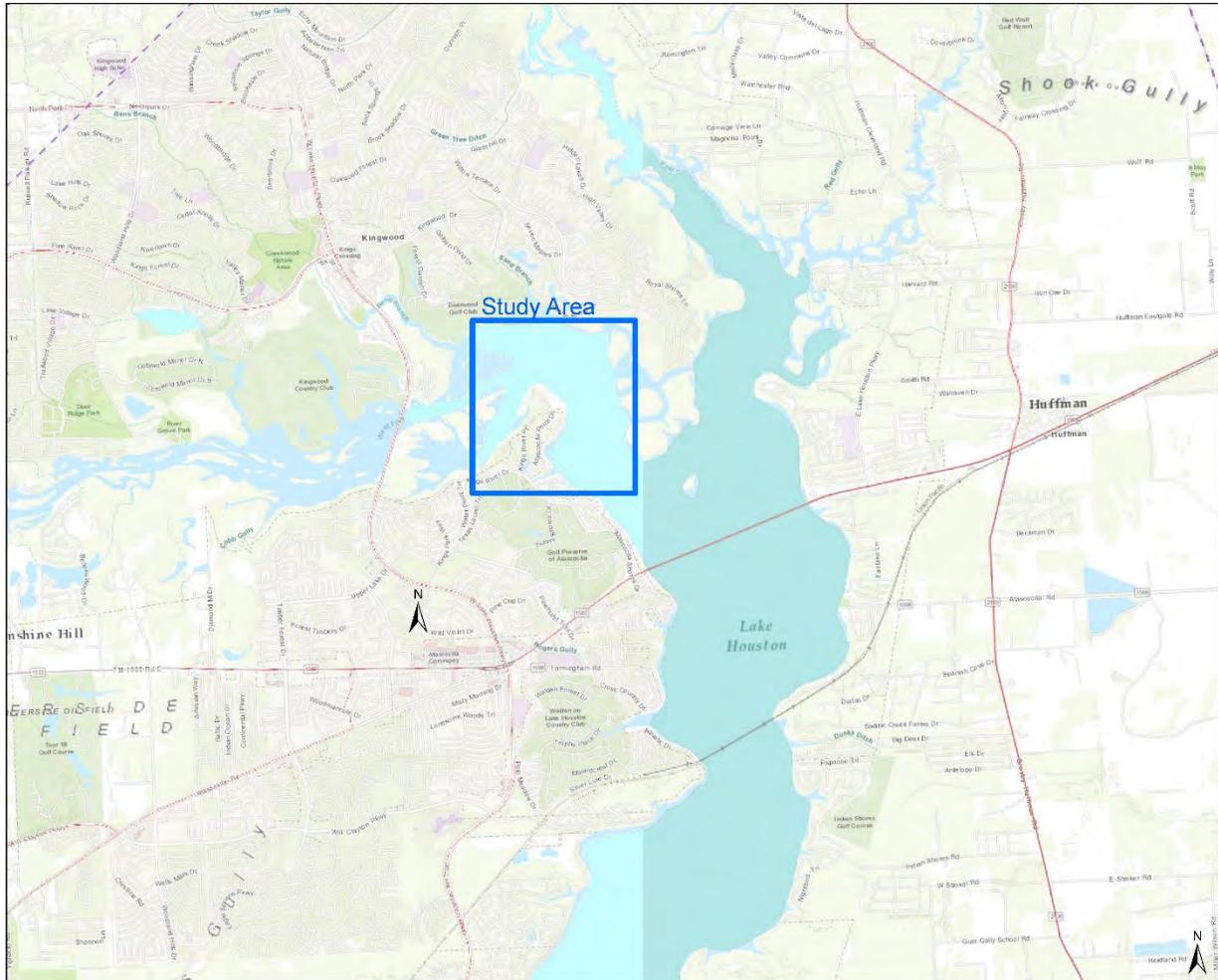


Lake Houston Sub-bottom Profiling and Coring

FINAL REPORT



Prepared for:

City of Houston
Department of Solid Waste Management

April 05, 2019

Prepared by:



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1. Introduction

Tetra Tech, Inc. (Tetra Tech) is pleased to provide this report to the City of Houston (City) to document field operations and results for the Lake Houston sediment study. Field operations were performed in February and March of 2019. The study was conducted in support of efforts to delineate and estimate volume of sediments deposited during Hurricane Harvey in 2017. The study area is shown in Figure 1-1.

The study included acquisition of over 15 miles of sub-bottom profiler (SBP) reflection data along 53 transects and collection and logging of 26 sediment cores to investigate the top 5 to 10 feet of sediments in the study area.

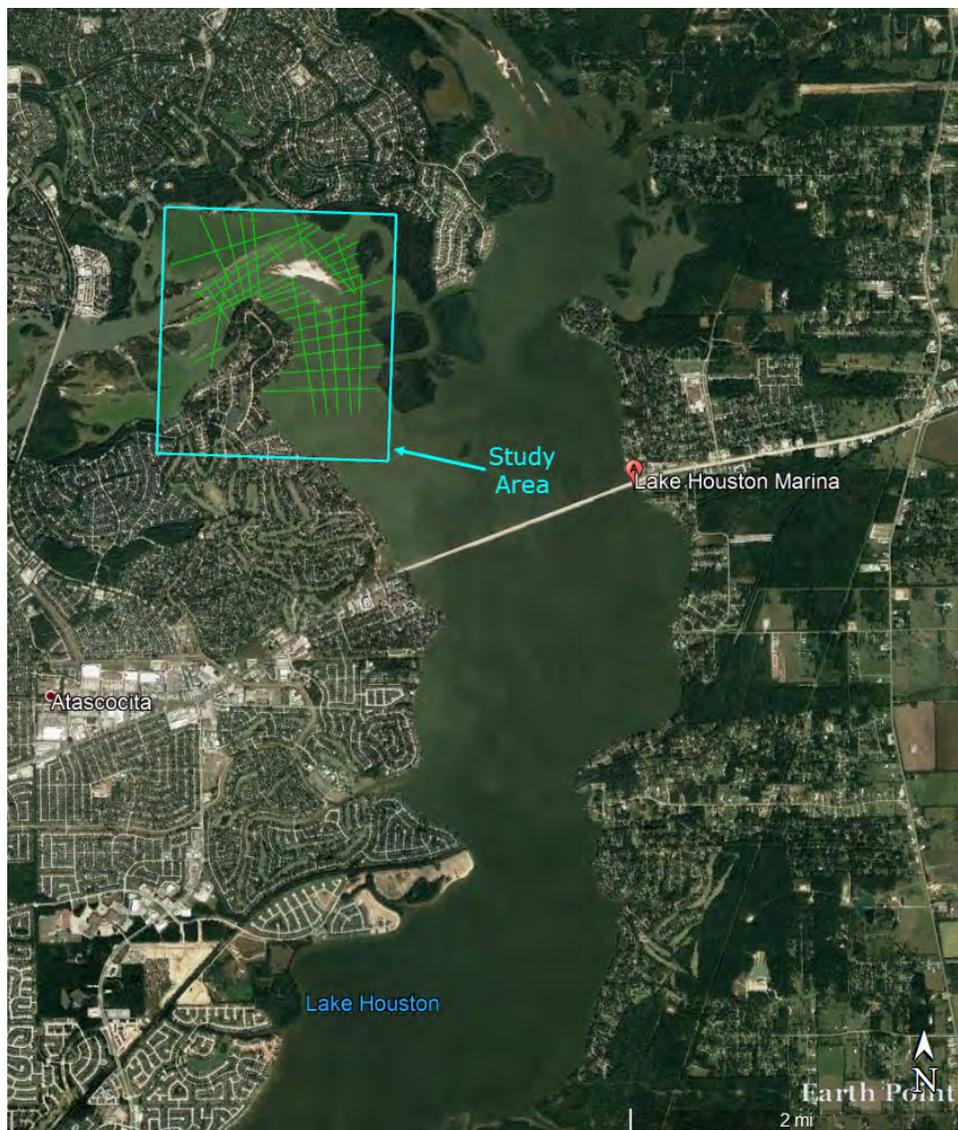


Figure 1-1. Lake Houston Study Area

2. Summary of Operations

The SBP and coring field efforts were performed in two phases during February and March of 2019 by Chris Ransome & Associates, Inc. (CRA), with support and oversight from Tetra Tech. On-site core logging, data interpretation and reporting was done by Tetra Tech personnel. Vessel operations were conducted out of Lake Houston Marina.

The project team members and their roles in the project are provided in Table 2-1. A summary of field operations is provided in Table 2-2.

Table 2-1. Field Operations Personnel

Name	Role
Mary Jones	Tetra Tech Project Manager
Joanna Hobson	Tetra Tech Task Manager/Processing/Reporting
Kim Hargett	CRA Project Manager
Cory Graves	Tetra Tech on-site Oversight for SBP Survey and Core Collection
Richard Sylwester	CRA Geophysical Expert for SBP Survey
Aaron Yoho	CRA Field Lead Sub-bottom Profiler
Peter Polivka	Tetra Tech Coring Lead
Kevin Arcieri	CRA Field Lead Coring
Michael Bigsby	Geomorphologist /on-site Core Processing/Reporting
Cameron Reister	Geomorphologist /on-site Core Processing

Table 2-2. Schedule of Field Operations

Date	Task
02/17/19	Mobilization for SBP Survey
02/18/19	SBP Acquisition
02/19/19	SBP Acquisition
02/20/19	SBP Acquisition
02/21/19	Demobilization of SBP Survey
03/04/19	Mobilization for Coring Operations
03/05/19	Core Collection / Logging
03/06/19	Core Collection / Logging
03/07/19	Core Collection / Logging
03/08/19	Core Collection / Logging
03/09/19	Demobilization of Coring Operations

The primary equipment used for the SBP survey and coring efforts is shown in Table 2-3.

Table 2-3. Survey and Sampling Equipment

Equipment	Manufacturer/Model
Sub-bottom Profiler	EdgeTech 4-24 Chirp System and Discover acquisition software
Vibracore System	SDI 24 V Electric Vibracore-D

2.1 Sub-bottom Profiler

The SBP survey was performed from February 18th to 20th, 2019 using a 20-foot vessel configured for shallow water surveying (Figure 2-1). Subsurface reflection data were collected using an EdgeTech 4-24 Chirp SBP system (Figure 2-2) to gather information on the acoustic characteristics and thickness of sediments along transects crossing the study area. The SBP towfish was suspended beneath the waterline from a chain secured to the port side of the vessel. A technician from CRA acquired the SBP data in JSF format (a proprietary EdgeTech format) using EdgeTech’s Discover software that was integrated with a real-time kinematic (RTK) global navigation satellite system (GNSS). Data were reviewed in real time for data quality and preliminary assessment by CRA’s marine geophysicist.



Figure 2-1. Survey vessel configured for SBP operations

Figure 2-3 shows an example of real-time SBP data displayed and monitored on the acquisition computer installed on the vessel. Chart 1 in Appendix A shows the transects along which SBP data were collected. CRA’s marine geophysicist provided a technical summary from the SBP data acquisition effort; this report is provided in Appendix B.



Figure 2-2. EdgeTech 424 sub-bottom profiler

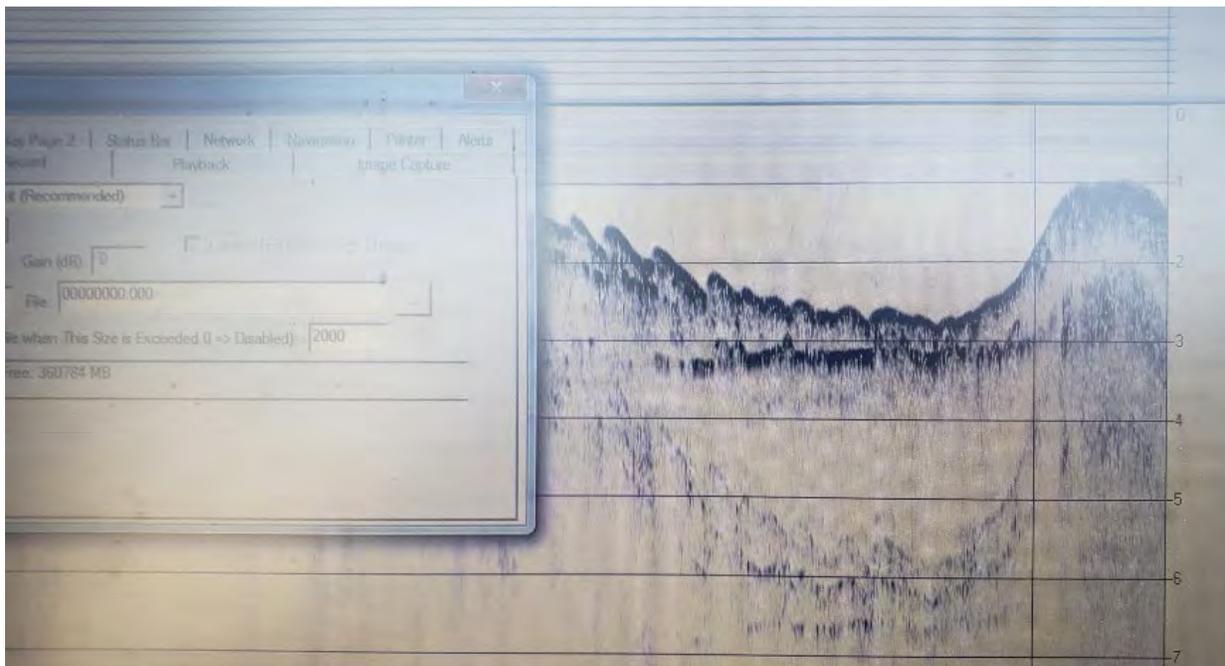


Figure 2-3. Sub-bottom profiler data display during acquisition

2.2 Vibracore Operations

Sediment core locations were selected following preliminary review of the SBP data to 1) target areas of good SBP penetration that indicated areas of fine-grained sediment deposition, and 2) to effectively represent the study area. Cores were collected between March 05th and March 08th, 2019 from a 24-foot pontoon boat configured for coring operations (Figure 2-4). Vessel operations were conducted during daylight hours with a crew of two from CRA and one Tetra Tech employee.



Figure 2-4. Pontoon boat configured for core collection

Cores were collected using an SDI 24-V electric vibracore deployed off the bow of vessel (Figure 2-5). As conditions allowed, 10-foot long core barrels (3-inch diameter) were deployed. In shallow areas (less than 3 feet of water) the core barrels were modified to 8-foot and 7-foot lengths to allow the coring system to be oriented vertically before deployment and insertion into the bottom. Target core penetration was 10 feet below the lake bed or refusal. The average core recovery percentage $[(\text{coring depth} - \text{core length}) / \text{coring depth} \times 100]$ was 91.2 percent. Cores were stored vertically on the CRA vessel during coring activities until the cores were transported to shore for stratigraphic logging.



Figure 2-5. Vibracore System

The X,Y location and time that each core was collected were logged using HYPACK®v2017. Vibracores were collected within 10 feet of the planned core location. The samples were turned over to Tetra Tech geomorphologists on shore for logging. Chart 2 in Appendix A shows where the cores were collected, and the sediment type observed at the top of each core (lakebed material type).

3. Data Processing and Core Logging

All georeferenced data obtained during the Lake Houston sediment study were referenced to NAD 83 datum and State Plane Texas South Central (TX-4204) grid coordinate system. Units were in U.S. Survey Feet. Water surface was measured daily from a CRA control point located on the pier at the Lake Houston Marina with the NAVD88 Elevation of 43.592 feet.

3.1 Sub-bottom Data

The SBP data were processed in the office using SonarWiz 7 software. The JSF format SBP data were imported into SonarWiz and bottom-tracked to determine the interface between the water and the lake bottom. Significant sub-bottom reflectors that suggest a change in sediment type or consolidation were digitized and then the thickness of the surficial sediment layer was calculated. Data from sediment core logs were brought in to SonarWiz to help to ground-truth the interpretation and provide additional information on changes in sediment type not clearly detected in the SBP record. Figure 3-1 shows the SBP record at core LH-06. Note that the base of the sand layer is not always clearly defined but the core data provide supplemental information to refine the interpretation.

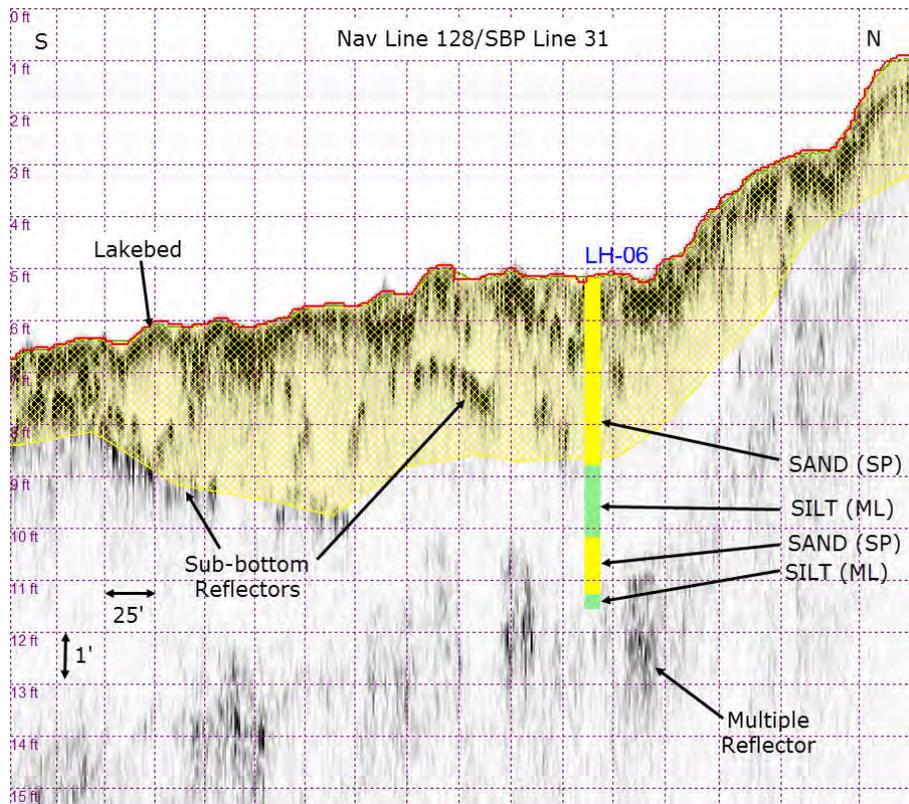


Figure 3-1. SBP example at Core LH-06 (SBP Line 31)

3.2 Core Logging

Sediment core logging occurred at the Lake Houston Marina located at 10611 FM 1960, Huffman, TX 77336. Twenty-nine (29) coring attempts were made. Three cores were not retained due to lack of recovery, resulting in 26 cores retained for stratigraphic logging. A total of 12 coring attempts encountered refusal; most often due to sand or densely packed sediment. The average core depth was 6 feet below the lake bed. A summary of the collected cores is presented in Table 3-1.

The sediment core processing began by cutting longitudinally along the aluminum core tube using electric shears and separating the two halves (Figure 3-2 and 3-3). A photograph of the core was taken and stored in the Esri Survey123 logging form to capture the state of the sediment core before it was logged.

To avoid potential artifacts from smearing of stratigraphy along the inside of the plastic liner, a small amount (a few millimeters) of sediment was removed from the outer edge of the core with a clean instrument. Once this sediment was removed, the logger determined the number of sediment layers.

The first sediment layer breaks were identified by obvious visual differences which include major sediment discontinuities (i.e. silt to gravel), sediment color, organic matter content, and structure/density. After obvious layer breaks were identified, the logger determined if there was evidence for further sediment layer breaks by hand texturing the sediment from one part of the layer and comparing the texture to another part of the layer. This process was repeated until all sediment layer breaks were identified and marked. Figure 3-2 shows an example of the different sediment layers observed at core location LH-06, which had 3.6 feet of light gray coarse sand over a layer of silt.

The next logging step was to record details of each sediment layer in the appropriate Esri Survey123 logging form. First, a photo of the individual sediment layer was taken. Next, the length of the sediment layer was recorded in feet and referenced to the lake bed surface. Then the sediment color was recorded using a Munsell Soil Color Chart (Figure 3-3). The sediment color was determined as a notation with hue, value, and chroma. The Munsell notation typically corresponded to a named color with modifiers; for example, very dusky red. At this point the logger re-textured the sediment layer to determine the final estimates of the percent of sand-silt-clay of the sediment.

Table 3-1. Summary of Collected Cores

Core Name	Date of Collection	Time of Collection	Latitude ^{1/}	Longitude ^{1/}	Water Surface Elevation ^{2/} (ft)	Depth of Water (ft)	Coring Depth	Recovery Length	Recovery Percentage
LH-01	3/5/2019	1042	3184462.6	13945005.21	41.3	4.2	10	9.9	99.0
LH-02	3/5/2019	1015	3183248.41	13944595.14	41.3	4.2	4.9	4.2	85.7
LH-03	3/6/2019	907	3186222.15	13944604.97	41.4	2	6.5	6.4	98.5
LH-04A	3/8/2019	943	3184243.68	13944235.94	41.4	4.2	7.2	7.1	98.6
LH-05	3/5/2019	1426	3187659.31	13944231.32	41.3	2.8	1.1	0.5	45.5
LH-06	3/7/2019	1204	3183957.97	13944044.4	41.5	5.2	6.4	6.4	100.0
LH-07	3/5/2019	1435	3187208.59	13944105.16	41.3	2.3	7	6.6	94.3
LH-08	3/7/2019	1019	3184425.52	13944008.94	41.5	3.2	7	5.3	75.7
LH-09	3/5/2019	1522	3187400.24	13943846.65	41.3	2.5	7	5.5	78.6
LH-10	3/7/2019	914	3184772.27	13943706.89	41.5	4.2	7	4.4	62.9
LH-11	3/7/2019	1236	3183267.18	13943621.15	41.5	6.8	5	4.9	98.0
LH-12	3/7/2019	1303	3184353.76	13943630.81	41.5	5.7	4.2	4.1	97.6
LH-13A	3/8/2019	925	3185286.24	13943475.96	41.4	4.3	9.2	9.2	100.0
LH-14	3/7/2019	1222	3183776.88	13943534.86	41.5	7.4	4.5	4.4	97.8
LH-15	3/6/2019	932	3187618.98	13943544.03	41.4	3.4	6.5	6.5	100.0
LH-16	3/7/2019	851	3185273.46	13943090.82	41.5	4.8	7	7.0	100.0
LH-17	3/8/2019	1000	3182909.29	13942930.85	41.4	10.2	4.5	4.5	100.0
LH-18	3/6/2019	1342	3186409.24	13942903.34	41.5	2	7	6.4	91.4
LH-19	3/6/2019	1404	3186720.8	13942437.59	41.5	3.7	5.1	5.0	98.0
LH-20	3/6/2019	1436	3186455.7	13942366.31	41.5	3.2	6	5.9	98.3
LH-21	3/6/2019	1450	3186012.28	13942243.58	41.5	6	10	9.3	93.0
LH-22	3/6/2019	953	3187882.88	13942295.18	41.4	5.2	7	6.5	92.9
LH-23	3/6/2019	1110	3186287.56	13940938.94	41.4	9.5	8	7.9	98.8
LH-24	3/6/2019	1132	3187463.75	13940414.97	41.5	3.1	6	5.1	85.0
LH-25A	3/8/2019	853	3187324.68	13943093.7	41.4	3.5	5	4.4	88.0
LH-26	3/6/2019	1155	3188511.91	13938429.36	41.5	10.7	4.2	4.0	95.0

1/ Coordinates are based on NAD83 State Plane Texas South Central System (feet)

2/ Vertical Datum: NAVD88



Figure 3-2. Sediment Layers Logged in Core LH-06



Figure 3-3. Core Logging

The sediment textural triangle applies a United States Department of Agriculture (USDA) texture classification to a sediment sample based on the relative percentages of clay, silt, and sand present within that sample. A logger estimates the percentages of each sediment class by means of hand texturing. The sediment class that makes up the largest percentage of the textural triangle for the sample is then used to determine the Unified Soil Classification System (USCS) texture code. The USCS texture code is a two-letter system where the first letter represents the size of the foremost particle: G= gravel, S = sand, M=Silt, C= clay, and O = organic. The second letter describes the consistency of the sample's particle size: P= poorly graded, W= well graded, H= high plasticity, L= low plasticity, PT represents a sediment sample that is almost completely organic.

Once the percent of the constituent parts of the sediment layer were estimated, the logger recorded the data in two different classification systems: USCS and USDA SCS. The USCS is generally used by engineers and geologists to classify soil/sediment into categories based on physical engineering properties. The USDA SCS is generally used by soil scientists to classify soils based on physical and chemical properties. If the layer was primarily organic matter, then the logger would record the plasticity and consistency and then only record the USCS class. The USDA SCS was not recorded because it only applies to mineral soils/sediments. Next, the

sediment layer structure was described based on geotechnical classifications such as homogenous, blocky, stratified, or lensed. After the sediment layer texture, color, and structure were logged, observations of any rocks, plant fragments, wood etc. was recorded on the field forms, as well as any indication of odor. Notable odor type including Sulphur, petrochemical or organic included if applicable. If any sublayers were present the logger recorded and described their characteristics. Finally, any general comments about the sediment layer were recorded, such as anthropogenic material. Electronic logging forms were used to record the sediment core physical characteristics. Core logs and core photos are presented in Appendix C.

4. Summary of Findings

4.1 SBP Data

Subsurface penetration varied from a maximum of just over 6 feet to little or no penetration. Lack of penetration with the SBP coincided with numerous multiple reflections of the lake floor. The core data input into SonarWiz were used to ground-truth the SBP data interpretation. In several places where a distinct sub-bottom reflector was observed a few feet below the lakebed, the cores confirmed this surficial sediment type as consisting of fine to medium grained sand overlying a different sediment type, usually silt. For example, Figure 4-1 from SBP Line 27 shows a layer of sediment, comprised of sand waves up to 1 foot in height overlying what is interpreted to be consolidated substrate. Core data from LH-10 show this top layer is comprised primarily of sand. Figure 4-2 shows another area of good SBP penetration from SBP Line 40 with 1 to 3 feet of surficial sediment. Core LH-19, LH-20, and LH-21 confirm the surficial sediment layer detected in the SBP record is comprised primarily of sand and overlies silt. Figure 4-3 shows the distribution of the surficial sand layer observed in the SBP data in the study area. This information is also displayed on Chart 3 in Appendix A.

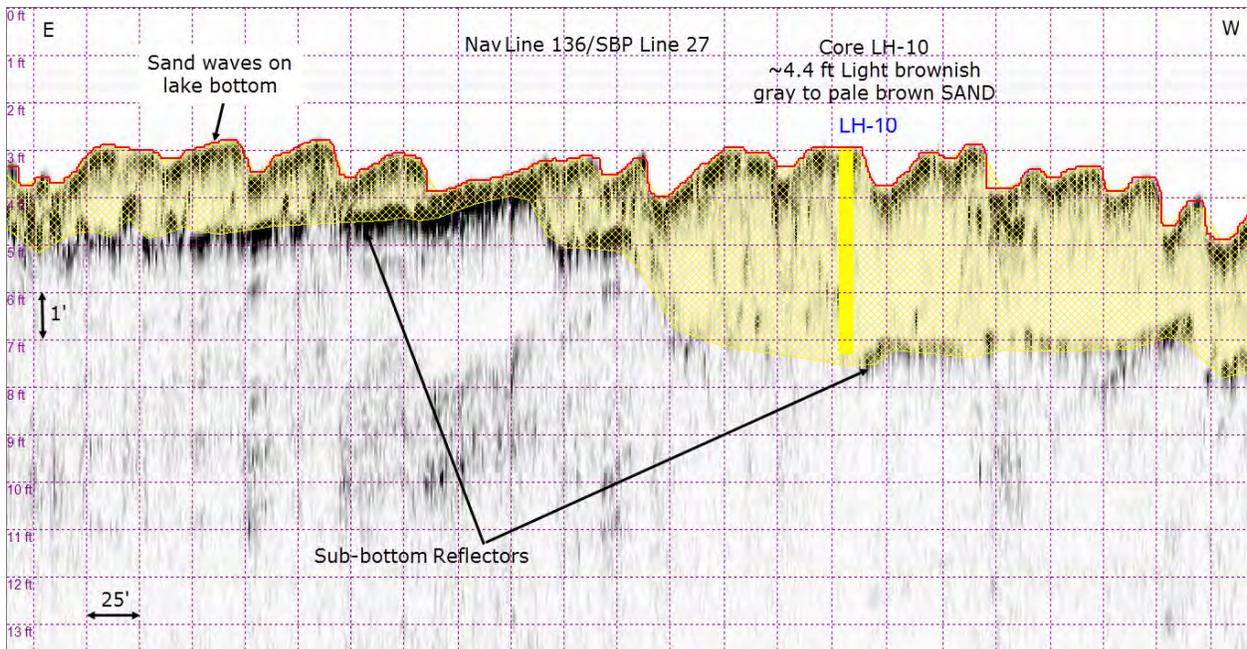


Figure 4-1. Data example from SBP Line 27 shows area of fine-grained sediment, ~1-4 feet in thickness. Core LH-10 contained 4.4 feet of SAND

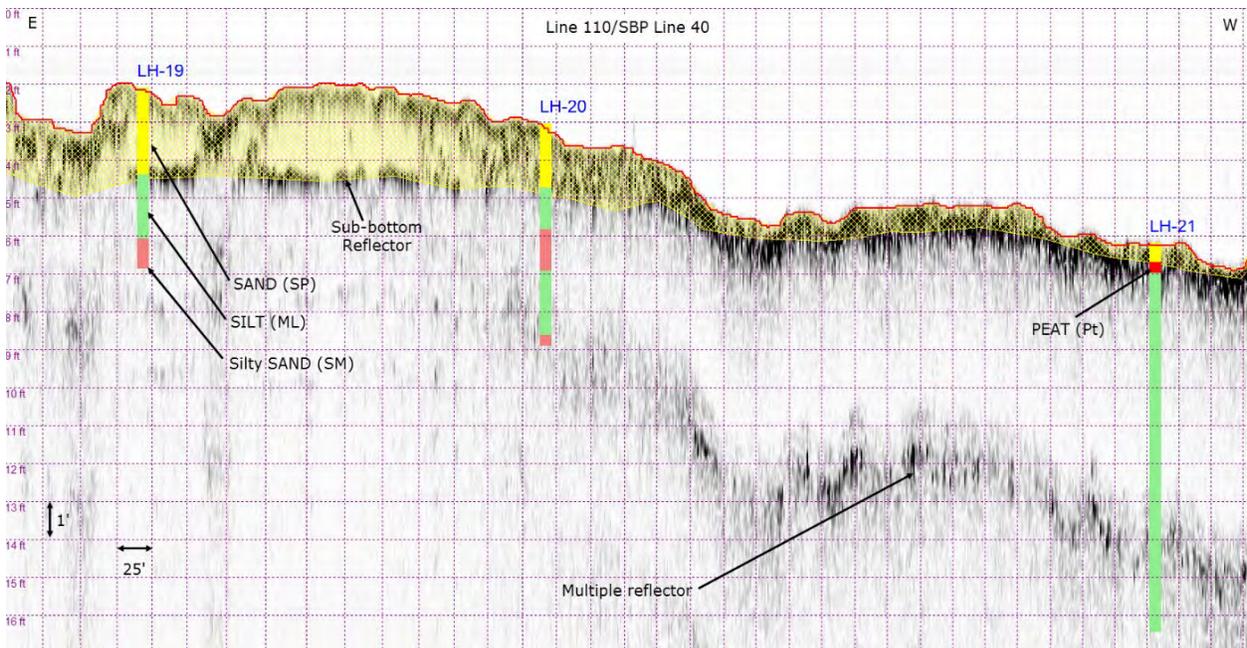


Figure 4-2. Data example from SBP Line 40 shows area of sediment ~1-3 feet in thickness. Cores LH-19, LH-20 and LH-21 show SAND over SILT correlates well with the SBP reflectors

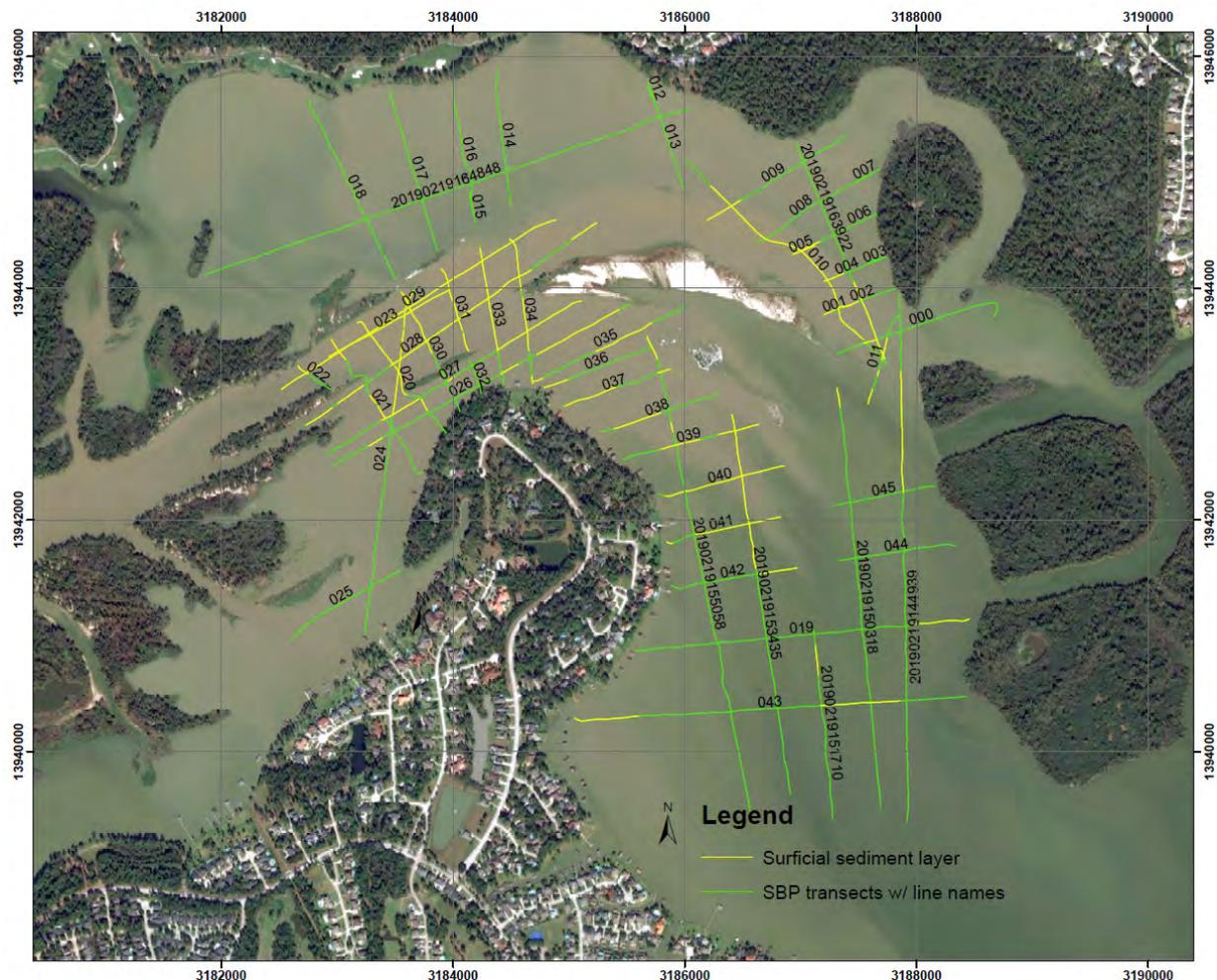


Figure 4-3. Surficial sediment layer (yellow) detected in SBP data (SBP transects in green)

4.2 Core Data

The most common USCS sediment type observed throughout the cores was as follows: 1) ML (lean silt), 2) SP (poorly graded sand), 3) SM (silty sand), and 4) CL (lean clay). Peat (Pt) and CH (heavy clay) were each observed once. In general, most of the cores displayed a fining downward sequence of sediment textures. The most common USCS sediment type observed in the top stratigraphic layer was SP (poorly graded sand) or SM (silty sand). Typically, this was underlain by ML (lean silt).

Chart 2 in Appendix A shows that fine to coarse sand and silty sand comprise the top layer of lake sediment in 22 of the 26 cores. The thickness of this surficial sand layer at each core location is also indicated on the chart. The thickness of the surficial sand layer observed in the cores ranged from 0.5 to over 5 feet.

The depositional environment of Lake Houston is associated with both lacustrine and fluvial processes due to the anthropogenic influences of controlled dams. The silt deposits observed in the sediment cores are likely associated with low energy (low water velocity) flow regimes. These may be interpreted as typically lacustrine environments where silt particles are allowed to settle out of suspension. This type of environment could be achieved during dry periods when the flow gates of the dams are closed to retain water capacity in the reservoir. The sand deposits observed in the sediment cores are likely associated with high energy (high water velocity) flow regimes. In these types of environments small particles, such as clay and silt, are kept in suspension and flow downgradient. This leaves the relatively larger sand particles to be deposited. During periods of increased precipitation, it is likely the flow gates at the dams on Lake Houston are open to prevent flooding. Under these conditions the environment where the cores were collected would be such that sand from areas upstream from the lake could be deposited near the downstream end of the dams.

5. Discussion

5.1 Historical Bathymetry

The City of Houston provided Tetra Tech with historical bathymetric datasets from surveys conducted by the Texas Water Development Board (TWDB) in 2011 (TWDB 2011) and in 2018 (TWDB 2018). While the survey data were collected before and after Hurricane Harvey, respectively, the surveys were too far apart in time to conclude that bathymetric changes over that period were the result of that specific event. In addition, the area of overlap between the two datasets does not cover the extent of the study area and therefore cannot be directly compared to the volume estimates calculated using the 2019 survey data. However, a comparison between the 2011 and 2018 datasets does provide useful information on where sediments have been deposited or eroded during the seven-year period. Note that the 2011 bathymetry survey coverage was not as extensive as the 2018 survey and did not extend to the north and east of the area commonly known as the mouth bar, the island in the middle of the survey area. Whether any dredging operations were conducted in the study area between 2011 and 2018 that contributed to the removal of sediment in the areas identified as scoured is unknown. A difference map between the 2011 lakebed and the 2018 lakebed in the study area is presented in Chart 3 in Appendix A. The chart shows that areas of deposition and scour generally correlate well with where surficial sand was or was not observed in the SBP and core data.

A rough estimate of the volume of sediment that has been deposited in the study area between 2011 and 2018 (based on where the two datasets overlap in the study area) was calculated:

Volume of sediment deposited 2011-2018 ~ 813,900 cubic yards

[Note that the coverage is not the same as the 2019 data and therefore not directly comparable to estimates made using the 2019 survey data discussed in Section 5.3]

5.2 Historical Cores

Most of the core locations were selected in the study area based on the results of the SBP survey and were situated on the SBP transects for correlation with the SBP data. However, core LH-26 was collected at a site approximately 1,100 feet southeast of the survey area, co-located with core H-5 which was collected in 2011 as part of the TWDB's volumetric and sedimentation survey of Lake Houston for the U.S. Army Corps of Engineers (TWDB 2011). Refer to Chart 1 in Appendix A for the location of LH-26 (and H-5). The core descriptions presented in Table 3-1 show that the sand layer at the top of the LH-26 core was not observed in core H-5. This finding suggests that the sand layer was deposited after 2011.

Table 5-1. 2011-2019 Core Comparison

Year	Contractor	Core	Easting (ft) ^{1/}	Northing (ft) ^{1/}	Sediment core description ^{2/}
2011	TWDB	H-5	3188506.67	13938425.52	0-6" loose silty clay sediment 2.5Y 3/1 6-8" denser sandy clay sediment 10YR 5/1 8-22" loose silty clay sediment 2.5Y 4/2 22-27" dense silty clay loam, organics present 5Y 4/1
2019	CRS/Tetra Tech	LH-26	3188511.91	13938429.36	0-0.7' Light gray (5Y 7/2), non-plastic, homogenous SAND (SP) 0.7-1.7' Dark gray to black (5Y 4/1 to 5Y 2.5/1), non-plastic, v. soft, homogenous SILT (ML) 1.7-4' Dark gray (2.5Y 4/1), high plasticity, firm, homogenous SILT (ML) with 1-5% plant fragments

^{1/} Coordinates are based on NAD83 State Plane Texas South Central System (feet)

^{2/} Full core log for LH-26 presented in Appendix C.

5.3 Sediment volume calculations

Surficial sand volumes in the study area were estimated using the SBP and core data collected during the 2019 field effort. The methods and results are described in the following sections.

5.3.1 Methods

Sediment volume estimates for the surficial sand layer in the study area were made from the 2019 survey data using two approaches:

- 1) **Core data only** - The thickness of the top sand layer was measured in 22 of the 26 cores and interpolated across the study area, including the mouth bar where no cores were collected, to create a grid surface. The grid did not include the subaerial portion of the mouth bar. The results of approach this shown in Chart 4. Profiles were cut through the surficial sediment layer interpolated from the core data at three locations across the study area. These profiles are provided in Appendix D.
- 2) **Core and SBP data** - The second method used a combination of the surficial sand thicknesses from the cores and the SBP data. The SBP data provided additional sand thickness data points over a larger area than the discrete core points. The sediment thickness values were interpolated using the same method as in the first approach. Again, this estimate does not include the subaerial portion of the mouth bar. The results of this approach are shown in Chart 5.

5.3.2 Mouth bar volume

The City requested that the subaerial portions of the mouth bar be included in the surficial sand volume calculations. The mouth bar data points were extracted from the light detection and ranging (LiDAR) data collected by others for the U.S. Army Corps of Engineers (USACE) in 2018 (USACE 2018) (Figure 5-1). LiDAR data were provided to Tetra Tech by the City. The volume estimate for the subaerial portion of the mouth bar was approximately 112,000 cubic yards.

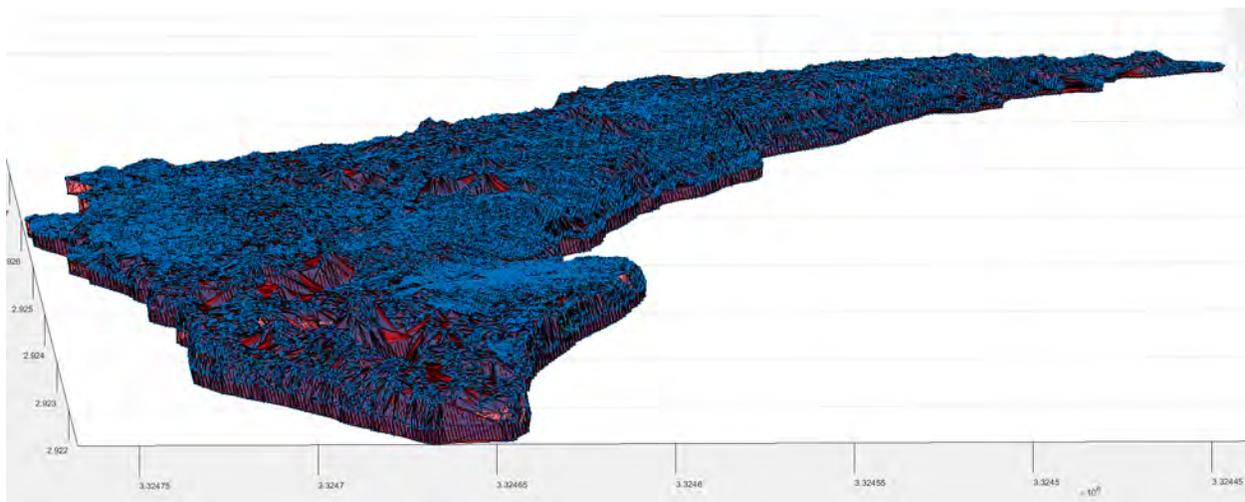


Figure 5-1. Subaerial portion of mouth bar extracted from 2018 LiDAR data (USACE 2018) to estimate volume of sediments in the mouth bar

5.3.3 Results

The volume estimates for the surficial sand layer calculated using the two approaches described in Section 5.3.1 are presented in Table 5-2.

Table 5-2. Surficial Sediment Volume Estimates

Method	Data	Volume (cubic yards)	Volume of subaerial mouth bar sediments (cubic yards)	Total volume (cubic yards)
1	Core	1,240,000	112,000	1,352,000
2	Core and SBP	900,000	112,000	1,012,000

5.4 Key Points

- Sand size material is typically deposited in a higher energy environment than finer grained materials such as silt and clay. Silt and clay deposits were observed underneath the surficial sand layer in most of the cores.
- Fine to coarse sand was observed in the top layer of 22 of the 26 cores (refer to Chart 2 in Appendix A). The sand thickness measurements were interpolated across the survey area to create a grid surface shown in Chart 3. The surface shows the estimated thickness of the surficial sand layer across the survey area based on the 22 core points.
- A surficial layer of sediment with sand waves up to a foot in height was observed in the SBP data, primarily in the northwest corner and south of the mouth bar. The surficial sediment layer detected in the SBP data is not continuous across the study area. Core data correlate well with areas of good SBP penetration and were used to ground-truth the SBP interpretation. The thickness of this surficial sand layer was generally less than a foot to over 5 feet in thickness and generally thins towards the south.
- Using a combination of the surficial sediment thicknesses from the SBP and core data increases the number of data points, thereby providing a more refined estimate of the surficial sediment thickness when the data are interpolated across the study area.
- Surficial sand volume estimates for the study area, including the subaerial portions of the mouth bar, ranged from ~1 million cubic yards based on core and SBP data interpolated across the study area, and 1.35 million cubic yards based on core data alone interpolated across the study area. Both estimates include the approximately 112,000 cubic yards contained in the mouth bar.

6. References

TWDB, 2013, Volumetric and Sedimentation Survey of Lake Houston December 2011 Survey, https://www.twdb.texas.gov/hydro_survey/houston/2011-12/Houston2011_FinalReport.pdf, accessed March 2019.

TWDB, 2018, Bathymetric Survey of the West Fork San Jacinto River June 2018 Survey, https://www.twdb.texas.gov/hydro_survey/SanJacintoRiver/2018-06/WFSJRiver18_FinalReport.pdf, accessed March 2019.

USACE, 2018, LiDAR data from Lake Houston provided by the City for this project.

APPENDIX A

CHARTS



Legend

Surficial sediment USCS Description

- CH - Fat CLAY
- ML - SILT
- SM - Silty SAND
- SP - SAND

Top of core layer thickness in feet

Notes

1. Coordinate System: NAD83, State Plane Texas S Central, U.S. Survey Feet
2. Survey Date - February-March, 2019
3. Sub-bottom Profiler data collected by CRA
4. Sediment cores collected by CRA
5. Core logging & interpretation by Tetra Tech



Lake Houston

Surficial Sediment Types from Core Data

1:10,000

0 500 1,000 1,500 2,000 Feet

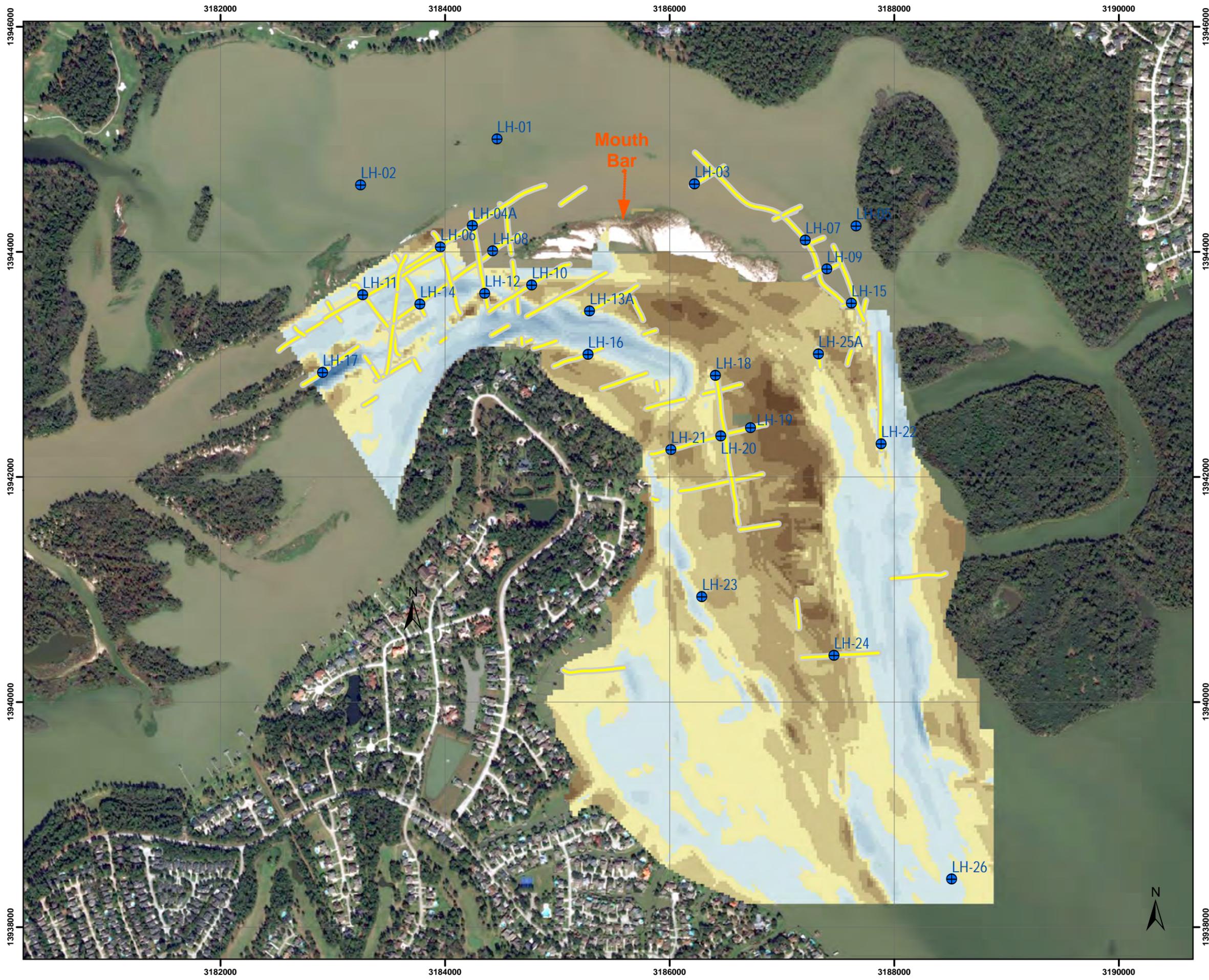
TETRA TECH

CRA

Document Name:
02_LH_TopLayer

Date: 4/5/2019

**Chart
2**



Legend

- Core Location w/ Label
- Surficial sand extents

Areas of deposition

5.1 - 6	3.1 - 4	1.1 - 2
4.1 - 5	2.1 - 3	0 - 1

Areas of scour

-0.9 - 0	-5.9 - -5	-10.9 - -10
-1.9 - -1	-6.9 - -6	-11.9 - -11
-2.9 - -2	-7.9 - -7	-12.9 - -12
-3.9 - -3	-8.9 - -8	-13.6 - -13
-4.9 - -4	-9.9 - -9	

- ### Notes
1. Coordinate System: NAD83, State Plane Texas S Central, U.S. Survey Feet
 2. Survey Date - February-March, 2019
 3. SBP data and core samples collected by CRA
 4. Core logging and interpretation by Tetra Tech
 5. Surficial sand extents estimated from 2019 SBP and core data
 6. 2018 bathymetry from TWDB, 2018
 7. 2011 bathymetry from TWDB, 2011



Lake Houston

Bathymetry Difference 2018-2011

1:10,000

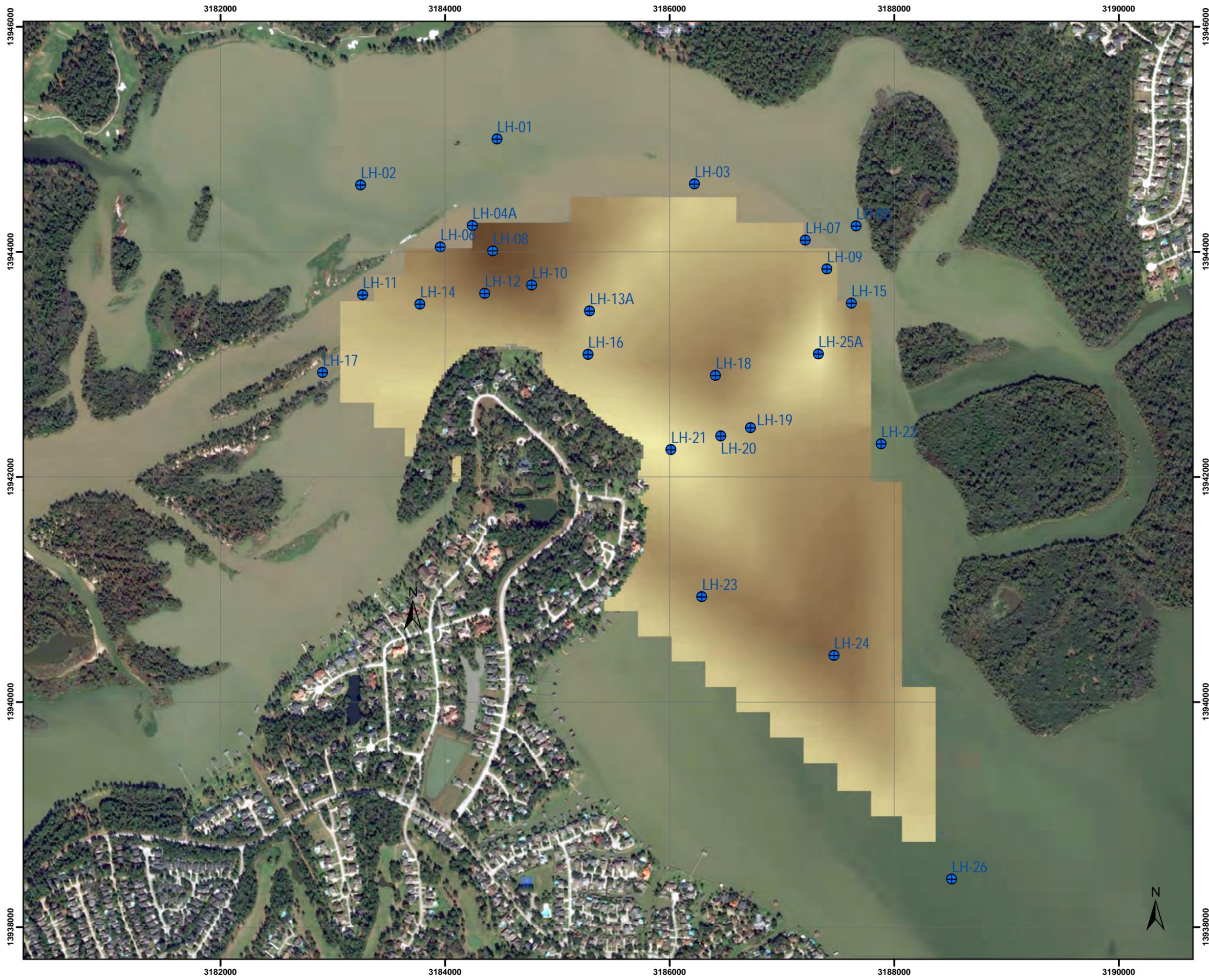
0 500 1,000 1,500 2,000 Feet

Tetra Tech **CRA**

Document Name:
03_LH_2011_2018_Difference

Date: 4/5/2019

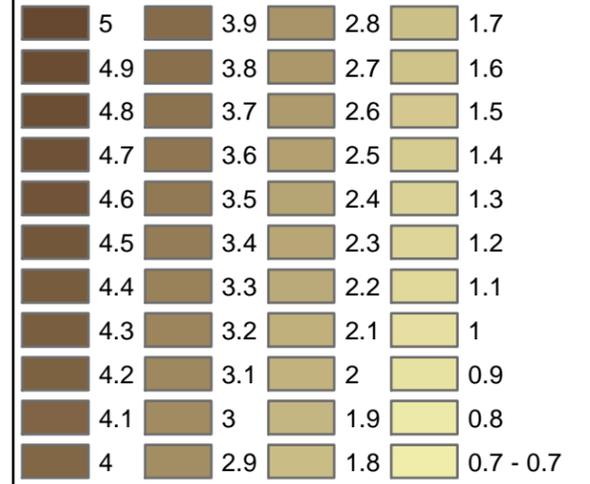
Chart 3



Legend

⊕ Core Location w/ Label

**Surficial Sand Layer Thickness (ft)
Interpolated from Core Data**



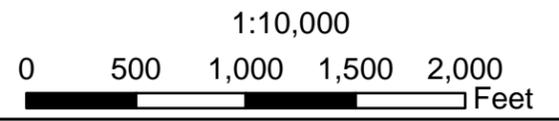
Notes

1. Coordinate System: NAD83, State Plane Texas S Central, U.S. Survey Feet
2. Survey Date - February-March, 2019
3. Sediment cores collected by CRA
4. Core logging and interpretation by Tetra Tech
5. Estimated Sand Volume = 1.24 million cu-yds (*)

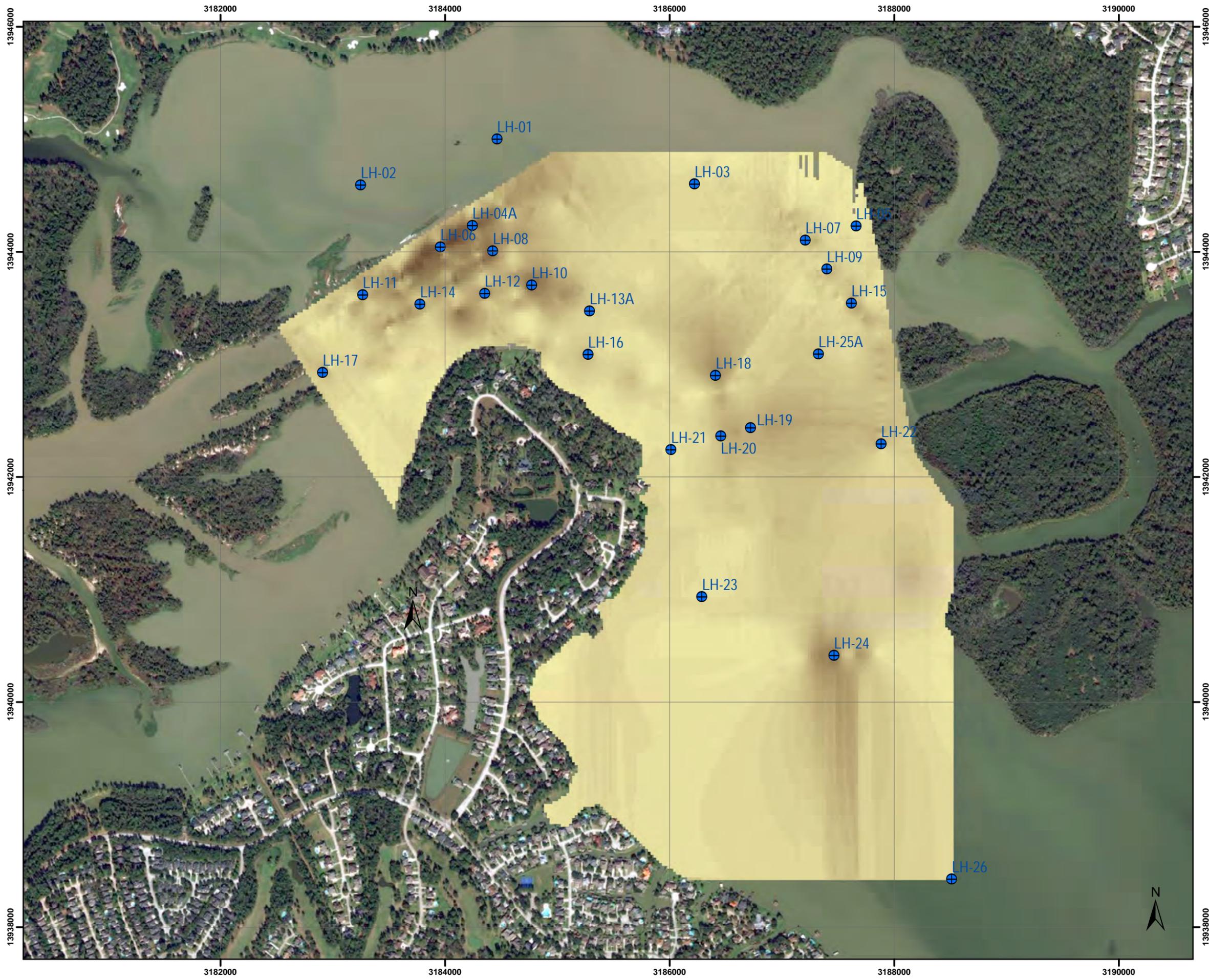
* Volume does not include volume of subaerial mouth bar sediments estimated from LiDAR data to be ~112,000 cu-yds



**Lake Houston
Surficial Sand Thickness
Core Data**



Document Name:
04_LH_Sand_Thickness_Cores
Date: 4/5/2019



Legend

⊕ Core Location w/ Label

**Surficial Sand Layer Thickness (ft)
Interpolated from SBP and Core Data**

5.81 - 6	3.81 - 4	1.81 - 2
5.61 - 5.8	3.61 - 3.8	1.61 - 1.8
5.41 - 5.6	3.41 - 3.6	1.41 - 1.6
5.21 - 5.4	3.21 - 3.4	1.21 - 1.4
5.01 - 5.2	3.01 - 3.2	1.01 - 1.2
4.81 - 5	2.81 - 3	0.81 - 1
4.61 - 4.8	2.61 - 2.8	0.61 - 0.8
4.41 - 4.6	2.41 - 2.6	0.41 - 0.6
4.21 - 4.4	2.21 - 2.4	0.21 - 0.4
4.01 - 4.2	2.01 - 2.2	0.02 - 0.2

Notes

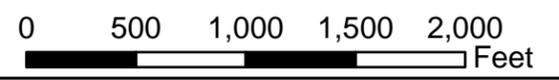
1. Coordinate System: NAD83, State Plane Texas S Central, U.S. Survey Feet
2. Survey Date - February-March, 2019
3. Sediment cores collected by CRA
4. Core logging and interpretation by Tetra Tech
5. Estimated Sand Volume = 900,000 cu-yds (*)

* Volume does not include volume of subaerial mouth bar sediments estimated from LiDAR data to be ~112,000 cu-yds



**Lake Houston
Surficial Sand Thickness
SBP and Core Data**

1:10,000



Document Name:
05_LH_Sand_Thickness_SBP_Core

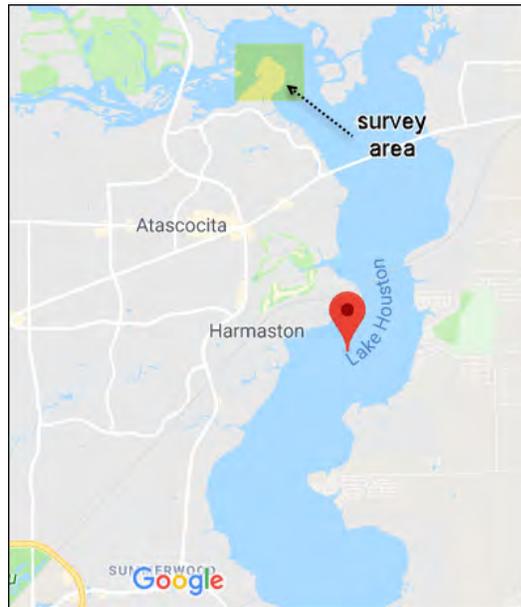
Date: 4/5/2019

**Chart
5**

APPENDIX B

GEOPHYSICIST'S TECHNICAL MEMORANDUM

TECHNICAL FIELD REPORT
for the
ULTRA HIGH-RESOLUTIONS SBP SURVEY
LAKE HOUSTON, TEXAS



Prepared for:
CRA
Houston Texas

Prepared by:
Northwest Geophysical Services
Redmond, Washington

February 27, 2019

CRA
2121 Brittmoore Road
Houston, Texas 77043

February 23, 2019

ATTENTION: Kimberly Hargett

Re: SUMMARY OF THE TECHNICAL RESULTS OF THE ULTRA-HIGH-RESOLUTION SUBBOTTOM REFLECTION SURVEY, LAKE HOUSTON, TEXA

Dear Ms. Hargett

1. INTRODUCTION

This report is a summary of the operations and sediment acoustic characteristics from the subbottom reflection survey that was conducted February 18-21, 2019 on Lake Houston. The objectives of the geophysical investigation were to:

- A. Obtain subsurface acoustic information to delineate the vertical and lateral extent of potential sediment flood deposits resulting from Hurricane Harvey.
- B. Identify areas where sediment samples could be obtained to ground truth the subsurface reflection data.
- C. Correlate the geophysical data with the sediment samples to delineate and quantify the Hurricane Harvey deposit.

Detailed analysis and mapping of the interpreted geophysical data, selection of coring sites, vibracoring operations, and analysis of the sediment samples will be provided by Tetra Tech. Once those tasks are completed they will integrate the geophysical and sediment analysis results to develop a Hurricane Harvey Flood Deposit Isopach Map.

2. SURVEY OPERATIONS

The data were collected on 58 transects, covering approximately 15 miles, using an EdgeTech SB-424, a ultra-high resolution CHIRP subbottom profiler operating over a bandwidth of 4 to 24 kHz. The map shows the tracklines and small circles indicate some of the locations of good subsurface penetration.



The subbottom transducer was suspended by chain from the port side of the vessel. The reflection data were acquired and archived on EdgeTech Discover software that was interfaced with the GPS navigation system. The data were viewed in real-time on the acquisition computer along with the navigation data. Real-time viewing of the data made it possible to make adjustments to the amplifier gains, power, and pulse length as needed to enhance the subbottom image. These adjustments do not affect the digitally recorded data that can be reprocessed during post-survey data analysis to enhance subtle changes in subsurface reflection characteristics.

3. PROCEDURES FOR MAPPING HURRICANE HARVEY DEPOSITS

The interpreted information from the geophysical data along with the analysis of the sediment from the vibrocores will be used to attempt to determine the contact between the routine sediment deposits and deposits from Hurricane Harvey. The procedures for conducting this analysis is described in the June 13, 2013 NJDEP Waterway Debris Removal Project memorandum developed by The Richard Stockton Coastal Research Center following Hurricane Sandy offshore New Jersey in 2012.

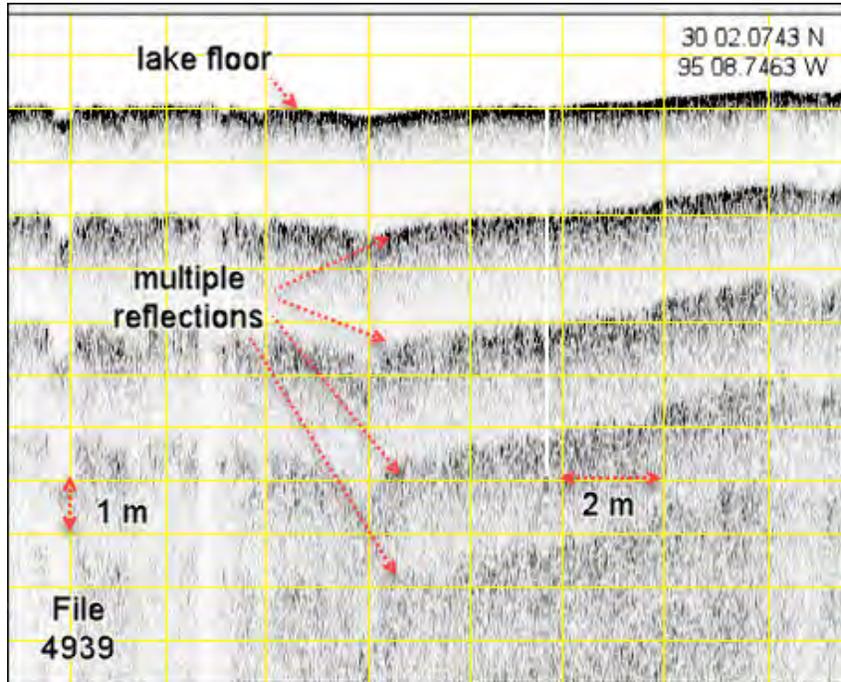
4. PRELIMINARY ASSESSMENT OF THE GEOPHYSICAL DATA

During the survey the data were preliminarily and qualitatively analyzed by applying the method of seismic facies analysis. A seismic facies unit is defined as a sedimentary or geologic unit which is different from adjacent units in its seismic characteristics. Parameters or seismic characteristics that were considered include reflection amplitude (light or dark reflection pattern), dominant frequency (spacing of reflection horizons), reflection continuity, abundance of reflections, and geometry of the unit.

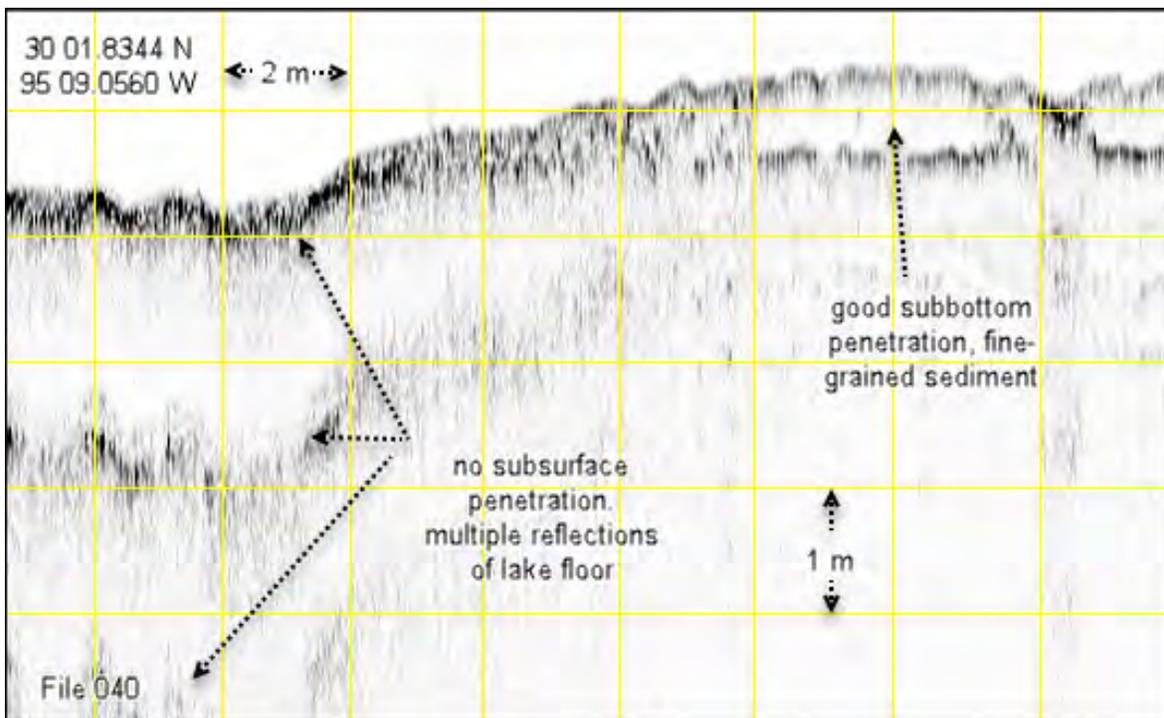
These geophysical attributes can often be correlated with sediment characteristics such as fine-grained, coarse-grained, clays, gravels, organic debris etc. For example, subbottom reflection images that have a very low amplitude (light color or acoustically transparent) is characteristic of fine-grained, high water content sediment such as clay and silt. An increase in the grain size to sand and gravel, or an increase in compaction, results in an increase in amplitude of the reflection of a given horizon or strata; the reflection becomes darker. The presence of biogenic gas and organic debris also increases the reflection amplitude and a subsequent reduction of subsurface penetration. Usually in both of these situation there is little or no subsurface penetration and multiple reflections of the lake bed can be observed. Examples of the predominant reflections characteristics are presented in the following section.

5. REPRESENTATIVE EXAMPLES OF SUBBOTTOM REFLECTION DATA

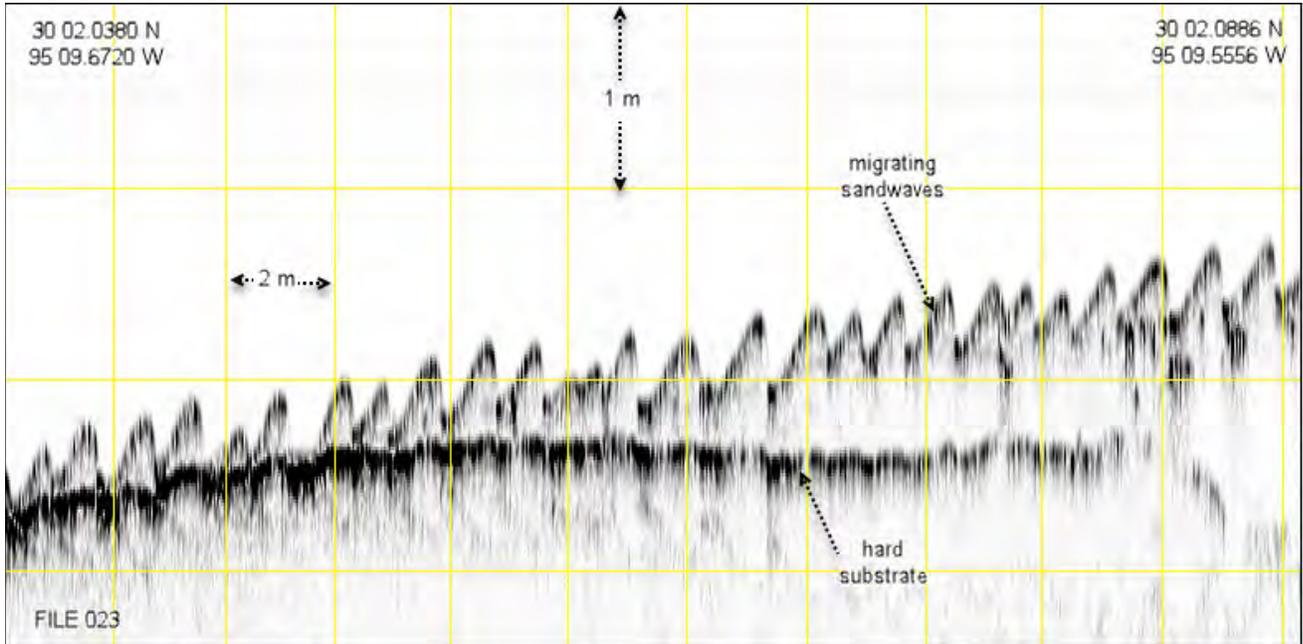
The subbottom data varied considerably over the survey area with the best subsurface penetration occurring along the transects in the northwest (Transects 130-135 for examples). Poorest subsurface penetration was predominantly along the eastern regions of the survey area (Transects 101- 121 for example). The following are data examples from these two regions.



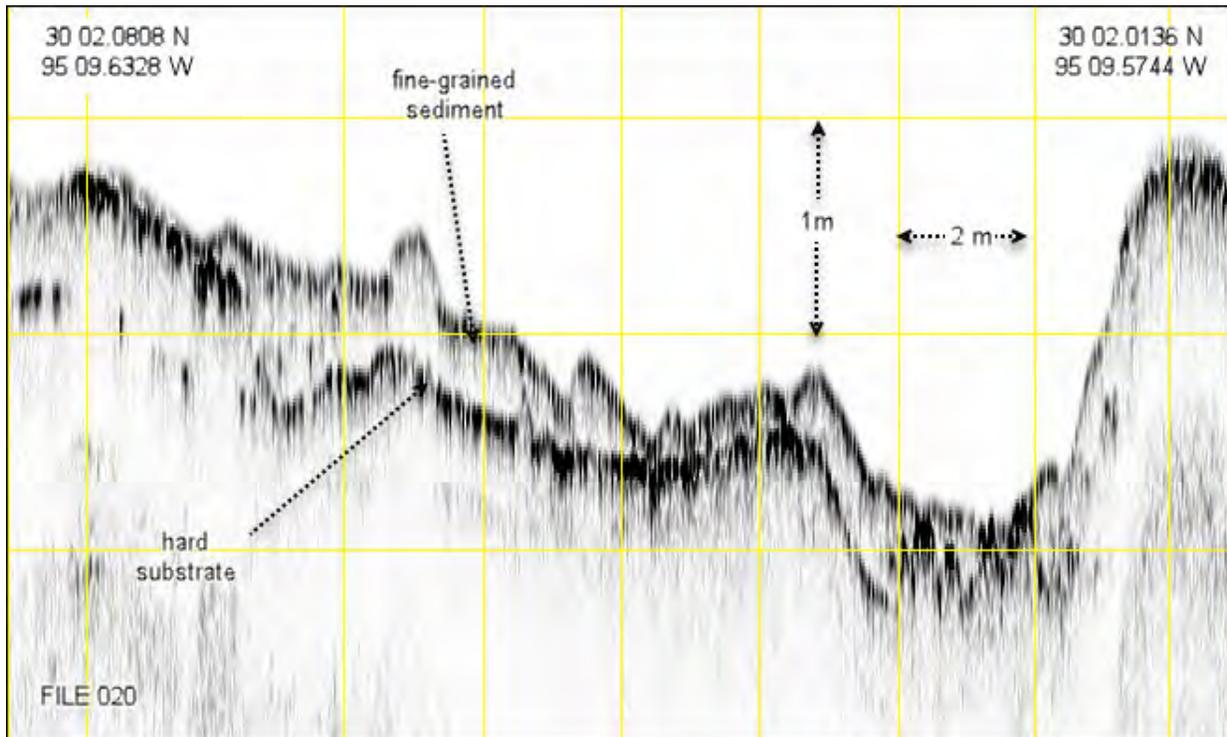
Numerous multiple reflections with no subsurface penetration. Suggest hard substrate or the presence of organic material. Will need to verify with coring (Line 101).



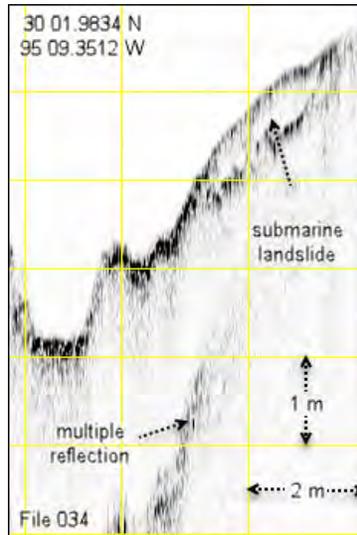
Multiple reflections on the left and good subbottom penetration on the right side of the image (Line 110)



Migrating sand waves over hard substrate (Line 133)



Excellent subsurface penetration over hard substrate material (Line 130)



Submarine landslide. These may be a source of a significant amount of sediment (L 126)

6. SUMMARY OF THE SUBBOTTOM INVESTIGATION

Subsurface penetration varied from a maximum of approximately 1.5 m to little or no penetration that coincided with numerous multiple reflections from the lake floor. The results from the sampling program will be able to verify the general nature of the sediment (fine-grained, dense and compacted, organic etc.) under each of these conditions.

A previous study in Lake Houston (Volumetric and Sedimentation Survey of Lake Houston, December 2011, Texas Water Development Board) was able to obtain sediment samples using the same vibrocore proposed for this project. Some information from that study may provide baseline sediment characteristics (pre-Harvey) to help interpret the more recent hurricane deposits

7. LIMITATIONS

This report presents a general summary of the characteristics of the high-resolution subbottom reflection data acquired on this survey. The interpreted results of the data, and preparation of isopach maps of the sediment deposited by Hurricane Harvey will be provided by others. The findings and statements presented in this summary report reflect my professional judgement and opinions and should not be considered as scientific or engineering certainties.

Dick Sylwester (Registered Engineering Geologist)
 Senior Marine Geophysicist
 Northwest Geophysical Service

APPENDIX C

CORE LOGS AND PHOTOS

FIELD SEDIMENT LOG

LH-01

Project: Lake Houston		Coordinates: Lat: 30.03813173 Units: Decimal Degrees Long: -95.15637693 Horizontal Datum: WGS84	
Project Number: 194-9189		Channel Bed Elevation: 37.1 ft Vertical Datum: NAVD88	
Coring Date: 3/5/19	Logging Date: 3/5/19	Core Diameter: 3.625 in	Core Type: Vibracore Driller: CRA
Logger: MEB	Logging Comments:		

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 36.1		USCS: ML, USDA: Silt 10% Sand, 85% Silt, 5% Clay, Dark Gray to Black (2.5Y 4/1 to 5Y 2.5/1), Low Plasticity, Very Soft Consistency, Homogenous Structure, Slight Organic Odor. 1.5 - 1.8 ft sublayer of higher fine sand content. 4.1ft is a thin lens of secondary color and continues at irregular intervals until the bottom of the layer. This layer had a higher water content from 0 - 1.4 ft.		99%	
2 35.1					
3 34.1					
4 33.1					
5 32.1					5.4
6 31.1		USCS: SM, USDA: Loamy Fine Sand 85% Sand, 15% Silt, 0% Clay, Dark Gray (2.5Y 4/1), Non-Plastic, Homogenous Structure, >10% Wood	31.7		
7 30.1			5.9		
8 29.1		USCS: ML, USDA: Silt 0% Sand, 90% Silt, 10% Clay, Dark Gray (2.5Y 4/1), Low Plasticity, Very Soft Consistency, Homogenous Structure	31.2		
9 28.1					
10 27.1				9.9	

Coring Depth: 10.0 ft, Coring Depth Elevation: 27.1 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOER\DOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring **Water Depth:** 4.2 ft **Water Surface Elevation:** 41.3 ft

FIELD SEDIMENT LOG

LH-02

Project: Lake Houston		Coordinates: Lat: 30.0371144 Long: -95.16025474		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.1 ft		Horizontal Datum: WGS84	
Coring Date: 3/5/19		Logging Date: 3/5/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments: 4.2 feet of recovery		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Lithology	Material Description	Depth (ft)	Sediment Core(s)	Remarks and Other Tests
Elev. (ft)			Elev. (ft)	Core sections with recovery	
1 36.1		USCS: ML, USDA: Silt Loam 20% Sand, 80% Silt, 0% Clay, Very Dark Gray (2.5Y 3/1), Non-Plastic, Very Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Twigs	0.9 36.2	86%	
2 35.1		USCS: SM, USDA: Loamy Sand 90% Sand, 10% Silt, 0% Clay, Very Dark Gray to Dark Gray (5Y 3/1 to 2.5Y 4/1), Non-Plastic, Homogenous Structure, 6-10% Twigs, Wood	2.2 34.9		
3 34.1		USCS: SP, USDA: Fine Sand 100% Sand, 0% Silt, 0% Clay, Grayish Brown (2.5Y 5/2), Homogenous Structure	4.2 32.9		
4 33.1					

Coring Depth: 4.9 ft, Coring Depth Elevation: 32.2 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERIDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 4.2 ft

Water Surface Elevation: 41.3 ft

LH-03

Project: Lake Houston		Coordinates: Lat: 30.03687266 Long: -95.15086067		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 39.4 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 38.4		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Gray (5Y 6/1), Non-Plastic, Homogenous Structure	1.2 38.3		
2 37.4		USCS: SM, USDA: Very Fine Sandy Loam 60% Sand, 35% Silt, 5% Clay, Dark Gray (2.5Y 4/1), Non-Plastic, Lensed Structure - Multiple sand lenses throughout layer, 6-10% Plant Fragments, 1-5% Roots, Twigs, Wood	3.6 35.8		
3 36.4			4.3 35.1		
4 35.4		USCS: SM, USDA: Loamy Fine Sand 80% Sand, 20% Silt, 0% Clay, Light Brownish Gray to Grayish Brown (2.5Y 6/2 to 10YR 5/2), Non-Plastic, Lensed Structure - Lens of silt, depth 3.8-3.9 ft.	5.0 34.4		
5 34.4			6.4 33.0		
6 33.4		USCS: ML, USDA: Silt 5% Sand, 90% Silt, 5% Clay, Olive Gray (5Y 4/2), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Wood			
		USCS: CL, USDA: Loam 40% Sand, 45% Silt, 15% Clay, Dark Gray to Olive Gray (2.5Y 4/6 5Y 4/2), Medium Plasticity, Hard Consistency, Homogenous Structure - Increasing sand volume with depth, 1-5% Roots			

Coring Depth: 6.5 ft, Coring Depth Elevation: 32.9 ft

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 2.0 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-04A

Project: Lake Houston		Coordinates: Lat: 30.03603734 Long: -95.15714831		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.2 ft		Horizontal Datum: WGS84	
Coring Date: 3/8/19		Logging Date: 3/8/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Elev. (ft)	Lithology	Material Description	Depth (ft)	Elev. (ft)	Sediment Core(s)	Remarks and Other Tests
1	36.2	[Cross-hatched pattern]	USCS: SP, USDA: Fine Sand 95% Sand, 5% Silt, 0% Clay, Light Gray to Gray (2.5Y 7/2 to 2.5Y 6/1), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments, 1-5% Twigs, Wood Silt loam sublayer, depth 3.55-3.75 ft.			100%	
2	35.2						
3	34.2	[Vertical lines pattern]	USCS: ML, USDA: Silt Loam 10% Sand, 75% Silt, 15% Clay, Grayish Brown to Light Brownish Gray (2.5Y 5/2 to 2.5Y 6/2), Low Plasticity, Soft Consistency, Stratified Structure - Alternating sand and silt loam., 1-5% Plant Fragments Sand sublayers at depths 5.3-5.55 ft and 6.9-7.1 ft.			100%	
4	33.2						
5	32.2						5.0
6	31.2					100%	
7	30.2			7.1	30.1		

Coring Depth: 7.2 ft, Coring Depth Elevation: 30.0 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERIDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 4.2 ft

Water Surface Elevation: 41.4 ft

630 Riverfront Dr, Suite 100
 Sheboygan, WI 53081

FIELD SEDIMENT LOG



Sheet 1 of 1

LH-05

Project: Lake Houston		Coordinates: Lat: 30.03571565 Long: -95.14636008		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.5 ft		Horizontal Datum: WGS84	
Coring Date: 3/5/19		Logging Date: 3/5/19		Core Diameter: 3.625 in	
Logger: MEB		Core Type: Vibracore		Driller: CRA	
Logging Comments:					

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
--------------------------	-----------	----------------------	--------------------------	---	-------------------------

1 37.5		USCS: CH, USDA: Clay 1% Sand, 9% Silt, 90% Clay, Gray to Light Olive Yellow (5Y 5/1 to 2.5Y 5/6), High Plasticity, Hard Consistency, Homogenous Structure, 1-5% Roots, Twigs, Wood	0.5 38.0	 55%	
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Coring Depth: 1.1 ft, Coring Depth Elevation: 37.4 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERIDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

Core Segment (with % recovery)

**Water Level Observations
 At Time Of Coring**

Water Depth: 2.8 ft

Water Surface Elevation: 41.3 ft

FIELD SEDIMENT LOG

LH-06

Project: Lake Houston		Coordinates: Lat: 30.03553674 Units: Decimal Degrees Long: -95.15807064 Horizontal Datum: WGS84	
Project Number: 194-9189		Channel Bed Elevation: 36.3 ft Vertical Datum: NAVD88	
Coring Date: 3/7/19	Logging Date: 3/7/19	Core Diameter: 3.625 in	Core Type: Vibracore Driller: CRA
Logger: MEB	Logging Comments:		

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 35.3		USCS: SP, USDA: Coarse Sand 100% Sand, 0% Silt, 0% Clay, Light Gray (5Y 7/2), Homogenous Structure		100%	
2 34.3			3.6 32.7		
3 33.3			5.0 31.3		
4 32.3		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Olive Gray (5Y 4/2), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	6.1 30.2		
5 31.3			6.4 29.9		
6 30.3		USCS: SP, USDA: Fine Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (2.5Y 7/2), Non-Plastic, Homogenous Structure, 1-5% Wood			
		USCS: ML, USDA: Silt Loam 5% Sand, 80% Silt, 15% Clay, Dark Gray (2.5Y 4/1), Medium Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, Slight Organic Odor.			
Coring Depth: 6.4 ft, <i>Coring Depth Elevation: 29.9 ft</i>					

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 5.2 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-07

Project: Lake Houston		Coordinates: Lat: 30.03540975 Long: -95.14779686		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 39.0 ft		Horizontal Datum: WGS84	
Coring Date: 3/5/19		Logging Date: 3/5/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 38.0		USCS: SP, USDA: Sand 100% Sand, 0% Silt, 0% Clay, Light Gray (2.5Y 7/1), Homogenous Structure, 1-5% Plant Fragments			
2 37.0		USCS: ML, USDA: Silt Loam 5% Sand, 85% Silt, 10% Clay, Dark Gray (10YR 4/1), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	2.3 36.7		
3 36.0					
4 35.0					
5 34.0					
6 33.0		USCS: CL, USDA: Silty Clay Loam 15% Sand, 50% Silt, 35% Clay, Dark Gray (10YR 4/1), High Plasticity, Firm Consistency, Homogenous Structure, 6-10% Plant Fragments, 1-5% Twigs	5.7 33.3		
7 32.0			6.6 32.4		

Coring Depth: 7.0 ft, Coring Depth Elevation: 32.0 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOER\DOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 2.3 ft

Water Surface Elevation: 41.3 ft

630 Riverfront Dr, Suite 100
Sheboygan, WI 53081

FIELD SEDIMENT LOG



Sheet 1 of 1

LH-08

Project: Lake Houston		Coordinates: Lat: 30.03539705 Long: -95.15659751		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.3 ft		Horizontal Datum: WGS84	
Coring Date: 3/7/19		Logging Date: 3/7/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Elev. (ft)	Lithology	Material Description	Depth (ft)	Elev. (ft)	Sediment Core(s)	Remarks and Other Tests
1	37.3		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Brownish Gray to Pale Brown (2.5Y 6/2 to 2.5Y 7/3), Non-Plastic, Lensed Structure - Lens of silt at 0.9-1.0 ft. Lens of silt.			75% <small>Core sections with recovery</small>	
2	36.3						
3	35.3						
4	34.3						
5	33.3						
6	32.3						
7	31.3						

Coring Depth: 7.0 ft, Coring Depth Elevation: 31.3 ft

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Core Legend



Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 3.2 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-09

Project: Lake Houston		Coordinates: Lat: 30.03468194 Long: -95.14721843		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.8 ft		Horizontal Datum: WGS84	
Coring Date: 3/5/19		Logging Date: 3/5/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Elev. (ft)	Lithology	Material Description	Depth (ft)	Elev. (ft)	Sediment Core(s)	Remarks and Other Tests
1	37.8		USCS: SP, USDA: Sand 100% Sand, 0% Silt, 0% Clay, Gray (2.5Y 5/1), Homogenous Structure				
2	36.8		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Dark Gray (2.5Y 4/1), Low Plasticity, Very Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	2.4	36.4	79% Core sections with recovery	
3	35.8						
4	34.8						
5	33.8		USCS: CL, USDA: Silty Clay Loam 15% Sand, 55% Silt, 30% Clay, Gray to Reddish Brown (5Y 5/1 to 5YR 5/3), Medium Plasticity, Firm Consistency, Homogenous Structure, 1-5% Roots, Twigs	4.7	34.1		
6	32.8			5.5	33.3		
7	31.8						

Coring Depth: 7.0 ft, Coring Depth Elevation: 31.8 ft

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 2.5 ft

Water Surface Elevation: 41.3 ft

FIELD SEDIMENT LOG

LH-10

Project: Lake Houston		Coordinates: Lat: 30.0345356 Long: -95.15553363		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.3 ft		Horizontal Datum: WGS84	
Coring Date: 3/7/19		Logging Date: 3/7/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 36.3		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Brownish Gray to Pale Brown (2.5Y 6/2 to 2.5Y 7/3), Non-Plastic, Lensed Structure - Small lens of silt at 0.9 ft. Thin lens of silt.	4.4 32.9	 63%	
2 35.3					
3 34.3					
4 33.3					
5 32.3					
6 31.3					
7 30.3					

Coring Depth: 7.0 ft, Coring Depth Elevation: 30.3 ft

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Core Legend



Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

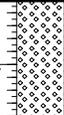
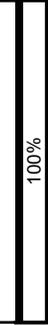
Water Depth: 4.2 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-11

Project: Lake Houston		Coordinates: Lat: 30.03443591 Long: -95.1602965		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 34.7 ft		Horizontal Datum: WGS84	
Coring Date: 3/7/19		Logging Date: 3/7/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 33.7		USCS: SP, USDA: Coarse Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (2.5Y 7/2), Non-Plastic, Homogenous Structure	2.0 32.7	 100%	
2 32.7		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Grayish Brown to Dark Gray (2.5Y 5/2 to 2.5Y 4/1), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	3.6 31.1		
3 31.7		USCS: ML, USDA: Silt Loam 20% Sand, 70% Silt, 10% Clay, Grayish Brown to Light Brownish Gray (2.5Y 5/2 to 2.5Y 6/2), Low Plasticity, Soft Consistency, Lensed Structure - Sand lens, depth 4.4-4.55 ft, 1-5% Plant Fragments Sand lens.	4.6 30.1		
4 30.7		USCS: ML, USDA: Silt 5% Sand, 90% Silt, 5% Clay, Dark Gray (5Y 4/1), Low Plasticity, Soft Consistency, Homogenous Structure	4.9 29.8		
5 29.7					

Coring Depth: 5.0 ft, Coring Depth Elevation: 29.7 ft

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Core Legend



Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 6.8 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-12

Project: Lake Houston		Coordinates: Lat: 30.03436433 Long: -95.15686344		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 35.8 ft		Horizontal Datum: WGS84	
Coring Date: 3/7/19		Logging Date: 3/7/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Lithology	Material Description	Depth (ft)	Sediment Core(s)	Remarks and Other Tests
Elev. (ft)			Elev. (ft)	Core sections with recovery	
1		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Gray to Light Brownish Gray (2.5Y 7/2 to 2.5Y 6/2), Non-Plastic, Homogenous Structure - Lens of organic debris, depth 0.75-1.0 ft., 1-5% Plant Fragments, 6-10% Wood		 100%	
34.8					
2					
3					
3					
32.8					
4					
31.8		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Dark Gray (5Y 4/1), Low Plasticity, Soft Consistency, Homogenous Structure	3.9 31.9 4.1 31.7		

Coring Depth: 4.2 ft, Coring Depth Elevation: 31.6 ft

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 5.7 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-13A

Project: Lake Houston		Coordinates: Lat: 30.03385448 Long: -95.15393421		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.1 ft		Horizontal Datum: WGS84	
Coring Date: 3/8/19		Logging Date: 3/8/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 36.1		USCS: SP, USDA: Fine Sand 90% Sand, 10% Silt, 0% Clay, Light Gray to Grayish Brown (2.5Y 7/2 to 2.5Y 5/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments	1.6 35.5 2.2 34.9	100%	
2 35.1		USCS: SM, USDA: Very Fine Sandy Loam 65% Sand, 25% Silt, 10% Clay, Gray (5Y 5/1), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments	3 34.1 4 33.1		
3 34.1		USCS: ML, USDA: Silt Loam 10% Sand, 80% Silt, 10% Clay, Olive Gray to Light Gray (5Y 5/0 2.5Y 7/2), Non-Plastic, Soft Consistency, Homogenous Structure Silty sand lens at depth 3.8-4.05 ft.	5 32.1 6 31.1 7 30.1		
4 33.1		USCS: SM, USDA: Loamy Fine Sand 80% Sand, 20% Silt, 0% Clay, Light Brownish Gray (2.5Y 6/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments, 6-10% Wood	8 29.1		
5 32.1		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Gray (2.5Y 5/1), Low Plasticity, Soft Consistency, Lensed Structure - Two small pockets of organics and sand., 1-5% Plant Fragments, 1-5% Roots	9 28.1 9.6 27.6		

Coring Depth: 9.6 ft, Coring Depth Elevation: 27.5 ft

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 4.3 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-14

Project: Lake Houston		Coordinates: Lat: 30.03415274 Units: Decimal Degrees Long: -95.15869552 Horizontal Datum: WGS84	
Project Number: 194-9189		Channel Bed Elevation: 34.1 ft Vertical Datum: NAVD88	
Coring Date: 3/7/19 Logging Date: 3/7/19		Core Diameter: 3.625 in	Core Type: Vibracore Driller: CRA
Logger: MEB	Logging Comments:		

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 33.1		USCS: SP, USDA: Coarse Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (5Y 7/2), Non-Plastic, Homogenous Structure - Increasing grain size with depth., 5% Subrounded, Subangular Medium Gravel	2.5 31.6	100%	
2 32.1		USCS: ML, USDA: Silt Loam 20% Sand, 70% Silt, 10% Clay, Gray (5Y 5/1), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	3.6 30.5		
3 31.1		USCS: SP, USDA: Fine Sand 90% Sand, 10% Silt, 0% Clay, Light Brownish Gray (2.5Y 6/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments, 1-5% Twigs	3.9 30.2		
4 30.1		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Grayish Brown (2.5Y 5/2), Medium Plasticity, Firm Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Roots, Twigs, Wood	4.4 29.7		
Coring Depth: 4.5 ft, <i>Coring Depth Elevation: 29.6 ft</i>					

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

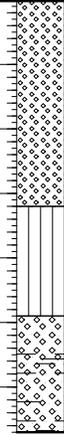
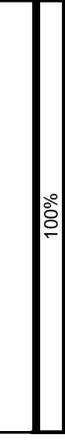
Water Depth: 7.4 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-15

Project: Lake Houston		Coordinates: Lat: 30.03383045 Long: -95.14655902		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.0 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Elev. (ft)	Lithology	Material Description	Depth (ft)	Elev. (ft)	Sediment Core(s)	Remarks and Other Tests
1	37.0		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Olive Gray (5Y 6/2), Non-Plastic, Homogenous Structure				
2	36.0			3.2	34.8		
3	35.0				4.9		33.1
4	34.0		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Dark Gray to Black (2.5Y 4/1 to 2.5Y 2.5/1), Low Plasticity, Soft Consistency, Lensed Structure - Lens of sand., 1-5% Plant Fragments Depth 3.3-3.5 ft sublayer of increased sand content.				
5	33.0			6.7	31.3		
6	32.0		USCS: SM, USDA: Sandy Loam 80% Sand, 15% Silt, 5% Clay, Gray (5Y 5/1), Non-Plastic, Homogenous Structure				

Coring Depth: 6.7 ft, Coring Depth Elevation: 31.3 ft

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 3.4 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-16

Project: Lake Houston		Coordinates: Lat: 30.03279717 Long: -95.1540146		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 36.7 ft		Horizontal Datum: WGS84	
Coring Date: 3/7/19		Logging Date: 3/7/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Lithology	Material Description	Depth (ft)	Sediment Core(s)	Remarks and Other Tests
Elev. (ft)			Elev. (ft)	Core sections with recovery	
1 35.7		USCS: SP, USDA: Coarse Sand 95% Sand, 5% Silt, 0% Clay, Light Brownish Gray to Pale Brown (2.5Y 6/2 to 2.5Y 7/3), Non-Plastic, Homogenous Structure	2.0 34.7	 100%	
2 34.7		USCS: ML, USDA: Silt 5% Sand, 85% Silt, 10% Clay, Gray (5Y 5/1), Non-Plastic, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Twigs, Roots	4.4 32.3		
3 33.7		USCS: SM, USDA: Loamy Fine Sand 80% Sand, 15% Silt, 5% Clay, Light Brownish Gray (2.5Y 6/2), Non-Plastic, Homogenous Structure	5.1 31.6		
4 32.7		USCS: SM, USDA: Very Fine Sandy Loam 55% Sand, 35% Silt, 10% Clay, Gray (2.5Y 6/1), Low Plasticity, Lensed Structure - Lens of sand, depth 5.7-6.0 ft., 1-5% Roots Lens of sand.	7.0 29.7		

Coring Depth: 7.0 ft, Coring Depth Elevation: 29.7 ft

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

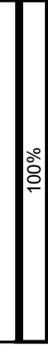
Water Depth: 4.8 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-17

Project: Lake Houston		Coordinates: Lat: 30.03257106 Long: -95.16149852		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 31.2 ft		Horizontal Datum: WGS84	
Coring Date: 3/8/19		Logging Date: 3/8/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Lithology	Material Description	Depth (ft)	Sediment Core(s)	Remarks and Other Tests
Elev. (ft)			Elev. (ft)	Core sections with recovery	
1		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (2.5Y 7/2), Non-Plastic, Homogenous Structure	1.3		
30.2			29.9		
2		USCS: ML, USDA: Silt Loam 15% Sand, 80% Silt, 5% Clay, Dark Grayish Brown to Gray (2.5Y 4/2 to 5Y 6/1), Non-Plastic, Soft Consistency, Lensed Structure - Dense loamy sand at depth 1.65-1.75 ft., 1-5% Plant Fragments	2.1		
29.2			29.1		
3					
4	USCS: SP, USDA: Fine Sand 90% Sand, 10% Silt, 0% Clay, Light Gray to Olive Gray (2.5Y 7/2 to 5Y 5/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments Sandy loam at depth 2.9-3.15 ft.	Coring Depth: 5.3 ft, <i>Coring Depth Elevation: 25.9 ft</i>	5.3		
27.2			25.9		
5					
26.2					

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 10.2 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-18

Project: Lake Houston		Coordinates: Lat: 30.03217919 Long: -95.1504467		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 39.5 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 38.5		USCS: SP, USDA: Coarse Sand 100% Sand, 0% Silt, 0% Clay, Light Gray (2.5Y 7/2), Homogenous Structure		 93%	
2 37.5					
3 36.5			3.7 35.8		
4 35.5		USCS: ML, USDA: Silt Loam 15% Sand, 70% Silt, 15% Clay, Olive Gray to Light Brownish Gray (5Y 5/2 to 2.5Y 6/2), Low Plasticity, Soft Consistency, Lensed Structure - Two sand lenses. Top lens depth 4.95-5.05 ft. Lower lens depth 5.5-5.8 ft., 1-5% Plant Fragments, 1-5% Roots, Twigs, Slight Organic Odor.			
5 34.5		Two sand lenses.	6.4 33.1		
6 33.5					
7 32.5					

Coring Depth: 7.0 ft, Coring Depth Elevation: 32.5 ft

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Core Legend



Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

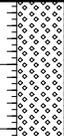
Water Depth: 2.0 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-19

Project: Lake Houston		Coordinates: Lat: 30.03087098 Long: -95.14951108		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.8 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 36.8		USCS: SP, USDA: Sand 100% Sand, 0% Silt, 0% Clay, Light Gray to Pale Brown (5Y 7/2 to 2.5Y 7/3), Homogenous Structure			
2 35.8		USCS: ML, USDA: Silt Loam 10% Sand, 80% Silt, 10% Clay, Grayish Brown (2.5Y 5/2), Non-Plastic, Soft Consistency, Homogenous Structure, 6-10% Plant Fragments, 1-5% Roots, Twigs	2.3 35.5		
3 34.8		USCS: SM, USDA: Loamy Fine Sand 75% Sand, 20% Silt, 5% Clay, Light Olive Gray (5Y 6/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments, 1-5% Roots, Twigs	4.3 33.5		
4 33.8			5.0 32.8		

Coring Depth: 5.1 ft, Coring Depth Elevation: 32.7 ft

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

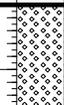
Water Depth: 3.7 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-20

Project: Lake Houston		Coordinates: Lat: 30.03069907 Long: -95.15035581		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.3 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 37.3		USCS: SP, USDA: Coarse Sand 100% Sand, 0% Silt, 0% Clay, Light Gray (5Y 7/2), Homogenous Structure, 1% Subrounded Coarse Gravel, 1-5% Wood	1.7 36.6	100%	
2 36.3		USCS: ML, USDA: Silt Loam 15% Sand, 80% Silt, 5% Clay, Olive Gray (5Y 5/2), Non-Plastic, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Roots	2.8 35.5		
3 35.3		USCS: SM, USDA: Loamy Fine Sand 70% Sand, 30% Silt, 0% Clay, Light Brownish Gray (2.5Y 6/2), Non-Plastic, Homogenous Structure, 1-5% Plant Fragments, 1-5% Charcoal, Twigs	3.9 34.4		
4 34.3		USCS: ML, USDA: Silt Loam 15% Sand, 80% Silt, 5% Clay, Grayish Brown (2.5Y 5/2), Non-Plastic, Soft Consistency, Homogenous Structure, 1-5% Roots, Twigs	5.6 32.7		
5 33.3		USCS: SM, USDA: Loamy Fine Sand 80% Sand, 20% Silt, 0% Clay, Grayish Brown (2.5Y 5/2), Low Plasticity, Homogenous Structure, 1-5% Plant Fragments, 1-5% Wood, Roots, Twigs, Slight Organic Odor.	5.9 32.4		
6 32.3					

Coring Depth: 6.0 ft, Coring Depth Elevation: 32.3 ft

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Core Legend



Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 3.2 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-21

Project: Lake Houston		Coordinates: Lat: 30.0304019 Long: -95.15176909		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 35.5 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Elev. (ft)	Lithology	Material Description	Depth (ft)	Elev. (ft)	Sediment Core(s)	Remarks and Other Tests
1	34.5		USCS: SP, USDA: Sand 90% Sand, 10% Silt, 0% Clay, Light Gray (5Y 7/2), Non-Plastic, Homogenous Structure	0.5	35.0	94%	
2	33.5		USCS: Pt, Olive Gray (5Y 4/2), Non-Plastic, Very Soft Consistency, Homogenous Structure, >10% Plant Fragments, >10% Roots, Twigs, Slight Organic Odor.	0.8	34.7		
3	32.5		USCS: ML, USDA: Silt Loam 15% Sand, 80% Silt, 5% Clay, Olive Gray to Light Brownish Gray (5Y 5/2 to 2.5Y 6/2), Non-Plastic, Very Soft Consistency, Lensed Structure - Lens of sand at depth 1.25-1.4 ft., 1-5% Plant Fragments, 1-5% Roots Loamy sand in lens.	1.7	33.8		
4	31.5		USCS: ML, USDA: Silt 10% Sand, 85% Silt, 5% Clay, Dark Gray (2.5Y 4/1), Non-Plastic, Very Soft Consistency, Homogenous Structure, 6-10% Plant Fragments, 1-5% Wood, Roots	4.0	31.5		
5	30.5		USCS: ML, USDA: Silt 0% Sand, 90% Silt, 10% Clay, Gray to Black (5Y 5/1 to 5Y 2.5/1), Non-Plastic, Soft Consistency, Homogenous Structure, 1-5% Roots	9.3	26.2		
6	29.5						
7	28.5						
8	27.5						
9	26.5						
10	25.5						

Coring Depth: 10.0 ft, Coring Depth Elevation: 25.5 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009 - GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

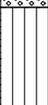
 Core Segment (with % recovery)

Water Level Observations At Time Of Coring **Water Depth:** 6.0 ft **Water Surface Elevation:** 41.5 ft

FIELD SEDIMENT LOG

LH-22

Project: Lake Houston		Coordinates: Lat: 30.03037436 Long: -95.14585552		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 36.2 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft)	Lithology	Material Description	Depth (ft)	Sediment Core(s)	Remarks and Other Tests
Elev. (ft)			Elev. (ft)	Core sections with recovery	
1 35.2		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (5Y 7/2), Non-Plastic, Homogenous Structure			
2 34.2					
3 33.2			3.2		
4 32.2		USCS: ML, USDA: Silt 0% Sand, 95% Silt, 5% Clay, Dark Gray to Very Dark Gray (10YR 4/1 to 10YR 3/1), Low Plasticity, Soft Consistency, Homogenous Structure	33.0		
5 31.2			5.2		
6 30.2			6.5		
7 29.2		USCS: ML, USDA: Silt Loam 5% Sand, 85% Silt, 10% Clay, Gray to Light Olive Yellow (10YR 5/1 to 2.5Y 5/4), High Plasticity, Hard Consistency, Homogenous Structure, 6-10% Roots, Twigs	29.7		

Coring Depth: 7.0 ft, Coring Depth Elevation: 29.2 ft

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 5.2 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-23

Project: Lake Houston		Coordinates: Lat: 30.02679148 Long: -95.1510353		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 31.9 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests	
1 30.9		USCS: ML, USDA: Silt 5% Sand, 90% Silt, 5% Clay, Gray to Black (5Y 5/1 to 5Y 2.5/1), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Wood, Roots, Slight Organic Odor. Wood debris, 4.7-4.85 ft.		99%		
2 29.9						
3 28.9						
4 27.9						
5 26.9		USCS: ML, USDA: Silt 0% Sand, 90% Silt, 10% Clay, Dark Gray (5Y 4/1), Non-Plastic, Very Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Roots, Wood	4.9 27.1			
6 25.9			6.0 25.9			
7 24.9						
8 23.9		USCS: ML, USDA: Silt 0% Sand, 90% Silt, 10% Clay, Dark Gray (5Y 4/1), Low Plasticity, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments	7.9 24.1			

Coring Depth: 8.0 ft, Coring Depth Elevation: 23.9 ft

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Core Legend

 Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 9.5 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-24

Project: Lake Houston		Coordinates: Lat: 30.02524498 Long: -95.14737502		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 38.3 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 37.3		USCS: SP, USDA: Sand 95% Sand, 5% Silt, 0% Clay, Light Gray (2.5Y 7/2), Non-Plastic, Homogenous Structure			
2 36.3					
3 35.3					
4 34.3			4.2 34.2		
5 33.3		USCS: SM, USDA: Loamy Fine Sand 80% Sand, 15% Silt, 5% Clay, Dark Grayish Brown to Light Gray (2.5Y 4/2 2.5Y 7/2), Non-Plastic, Lensed lens 4.4-4.6 ft., 1-5% Plant Fragments, 1-5% Twig	5.1 33.4		Structure - Sand
6 32.3					

Coring Depth: 6.0 ft, Coring Depth Elevation: 32.3 ft

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Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 3.1 ft

Water Surface Elevation: 41.5 ft

FIELD SEDIMENT LOG

LH-25A

Project: Lake Houston		Coordinates: Lat: 30.03261947 Long: -95.14753546		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 37.9 ft		Horizontal Datum: WGS84	
Coring Date: 3/8/19		Logging Date: 3/8/19		Core Diameter: 3.625 in	
Logger: MEB		Logging Comments:		Core Type: Vibracore	
				Driller: CRA	

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) Core sections with recovery	Remarks and Other Tests
1 36.9		USCS: SM, USDA: Fine Sandy Loam 55% Sand, 40% Silt, 5% Clay, Grayish Brown (2.5Y 5/2), Non-Plastic, Homogenous Structure	0.6 37.3 0.9 37.0		
2 35.9		USCS: SP, USDA: Fine Sand 90% Sand, 10% Silt, 0% Clay, Light Brownish Gray (10YR 6/2), Non-Plastic, Homogenous Structure, >10% Wood, Twigs			
3 34.9		USCS: ML, USDA: Silt Loam 10% Sand, 80% Silt, 10% Clay, Dark Grayish Brown to Light Gray (2.5Y 4/2 to 2.5Y 7/2), Non-Plastic, Soft Consistency, Homogenous Structure, 1-5% Plant Fragments, 1-5% Roots, Twigs Two sand lenses at depths 1.5-1.7 ft and 3.2-3.35 ft.	4.1 33.8 4.4 33.6		
4 33.9		USCS: CL, USDA: Silty Clay Loam 10% Sand, 50% Silt, 40% Clay, Grayish Brown (2.5Y 5/2), High Plasticity, Firm Consistency, Homogenous Structure, 6-10% Roots, Wood			
5 32.9					

Coring Depth: 5.0 ft, Coring Depth Elevation: 32.9 ft

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Core Legend



Core Segment (with % recovery)

Water Level Observations
At Time Of Coring

Water Depth: 3.5 ft

Water Surface Elevation: 41.4 ft

FIELD SEDIMENT LOG

LH-26

Project: Lake Houston		Coordinates: Lat: 30.019693 Long: -95.14427145		Units: Decimal Degrees	
Project Number: 194-9189		Channel Bed Elevation: 30.7 ft		Horizontal Datum: WGS84	
Coring Date: 3/6/19		Logging Date: 3/6/19		Core Diameter: 3.625 in	
Logger: MEB		Core Type: Vibracore		Driller: CRA	
Logging Comments:					

Depth (ft) Elev. (ft)	Lithology	Material Description	Depth (ft) Elev. (ft)	Sediment Core(s) <small>Core sections with recovery</small>	Remarks and Other Tests
1 29.7		USCS: SP, USDA: Sand 90% Sand, 10% Silt, 0% Clay, Light Gray (5Y 7/2), Non-Plastic, Homogenous Structure	0.7 30.0	 100%	
2 28.7		USCS: ML, USDA: Silt 0% Sand, 95% Silt, 5% Clay, Dark Gray to Black (5Y 4/1 to 5Y 2.5/1), Non-Plastic, Very Soft Consistency, Homogenous Structure	1.7 29.0		
3 27.7		USCS: ML, USDA: Silt Loam 10% Sand, 75% Silt, 15% Clay, Dark Gray (2.5Y 4/1), High Plasticity, Firm Consistency, Homogenous Structure, 1-5% Plant Fragments	4.0 26.7		
4 26.7					

Coring Depth: 4.2 ft, Coring Depth Elevation: 26.5 ft

LAKE HOUSTON SEDIMENT LOG - MDT - REVISED - 2009+.GDT - 3/27/19 20:05 - C:\USERS\BRAD.SCHROTEN\BOERIDOCUMENTS\GINT\LIBRARIES\LAKE HOUSTON.GPJ

Core Legend

 Core Segment (with % recovery)

**Water Level Observations
At Time Of Coring**

Water Depth: 10.7 ft

Water Surface Elevation: 41.5 ft



LH-01
3-5-19 13 15



LH-Ø2

3-5-19 14:40



0.0

42

LH-Ø3

3-6-19 11:40



LH-4a
3-8-19 11:13



LH-Ø5

3-5-19

17:10



LH-Ø6
3-7-19 15:06



LH-Ø7

3-5-19 16:03

DEWALT

USA

LH-Ø8

3-7-19 11:03



LH-Ø9

3-5-19 16:44



LH-10

3-7-19 11:21



00

4.9

LH-11

3-7-19 14:08



LH-12

3-7-19 15:29

POWERHORSE



LH-13a
3-8-19 11:44



LH-14
3-7-19 14:38

NITRILE
GLOVES
100



LH-15
3-6-19 11:15



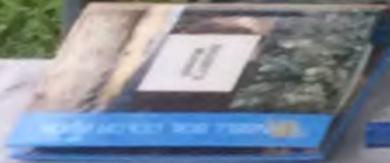
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3-7-19 11:39

NITRILE
GLOVES

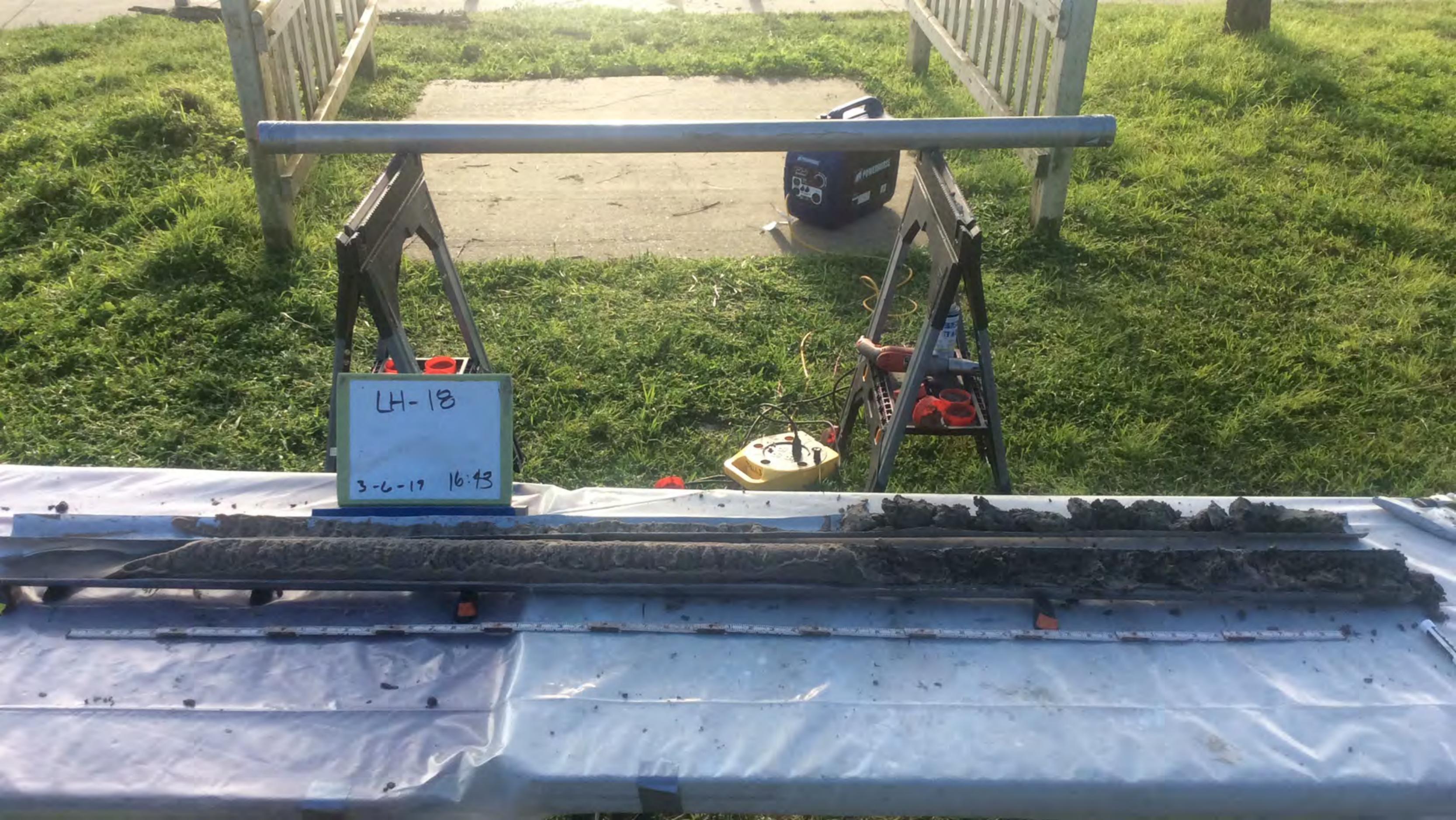
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LH-17
3-8-19 10:43



LH-18

3-6-19 16:43



LH-19
3-6-19 17:05



LH-20
3-6-19 16:11



28

39

44

59





LH-21
3-6-17 15 42



LH-22
3-6-19 10:35



LH-23
3-6-19 13:07

LH-24
3-6-19 13:50



LH-25a

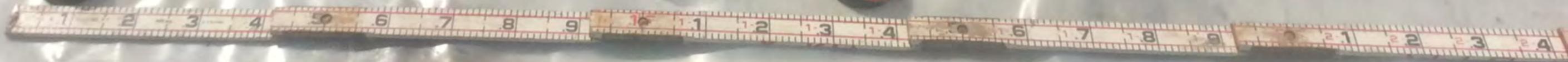
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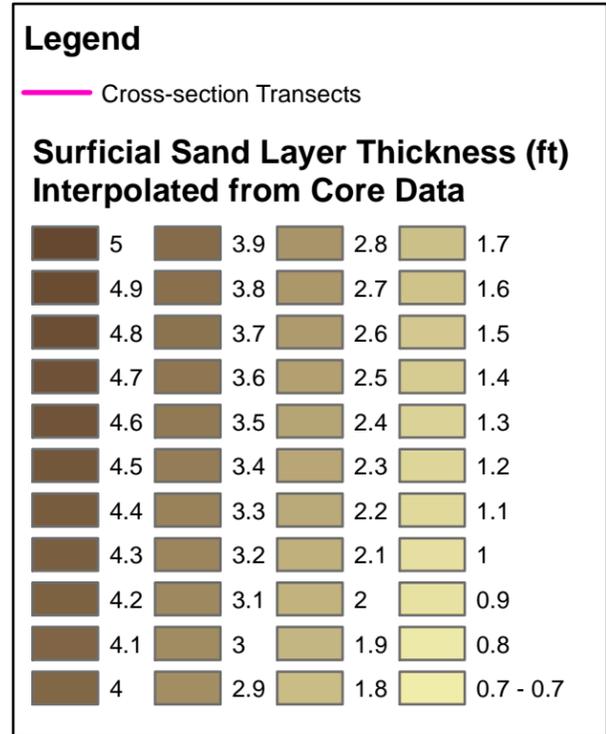
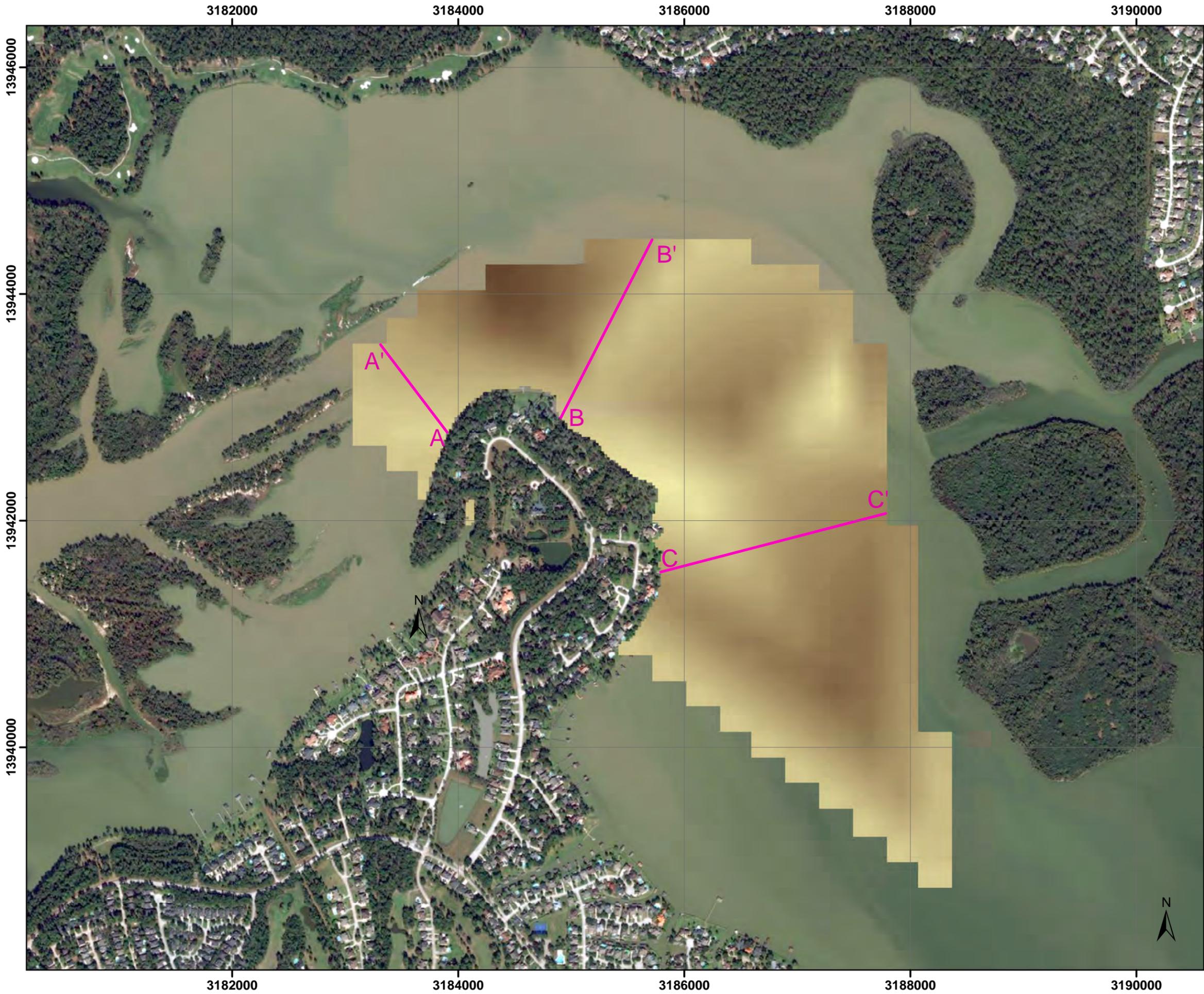
LH-26

3-6-19

14:11



APPENDIX D
PROFILES



- Notes**
1. Coordinate System: NAD83, State Plane Texas S Central, U.S. Survey Feet
 2. Survey Date - February-March, 2019
 3. Sediment cores collected by CRA
 4. Core logging & interpretation done by Tetra Tech
 5. Thickness surface interpolated from surficial sand layer observed in core samples
 6. Cross sections do not include subaerial mouth bar sediments



Lake Houston
Surficial Sand Layer Thickness
Cross-section Transects

1:10,000

0 500 1,000 1,500 2,000
Feet

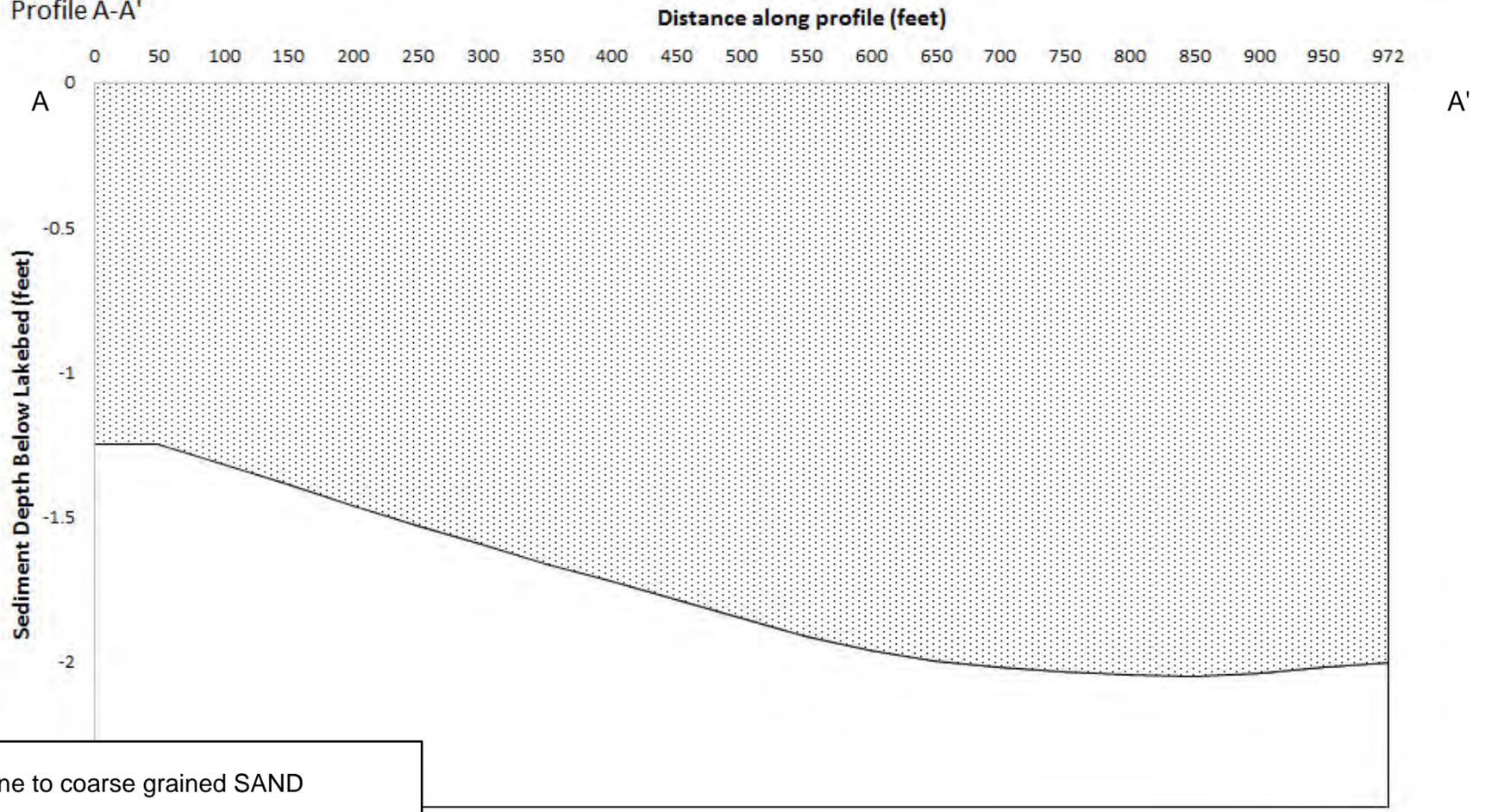



Document Name:
06_XSection_Basemap

Date: 4/5/2019

Chart
6

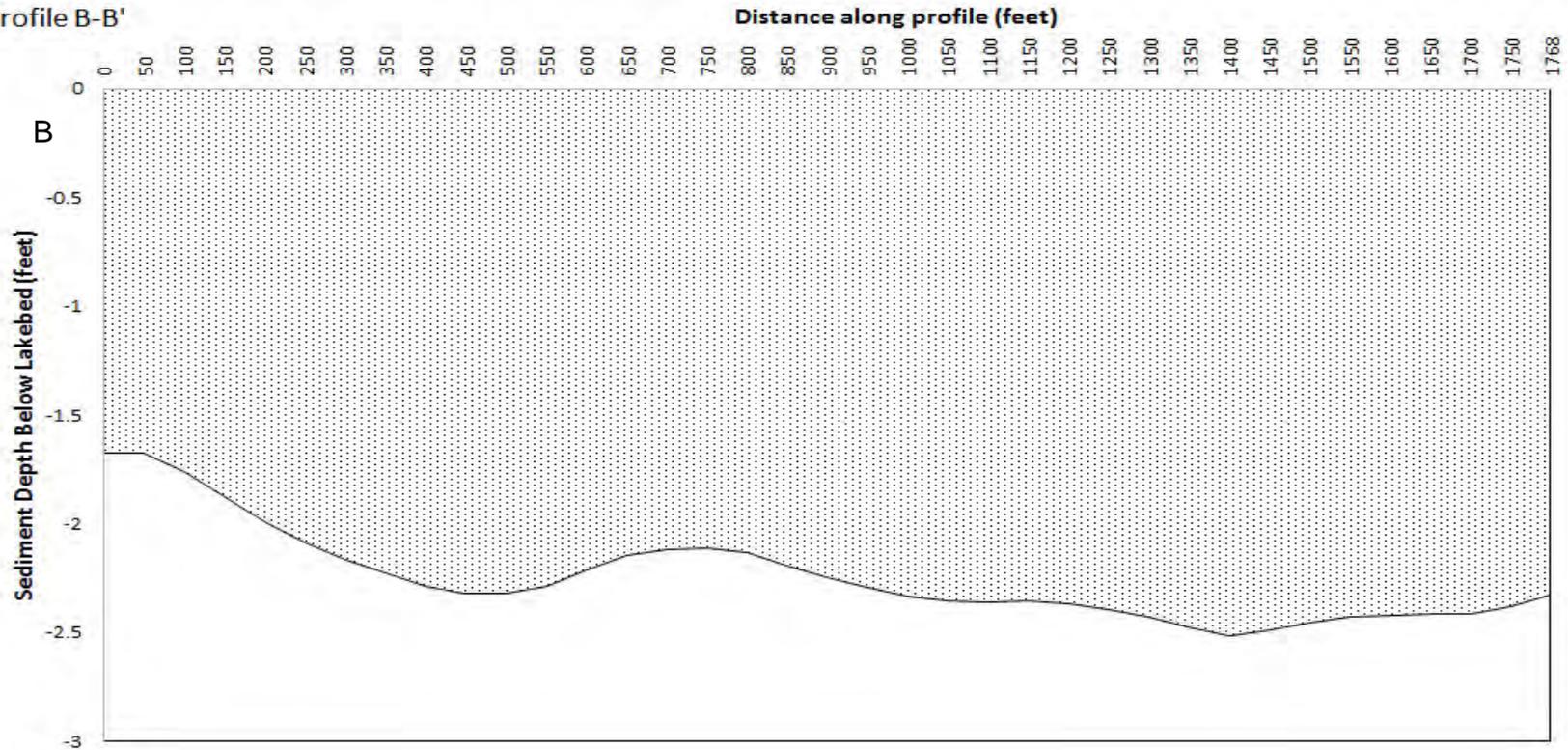
Profile A-A'



 Fine to coarse grained SAND
Sediment depths are relative to lake bed

Typical Cross Section A-A'

Profile B-B'

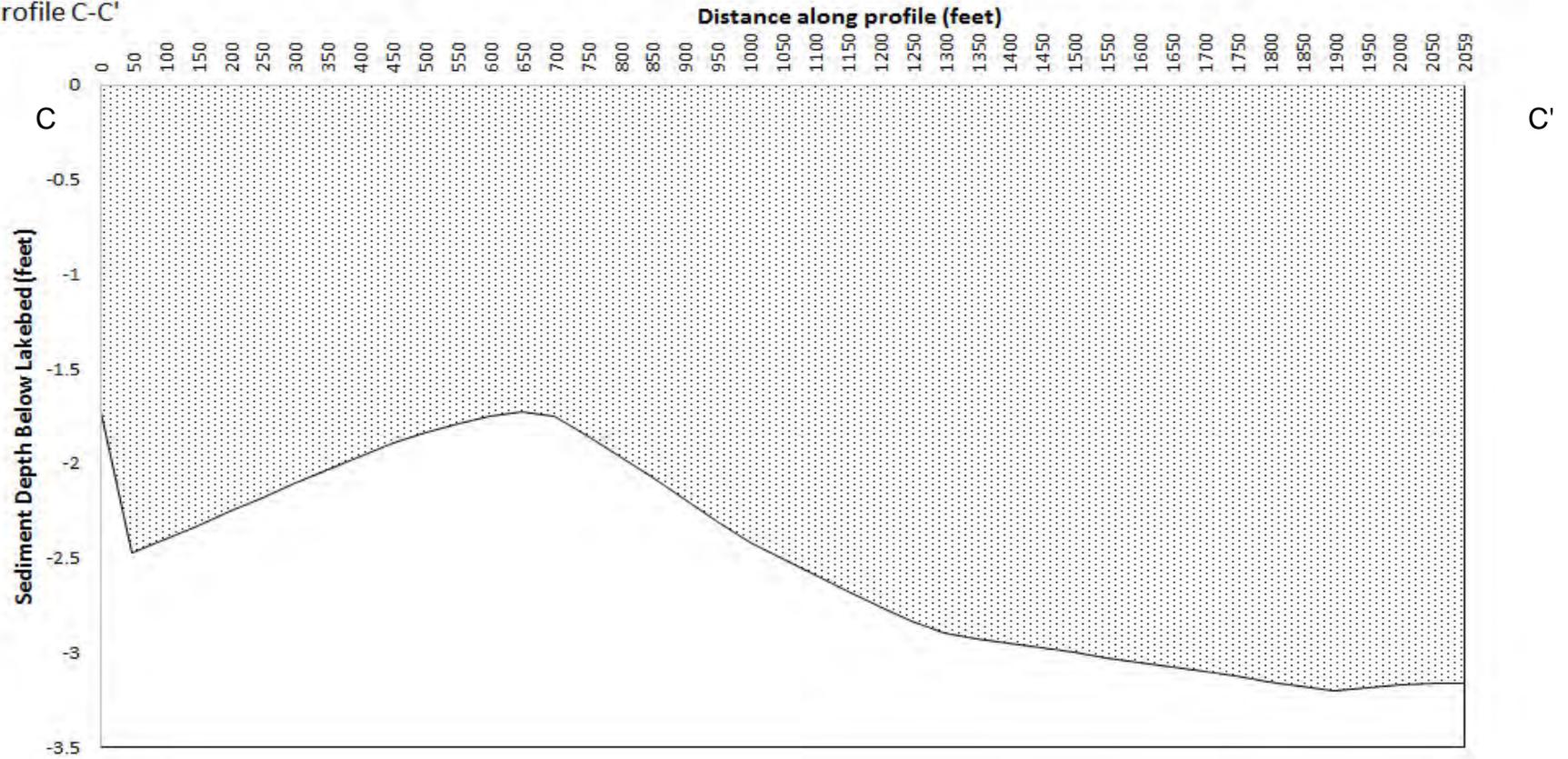


B'

 Fine to coarse grained SAND
Sediment depths are relative to lake bed

Typical Cross Section B-B'

Profile C-C'



Fine to coarse grained SAND

Sediment depths are relative to lake bed

DRAFT

Typical Cross Section C-C'

Lake Houston
Sub-bottom Profiling and Coring

Document Name: 09_XSection_C-CPrime

Date: 4/5/2019

Chart
9

