RESULTS OF THE SUMMER 2002 BATHYMETRIC AND SIDE-SCAN SONAR SURVEY AT THE HISTORIC AREA REMEDIATION SITE

Final Report

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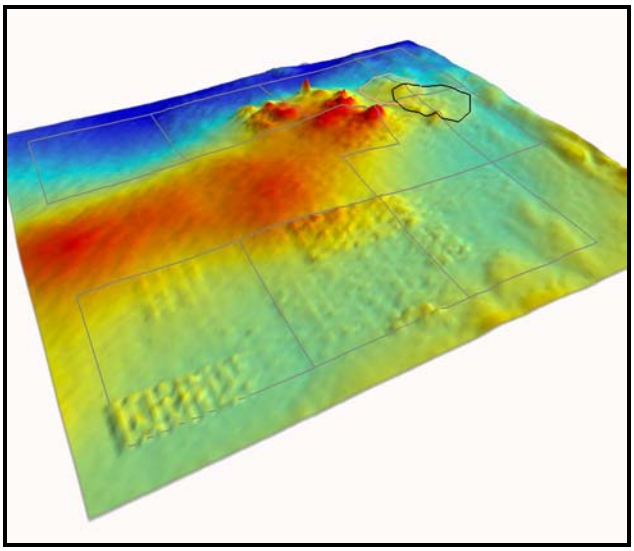

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TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii
LIST OF ACRONYMS iii
LIST OF TABLES iv
LIST OF FIGURES iv

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Survey Objectives 1

2.0 METHODS 3
2.1 Navigation and Survey Control 3
2.2 Bathymetric Survey 3
2.2.1 Bathymetric Data Acquisition 3
2.2.2 Bathymetric Data Processing 6
2.2.2.1 Sound Velocity Corrections 7
2.2.2.2 Tidal (or Water-Level) Corrections 7
2.2.2.3 Cross-Check Comparisons 8
2.2.2.4 Data Reduction 8
2.2.3 Bathymetric Data Analysis and Presentation 8
2.3 Side-Scan Sonar and Sub-bottom Profiling Survey 9
2.3.1 Field Methods 9
2.3.2 Side-Scan Sonar Data Processing and Analysis 10
2.3.3 Sub-bottom Profiling Data Processing and Analysis 10

3.0 RESULTS 11
3.1 Bathymetric Data Quality Review 11
3.1.1 Sound Velocity Analysis 11
3.1.2 Tidal Data Analysis 15
3.1.3 Cross-Check Comparisons 19
3.2 Bathymetric Characterization of the HARS 21
3.2.1 Comparisons with Prior Surveys 21
3.3 Side-Scan Sonar and Sub-bottom Characterization of the HARS 27
3.3.1 Side-Scan Sonar 27
3.3.1.1 2002 Survey Results 27
3.3.1.2 Comparison to Other Data Sets 31
3.3.2 Sub-bottom 39

4.0 DISCUSSION 44

5.0 CONCLUSIONS 48

6.0 REFERENCES 49

APPENDICES

ACKNOWLEDGMENTS

This report presents the results of a combined bathymetric, side-scan sonar, and sub-bottom profile survey conducted over the Historic Area Remediation Site (HARS) located in the inner New York Bight approximately 6 nautical miles east of Sandy Hook, New Jersey. Science Applications International Corporation (SAIC) of Newport, RI conducted the fieldwork from 29 July 2002 through 12 September 2002 under contract to the U.S. Army Corps of Engineers (USACE), New York District (NYD). Dr. Stephen Knowles was the NYD manager of technical activities for this contract and Ray Valente was SAIC's project manager. Dr. Knowles provided logistical and planning support for the survey, with assistance from Mr. Tim LaFontaine of the NYD's Caven Point facility.

All fieldwork was conducted aboard the *R/V Beavertail,* owned and operated by P&M Marine Services of Jamestown, RI. Steve Moreau was the vessel captain and John Lawless was the deckhand during all of the survey operations. The *Beavertail* was based out of the Atlantic Highlands Municipal Marina for the duration of the survey operations. The crew of the *Beavertail* are commended for their skill in vessel handling while conducting all survey operations, as well as their dedication during long hours of operation at the HARS.

Mr. Jeff McKee of the USACE Baltimore District enabled their Datasonics SIS-1000 combined side-scan sonar and sub-bottom profiling system to be used extensively during different portions of this project. The use of this system provided some equipment lease cost savings and also increased the flexibility of the survey schedules. Although some initial problems were encountered due to the older topside processor operating system, the system did provide useful data and should be considered for future work at the HARS.

John Morris, Kurt Rosenberger, Natasha Pinckard, Brian Andrews, Ben Allen, Karen Shufeldt, Kate Montgomery, Pam Luey, and Tom Waddington of SAIC were responsible for mobilizing the bathymetric survey, sub-bottom profiling, side-scan sonar, CTD, and tide gauge equipment and conducting various portions of the survey operations aboard the *Beavertail*.

Kurt Rosenberger, Pam Luey, Brian Andrews, Karen Shufeldt, and Tom Waddington processed the hydrographic survey, side-scan sonar, and sub-bottom profile data and created the resulting graphic data products. Tom Waddington, Brian Andrews, and Karen Shufeldt authored this report and prepared the supporting figures and tables. Ray Valente provided technical oversight and final review of this report. Michelle San Antonio and Megan Thomas of SAIC were responsible for report production.

LIST OF ACRONYMS

CTD	conductivity-temperature-depth
DGPS	Differential Global Positioning System
EPA	Environmental Protection Agency
HARS	Historic Area Remediation Site
m/s	meters per second
MDS	Mud Dump Site
MLLW	Mean Lower Low Water
MTL	mean tide level
NOAA	National Oceanic and Atmospheric Administration
NYD	New York District
OLLD	Ocean and Lake Levels Division
PRA	Priority Remediation Area
SMMP	Site Management and Monitoring Plan
SPI	sediment-profile imaging
TIN	triangulated irregular network
TVG	time varied gain
USACE	U.S. Army Corps of Engineers

LIST OF TABLES

Page

Table 2-1. Summary of Bathymetric, Side-Scan Sonar, and Sub-bottom Profile Survey Operations Aboard the R/V Beavertail at the Historic Area Remediation Site (HARS), Summer 2002 4

Table 3-1. Summary of Observed Tidal Height Differences Between Sandy Hook (Corrected) and the HARS Pressure Tide Gauge 18

LIST OF FIGURES

Figure 1.1-1. Location of the Historic Area Remediation Site in the New York Bight 2

Figure 2.2-1. Survey lanes occupied over the HARS during the summer 2002 single-beam bathymetry, side-scan sonar, and sub-bottom profile survey 5

Figure 3.1-1. Summary of sound velocity profiles generated from the deepest of the CTD casts taken on each field survey day 12

Figure 3.1-2. Vertical profile data from the three CTD casts taken on 18 August 2002 13

Figure 3.1-3. Vertical profile data from the three CTD casts taken on 8 September 2002 14

Figure 3.1-4. Time series comparison of the observed tidal heights from the NOAA Sandy Hook tide gauge (with offset correctors applied) and the HARS pressure tide gauge for the period from 14 through 19 August 2002 17

Figure 3.1-5. Histogram of difference values illustrating the results of the cross-check comparison between the east-west and north-south survey lane sounding data 20

Figure 3.1-6. Color-coded display of the difference points resulting from the cross-check comparison between east-west and north-south survey lane sounding data 22

Figure 3.1-7. Display of all cross-check difference values greater than 2 ft and less than –2 ft over a grid surface depicting percent slope of 2002 bathymetry 23

Figure 3.2-1. Color-coded trackline display of all of the survey lanes occupied during the 2002 bathymetric survey at the HARS 24

Figure 3.2-2. Hill-shaded gridded relief model based on the August 2002 bathymetric survey 25

LIST OF FIGURES (CONTINUED)

Page

Figure 3.2-3. Hill-shaded gridded relief model of the September 1998 bathymetric survey at the HARS over PRAs 1, 2, and 3 (after a sound velocity adjustment was applied) 26

Figure 3.2-4. Bathymetric depth difference between the August 2002 survey and the September 1998 survey over PRAs 1, 2, and 3.....28

Figure 3.2-5. Bathymetric depth difference grid generated between the August 2002 survey and the 1998 survey showing the recorded placement activity over PRAs 1, 2, and 3 between the times of the surveys 29

Figure 3.3-1. Side-scan sonar mosaic (100 kHz) over PRAs 1, 2, 3, and 4 30

Figure 3.3-2. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRAs 1, 2, 3, and 4.....32

Figure 3.3-3. Surface features visible in the side-scan sonar data over PRAs 1, 2, 3 and 4.....33

Figure 3.3-4. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 1 34

Figure 3.3-5. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 2 35

Figure 3.3-6. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 3 36

Figure 3.3-7. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 4 37

Figure 3.3-8. Disposal events recorded between 1 September 1998 and 25 October 2002 over the side-scan sonar mosaic within PRAs 1, 2, 3, and 4 38

Figure 3.3-9. Composite map illustrating the August 2002–September 1998 bathymetric depth difference data overlaid on the side-scan sonar mosaic to demonstrate the correlation between seafloor composition and topography over PRAs 1, 2, 3, and 4.....40

Figure 3.3-10. The map on the left shows disposal events recorded between 4 March 2000 and 25 October 2002 over the 2002 side-scan sonar mosaic 41

LIST OF FIGURES (CONTINUED)

Page

Figure 3.3-11. Comparison graphic of the 2002 side-scan sonar mosaic (left) and the 2000 side-scan sonar mosaic (right) 42

Figure 3.3-12. Features visible in the sub-bottom profile data over PRAs 1, 2, 3, and 4 43

Figure 4-1. The original bathymetric depth difference grids generated between the 2002 survey and the prior surveys over PRA's 1, 2, and 3 and the 1997 Category II Mound Area 46

Figure 4-2. Composite map showing the 2002 bathymetric depth difference (in 3 ft intervals) with disposal events (1 September 1998–31 July 2002) overlaid on the side-scan sonar mosaic to demonstrate accumulating remediation material over PRAs 1, 2, and 3 since 1998.....47

1.0 INTRODUCTION

1.1 Background

Sediments dredged from New York Harbor were deposited at the Mud Dump Site (MDS), located in the New York Bight about six nautical miles east of Sandy Hook, New Jersey, until September 1997. Based on an agreement among the Environmental Protection Agency (EPA), the Department of the Army, and the Department of Transportation, the MDS and some surrounding historical dredged material disposal areas were re-designated as the Historic Area Remediation Site (HARS; Figure 1.1-1) beginning in September 1997.

The HARS SMMP serves as a guideline document for the monitoring of the PRAs during the course of remediation efforts. The recommended routine monitoring tools in the SMMP include high-resolution bathymetry, sediment-profile imaging (SPI), sediment coring, sediment chemistry and toxicity testing, tissue chemistry testing, benthic community analyses, and fish/shellfish surveys. Over the last several years, periodic monitoring surveys have been conducted following the guidelines of the SMMP to document the overall environmental conditions within the HARS. The 2002 field monitoring surveys were the first ones conducted within the HARS since 1999. The primary focus of this report is the broad-scale physical characterization of the entire HARS that was a significant portion of the 2002 monitoring effort. In addition, the 2002 monitoring effort also entailed more detailed environmental monitoring around the 1993 capped dioxin mound, the 1997 capped dioxin mound, and the red clay disposal area. The comprehensive results from each of these smaller area monitoring efforts are presented in three separate companion reports (SAIC 2003a, SAIC 2003b, and SAIC 2003c).

1.2 Survey Objectives

The primary objective for this portion of the 2002 monitoring effort was to obtain an updated broad-scale physical characterization of the entire HARS, including the buffer areas and the no discharge zone. The high-resolution single-beam bathymetry acquired during this effort provided a new baseline dataset that will be used to monitor and plan future placement activity at the HARS. In addition, this broad-scale characterization also provided updated side-scan sonar imagery over the active placement portions of the HARS, including PRAs 1, 2, 3, and 4, as well as the capped mound areas and the red clay disposal area.

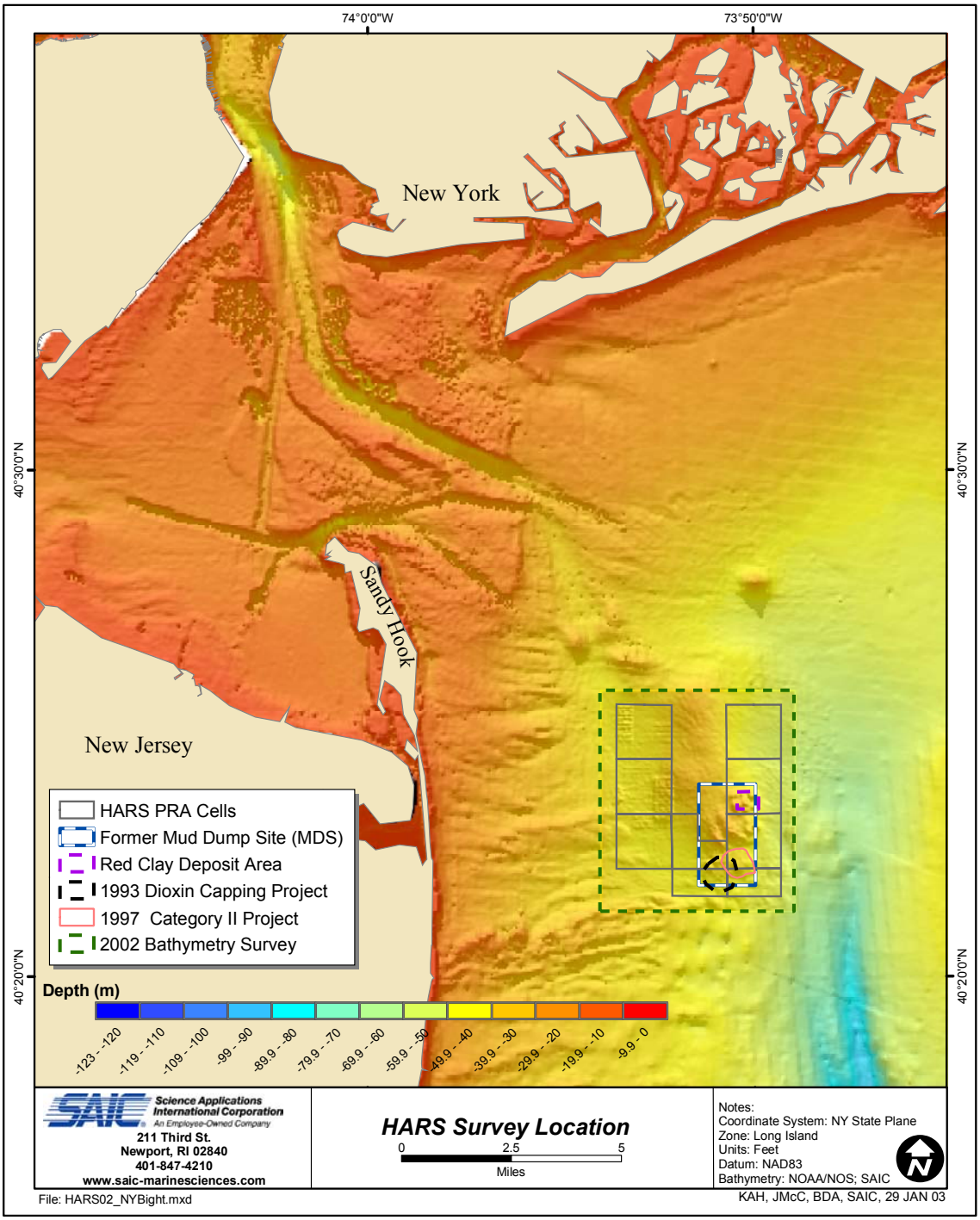


Figure 1.1-1. Location of the Historic Area Remediation Site in the New York Bight. Bathymetric data inside the HARS are from the 2002 single-beam survey. Bathymetric data for all other areas are from the NOAA Coastal Relief Model, Volume 1.

2.0 METHODS

This portion of the 2002 monitoring effort entailed a single-beam bathymetric survey over the entire HARS, as well as side-scan sonar operations over PRA's 1, 2, 3, and 4, the capped dioxin mounds, and the red clay area. A detailed description of the field data acquisition and processing techniques for each of the main survey elements is presented in the sections below. All of the bathymetric and side-scan sonar survey operations were conducted aboard the *R/V Beavertail* that was based out of the Atlantic Highlands Municipal Marina for the duration of these operations that extended from 29 July 2002 through 12 September 2002 (Table 2-1). With the exception of a prolonged period of large easterly swell that occurred from 28 August through 3 September, the survey operations were not affected by any significant weather or equipment-related downtime. Other than the period addressed above, only two complete survey days were lost due to weather, and a few other survey days were shortened due to building southerly seas in the afternoon.

2.1 Navigation and Survey Control

During field operations, a Trimble DSM212L Differential Global Positioning System (DGPS) receiver provided precise navigation data. Because of its proximity to the survey area, the U.S. Coast Guard differential beacon broadcasting from Sandy Hook, NJ was used for generating the real-time differential corrections. During all survey operations, the DGPS system output real-time navigation data (NAD83 Latitude and Longitude) at a rate of once per second to an accuracy of ±3 m.

Coastal Oceanographic's HYPACKMax® survey and data acquisition software was used to provide the real-time interface, display, and logging of the vessel position and depth sounding data. Prior to field operations, HYPACKMax® was used to define a State Plane grid (New York – Long Island State Plane Coordinates) around the survey area and to establish the planned bathymetric and side-scan survey lanes. During the survey operations, the incoming navigation data were translated into state plane coordinates, time-tagged, and stored within HYPACKMax®. Depending on the type of field operations being conducted, the real-time navigation information was displayed in a variety of user-defined modes within HYPACKMax®.

2.2 Bathymetric Survey

2.2.1 Bathymetric Data Acquisition

Single-beam, bathymetric data, meeting the USACE Class I survey standards (USACE 2002), were acquired over the entire HARS, encompassing an area measuring approximately 23,300 ft by 26,600 ft. Depth soundings were acquired continuously along 265 east-west main-scheme survey lanes spaced at 100 ft intervals. In addition, single-beam bathymetric data were also acquired along 51 north-south survey lanes in conjunction with the side-scan sonar and sub-bottom profiling survey operations; the north-south survey lanes provided the data necessary to complete the required cross-check comparisons with the main-scheme bathymetric data (Figure 2.2-1).

Table 2-1.

Summary of Bathymetric, Side-Scan Sonar, and Sub-bottom Profile Survey Operations Aboard the R/V Beavertail at the Historic Area Remediation Site (HARS), Summer 2002

Date	Day Type	Comments
7/28/2002	Mob	Mob survey gear on *Beavertail* alongside in Jamestown, RI
7/29/2002	Mob / Transit	*Beavertail* transit Jamestown to New Haven, CT
7/30/2002	Mob / Transit	*Beavertail* transit New Haven to Atlantic Highlands, NJ
7/31/2002	Survey	HARS EW Mainscheme bathy - Odd, Deploy Tide gauge
8/1/2002	Survey	HARS EW Mainscheme bathy - Odd
8/2/2002	Survey	HARS EW Mainscheme bathy - Odd
8/3/2002	Survey	HARS EW Mainscheme bathy - Odd
8/4/2002	Survey	HARS EW Mainscheme bathy - Odd
8/5/2002	Survey	HARS EW Mainscheme / NS Cross-check (large S swell)
8/6/2002	Weather	20-30kt NW winds
8/7/2002	Survey	HARS EW Mainscheme bathy - Odd
8/8/2002	Survey	HARS EW Mainscheme bathy - Odd / Retrieve Tide gauge to check data
8/9/2002	Survey	HARS EW Mainscheme bathy - Odd / Re-deploy Tide Gauge
8/10/2002	Survey	HARS EW Mainscheme bathy - Odd
8/11/2002	Survey	HARS EW Mainscheme bathy - Odd
8/12/2002	Survey	HARS EW Mainscheme bathy - Odd
8/13/2002	Survey	HARS EW Mainscheme bathy - Finish Odd / Begin Even
8/14/2002	Mob	Highlands to Caven Point and back - load winch, side-scan, and sub-bottom systems
8/15/2002	Weather	20-25kt SW winds, large S swell
8/16/2002	Survey	HARS EW Sub - bathy and sub-bottom over mounds
8/17/2002	Survey	HARS EW Sub - bathy and sub-bottom over mounds
8/18/2002	Survey	HARS EW Sub - bathy and sub-bottom over mounds
8/19/2002	Survey	HARS EW Sub - bathy and sub-bottom over mounds
8/20/2002	Survey	HARS EW Sub - bathy and sub-bottom over mounds
8/21/2002	Survey	HARS EW Mainscheme bathy - Even
8/22/2002	Survey	HARS EW Mainscheme bathy - Even (large S swell)
8/23/2002	Survey	HARS EW Mainscheme bathy - Even
8/24/2002	Survey	HARS EW Mainscheme bathy - Even
8/25/2002	Survey	HARS EW Mainscheme bathy - Even
8/26/2002	Survey	HARS EW Mainscheme bathy - Even
8/27/2002	Survey	HARS EW Mainscheme bathy - Even / Retrieve Tide Gauge
8/28/2002	Weather / Transit	Building Easterly swell - transit Atlantic Highlands to Caven Point
8/29 thru 9/2	Off	Boat moored at Caven Point during extended period of large easterly swell
9/3/2002	Weather / Transit	Subsiding seas - transit Caven Point to Atlantic Highlands
9/4/2002	Survey	HARS EW Mainscheme bathy - Even / Deploy Tide Gauge
9/5/2002	Survey	HARS NS side-scan/sub-bottom, cross-check bathy PRAs 1, 2, and 3
9/6/2002	Survey	HARS NS side-scan/sub-bottom, cross-check bathy PRA 4, dioxin mounds, and red clay area
9/7/2002	Survey	Shark River single beam and side-scan (extended field day)
9/8/2002	Survey	HARS EW Mainscheme bathy - Even
9/9/2002	Survey	HARS EW Mainscheme - Even, data gap fills, tide gauge retrieval
9/10/2002	Demob / Transit	*Beavertail* transit Atlantic Highlands to New Haven, CT
9/11/2002	Weather	30-40 kt NW winds
9/12/2002	Demob / Transit	*Beavertail transit* New Haven to Jamestown, RI
9/13/2002	Demob	Demob survey gear from *Beavertail* alongside in Jamestown, RI

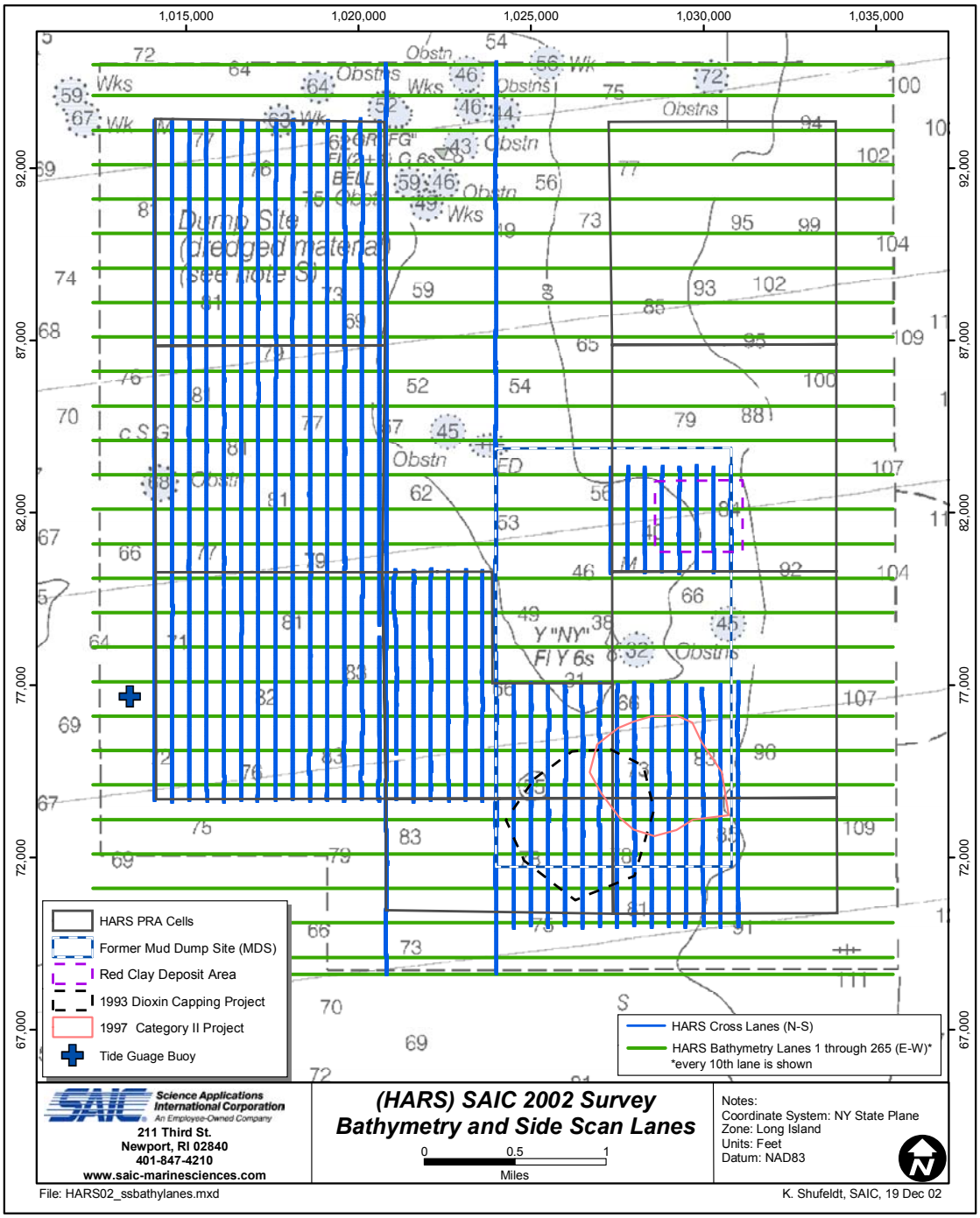


Figure 2.2-1. Survey lanes occupied over the HARS during the summer 2002 single-beam bathymetry, side-scan sonar, and sub-bottom profile survey. Because east-west lanes were closely spaced at 100 ft, only the northernmost, southernmost, and every tenth lane in between are represented on the map.

During the bathymetric survey operations, the HYPACKMax® survey software was interfaced with an Odom Hydrotrac® survey echosounder, as well as the Trimble DGPS. The Hydrotrac® used a narrow-beam (3°), 208-kHz transducer, produced a continuous analog record of the bottom, and transmitted approximately 5 digital depth values per second to HYPACKMax®. Within HYPACKMax®, the time-tagged position and depth data were merged to create continuous depth records along the actual survey track. These records were viewed in real-time to ensure adequate coverage of the survey area.

The echosounder transducer was attached to an over-the-side pole mount that was deployed along the starboard side of the *Beavertail.* An accurate horizontal distance offset was measured between the transducer and DGPS antenna and applied within HYPACKMax® during data acquisition. Though the vessel draft may have changed slightly during the course of the survey operations due to changes in vessel loading (primarily fuel), the transducer draft was maintained at three feet throughout the survey by routinely monitoring the height of the pole. The three-foot draft correction was applied directly to the raw echosounder data within the Hydrotrac® topside recorder and no further draft corrections were applied within HYPACKMax®. Based on settlement and squat tests conducted aboard the *Beavertail* prior to the survey operations, the dynamic draft impacts at standard survey speeds (generally below six knots) were negligible.

A Seabird Electronics SBE-19® conductivity-temperature-depth (CTD) profiler was used to calculate vertical profiles of the water column sound velocity at the beginning, middle, and end of each survey day. On a few of the weather shortened survey days, only two CTD casts were obtained. Typically, at least one of the daily casts was taken in deeper waters along the eastern edge of the survey area to account for the sound velocity over the full range of depths encountered during the survey. These CTD sound velocity data were used to correct the raw echosounder data that were acquired using a constant assumed sound velocity of 4921 ft/sec (1500 m/sec).

To monitor tidal and other water level impacts during this survey, a bottom-mounted tide gauge was deployed along the western buffer zone of the HARS, adjacent to a guard buoy that was deployed by the USACE (Figure 2.2-1). The tide gauge consisted of a calibrated pressure sensor and an internal data logger that recorded a water height above the sensor at six-minute intervals throughout the survey. Data from this gauge were used to make comparisons with the data from the primary National Oceanic and Atmospheric Administration (NOAA) tide gauge at Sandy Hook and to help document non-tidal water level differences between the HARS and Sandy Hook Bay. The tide gauge was deployed just prior to the start of survey operations and was recovered after the completion of the last survey lane. The gauge was checked sporadically during the survey and was also retrieved prior to the one-week down period in late August.

2.2.2 Bathymetric Data Processing

The bathymetric data were fully edited and processed using the HYPACKMax® single-beam data processing modules. Raw position and sounding data were edited as necessary to remove or correct questionable data, sound velocity and draft corrections were applied, and the sounding data was reduced to Mean Lower Low Water (MLLW) using observed tides obtained from NOAA.

2.2.2.1 Sound Velocity Corrections

During bathymetric survey data acquisition, an assumed and constant water column sound velocity of 4921 ft/sec (1500 m/sec) was entered into the Odom echosounder. To account for the variable speed of sound through the water column, daily CTD sound velocity casts were taken at the beginning, middle, and end of each survey day. Each CTD cast was processed to produce a one-meter bin-averaged sound velocity profile from the sea surface down to the depth of the cast. The digital CTD cast data were grouped by day and stored within a master spreadsheet file for additional analysis and eventual export into HYPACKMax®. The results of this daily sound velocity analysis are presented in Section 3.

After the daily sound velocity processing and analysis was completed, the data were used to generate a daily sound velocity profile table within HYPACKMax®. This average sound velocity table was based on a composite of all the casts obtained on a particular day and extended well beyond the deepest depth encountered on the survey. Based on the assumed sound velocity entered into the echosounder during data acquisition and the observed sound velocity reflected in the daily sound velocity profile table, HYPACKMax® computed and applied the required sound velocity corrections to all of the sounding records.

2.2.2.2 Tidal (or Water-Level) Corrections

Observed water level data from the NOAA primary tide station at Sandy Hook, NJ were obtained through NOAA's Ocean and Lake Levels Division's (OLLD) National Water Level Observation Network. The six-minute Sandy Hook tide data were periodically downloaded from the OLLD web site and the appropriate range and phase offsets were applied to transfer these data out to the HARS. Based on conventions used in the past, a phase offset of –45 minutes and a ratio offset of 0.95 were applied to the observed Sandy Hook time and tidal height data. The corrected Sandy Hook water level data were used to create daily tidal corrector files within HYPACKMax® that were then used to reduce all of the sounding data to the MLLW vertical datum.

In addition, the on-site bottom-mounted tide gauge was operational throughout the bathymetric survey operations, and all tide data was successfully recovered from this gauge. Because the HARS tide gauge data were not referenced to any datum, the data had to be reduced to a consistent vertical datum before it could be compared to the Sandy Hook gauge data. In addition, because this gauge was periodically retrieved during the survey to ensure data recovery, the actual datum shifted slightly after each of these redeployments. Because of this slight datum shift, the HARS tide gauge data had to be grouped and analyzed by each of the discrete deployment periods.

Eventually, the adjusted HARS tide gauge data were merged with the corrected Sandy Hook tide gauge data and grouped together by day within a master tidal spreadsheet for additional daily analysis and eventual export into HYPACKMax®. The results of this tide gauge analysis are presented in Section 3.

2.2.2.3 Cross-Check Comparisons

After the bathymetric data were fully edited and reduced to MLLW, cross-check comparisons on overlapping data were performed to verify the proper application of the correctors and to evaluate the overall consistency of the entire data set. Because of the survey pattern used for acquiring the bathymetric survey data (i.e., 265 east-west lanes and 51 north-south lanes), an extensive number of cross-check comparison points were created at the intersections between the different survey lanes. Using the HYPACKMax® Statistics routine it was possible to systematically compute the differences between all points from different survey lanes that fell within a user-specified distance of each other. For this dataset, the cross-check comparison was based on a search radius of 25 ft. The results of this cross-check analysis are presented in Section 3.

The other technique used to evaluate the cross-check agreement for this survey first involved the generation of a triangulated irregular network (TIN) surface model for the east-west bathymetric survey data. This primary TIN model was generated within the HYPACKMax® TIN routine using the mapped xyz file that was created using just the mainscheme east-west survey lanes. In addition to the individual model created from the east-west dataset, a TIN-to-TIN model was also created using both the east-west and north-south data together. The generation of a TIN-to-TIN surface model enabled another type of cross-check comparison technique that essentially superimposed the actual data points from one survey (the sparser north-south survey) onto the modeled surface created from the second survey (the denser east-west survey). The subsequent difference matrix that was created from this TIN-to-TIN comparison could then be analyzed to highlight areas of significant change between the surveys.

2.2.2.4 Data Reduction

After the data were verified through the cross-check comparisons, they were run through the HYPACKMax® Mapper routine to reduce the size of the full data set in a systematic way. Because of the rapid rate at which the survey echosounder generated data (approximately five depths per second during this survey), the along-track data density was very high (multiple soundings per meter). This data set contained many redundant data points that could be eliminated without any effect on the overall quality of the data. The Mapper routine examined the full data set along each survey lane and averaged all data points that fell within a user-specified grid cell to produce a single average value for each cell. The output from this routine was a merged, ASCII-xyz file that was less than 5% of the size of the original data set. This greatly reduced, but still representative, data set was far more efficient to use in the subsequent modeling and analysis routines. In addition, the averaging algorithm helped to filter out the impacts of the sea action that was prevalent during most of the survey operations. For this survey, the data were mapped to an interval of 25 ft for use in all subsequent analyses.

2.2.3 Bathymetric Data Analysis and Presentation

The primary intent of this analysis was to evaluate the seafloor surface defined by the bathymetric data in an attempt to identify any unique features and to account for any observed differences with prior surveys. Because this single-beam bathymetric survey data covered only a small percentage of the total seafloor area (approximately 5%), these analysis tools relied on a

large amount of interpolation between the discrete survey data points in order to generate a three-dimensional seafloor surface model. This interpolation usually works well in flat or gently-sloping areas, but in steep and irregular areas the interpolation of the surface can be very dependent upon the orientation of the survey lanes and the density of the data around the area. The reduced 25-foot averaged trackline data were imported to ArcGIS 8.2 for gridding to a continuous raster surface. The Spatial Analyst extension for ArcGIS was used to explore the variance of the bathymetric trackline data and determine the optimal gridding parameters. Several gridding routines were investigated before final interpolation using Kriging. The Kriging method produced a variance grid along with the calculated surface. This variance grid provided a good indication of how well the chosen Kriging parameters calculated the surface. For this dataset, a 150-foot fixed search radius along with a spherical semivariogram model appeared to provide the best Kriging results (mean variance of 0.48 with a standard deviation of 0.18). The resulting gridded dataset was based on a 200-foot grid cell size and was comprised of 133 rows and 117 columns; this gridded dataset was used for all subsequent analysis and graphics production.

The primary analysis done on the final bathymetric gridded dataset was a depth difference comparison with the most recent prior bathymetric dataset. Because most of the placement at the HARS since its designation in 1998 has been focused in PRAs 1, 2, and 3, the depth difference comparison was focused in this area. For PRAs 1, 2, and 3, the most recent complete prior dataset originated from a single-beam bathymetric survey conducted in September 1998, shortly after the designation of the HARS. Before the depth difference comparisons could be made, the prior dataset had to be reviewed for consistency, modified to correct a speed of sound artifact, and then gridded based on the same technique outlined in the preceding paragraph. Within ArcGIS 8.2, a bathymetric difference grid was then generated that helped illustrate the magnitude of change within this area since the last survey.

2.3 Side-Scan Sonar and Sub-bottom Profiling Survey

2.3.1 Field Methods

The side-scan sonar and sub-bottom profiling surveys were conducted primarily along a series of north-south survey lanes that were run in early September over PRAs 1, 2, 3, and 4, as well as over the approximate footprint of the 1993 and 1997 capped mounds and the red clay disposal area. Side-scan sonar and sub-bottom profiling data were acquired with a Datasonics/Benthos SIS-1000® combined digital sub-bottom profiling and side-scan sonar system. Although the original scope of work called only for the acquisition of side-scan sonar data during these operations, because the SIS-1000 acquires side-scan and sub-bottom data simultaneously, all of the north-south lanes conducted during these survey operations provided both data types. (In some of the areas, the sub-bottom data proved particularly useful in assisting with the physical interpretation of the seafloor.)

The SIS-1000 side-scan sonar component operates at a swept frequency range of 90 to 110 kHz and the sub-bottom component operates at a swept frequency range of 2 to 7 kHz. The SIS-1000® fish was towed behind the survey vessel with an armored signal cable that provided power to the towfish and two-way communication with the SIS1000® topside data acquisition

system. This system recorded acoustic data from the towfish and position information from the navigation system, and displayed real-time side-scan and sub-bottom imagery on a PC monitor connected to the topside acquisition system.

Side-scan sonar systems provide an acoustic image of the seafloor by detecting the strength of the backscatter returns from signals emitted from a towed side-scan sonar transducer array. The side-scan transducers operate similar to a conventional depth-sounding transducer except that the towfish has a pair of opposing transducers aimed perpendicular to and directed on either side of the vessel track. Side-scan sonar data can reveal general seafloor characteristics and also provide the size and location of distinct objects. Dense objects (e.g., metal, rocks, hard sand seafloor areas) will reflect strong signals and appear as dark areas in the records presented in this report. Conversely, areas characterized by soft features (e.g., silt or mud sediments), which absorb sonar energy, appear as light areas in the sample records.

Sub-bottom profiling is a standard technique used for distinguishing and measuring various sediment layers that exist below the sediment/water interface. Sub-bottom systems are able to distinguish these sediment layers by measuring differences in acoustic impedance between them. Acoustic impedance is a function of the density of a layer and speed of sound within that layer and is affected by differences in grain size, roughness, and porosity. Sound energy transmitted to the seafloor is reflected off the boundaries between sediment layers of different acoustic impedance. A sub-bottom system uses the energy reflected from these boundary layers to build the image. The depth of penetration and the degree of resolution of a sub-bottom system depends on the frequency and pulse width of the acoustic signal and the characteristics of the various layers encountered.

2.3.2 Side-Scan Sonar Data Processing and Analysis

During data acquisition, each survey lane was saved into a separate file to facilitate post-processing. During post-processing, each lane was re-played within SonarWeb®, water column and time varied gain (TVG) adjustments were made, and then the data were merged together using the SonarWeb® mosaic utility. After the mosaic was completed, it was saved and exported as a geo-referenced TIFF (Tagged Image File Format) file. This TIFF file was then used for a variety of subsequent analysis techniques.

2.3.3 Sub-bottom Profiling Data Processing and Analysis

During data acquisition, each survey lane was saved into a separate file to facilitate post-processing. After data acquisition, the sub-bottom data were analyzed and edited as necessary using the Chesapeake Technologies SonarWeb® software. SonarWeb® allowed manual detection, tracking, and digitizing of any sub-bottom layers that were present in the data and also allowed the data to be re-displayed under a variety of different configurations. Because the sub-bottom data were not a required component for the general survey of the HARS, these data were only used in selected areas where it provided particularly useful information on the seafloor conditions. A more in-depth analysis of the sub-bottom profiling data was conducted on the data specifically acquired over the 1993 and 1997 capped mounds (SAIC 2003a and SAIC 2003b).

3.0 RESULTS

3.1 Bathymetric Data Quality Review

This section presents the results of the various analyses that were conducted to improve and/or assess the quality and consistency of the bathymetric survey data. The first two subsections below provide a thorough review and analysis of the sound velocity and tidal data that were acquired during the course of this survey. The third subsection presents the results of the cross-check analysis and addresses the overall consistency of the complete dataset. The variability associated with both the water column sound velocity and tidal heights represented the two most significant vertical corrections that were applied to produce the final post-processed bathymetric data. Accurate measurement of sound velocity and tidal heights throughout the survey operations and proper application of the resulting correctors were essential to produce consistent survey results.

3.1.1 Sound Velocity Analysis

At least two vertical CTD casts were taken on each field survey day, and all CTD data were retrieved and processed as required. A summary view of the sound velocity profiles for the deepest CTD cast taken for each day of the survey shows that the profiles were generally consistent throughout the survey period with some relatively significant changes noted primarily after the week-long weather delay into early September (Figure 3.1-1). These changes are addressed in greater detail in the following paragraphs. Appendix A provides a speed of sound vertical profile plot for all of the CTD casts that were taken during each day of this survey.

Although the water column sound velocity was the primary measurement of interest obtained from the CTD data, other water column data (e.g., water temperature, salinity, and density) were also acquired. The vertical profile data from the three CTD casts taken on 18 August 2002 were consistent with all of the CTD data that was processed from 31 July through 27 August and were considered representative of water column characteristics during that period (Figure 3.1-2). These casts showed a near linear decrease in computed sound velocity from the surface down to the depth of the cast (from approximately 1525 to 1490 m/sec). This decrease in computed sound velocity through the water column was primarily a function of the near linear decrease in water temperature that was also noted from the surface down to depth (from approximately 23ºC to 10º C). Both density and salinity increased with increasing depths and those parameters by themselves would normally have tended to increase the computed sound velocity as well. However, water temperature has a far greater sound velocity impact than either salinity or density and tends to be the primary factor impacting the computation of sound velocity, particularly in the upper water column.

Survey operations were suspended during an extended period of large easterly seas from 28 August through 3 September; there was also a significant amount of rain during this period. When survey operations resumed on 4 September, the CTD cast results showed somewhat different trends than the casts from the earlier period (Figure 3.1-3). The vertical profile data (e.g., water temperature, salinity, density, and sound velocity) from the three CTD casts taken

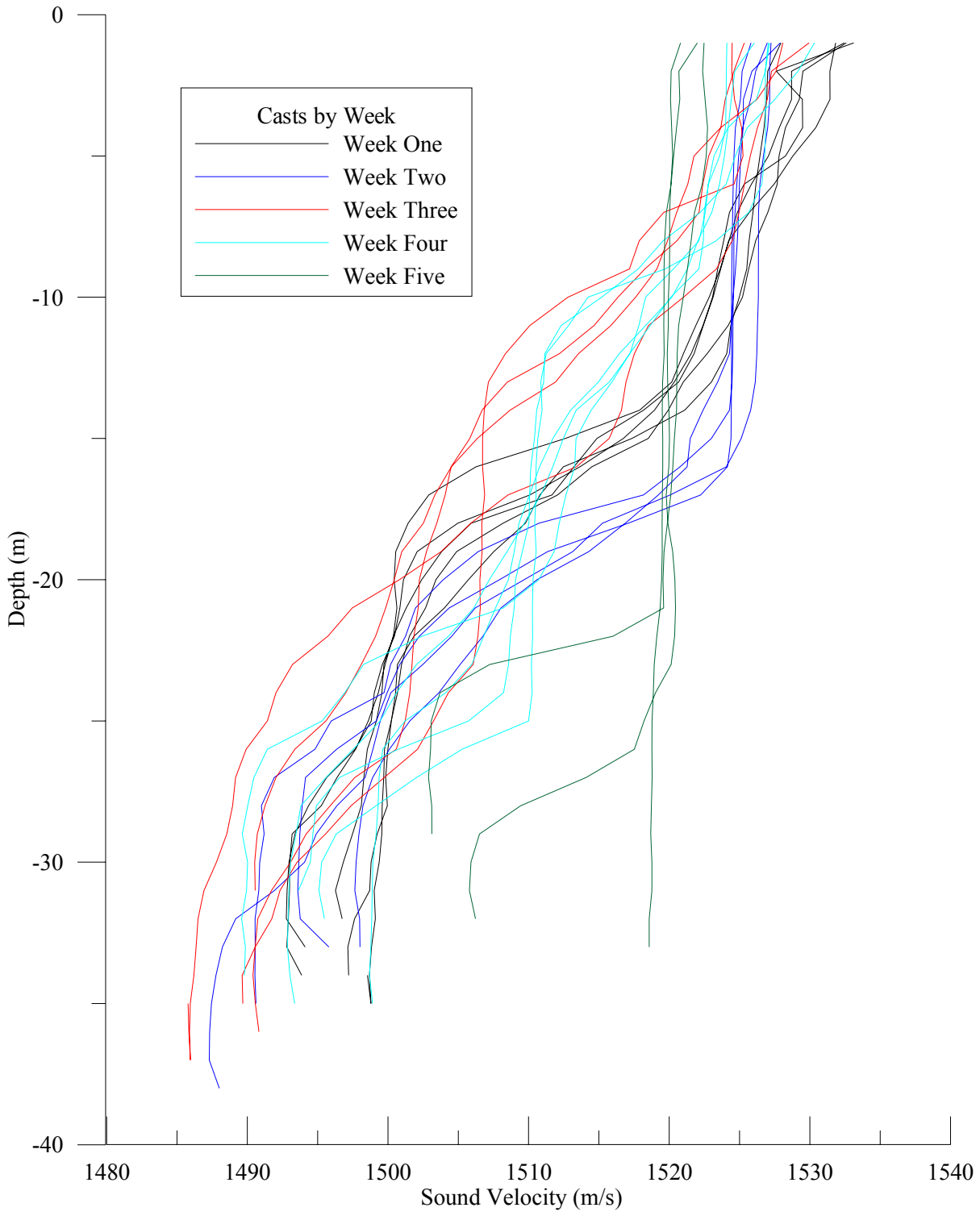


Figure 3.1-1. Summary of sound velocity profiles generated from the deepest of the CTD casts taken on each field survey day

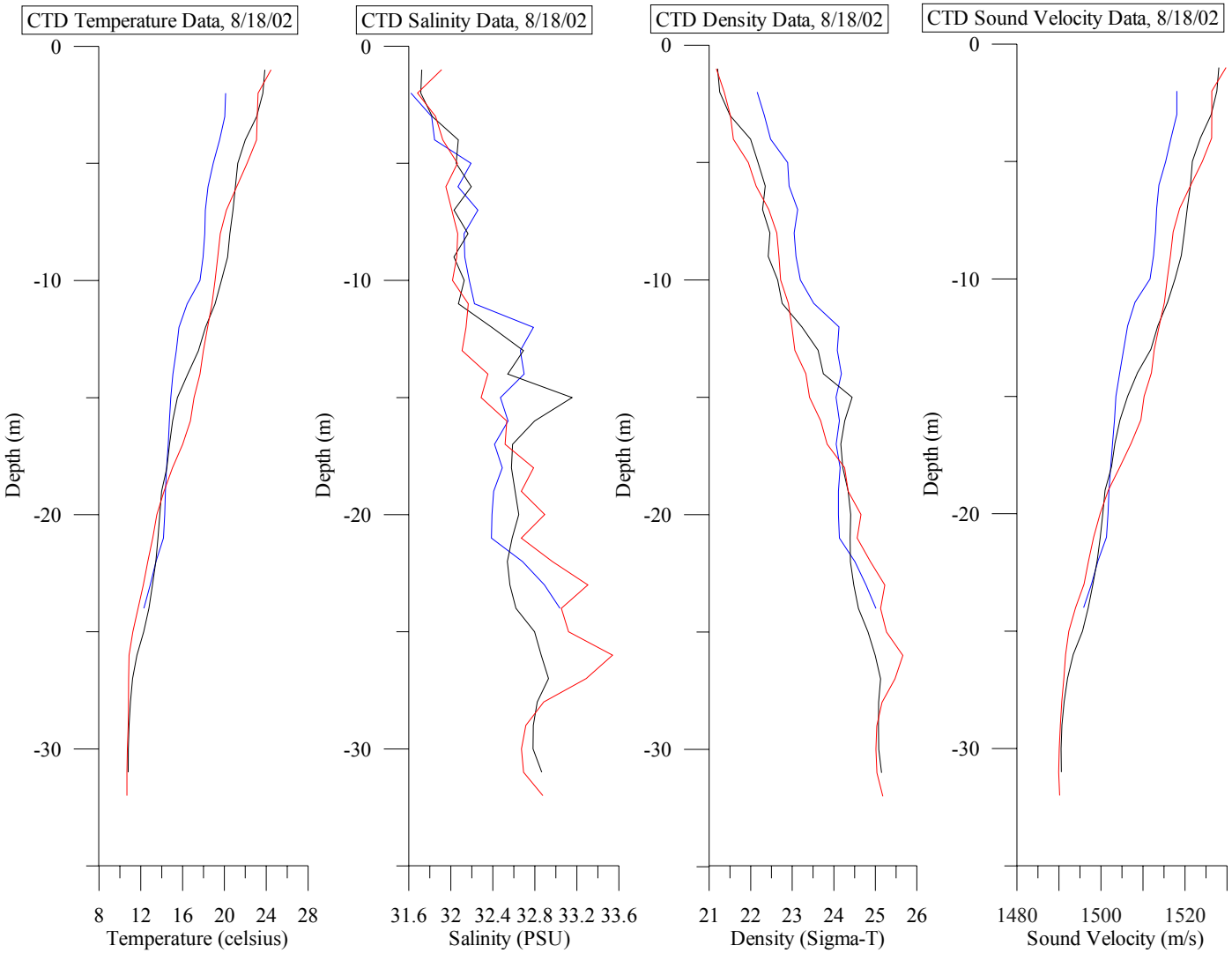


Figure 3.1-2. Vertical profile data from the three CTD casts taken on 18 August 2002

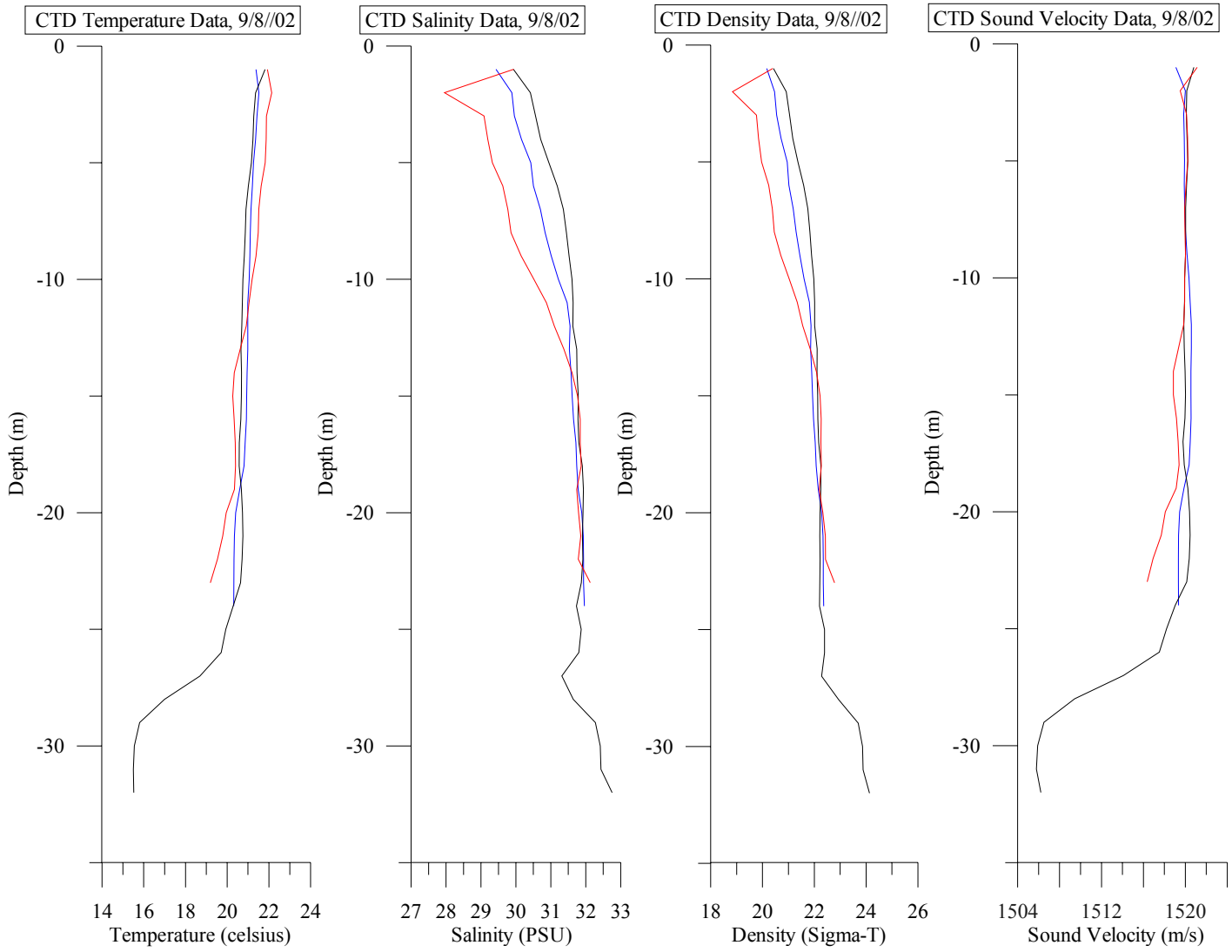


Figure 3.1-3. Vertical profile data from the three CTD casts taken on 8 September 2002

on 8 September 2002 were consistent with most of the CTD data that was processed from 4 September through 9 September and were considered representative of water column characteristics during that period. Due to storm-induced mixing of the water column, the water temperature profile was nearly uniform (at around 21º C) for the upper 25 m of the water column, with a relatively sharp decrease in temperature below that depth. As with the earlier period data, the sound velocity data closely mirrored the water temperature profile. The two shallow-water casts did not cross the thermocline and the computed sound velocity for these two casts was almost constant (at around 1520 m/sec) throughout the water column. The single deep cast for that day did cross the thermocline, resulting a relatively sharp decrease in the computed sound velocity (down to 1503 m/sec). Because the lower water column warmed considerably during this period of mixing (from 10ºC to 15ºC), the lower water column sound velocities were now about 10 m/sec higher than observed during the earlier period.

As discussed above, the primary differences noted in the daily sound velocity casts were related to depth, with a generally consistent decrease in measured sound velocity with deeper depths. In most cases, two of the daily casts were taken at the eastern edge of the survey area (at the beginning and end of the survey day) in shallower water and the midday cast was taken on the eastern edge of the survey area in deeper water. In most cases, the upper water column data for all three of the daily casts agreed well and there was little indication of any significant temporal or spatial differences noted in the upper water column sound velocity data. However, the deeper cast consistently exhibited lower sound velocity values at the deeper depths.

When post-processing bathymetric data, it is a relatively common practice to average the entire sound velocity profile and to then use this average sound velocity value to generate a corrector based on the water depth and the assumed sound velocity that had been entered into the echosounder during data acquisition. Had the averaging technique been used for these data, then the deeper velocity casts would have shown a consistently lower average sound velocity than the shallower velocity casts, even though the casts were similar at their common depths. Within the HYPACKMax® processing module, the entire velocity profile was entered as a table and the resulting sound velocity correctors were generated based upon the depth of each sounding. Essentially, the sound velocity corrector accounted for the vertical offset caused by the travel time differences between the assumed velocity entered into the echosounder and the observed sound velocity profile. Because there was little daily temporal or spatial change noted in the sound velocity data and the survey lanes were run across the entire survey area (across both deep and shallow water), the deeper cast was always used to create the daily sound velocity profile file that was used to apply velocity correctors for each day's data.

3.1.2 Tidal Data Analysis

The HARS tide gauge was operational throughout the survey, and all data were recovered as required. Because the gauge was retrieved sporadically during the survey (to ensure proper operation), the actual datum of the gauge shifted slightly during each redeployment and the subsequent tide gauge time series analyses were also grouped by these discrete deployment periods. For each of these deployment periods, all of the recorded tidal heights were averaged over the period to obtain a measure of the mean tide level. Using the NOAA published differences between the mean tide level (MTL) and MLLW datums for the northern New Jersey

coast (at Long Branch), an approximate MLLW datum was established for each of the discrete tide gauge deployment periods. The adjusted tide gauge data were then used to make direct comparisons with the corrected Sandy Hook tide data. As discussed in section 2.1.2, a phase offset of –45 minutes and a ratio offset of 0.95 were applied to transfer the observed Sandy Hook tide data out to the HARS.

Time series plots showing the direct comparison between the corrected Sandy Hook tide data and the HARS tide gauge for the entire survey period are provided in Appendix B. The tide data have been grouped in approximately one-week increments to reflect the different deployment periods and for ease of viewing. In general, the agreement between the corrected Sandy Hook data and the HARS tide gauge was consistent throughout the survey. The overall agreement was strongest during the middle of August and coincided with the longest continuous deployment of the tide gauge.

A direct comparison between the corrected Sandy Hook tide data and the HARS tide gauge for a period from 14 through 19 August was considered representative of the general agreement noted throughout the survey operation (Figure 3.1-4). Because the HARS tide gauge recorded only a single water height value every six minutes, this data was somewhat "noisy" due to surface wave effects; these impacts were more pronounced during periods of high and low tides when there was little tidal height change between observations. The NOAA tide gauge at Sandy Hook recorded tidal height values at 10-second intervals and then used these values to compute a running six-minute average.

Though the overall tidal height agreement was consistently strong, there were some differences evident in this comparison. During the periods of high tide, the tidal heights indicated by the corrected Sandy Hook data were generally higher than the comparable tidal heights indicated by the HARS tide gauge. This difference varied throughout the period, though it was sometimes as high as 0.6 ft. This appeared to indicate that the 0.95 ratio corrector applied to the Sandy Hook data was too high (at least over this deployment period). Although the phasing agreement was also generally strong, there were some periodic differences in phasing between the corrected Sandy Hook data and the HARS tide gauge. During these slightly off-phase periods, the corrected Sandy Hook data generally ran slightly ahead of the HARS tide gauge. This appeared to indicate that the –45 minute time corrector applied to the Sandy Hook data was sometimes too high.

A summary of the daily agreement between the HARS tide gauge and the corrected Sandy Hook data revealed a generally larger negative trend seen in the average and maximum differences between the two data sets and reflected slightly higher tidal heights observed in the corrected Sandy Hook tide data (Table 3-1). As discussed in the preceding paragraph, this is likely due at least in part to the use of a historical ratio corrector (0.95) for the Sandy Hook data that may be somewhat higher than it should be. The larger daily minimum and maximum differences noted were primarily a function of the potential for wave action to impact each individual HARS tide gauge data point. Because a longer data series generally improves the validity of the tidal datum computation, the agreement between the HARS and Sandy Hook tide data also appeared to be somewhat related to the length of deployment period of the HARS tide gauge. In this case, the

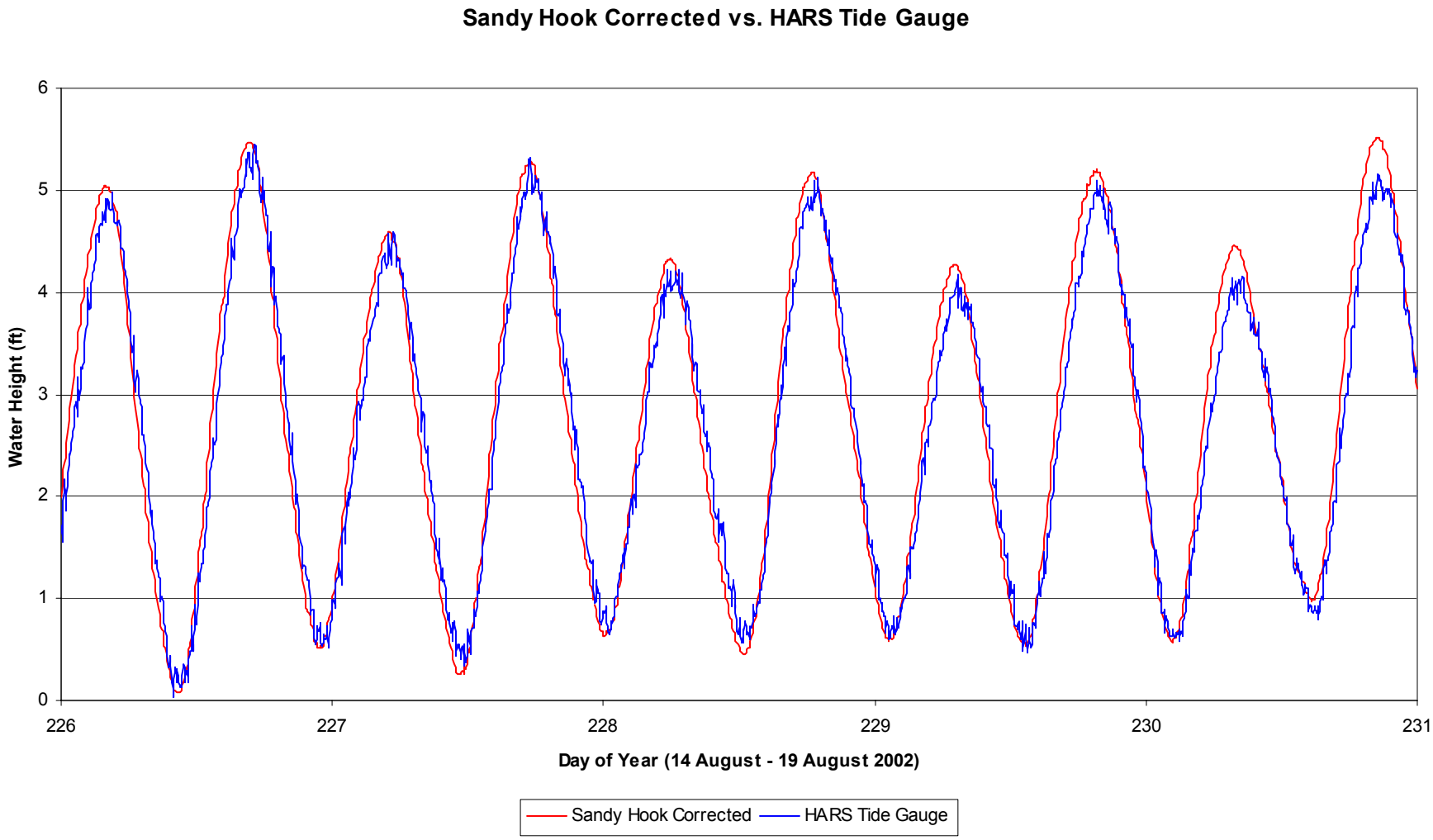


Figure 3.1-4. Time series comparison of the observed tidal heights from the NOAA Sandy Hook tide gauge (with offset correctors applied) and the HARS pressure tide gauge for the period from 14 through 19 August 2002.

Table 3-1.

Summary of Observed Tidal Height Differences
Between Sandy Hook (Corrected) and the HARS Pressure Tide Gauge

Day	Average	Standard Deviation	Max Difference	Time (UTC)	Min Difference*	Time (UTC)
7/31	-0.20	0.22	0.38	19:54	-0.67	16:54
8/1	-0.33	0.28	0.27	15:36	-0.88	9:24
8/2	-0.26	0.25	0.23	9:06	-0.76	14:24
8/3	-0.14	0.27	0.39	10:18	-0.72	5:36
8/4	-0.09	0.28	0.47	11:06	-0.69	6:48
8/5	-0.22	0.37	0.46	0:00	-0.96	18:00
8/6	-0.33	0.32	0.36	0:48	-1.09	7:54
8/7	-0.13	0.35	0.46	2:42	-0.79	20:00
8/8	0.00	0.33	0.53	14:36	-0.75	10:00
8/9	-0.01	0.27	0.5	16:12	-0.58	22:42
8/10	0.01	0.26	0.51	4:00	-0.59	23:12
8/11	-0.04	0.28	0.76	16:36	-0.66	12:36
8/12	-0.09	0.28	0.61	12:18	-0.73	18:00
8/13	-0.07	0.27	0.53	7:06	-0.77	0:48
8/14	-0.06	0.35	0.63	19:42	-0.7	1:24
8/15	0.01	0.30	0.59	21:12	-0.58	15:48
8/16	0.01	0.28	0.59	10:36	-0.55	17:06
8/17	-0.10	0.28	0.42	10:06	-0.61	17:30
8/18	-0.22	0.26	0.24	0:54	-0.74	18:00
8/19	-0.24	0.25	0.21	11:42	-0.78	18:54
8/20	-0.21	0.30	0.39	23:12	-0.86	8:30
8/21	0.11	0.25	0.6	13:00	-0.42	8:48
8/22	0.08	0.31	0.67	2:36	-0.62	21:48
8/23	-0.17	0.26	0.37	3:06	-0.74	9:54
8/24	-0.26	0.28	0.41	3:42	-1.06	22:48
8/25	-0.29	0.27	0.27	17:48	-1.01	11:42
8/26	-0.12	0.26	0.56	16:54	-0.79	0:48
8/27	-0.12	0.30	0.78	17:30	-0.76	0:00
9/4	-0.43	0.29	0.24	14:18	-1.02	21:06
9/5	-0.33	0.29	0.39	12:54	-1.11	20:36
9/6	-0.17	0.26	0.46	13:12	-0.76	8:18
9/7	-0.02	0.27	0.55	15:36	-0.73	22:06
9/8	0.02	0.27	0.64	15:54	-0.56	10:42
9/9	-0.15	0.27	0.48	4:12	-0.77	13:00
Average	-0.14	0.28	**0.47**		**-0.76**	

Notes:
* Negative difference values indicate higher computed tidal heights for Sandy Hook (corrected).
~ Shading indicates a partial collection of data for the day, due to adjustment of the Tidal Gauge.

strongest observed agreement between the HARS tide data and corrected Sandy Hook data coincided with the longest continued deployment period (9 through 27 August) of the HARS tide gauge.

During the data review portion of this study, these tidal comparison results were used to highlight specific days where the tidal differences may have had an impact on the processed data results. The largest observed differences generally occurred during the mid-cycle phase of the tide when there was a noticeable (though slight) phase offset between the HARS tide gauge and the corrected Sandy Hook data. Because the magnitude of the tide changes rapidly (up to 0.3 ft every 15 minutes) during the mid-cycle, even small time offsets could lead to fairly large differences between observed tides, though these impacts were generally limited to a fairly narrow time window. In addition, the sign of these differences varied depending on whether the tide was rising or falling.

Ultimately, because the magnitude of the observed differences between the corrected Sandy Hook tide data and the HARS tide data were relatively minor and not consistent, no further tidal adjustments were made and all of the edited survey data were reduced to MLLW based only on the corrected Sandy Hook tide data. As discussed, based on the review of the HARS tide gauge data there may be reason to consider making revisions to the range and phase offsets that were applied to the Sandy Hook data when transferring tides out to the HARS. Though revised offsets could be generated based on the recent HARS tide gauge deployment, as discussed above there were some limitations with this data (e.g., short deployment periods, little seasonal variability, lower resolution data). For this reason, an accurate revision to the historical tidal offsets should probably be based on a more comprehensive tidal study focused around the HARS. Of the numerous vertical offsets that may have impacted the accuracy of the final sounding data, the measurement and application of the proper tidal correction for each sounding was probably the most difficult to address consistently.

3.1.3 Cross-Check Comparisons

Despite at least a few feet of sea action during most of the data acquisition, the somewhat irregular seafloor in many areas, and some of the observed variability noted in the tide gauge comparisons, the cross-check results showed strong agreement between the north-south and east-west survey lanes. The HYPACKMax® Statistics routine identified 4,772 points that overlapped within 25 ft of each other between the east-west and north-south survey lanes. The computed mean difference for all of these comparisons was –0.11 ft with a standard deviation of 0.84 ft. The distribution of the differences about the mean was very consistent, with a similar number of points evenly distributed on both sides of the mean difference (Figure 3.1-5). Over 95% of the difference values fell within ±1.5 feet of the mean difference.

The slight negative bias indicated by the mean cross-check difference may have been a result of the active placement that occurred in the HARS during the course of this survey. Most of the north-south lanes run during this survey were focused over the active placement areas of the HARS (i.e., PRAs 1, 2, 3, and 4) and were run very near the end of the survey operations (and as much as a month after some of the east-west lanes in the same areas). Based on disposal logs, it

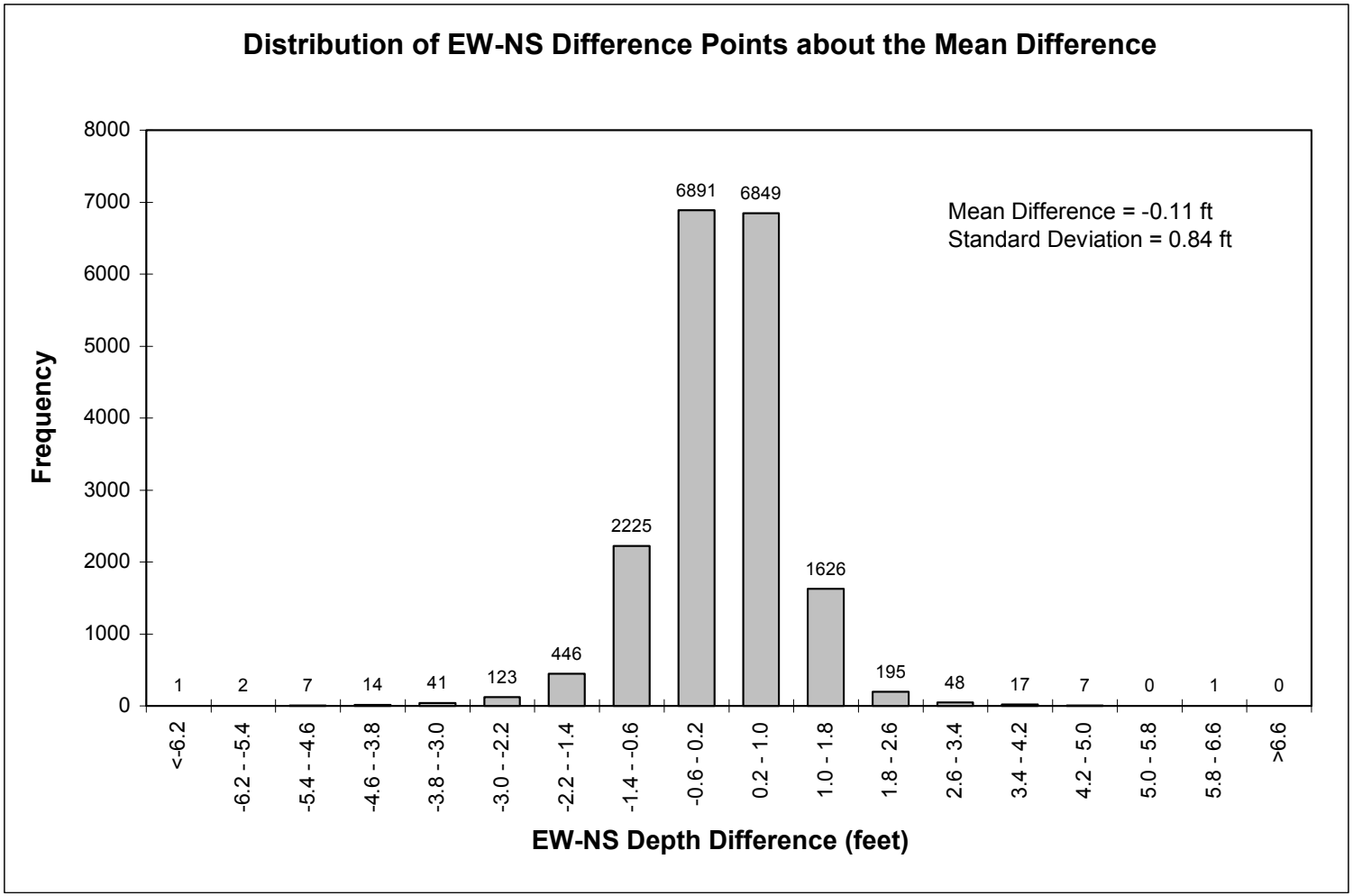


Figure 3.1-5. Histogram of difference values illustrating the results of the cross-check comparison between the east-west and north-south survey lane sounding data. Over 95% of the difference values fell within ±1.5 feet of the mean difference.

appeared that approximately 500,000 cubic yards of material was placed in the lower southwest corner of PRA 1 during the course of this survey. Based on the geographic distribution of the cross-check comparison data, the southwest corner of PRA 1 also showed up as the most prominent area with a consistent and larger negative bias in the depth difference results (Figure 3.1-6). This consistent negative bias indicated generally shallower soundings from the later north-south survey and was consistent with the placement of material in this area. Other areas with much smaller, but generally consistent differences (the western edge of PRAs 1, 2, and 3 and portions of PRAs 4 and 5) were attributed to minor tide corrector offsets between the north-south and east-west data.

Because of the minor variability inherent in all bathymetric survey data (especially with sea action and over an irregular bottom), a certain degree of difference should be expected between any two bathymetric survey data sets. If the surveys were conducted properly over the identical seafloor, then the differences should be randomly scattered and average out to around zero. If the trend of the differences was skewed in either a positive or a negative direction, then that would indicate that either the seafloor had changed or that one of the surveys had a bias that affected the data. Using the results from the TIN difference analysis it was useful to focus on those areas where differences greater than 2 ft (positive or negative) were indicated. When viewed in conjunction with a depiction of seafloor slope steepness, it was evident that all of the larger difference values were clustered within the areas of highest seafloor relief (Figure 3.1-7). Except for the southwest corner of PRA 1 where the mostly negative differences were likely indicative of recent placement in that area, the rest of the depth difference results were consistent with the types of random differences that would be expected when comparing two survey datasets that generally agreed well.

3.2 Bathymetric Characterization of the HARS

As discussed in the preceding section, no significant data problems were encountered during processing or analysis of the single-beam bathymetric data, and the entire HARS was well characterized based on these data. Both the color-coded trackline view and the gridded hill-shade model view showed that the HARS lies on a gradually sloping portion of the seafloor that has been greatly altered by the placement of large volumes of dredged material (and other products) over many years (Figures 3.2-1 and 3.2-2). The bottom topography within the HARS was quite variable and many irregular bottom features were evident throughout the site. The minimum depth observed during this survey was 33.5 ft MLLW and occurred near the center of the former Mud Dump Site about 1300 ft southwest of the existing “NY” buoy. The maximum depth of around 121.0 ft MLLW occurred in the lower southeast corner of the survey area.

3.2.1 Comparisons with Prior Surveys

Because placement of remediation material at the HARS has been concentrated in PRAs 1, 2, and 3 since 1998, this section is focused on evaluating the extent of that deposition based on comparisons between the recent and past surveys. Prior to the 2002 survey, the most recent comprehensive bathymetric survey over PRAs 1, 2, and 3 was conducted in September 1998, shortly after the designation of the HARS. The September 1998 dataset originated from a series of north-south single-beam survey lanes that were spaced at 25-meter intervals (Figure 3.2-3). In reviewing the 1998 survey prior to this comparison, a sound velocity artifact was detected in the

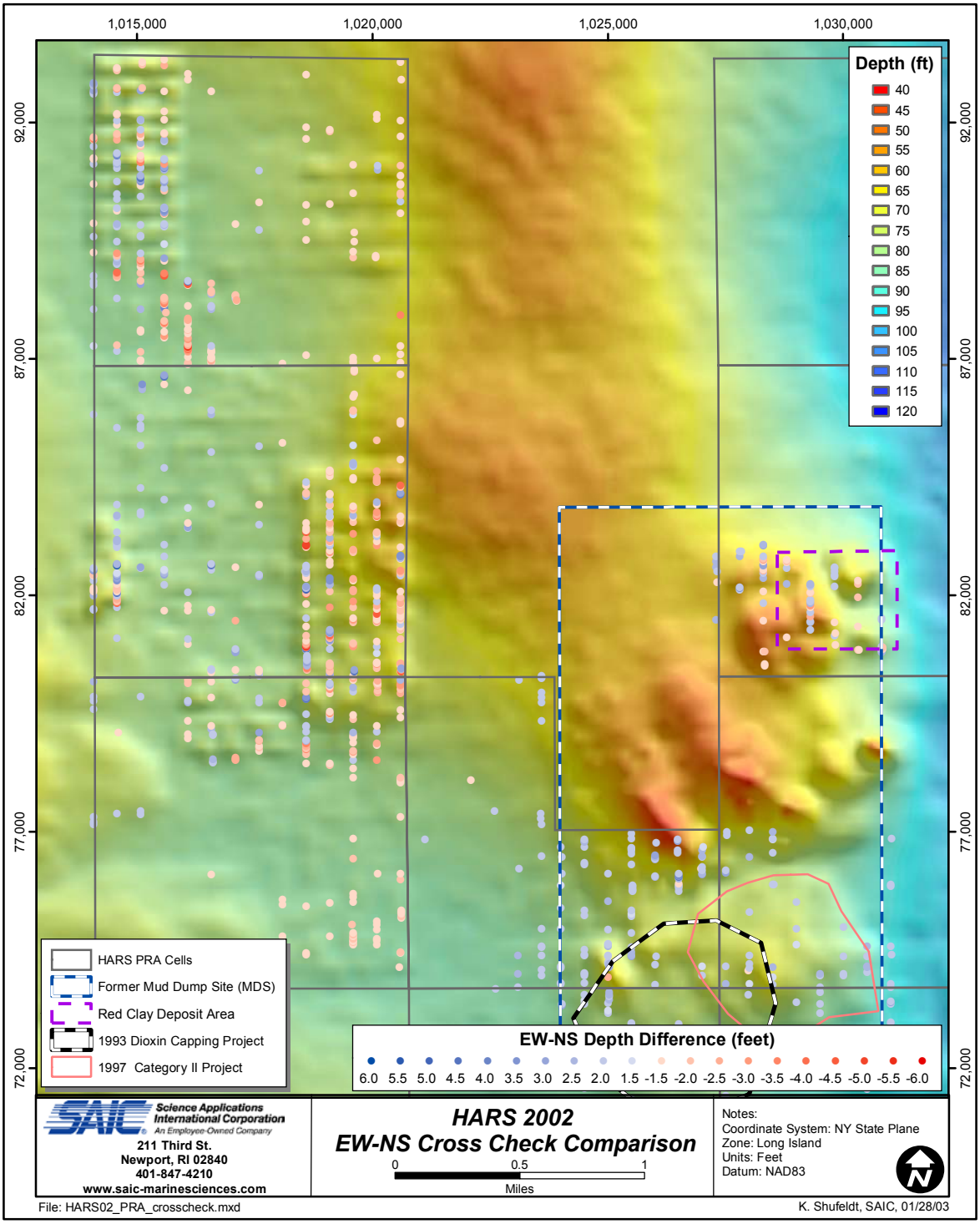


Figure 3.1-6. Color-coded display of the difference points resulting from the cross-check comparison between east-west and north-south survey lane sounding data. Only difference points greater than 1.5 feet or less than –1.5 feet are shown in this figure.

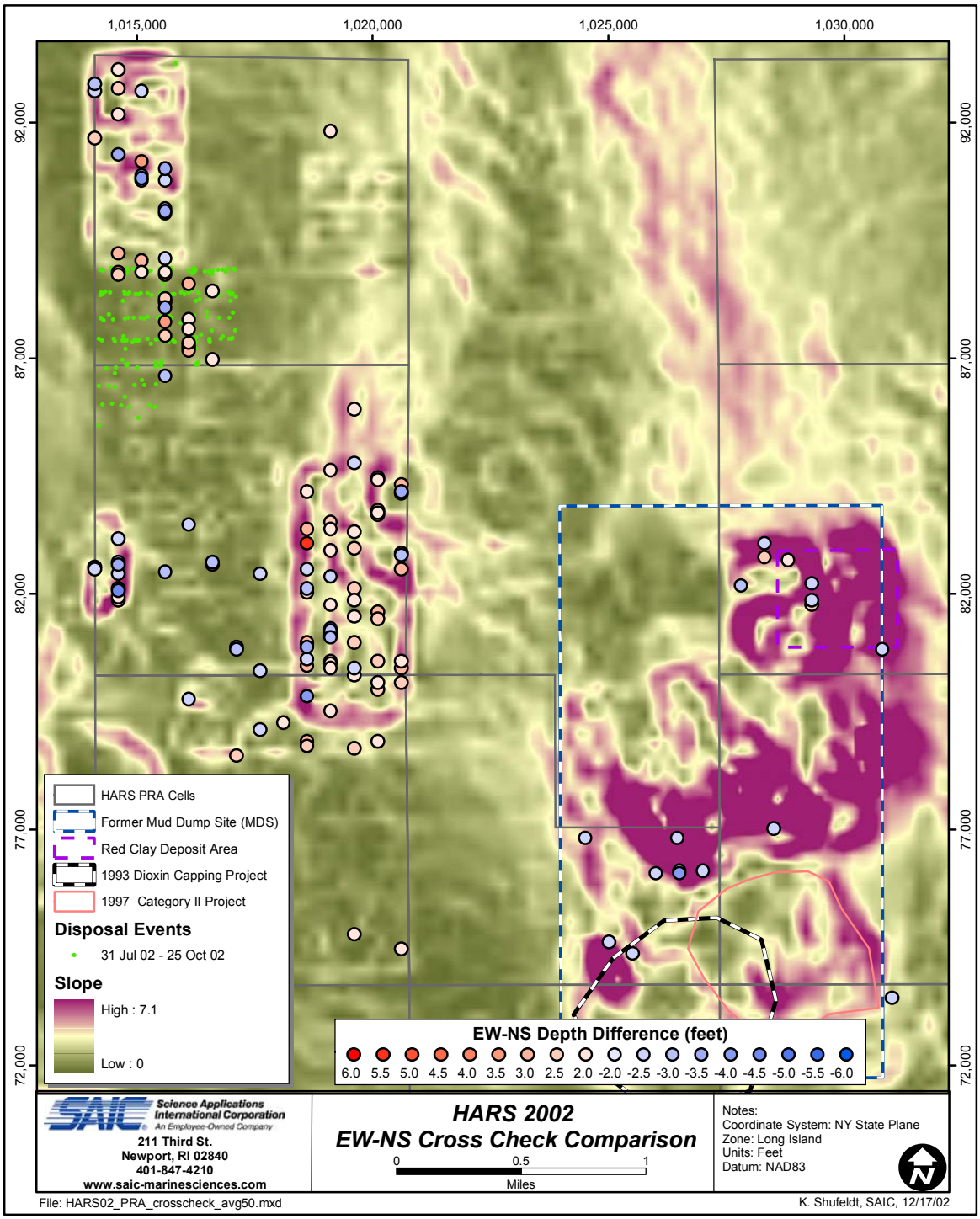


Figure 3.1-7. Display of all cross-check difference values greater than 2 ft and less than –2 ft over a grid surface depicting percent slope of 2002 bathymetry

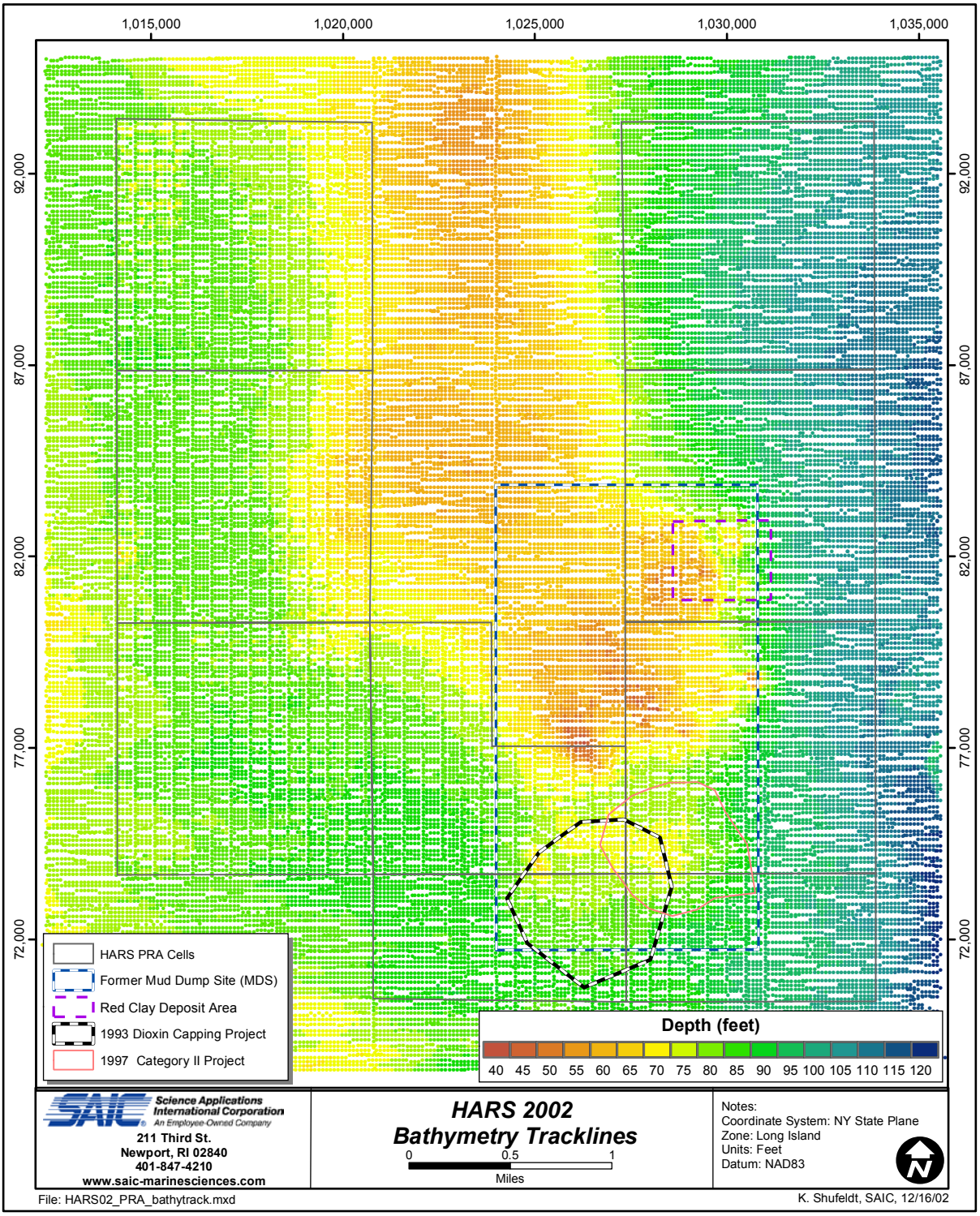


Figure 3.2-1. Color-coded trackline display of all of the survey lanes occupied during the 2002 bathymetric survey at the HARS

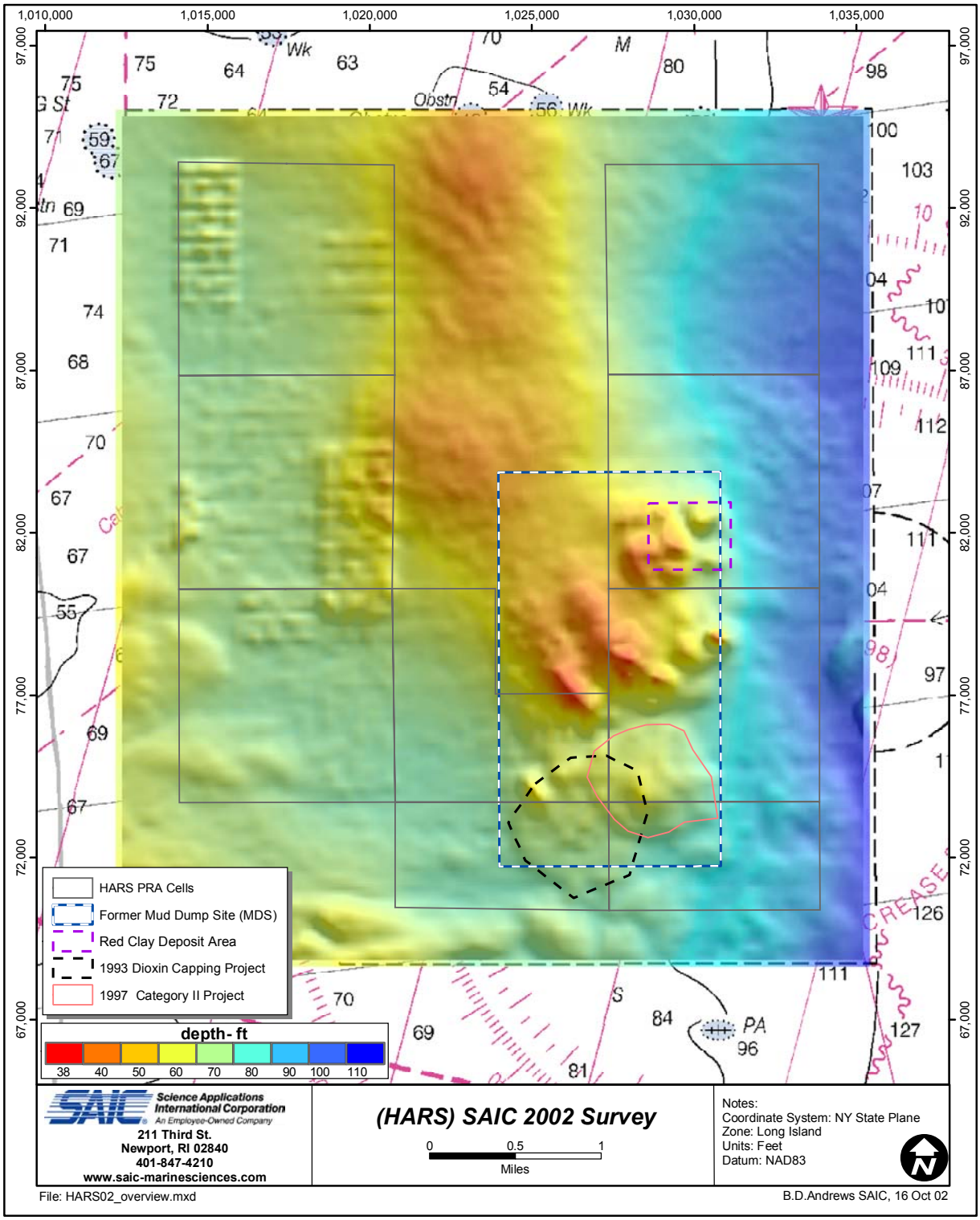


Figure 3.2-2. Hill-shaded gridded relief model based on the August 2002 bathymetric survey

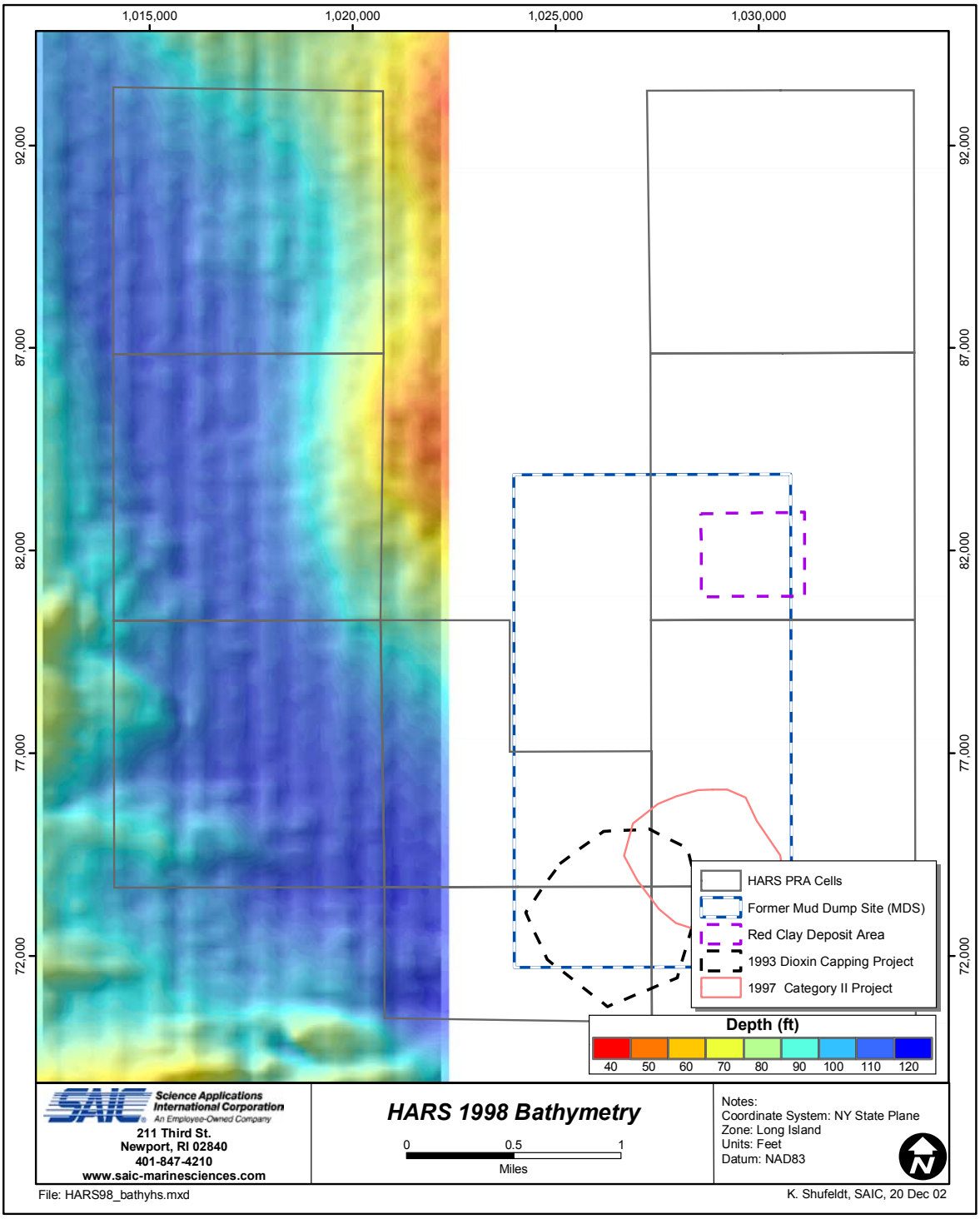


Figure 3.2-3. Hill-shaded gridded relief model of the September 1998 bathymetric survey at the HARS over PRAs 1, 2, and 3 (after a sound velocity adjustment was applied).

edited data that effectively decreased the depths for this entire survey by a factor of 1.025 times the water depth (generally between 1.2 to 2.0 ft). The sound velocity correction for the 1998 dataset was re-applied to the entire dataset prior to the depth difference comparisons with the 2002 survey. Though an apparent tide-related artifact was also observed in this 1998 dataset (evident as vertical banding in the daily data), it had less of an impact on the depth difference results and was not addressed.

The bathymetric depth difference grid generated between the 2002 and corrected 1998 surveys clearly showed dredged material accumulation (deposition) throughout many areas of PRAs 1, 2, and 3 (Figure 3.2-4). Based on the depth difference grid, it appeared that most of PRA 2 and about half of PRAs 1 and 3 were covered with more than 1.5 ft of remediation material. The greatest deposits occurred in the western half of PRA 1 and in the eastern half of PRA 2, where deposits measured up to 12.3 ft thick. Based on a summary of disposal activity generated from individual ADISS records, the dredged material placement history at the HARS since 1998 coincided closely with the total area of deposition indicated by the depth difference results (Figure 3.2-5). Between 1 September 1998 and 31 July 2002, the densest number of disposals occurred in the areas with the thickest deposits. These deposits appeared to form E-W rows of deposition aligned with the disposal event locations. Outside the designated placement areas within PRAs 1, 2, and 3, areas of ambient or historic dredged material show little change between the two surveys (Figure 3.2-4).

3.3 Side-Scan Sonar and Sub-bottom Characterization of the HARS

3.3.1 Side-Scan Sonar

3.3.1.1 2002 Survey Results

A complete 100kHz image mosaic, representing 100% side-scan bottom coverage, was created for three different areas of the HARS (e.g., PRAs 1, 2, 3, and 4; the dioxin mounds; and the red clay deposit area). This report addresses the results observed over PRAs 1, 2, 3, and 4, while three other companion reports address the similar results at the 1993 Dioxin Capping Project Mound (SAIC 2003a), the 1997 Category II Project Mound (SAIC 2003b), and the Red Clay Deposit Area (SAIC 2003c). Because the seafloor within this survey area was comprised of a wide range of bottom materials, the side-scan return provided a relative indication of the bottom type. In these mosaics, darker areas represented stronger acoustic returns (higher reflectance) and usually indicated harder seafloor surface materials such as well-consolidated sand and larger rocks or cobble. Within the PRAs they also indicated recent (2001–02), well-consolidated, but finer-grained, dredged material deposits. The lighter areas of the mosaic represented weaker acoustic returns (lower reflectance) and indicated slightly softer seafloor surface material such as unconsolidated fine sand, silt, or clay.

Although a good deal of resolution was lost when creating the small-scale mosaics over a large area, they provided a useful overview and enabled a broad seafloor characterization of the entire survey area. Based on the full area mosaic of PRAs 1, 2, 3, and 4 and a more detailed review of the higher resolution raw data, the entire area was comprised of sections of evident dredged material disposal (Figure 3.3-1). Darker, higher-reflectance, areas can be seen in each PRA,

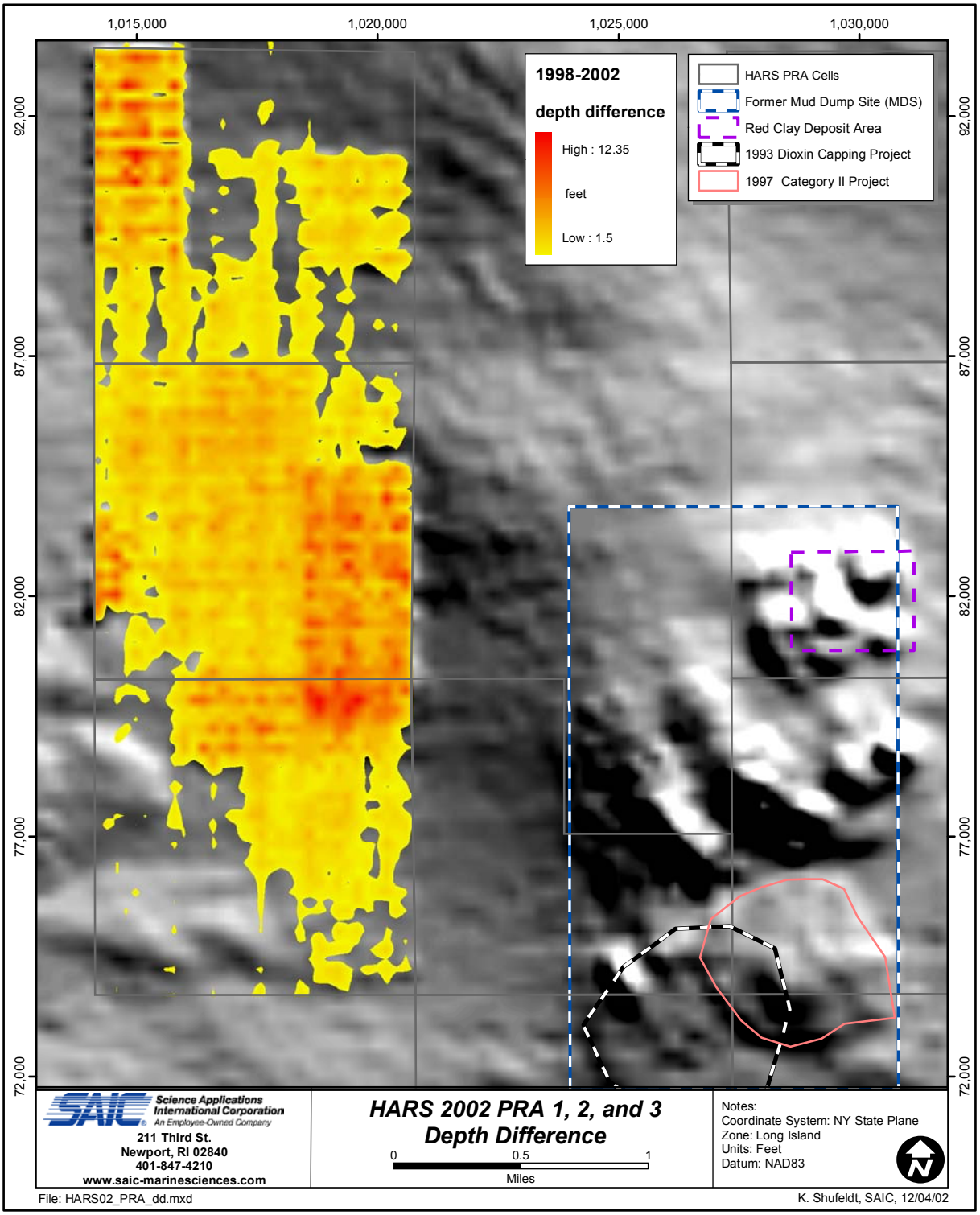


Figure 3.2-4. Bathymetric depth difference between the August 2002 survey and the September 1998 survey over PRAs 1, 2, and 3

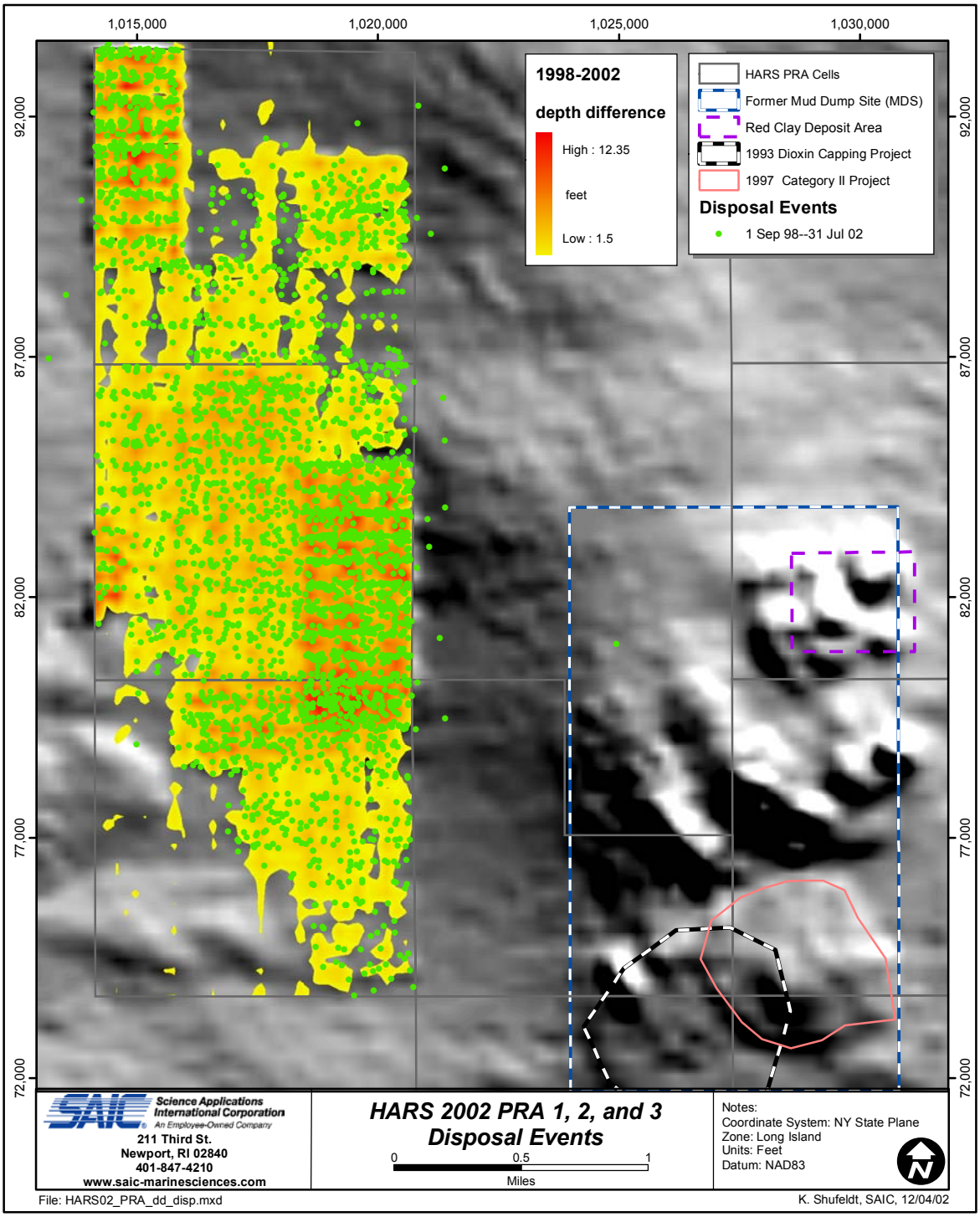


Figure 3.2-5. Bathymetric depth difference grid generated between the August 2002 survey and the 1998 survey showing the recorded placement activity over PRAs 1, 2, and 3 between the times of the surveys.

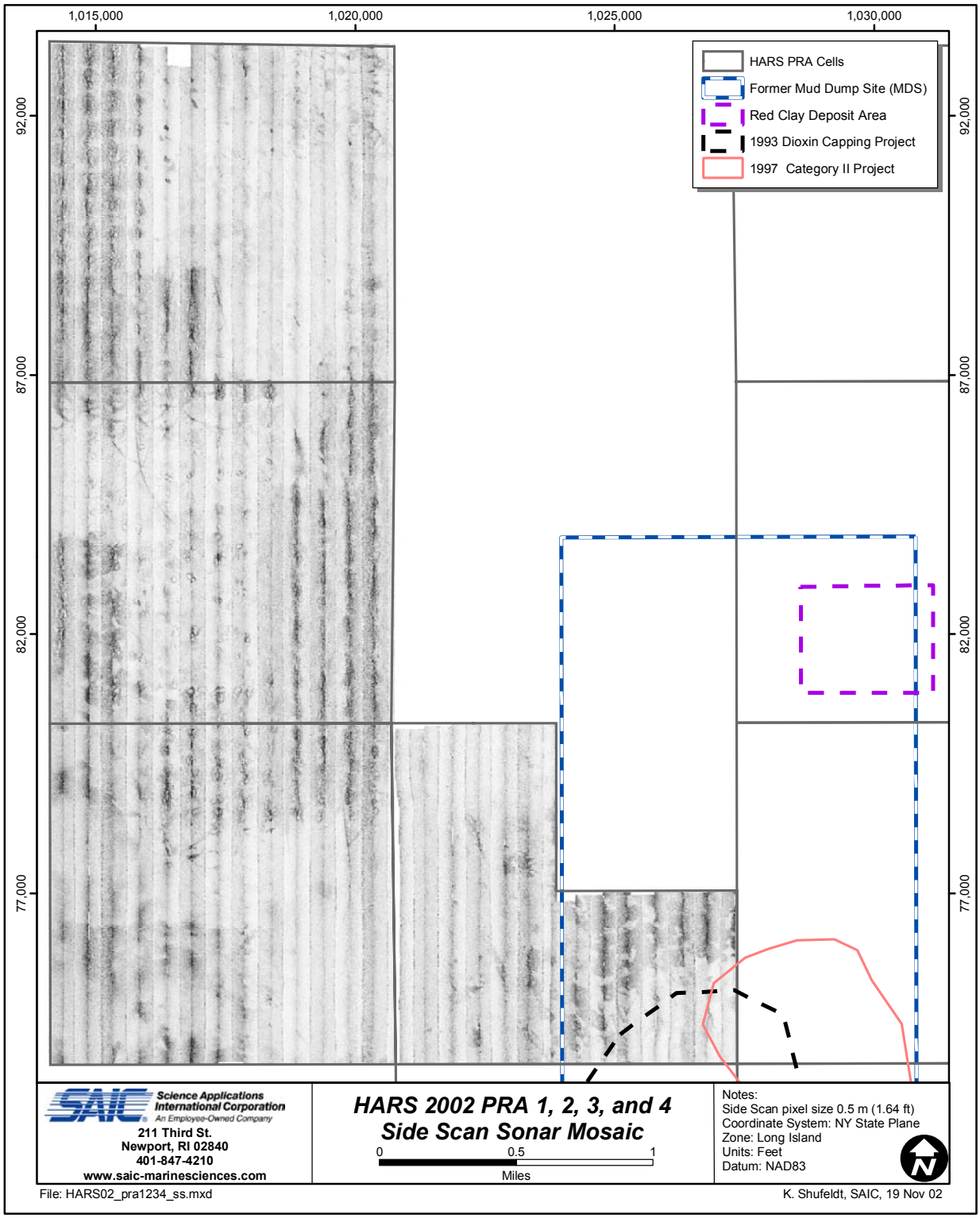


Figure 3.3-1. Side-scan sonar mosaic (100 kHz) over PRAs 1, 2, 3, and 4

contrasting with areas of lower reflectance. A review of the historic disposal logs for selected placement events within each of these different areas provided a broad overview of the types of dredged material that likely comprised these areas of high and low reflectance (Figure 3.3-2). (This broad overview of dredged material disposal type was based on a review of only a small subset of all the disposal logs that covered these areas for the last four years.)

Overall, the sediment surface within higher-reflectance areas was apparently composed of coarse sand, glacial till, and rock. However, recent red clay deposits in PRA 1 also emerged as relatively higher reflectance than the surrounding sediment, which was primarily silt (Figures 3.3-2 and 3.3-3). The stronger acoustic return evident in these areas was probably due to the increased surface roughness associated with the cohesive clay component of these recent deposits (Figure 3.2-2).

The individual disposal events associated with the recent silt and clay deposits were clearly evident along the entire western portion of PRA 1 (Figure 3.3-4). Though these somewhat linear disposal features appeared to be oriented along a north-south alignment in the imagery, that was primarily a function of the side-scan survey lane orientation. Both the bathymetry and disposal log data showed that these features were primarily aligned along an east-west orientation. Some (higher-reflectance) rock and glacial till was also deposited in the southeast corner of the PRA. In addition to the recent dredged material deposition in PRA 1, surface sediment in part of the northern end was composed of silt or fine sand (low reflectance) that was presumed to be ambient or historic dredged material. Rock and glacial till were deposited in parts of PRA 2 (Figures 3.3-2 and 3.3-3). As in PRA 1, individual disposal events were also seen in these darker, higher-reflectance areas (Figure 3.3-5). Apparent silt and clay deposits made up the rest of PRA 2 and within these softer sediments, placement trails from past disposal events were clearly evident.

PRAs 3 and 4 were composed of rock, glacial till, silt and clay, and ambient or historic dredged material (Figures 3.3-2, 3.3-6, and 3.3-7). The rock and glacial till deposits noted in PRA 2 continued into the northern section of PRA 3. Extensive areas of older, lower-reflectance silt and clay deposits also were evident in PRAs 3 and 4. In addition, coarse-grained ambient or historic dredged material surrounded some of the recent dredged material deposits. The historic dredged material had relatively high-reflectance and was only marginally distinguishable from the glacial till deposits. As described in the 1993 Dioxin Mound and 1997 Category II Mound reports, the more recent disposal events of fine- and coarse-grained dredged material may have covered the relatively coarse-grained ambient or historic dredged material (SAIC 2003a; 2003b). Sand waves were also visible within the raw data for these areas, although they were not evident in the 100 kHz mosaic (Figure 3.3-3).

3.3.1.2 Comparison to Other Data Sets

Disposal events recorded between 1 September 1998 and 25 October 2002 corresponded well with areas of obvious dredged material placement shown by the side-scan sonar mosaic (Figure 3.3-8). The recent silt and clay deposits in PRAs 1 and 2 and the rock and glacial till deposits in PRAs 1, 2, and 3 were clearly outlined by dense distributions of disposal points. In addition, these disposal points over the high-reflectance sediment occurred in lines that correlated well with the linear E-W disposal features in the mosaic. As mentioned previously, disposal logs

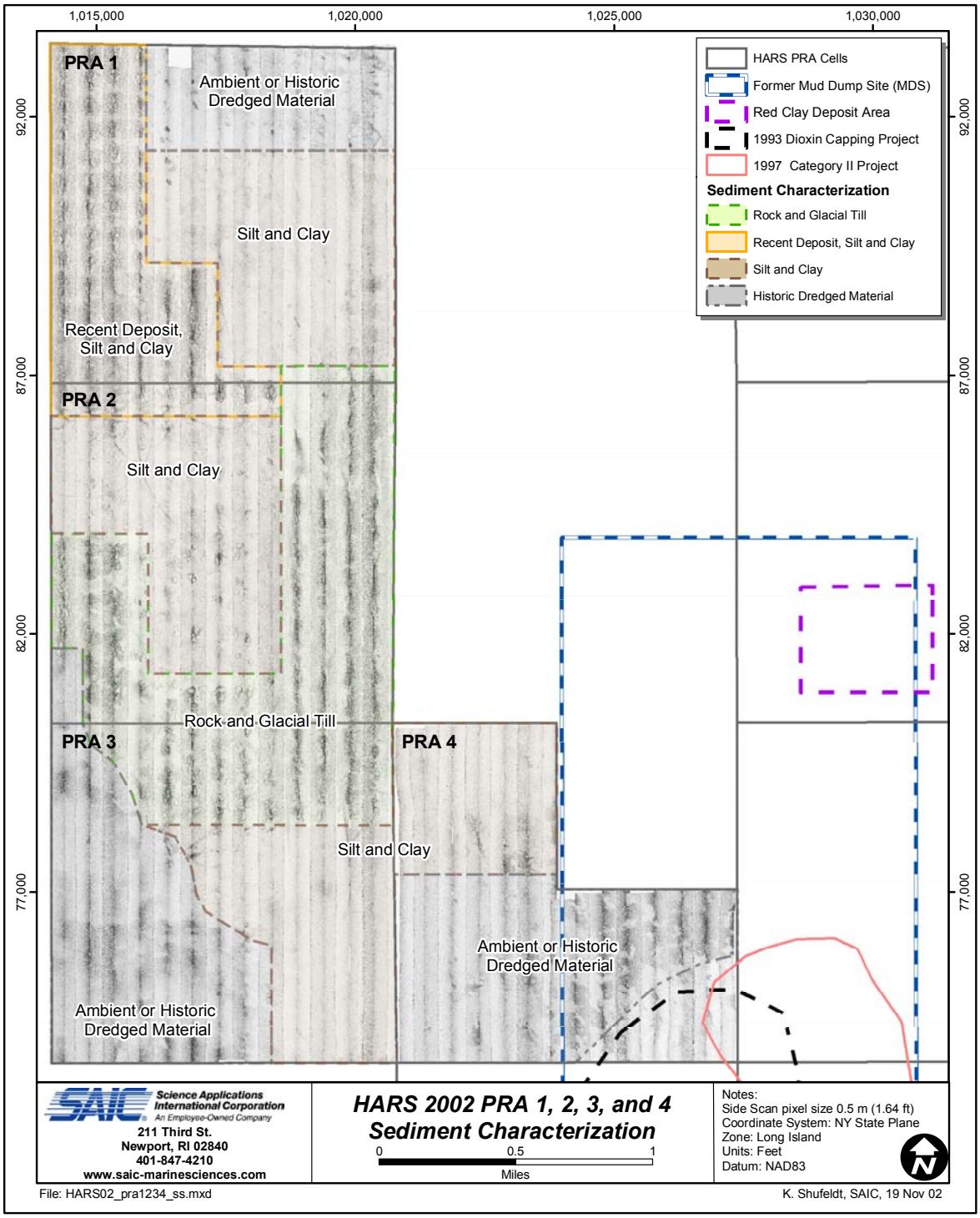


Figure 3.3-2. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRAs 1, 2, 3, and 4.

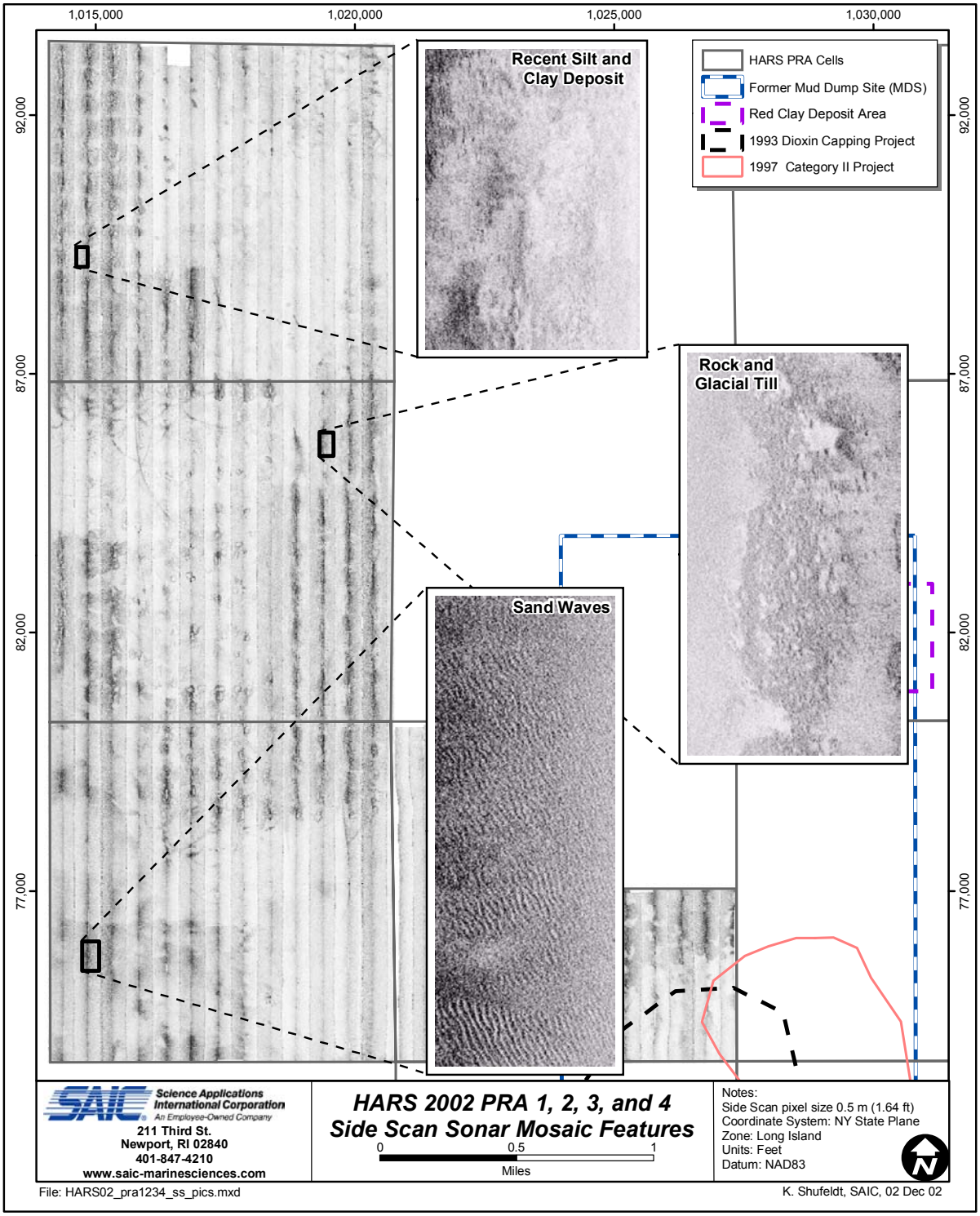


Figure 3.3-3. Surface features visible in the side-scan sonar data over PRAs 1, 2, 3, and 4

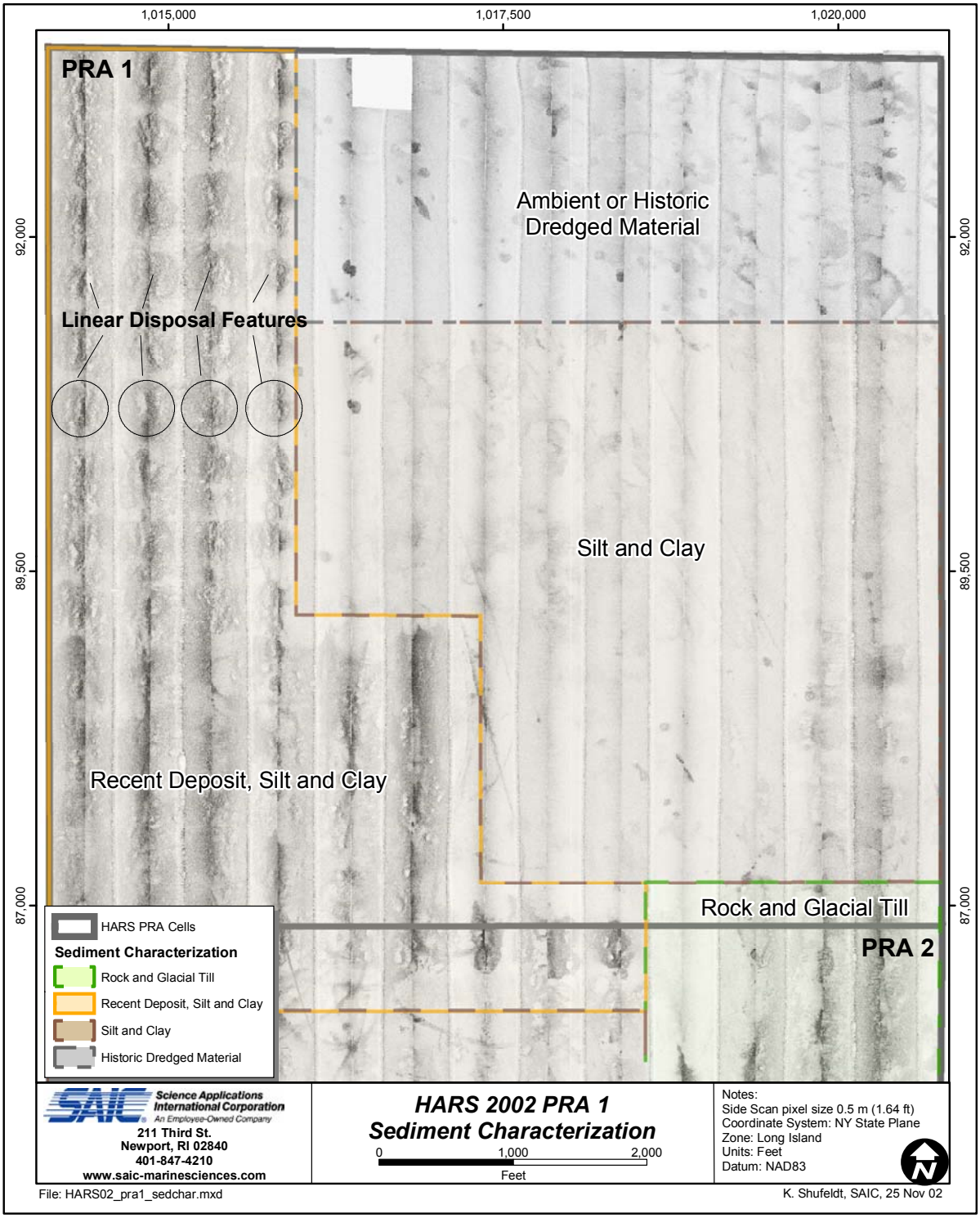


Figure 3.3-4. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 1

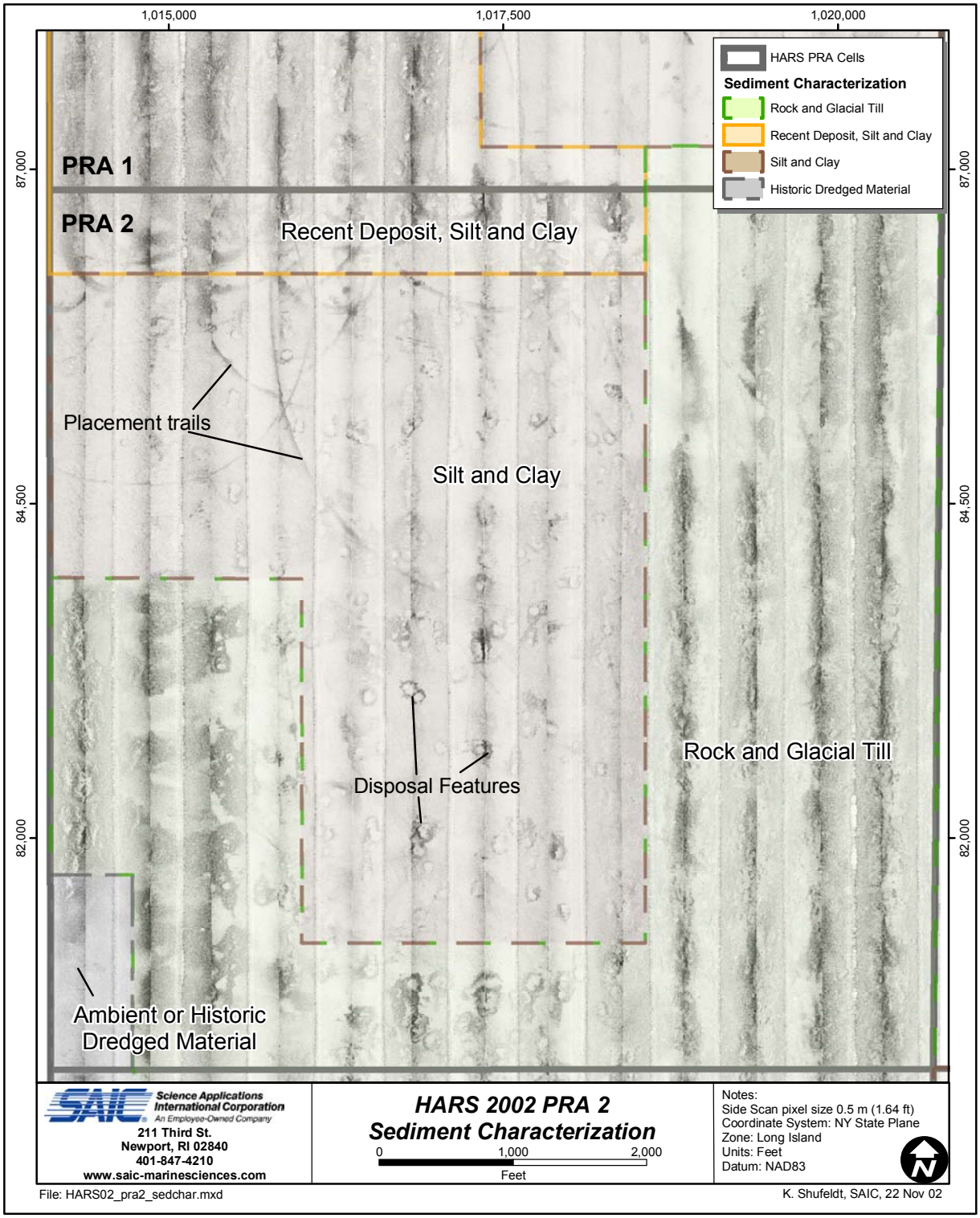


Figure 3.3-5. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 2

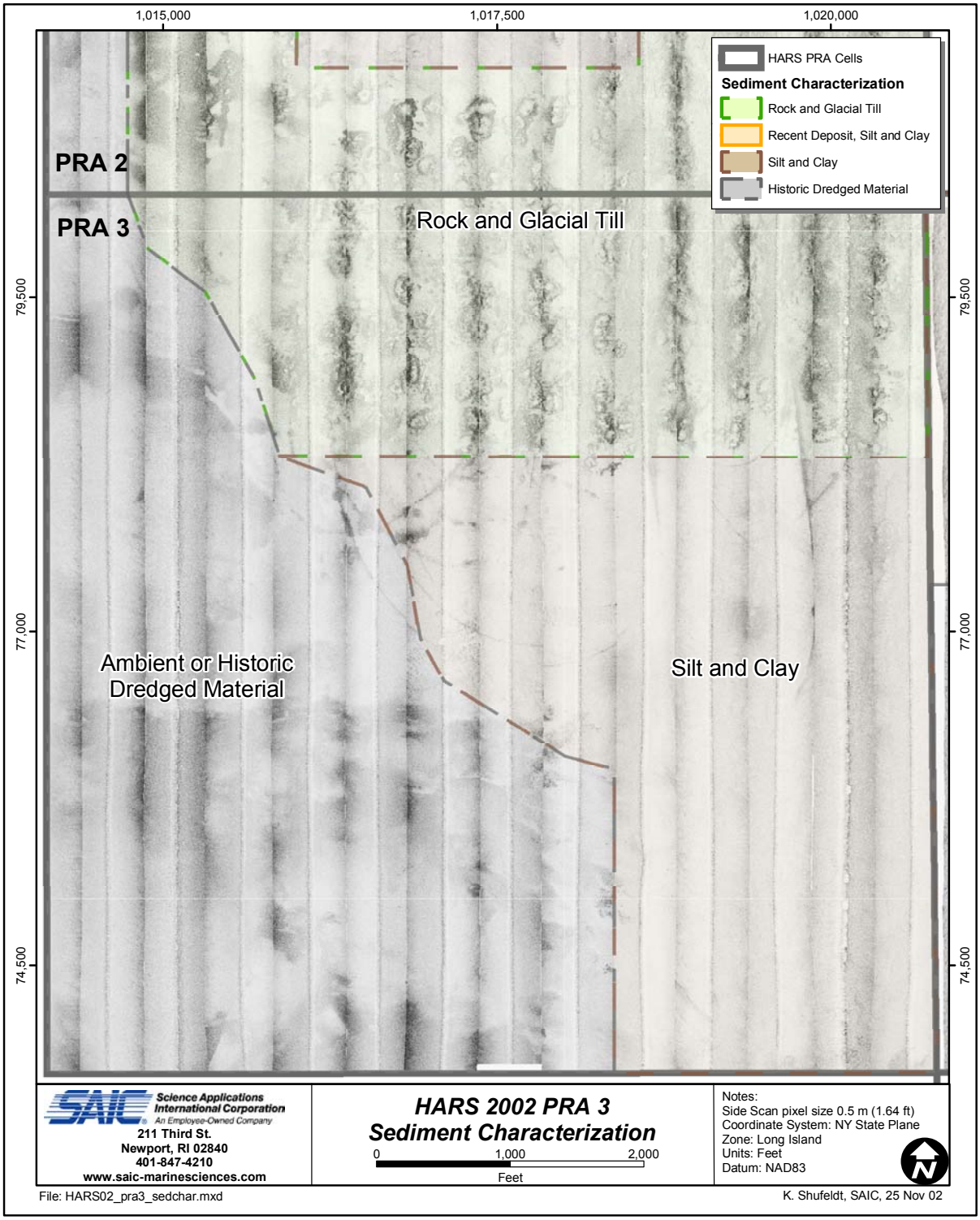


Figure 3.3-6. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 3

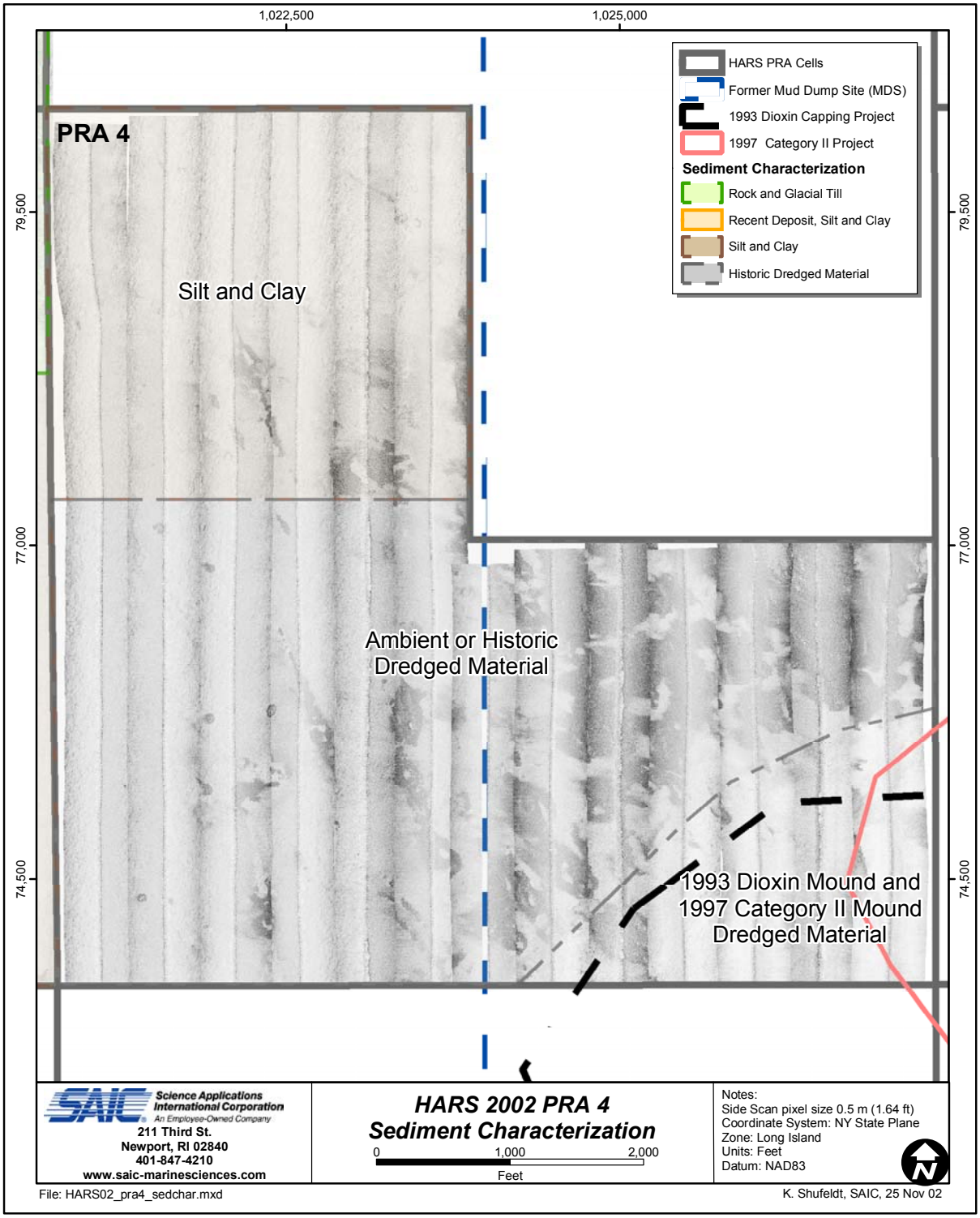


Figure 3.3-7. Broad sediment characterization based on review of the historic disposal logs for selected placement events of the side-scan sonar mosaic over PRA 4

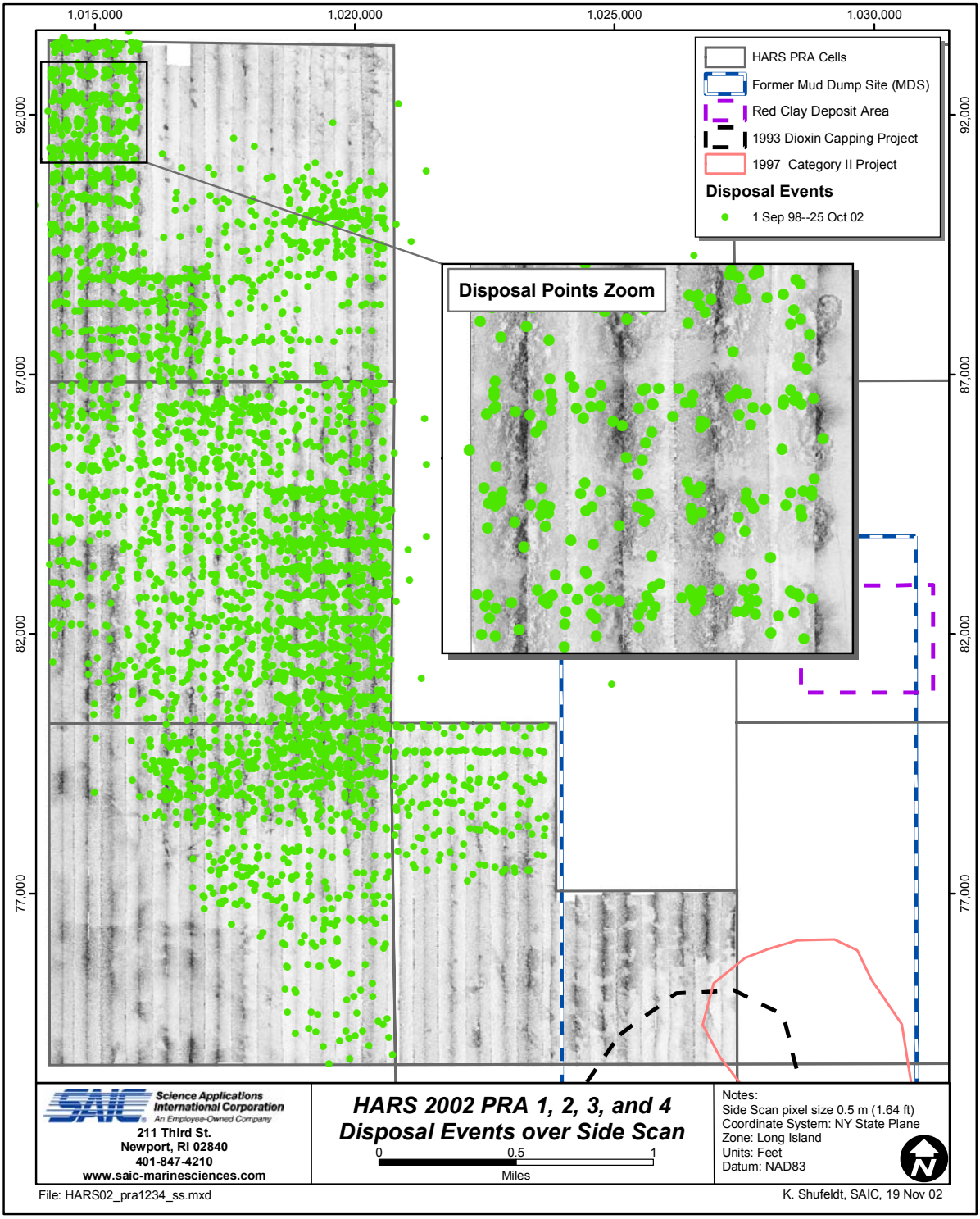


Figure 3.3-8. Disposal events recorded between 1 September 1998 and 25 October 2002 over the side-scan sonar mosaic within PRAs 1, 2, 3, and 4

from these events provided general information on the sediment composition of the dredged material in each barge, which aided in the broad sediment characterization of PRAs 1, 2, 3, and 4.

As shown in the bathymetry, disposal event points also aligned well with areas of recent sediment accumulation on the bottom (Figure 3.2-5). Similarly, the bathymetric depth difference correlated well with the evidence of disposal indicated by the side-scan sonar mosaic (Figure 3.3-9). The largest areas of deposition were shown to be over the recent silt and clay deposits within PRA 1 and the rock and glacial till deposits in PRAs 2 and 3. The largest deposits were over 12 ft thick in the northeastern section of PRA 3 (rock and glacial till).

The most recent previous side-scan sonar survey was conducted in March 2000 over PRAs 1, 2, and 3. This survey took place before much of the disposal between 1 September 1998 and 25 October 2002 had occurred (Figure 3.3-10). When compared to the current 2002 mosaic, the 2000 mosaic lacked the extensive silt and clay deposits in PRA 1 and the rock and glacial till deposits in PRAs 1, 2, and 3, though the coarse-grained ambient or historic dredged material was similar in both mosaics (Figure 3.3-11). In the 2000 mosaic, recent (late 1999/early 2000) silt, clay, and rock deposits in PRA 2 appeared as high-reflectance areas, while in the 2002 mosaic, the acoustic return was weaker relative to the surrounding recent rock and glacial till deposits. This indicated that the high reflectance associated with the recent silt and clay deposits in PRA 1 within the 2002 mosaic will likely diminish over time.

3.3.2 Sub-bottom

Sub-bottom profile data were also collected along the same lanes as the side-scan sonar data over PRAs 1, 2, 3, and 4, the dioxin mounds, and the red clay deposit area. Because it was not a requirement within this task order, the sub-bottom data were not closely analyzed for PRAs 1, 2, 3, and 4, and individual reflectors were not digitized for further analysis. More detailed sub-bottom results were generated to support the specific monitoring efforts conducted around the 1993 Dioxin Capping Project Mound (SAIC 2003a) and the 1997 Category II Capping Project Mound (SAIC 2003b).

In general, topographic features as well as some reflectors could be seen in the sub-bottom records over PRAs 1, 2, 3, and 4 (Figure 3.3-12). Because of the acoustic return pattern associated with the lower-frequency, wide-beam angle sub-bottom data, rocks and steep sediment deposits sometimes appeared as hyperbolic features on the seafloor. In the recent silt and clay deposits within PRA 1, individual hummocks (faint hyperbolas) could be seen rising approximately 2 to 4 meters above the surrounding seafloor in the sub-bottom record (Figure 3.3-12), suggesting that the silt and clay were forming cohesive clumps. More hummocks appeared in the sub-bottom records over the area of rock and glacial till in PRA 2. Although no sub-bottom reflectors could be detected beneath the rock and glacial till deposits in PRA 2, several sediment layers could be observed in areas of ambient or historic dredged material (Figure 3.3-12).

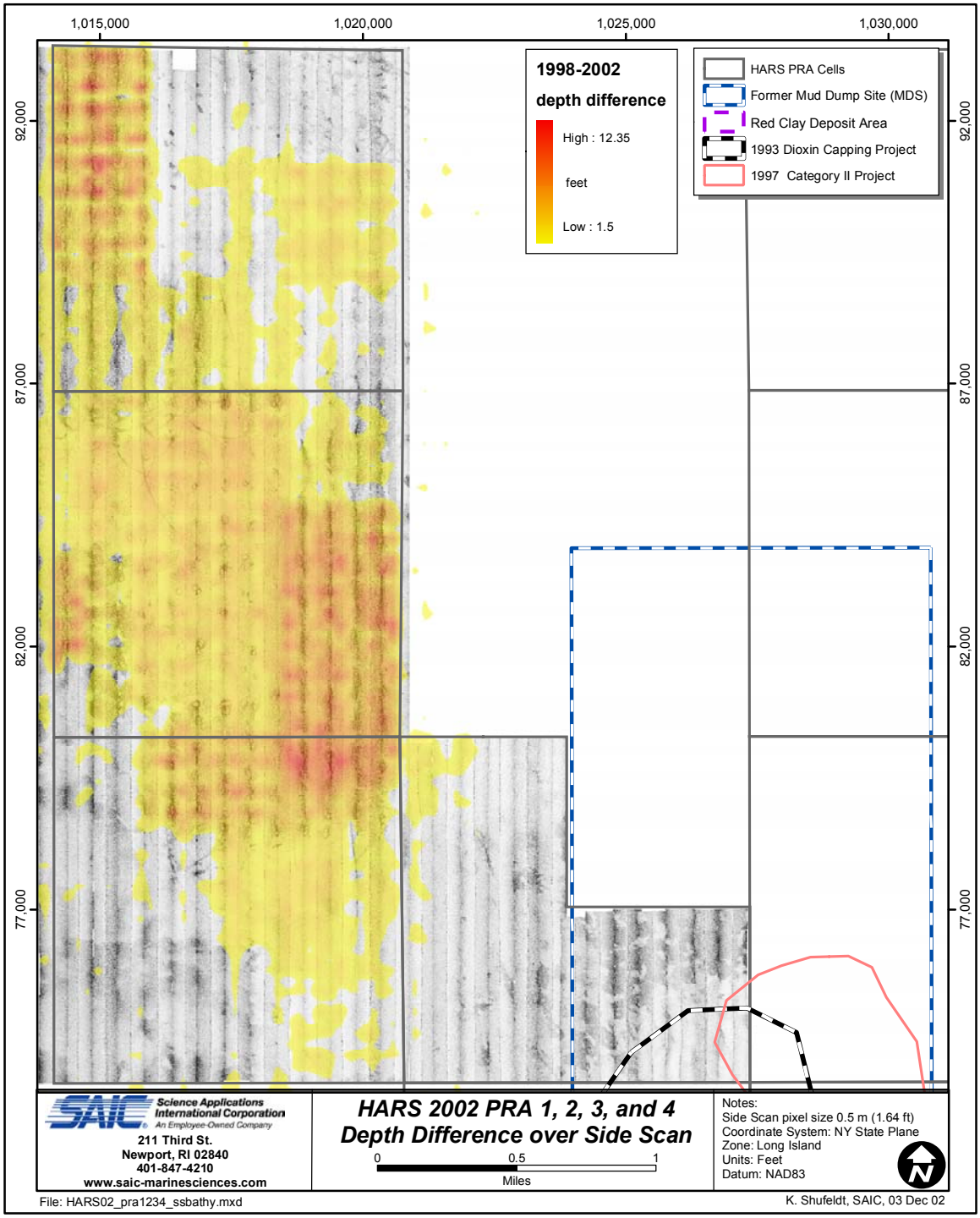


Figure 3.3-9. Composite map illustrating the August 2002–September 1998 bathymetric depth difference data overlaid on the side-scan sonar mosaic to demonstrate the correlation between seafloor composition and topography over PRAs 1, 2, 3, and 4.

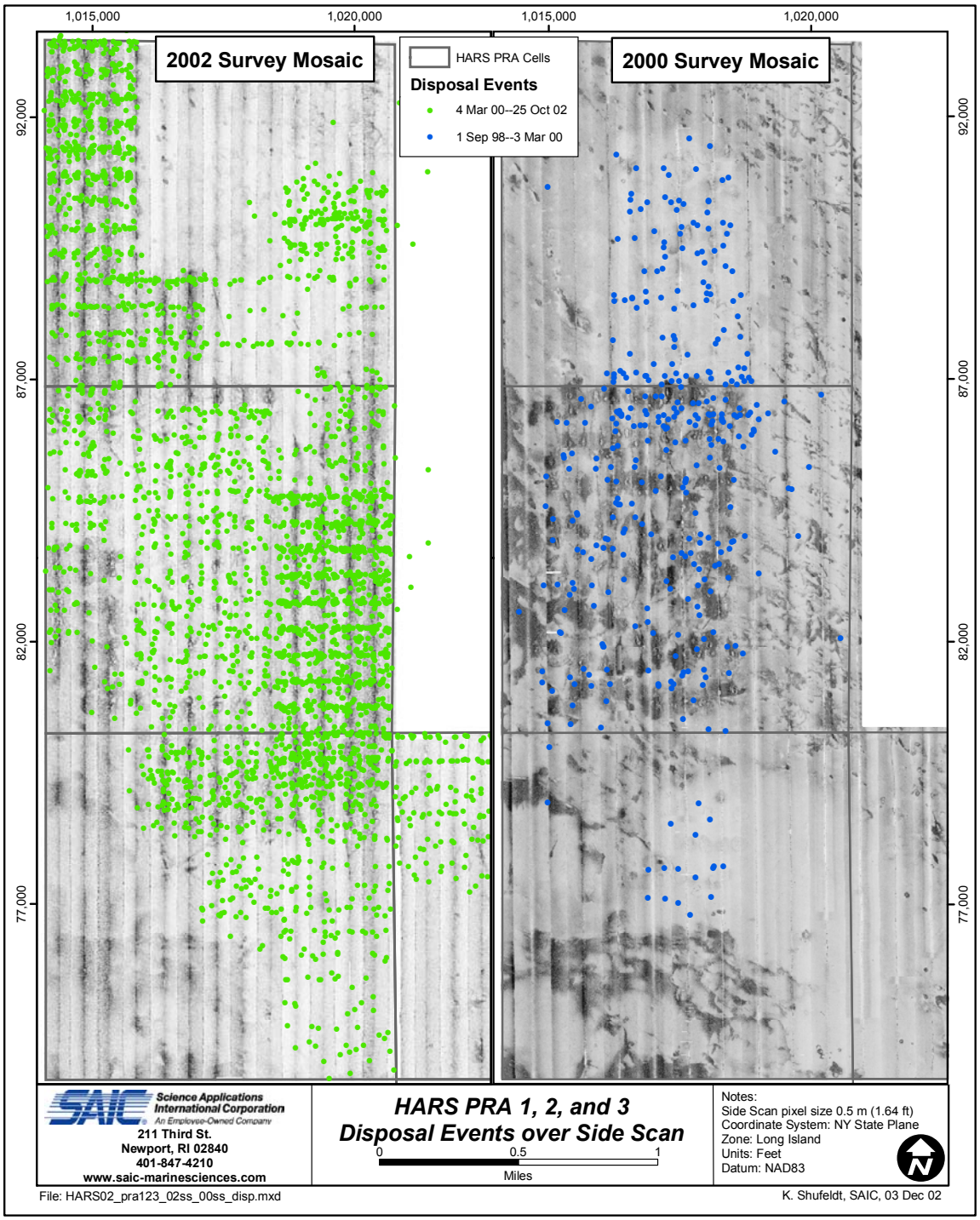


Figure 3.3-10. The map on the left shows disposal events recorded between 4 March 2000 and 25 October 2002 over the 2002 side-scan sonar mosaic. The map on the right shows disposal events recorded between 1 September 1998 and 3 March 2000 over the 2000 side-scan sonar mosaic. These views demonstrate that much disposal took place after the March 2000 side-scan sonar survey.

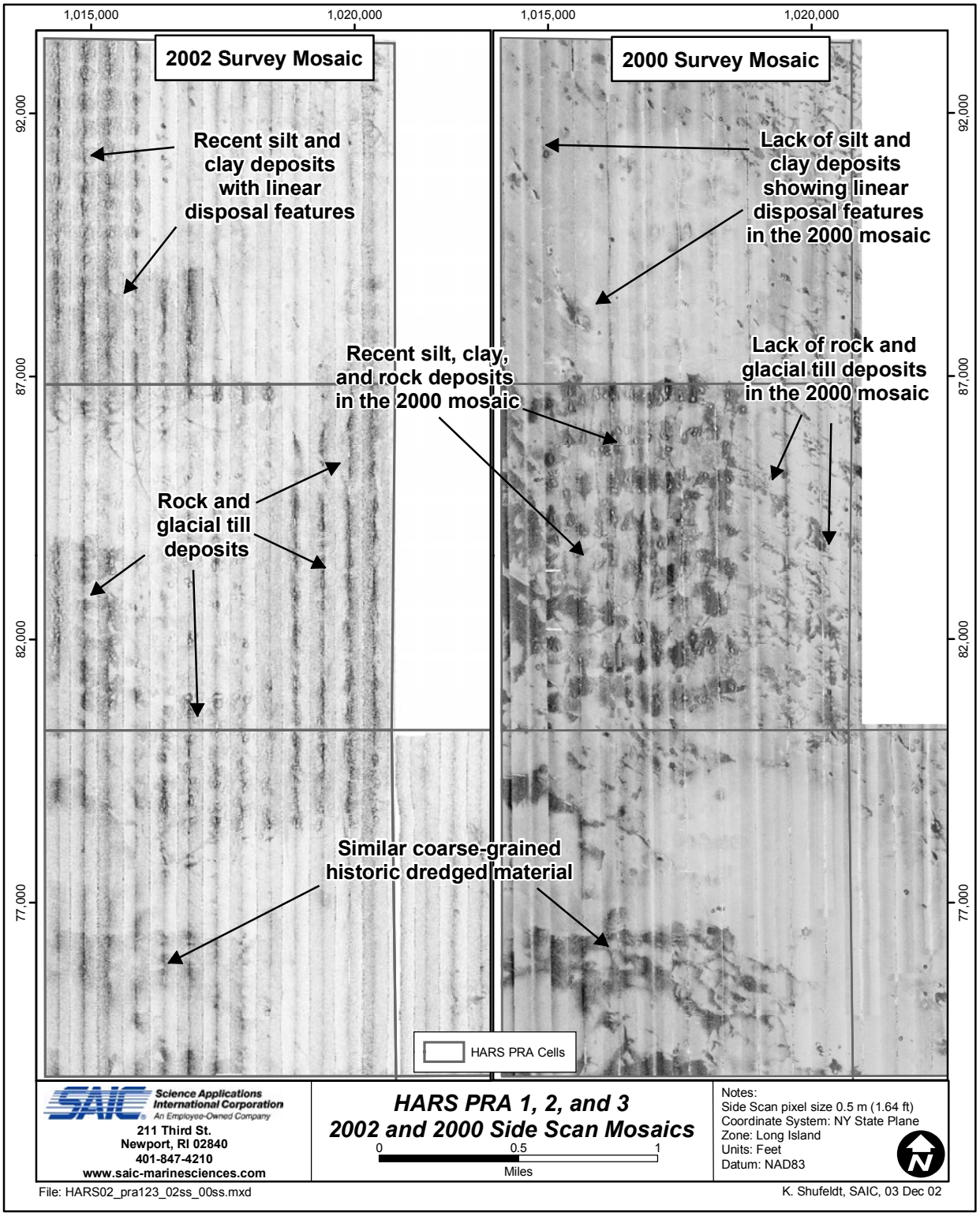


Figure 3.3-11. Comparison graphic of the 2002 side-scan sonar mosaic (left) and the 2000 side-scan sonar mosaic (right)

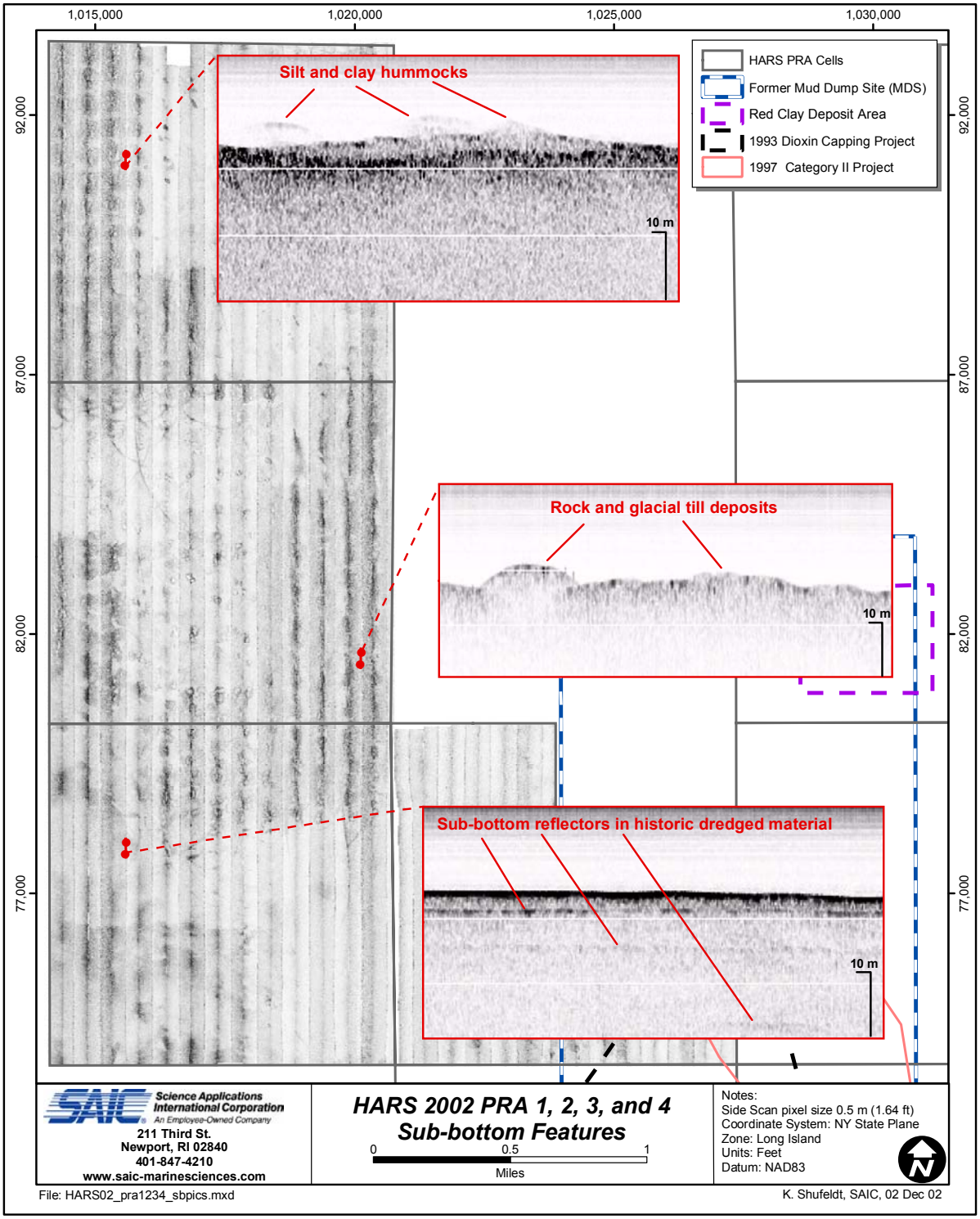


Figure 3.3-12. Features visible in the sub-bottom profile data over PRAs 1, 2, 3, and 4

4.0 DISCUSSION

The 2002 comprehensive survey at the HARS has provided a relatively complete picture of the current physical characteristics of the site and the immediate surroundings. The primary purpose of this effort was to generate the high-resolution single-beam bathymetry that will serve as the updated baseline dataset to plan and monitor future placement activity at the HARS. Based on the detailed data quality review conducted on this data, the 2002 bathymetry should meet this requirement. Extensive cross-check comparisons between north-south and east-west survey lanes showed consistently strong agreement throughout. The computed mean difference between the 4,772 east-west and north-south survey depths that overlapped within 25 ft of each other was –0.11 ft with a standard deviation of 0.84 ft. The distribution of the differences about the mean was very consistent, with a similar number of points evenly distributed on both sides of the mean. Though some of the observed difference may have resulted from on-going placement operations during the course of the survey, most of the difference was attributed to the small-scale variability inherent in any offshore bathymetric survey, due primarily to wave action and localized tidal change.

Of the numerous vertical offsets that impacted the accuracy of the final sounding data, the measurement and application of the proper tidal correction for each sounding was probably the most difficult to address consistently. Because the tidal height values changed rapidly during the mid-phase of the tide, even relatively small time offsets potentially had a large impact on the computed tide corrector. Though the 2002 survey included the deployment of a bottom-mounted tide gauge in the HARS, this gauge was primarily intended to provide a check of the tidal corrections that were being generated based on the historic range and phase offsets applied to the observed Sandy Hook tide gauge data. As discussed in the report (Section 3.1.2), based on the observed results between the HARS tide gauge and the corrected Sandy Hook tide data, there was some variability in the tidal relationships between these two areas. Based on some of the trends indicated by this variability there is reason to consider making minor revisions to the range and phase offsets that are applied when transferring Sandy Hook tides out to the HARS. Because of some limitations with the 2002 HARS tide gauge data (e.g., short deployment periods, little seasonal variability, lower resolution data), an accurate revision to the historical tidal offsets between Sandy Hook and the HARS should be based on a more comprehensive tidal study focused around the HARS.

After the 2002 bathymetric survey was fully processed and verified for consistency, it was compared to several other bathymetric survey datasets (both single-beam and multibeam) that had been acquired over different areas of the HARS over the last few years by different sources (e.g., USACE, USGS, and SAIC). These depth difference comparisons were completed to support the review of the comprehensive HARS bathymetry (described herein) as well as the detailed monitoring over the capped dioxin mounds (SAIC 2003a; 2003b). In some of these comparisons with prior datasets, consistent biases were detected between these surveys. In some cases, the observed biases were consistently negative and in other cases the biases were consistently positive. Because the observed differences with these other surveys were not

consistent and the cross-check results for the 2002 data were strong, it appeared that different problems were affecting these other data sets.

For instance, in comparisons with the prior 1998 bathymetry over PRAs 1, 2, and 3, a 1.5 to 2.0 ft positive bias was detected in the 1998 data that reduced the apparent placement extent over the area and made it appear as if many of the non-placement areas had experienced widespread erosion (Figure 4-1). A detailed review of the 1998 data revealed a sound velocity correction error that effectively reduced the depths of that survey; the magnitude of the error was dependent on the depth. Though a tide-related artifact was also evident in this 1998 dataset (evident as vertical banding in the daily data—Figure 3.2-3), it had less of an impact on the depth difference results and was not addressed.

Similarly, the initial comparison with the latest 2002 survey dataset over the 1997 Category II Mound showed a tide artifact that resulted in vertical banding and computed depth differences as large as five feet in areas that should have changed little since the last survey (Figure 4-1). This problem was traced to time and range offsets that were not properly applied to the computed tidal corrections that were originally generated for these data. After the proper tidal corrections were re-applied to this dataset, the comparison with the 2002 survey produced more representative results, though a fixed vertical offset was still evident in the data.

These problems encountered when attempting to generate valid depth difference comparisons between surveys illustrate the importance of the proper generation and application of vertical corrections to the bathymetric survey data. Any one of a number of potential vertical offset errors (e.g., static draft, dynamic draft, tides, speed of sound, waves, etc.) can have a major impact on the accuracy of a survey. If even one of these vertical offsets is incorrectly measured or applied to the raw sounding data, then the resulting bathymetric data products will have some degree of inaccuracy. The use of cross-check comparisons and other data quality check procedures should help to minimize the potential impact of these error sources, or at least make it more likely that any errors will be detected during the initial review process. If a data quality review is not conducted shortly after the data are acquired, then errors will likely not be detected until that dataset is compared to another dataset (assuming the subsequent dataset is accurate).

After the sound velocity offset problems were resolved for the 1998 bathymetric survey, the depth difference comparisons between this survey and the 2002 survey provided a good indication of the level of remediation that has occurred within PRAs 1, 2, and 3 since 1998. The depth difference results agreed well with the side-scan sonar mosaic and the historic placement records, and clearly indicated those areas with accumulating remediation material (Figure 4-2). Based on these results, a large portion of PRA 2 and smaller portions of PRAs 1 and 3 have been covered with at least 3 ft of remediation material since the designation of the HARS. Continued use of well-targeted placement for future disposal activities, as well as periodic monitoring surveys to confirm the results of these disposal activities, should help to ensure that the remediation of the HARS continues as planned.

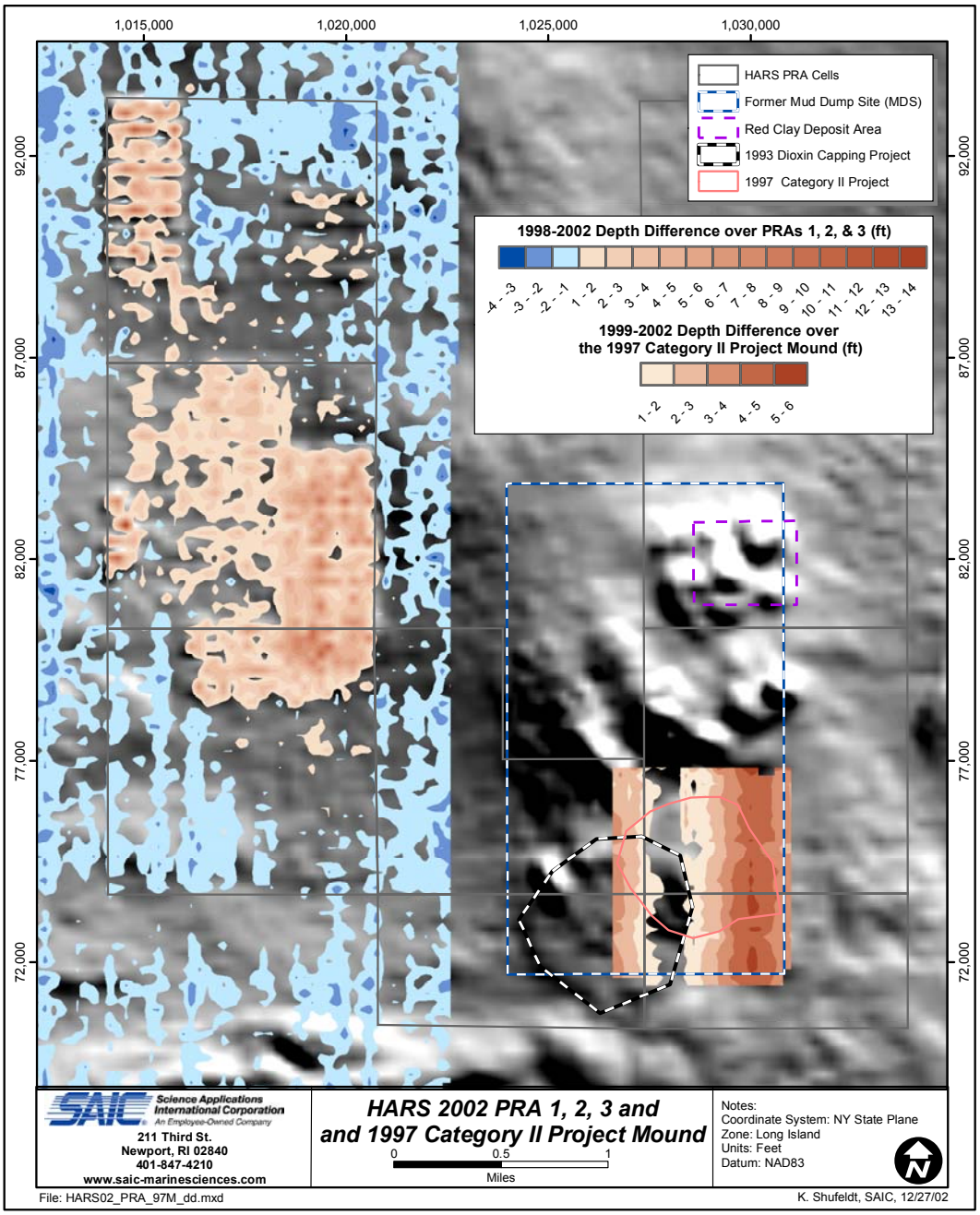


Figure 4-1. The original bathymetric depth difference grids generated between the 2002 survey and the prior surveys over PRA's 1, 2, and 3 and the 1997 Category II Mound Area. These depth difference results reflected a sound velocity correction problem with the prior 1998 survey over PRA's 1, 2, and 3 and a tidal offset problem with the prior 1999 survey over the 1997 Category II Mound. Both of these prior datasets were re-processed and then used to generate more representative depth difference grids (see the following figure for the updated depth difference grid over PRA's 1, 2, and 3).

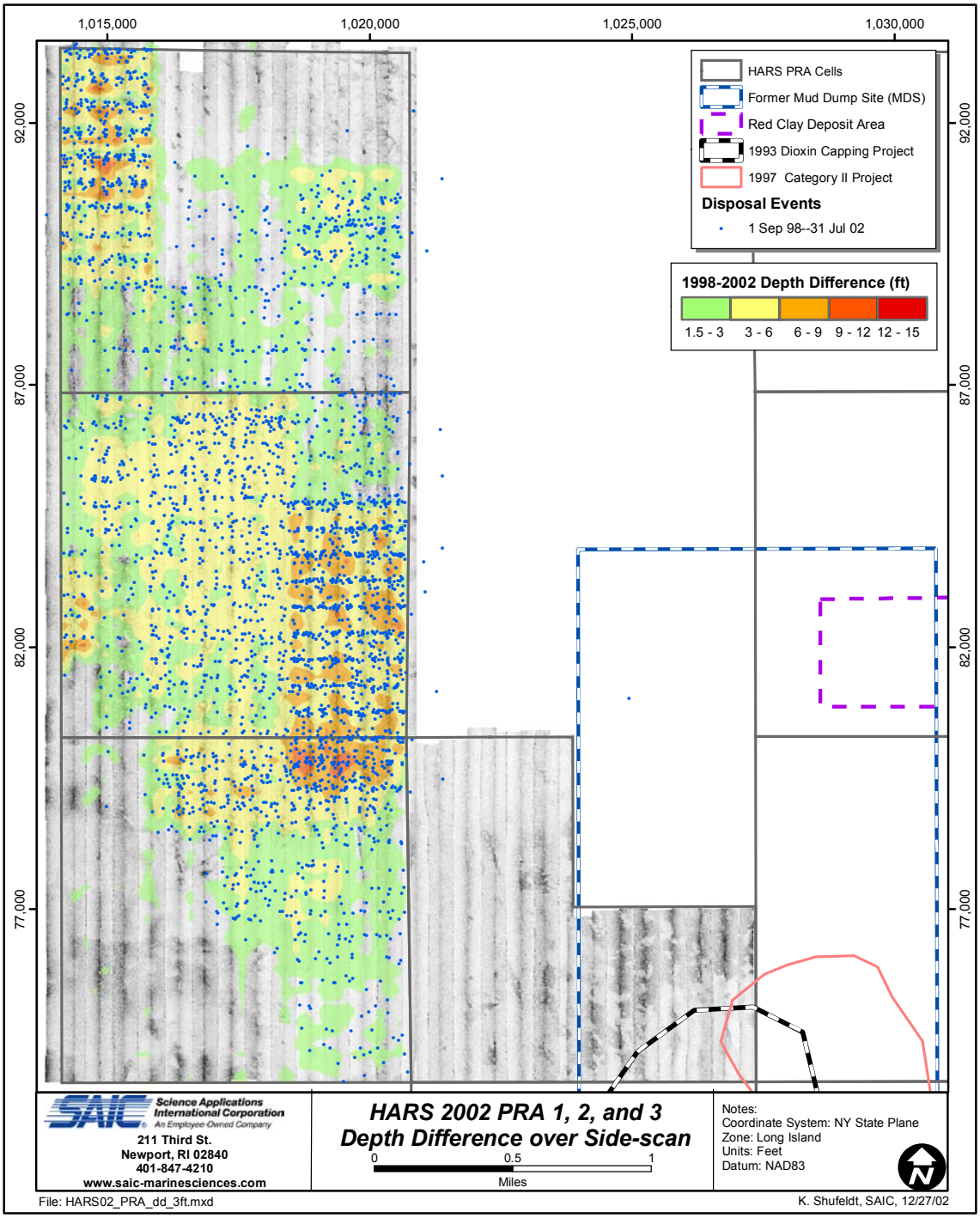


Figure 4-2. Composite map showing the 2002 bathymetric depth difference (in 3 ft intervals) with disposal events (1 September 1998–31 July 2002) overlaid on the side-scan sonar mosaic to demonstrate accumulating remediation material over PRAs 1, 2, and 3 since 1998.

5.0 CONCLUSIONS

- Based on the overall data quality results for the 2002 bathymetric survey at the HARS, this survey will provide a comprehensive bathymetric dataset to help plan and monitor future placement activity at the HARS. It will also provide an updated bathymetric dataset against which future HARS bathymetric monitoring surveys can be compared. Though minor variability can still be expected due to a number of potential small vertical offsets, future surveys (conducted properly) should compare well with the 2002 survey.

- Based on comparisons with a prior bathymetric survey conducted in 1998 shortly after the designation of the HARS, the 2002 bathymetric survey showed that the planned remediation efforts are progressing well in PRAs 1, 2, and 3. A large portion of PRA 2 and smaller portions of PRAs 1 and 3 have been covered with at least 3 ft of remediation material since the designation of the HARS. Continued use of well-targeted placement for future disposal activities, as well as periodic monitoring surveys to confirm the results of these disposal activities, should help to ensure that the remediation of the HARS continues as planned.

- The 2002 side-scan sonar data correlated well with the bathymetric depth difference results and provided a useful overview of the composition of the seafloor materials associated with the numerous placement activities that have occurred over the HARS. The side-scan sonar data interpretation was greatly aided by the material descriptions provided within the digital logs maintained for all HARS placement events.

- Of the numerous vertical offsets that may have impacted the accuracy of the final bathymetric data, the measurement and application of the proper tidal correctors was the most difficult to address consistently. Based on the observed results between the HARS tide gauge deployed during the 2002 survey and the corrected Sandy Hook tide data, there was some variability in the tidal relationships between these two areas. Because of some limitations with the 2002 HARS tide gauge data (e.g., short deployment periods, little seasonal variability, lower resolution data), an accurate revision to the historical tidal offsets between Sandy Hook and the HARS should be based on a more comprehensive tidal study focused around the HARS.

- The use of the government-owned SIS-1000® combined side-scan sonar and sub-bottom system (as opposed to separate leased systems) permitted far greater flexibility in scheduling the side-scan and sub-bottom survey operations. Though some data formatting problems arose due to the age of the topside processor operating system (and lack of any recent upgrades), this system was particularly well-suited for helping to characterize the complex seafloor stratigraphy over the numerous areas of the HARS that have been impacted by multiple past placement operations.

6.0 REFERENCES

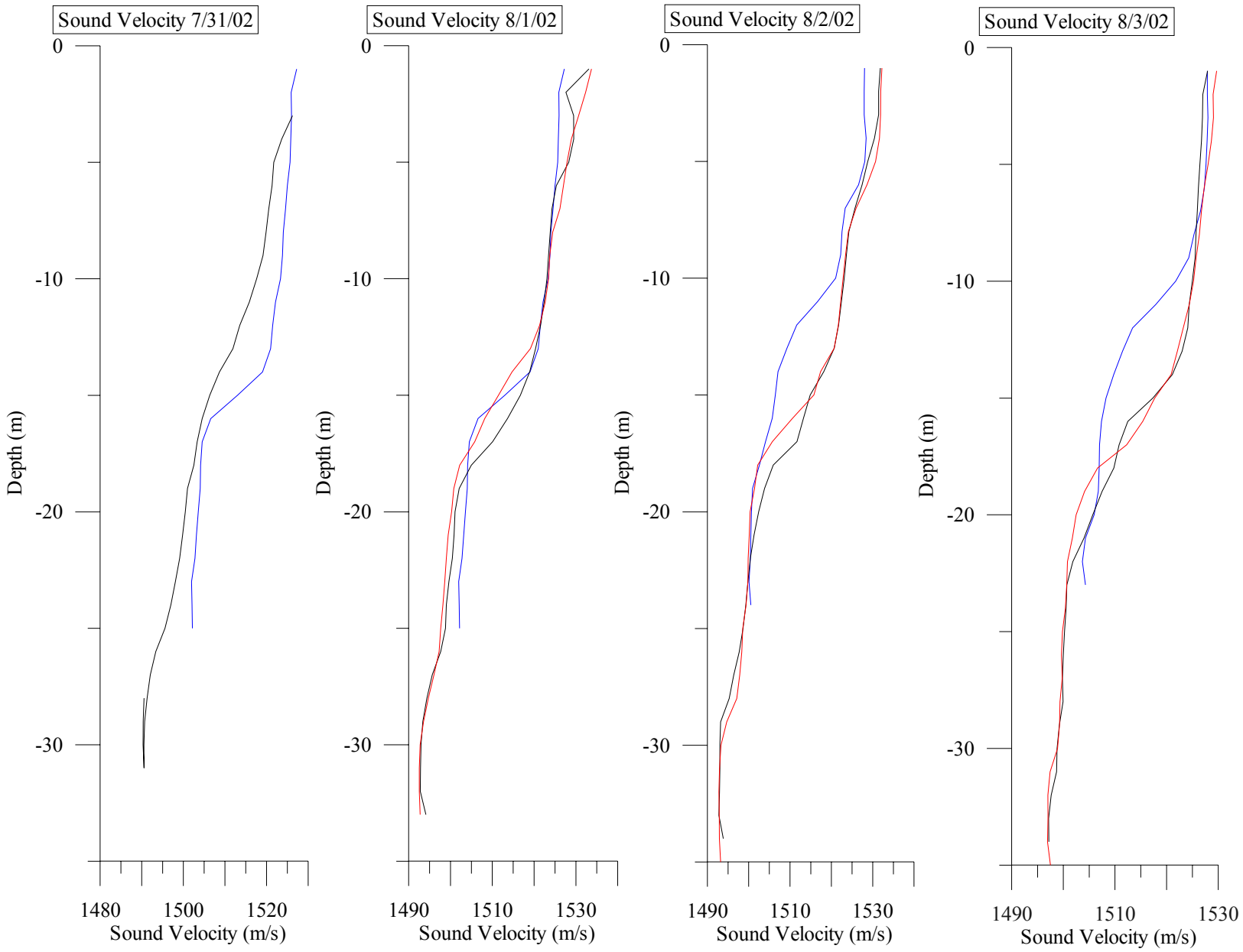
SAIC. 2003a. Results of the Summer 2002 Monitoring Surveys of the 1993 Dioxin Capping Project Mound at the Historic Area Remediation Site. SAIC Report No. 622. December 2002.

SAIC. 2003b. Results of the Summer 2002 Monitoring Surveys of the 1997 Category II Capping Project Mound at the Historic Area Remediation Site. SAIC Report No. 626. January 2003.

SAIC. 2003c. Results of the Summer 2002 Monitoring Surveys of Red Clay Deposits at the Historic Area Remediation Site.

U.S. Army Corps of Engineers 2002. Engineering and Design Hydrographic Surveying. Manual No. 1110-2-1003. January 2002.

Appendix A
CTD Data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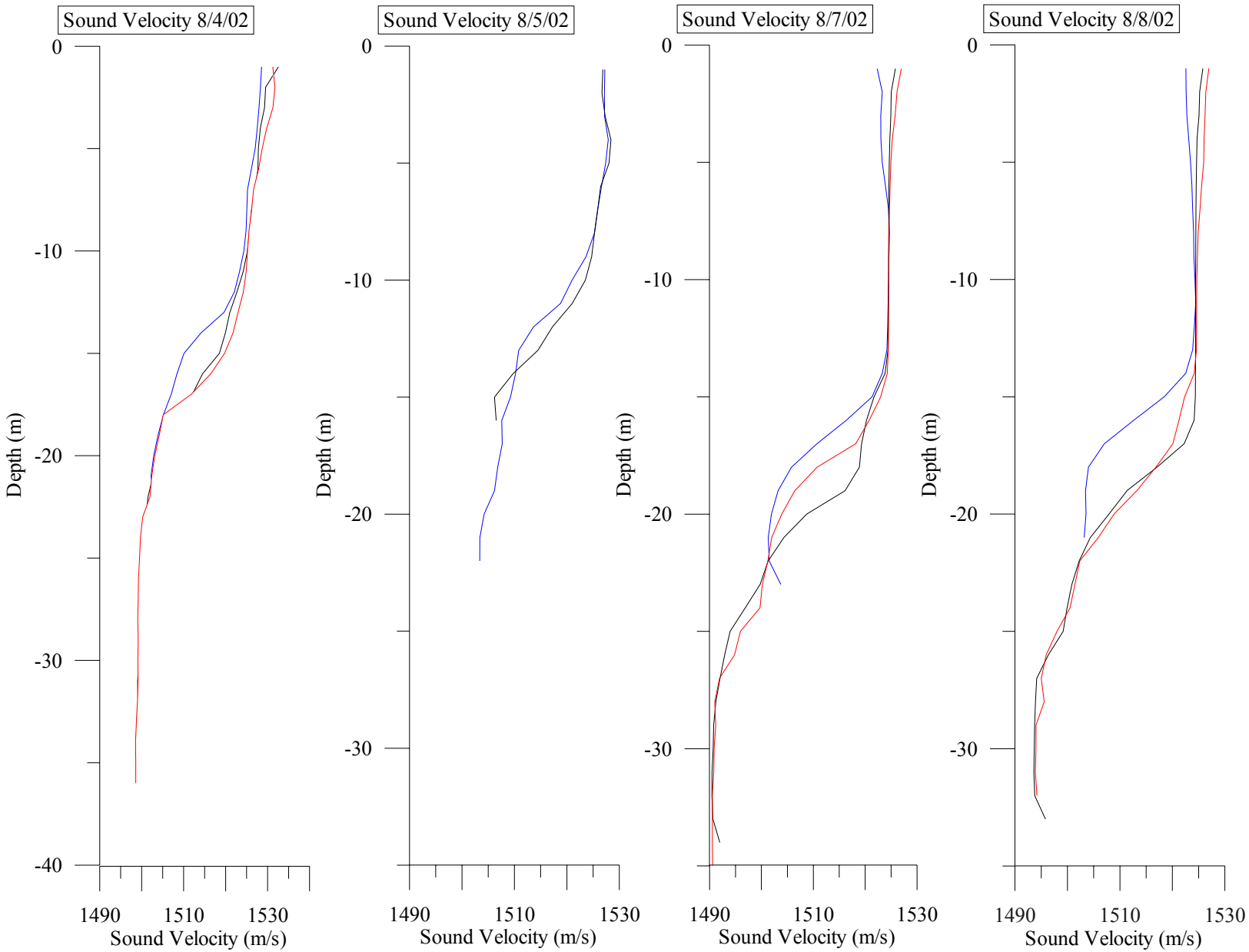
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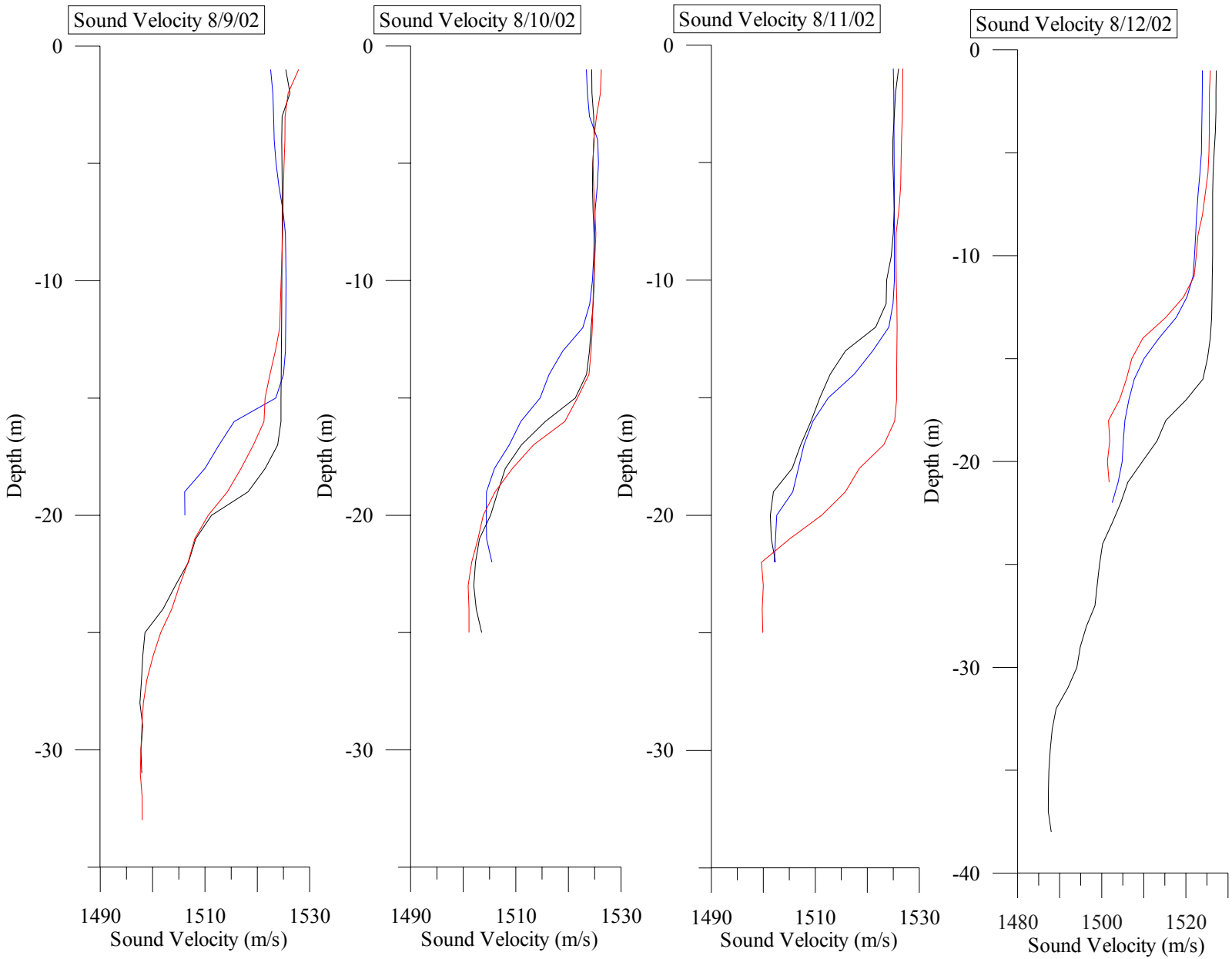
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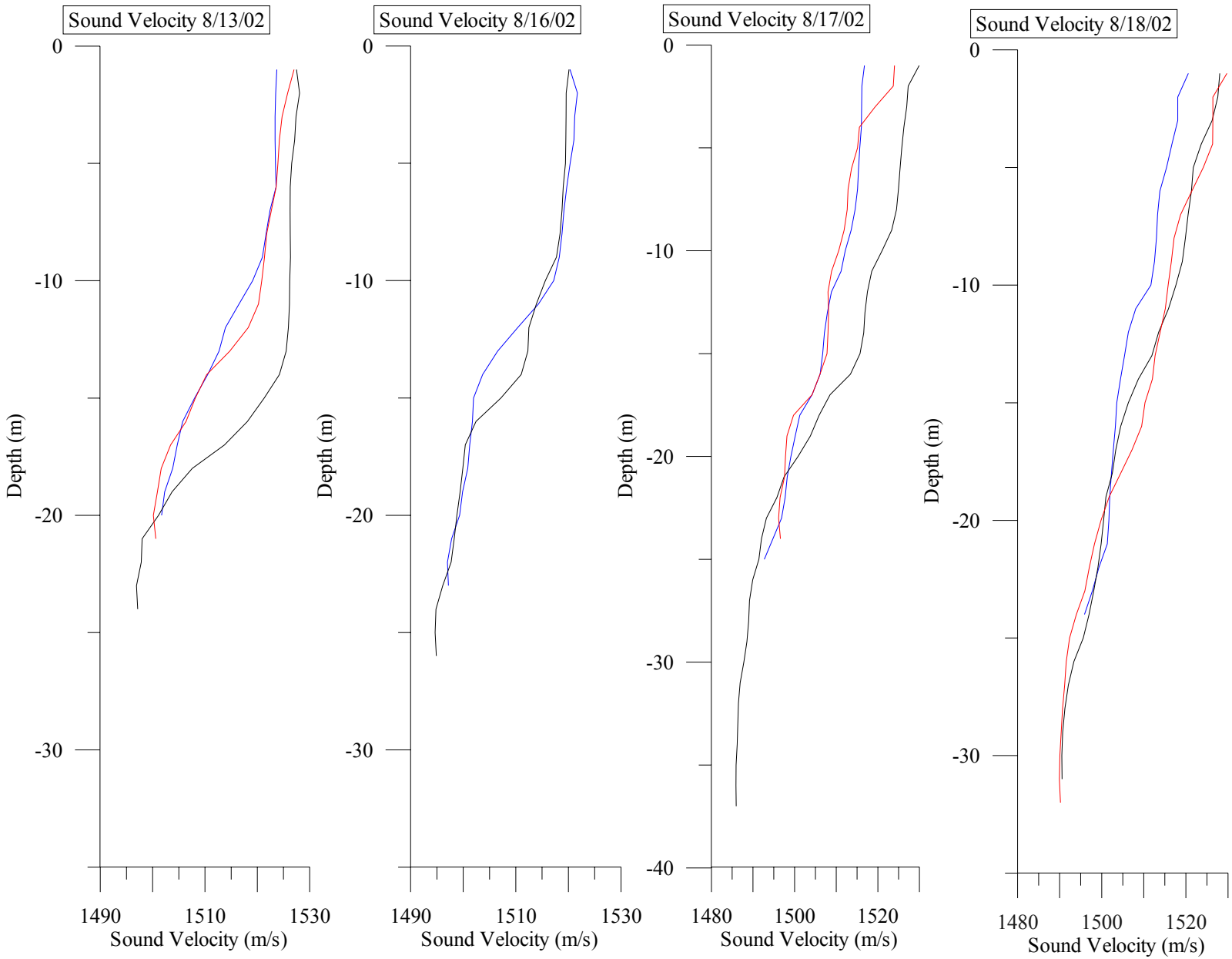
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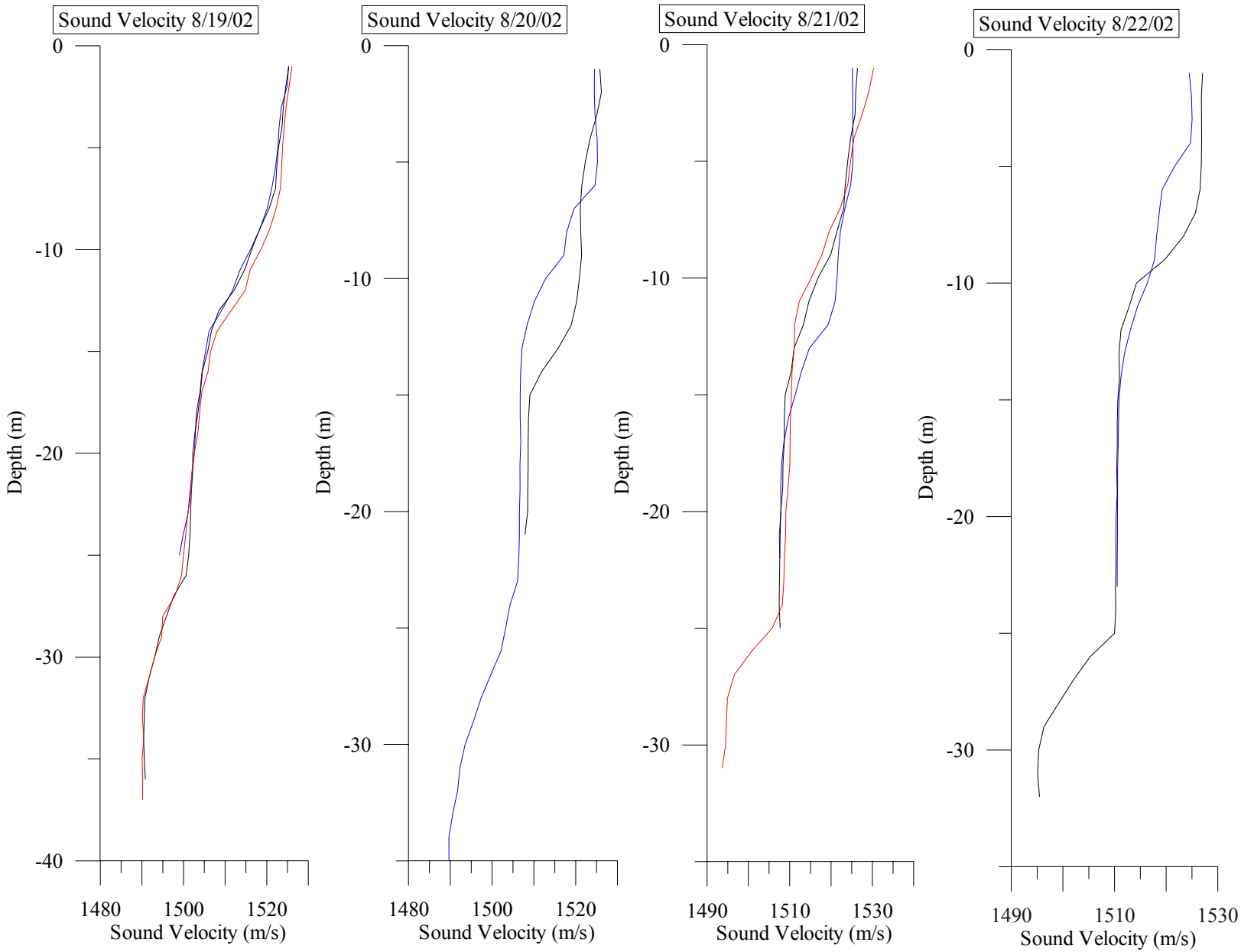
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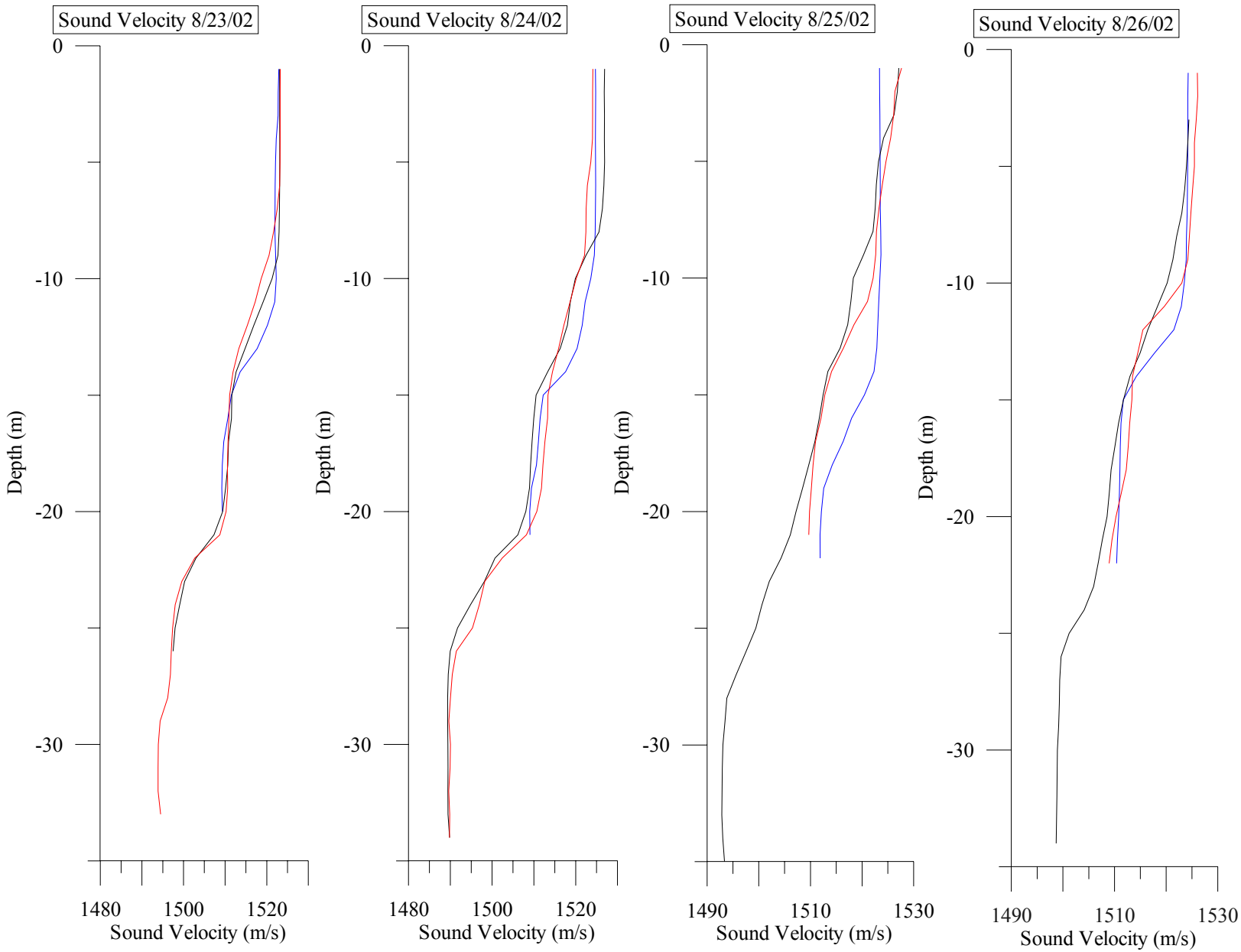
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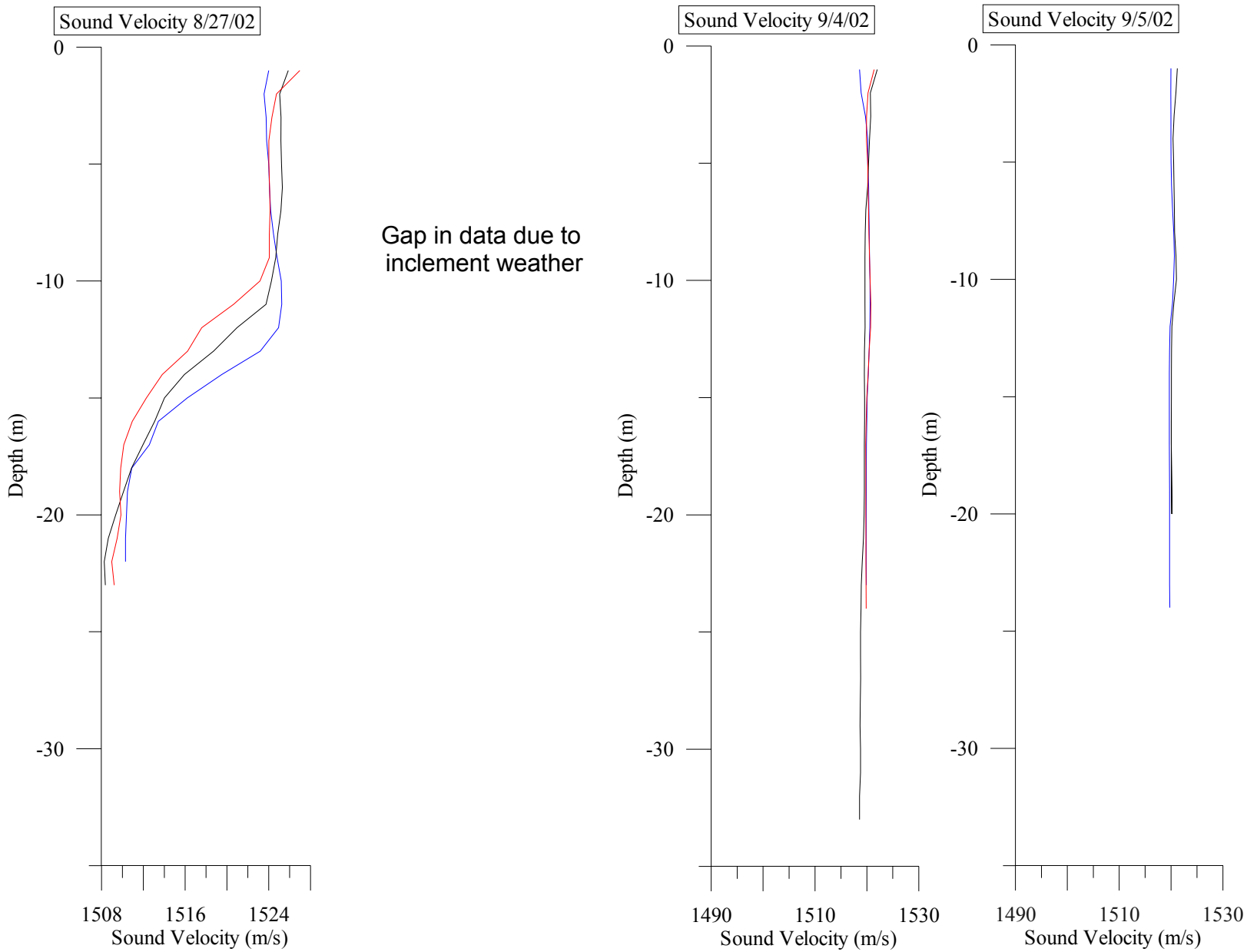
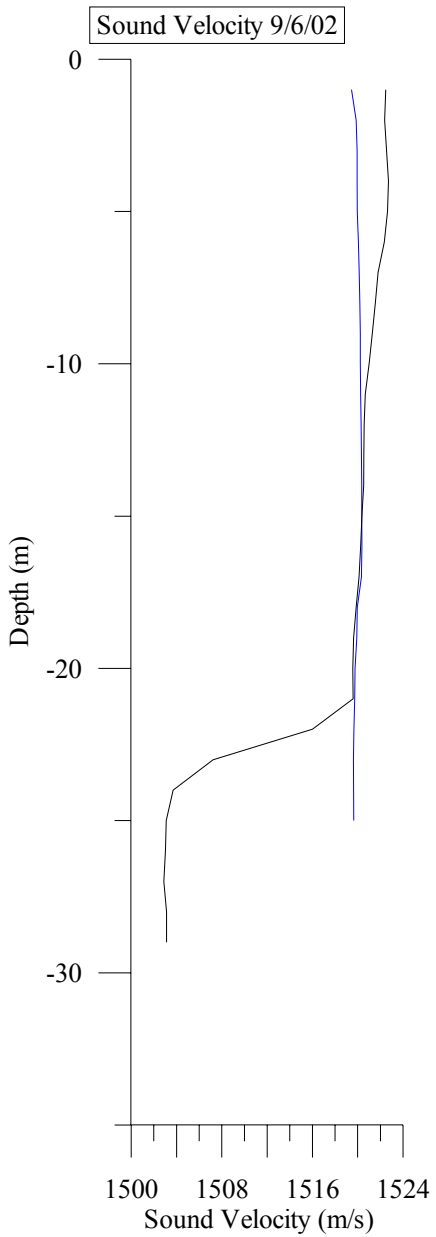
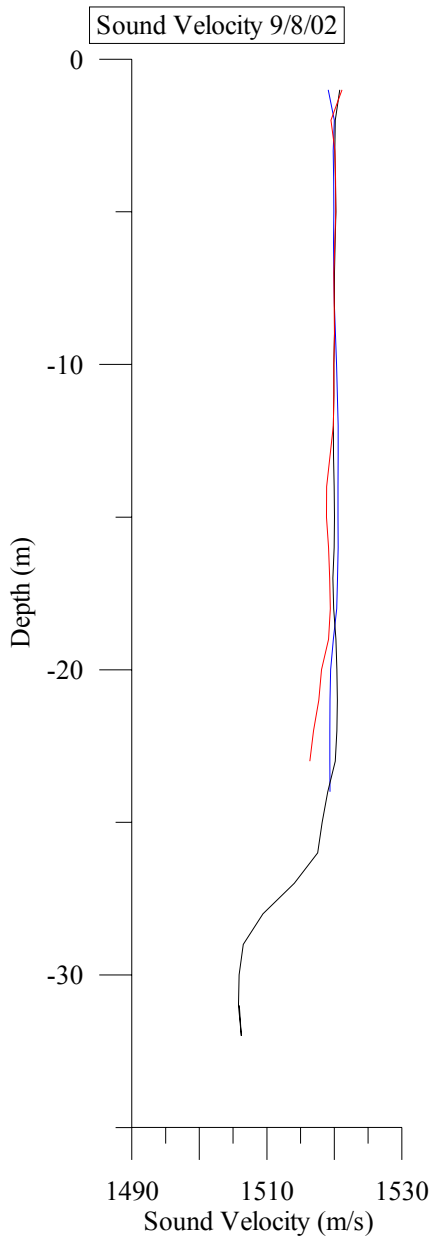
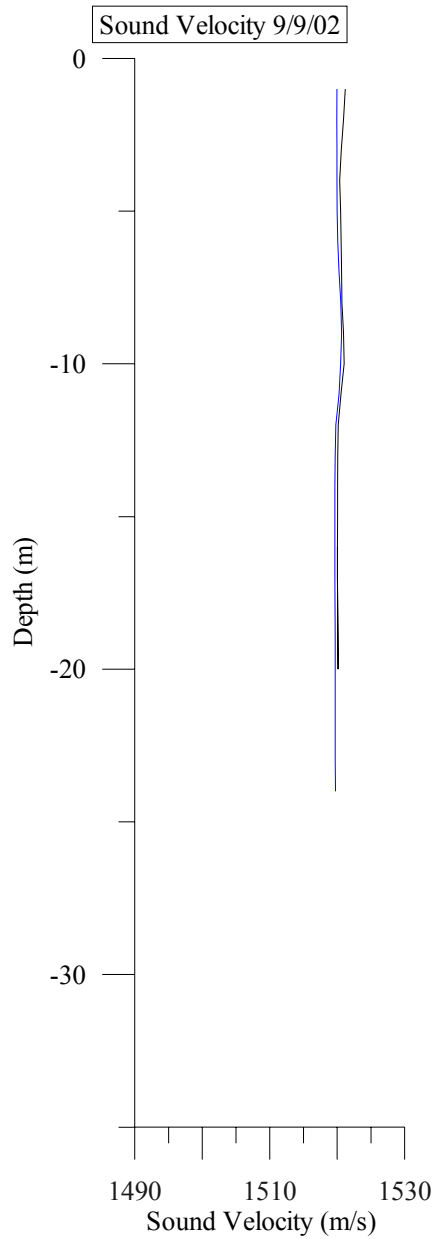
1530
Sound Velocity (m/s)

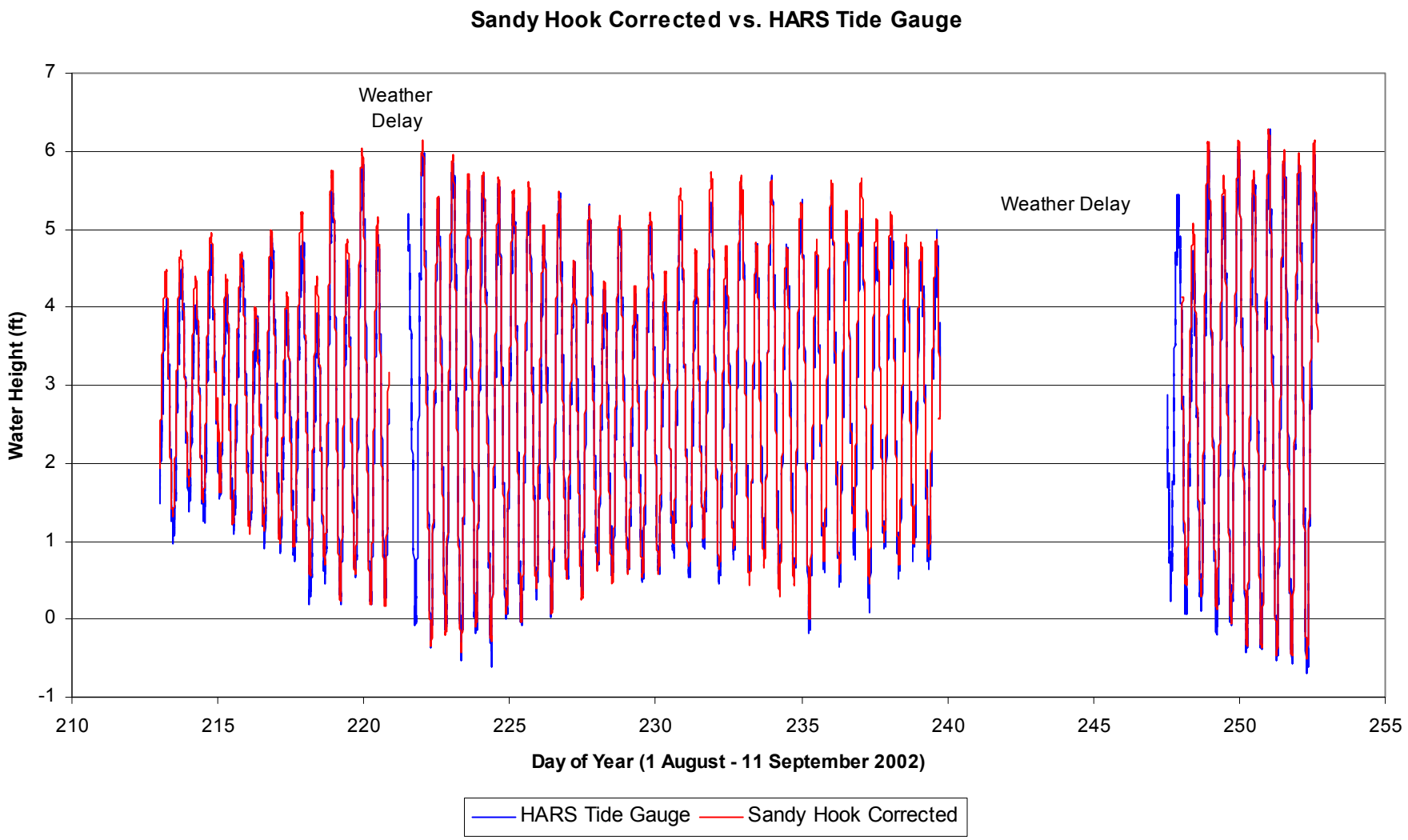

Sound Velocity 8/27/02
Depth (m)
0
-10
-20
-30
1508
1516
1524
Sound Velocity (m/s)
Gap in data due to
inclement weather
Sound Velocity 9/4/02
Depth (m)
0
-10
-20
-30
1490
1510
1530
Sound Velocity (m/s)
Sound Velocity 9/5/02
Depth (m)
0
-10
-20
-30
1490
1510
1530
Sound Velocity (m/s)

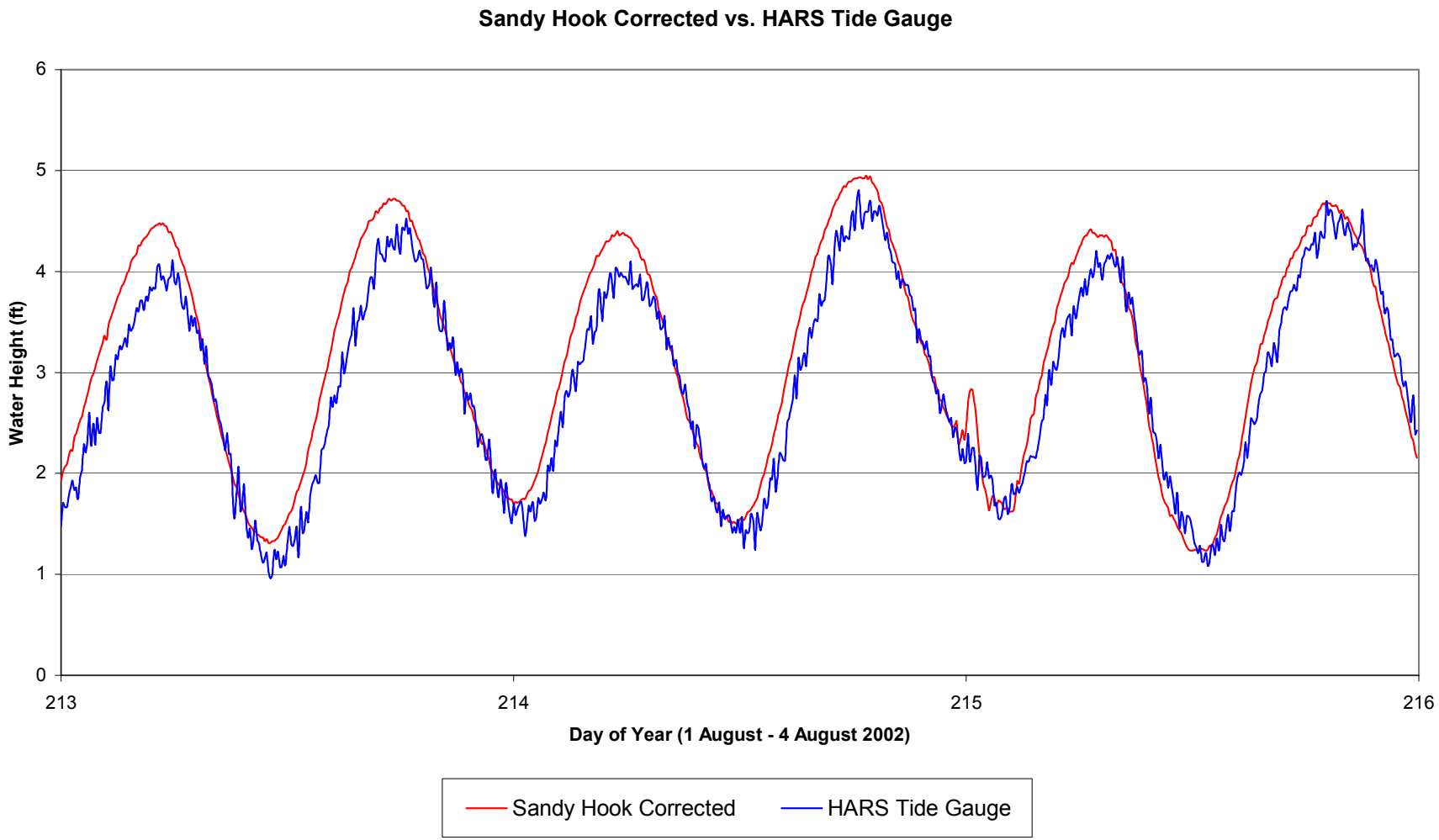

Sound Velocity 9/6/02
0
-10
-20
-30
Depth (m)
1500
1508
1516
1524
Sound Velocity (m/s)

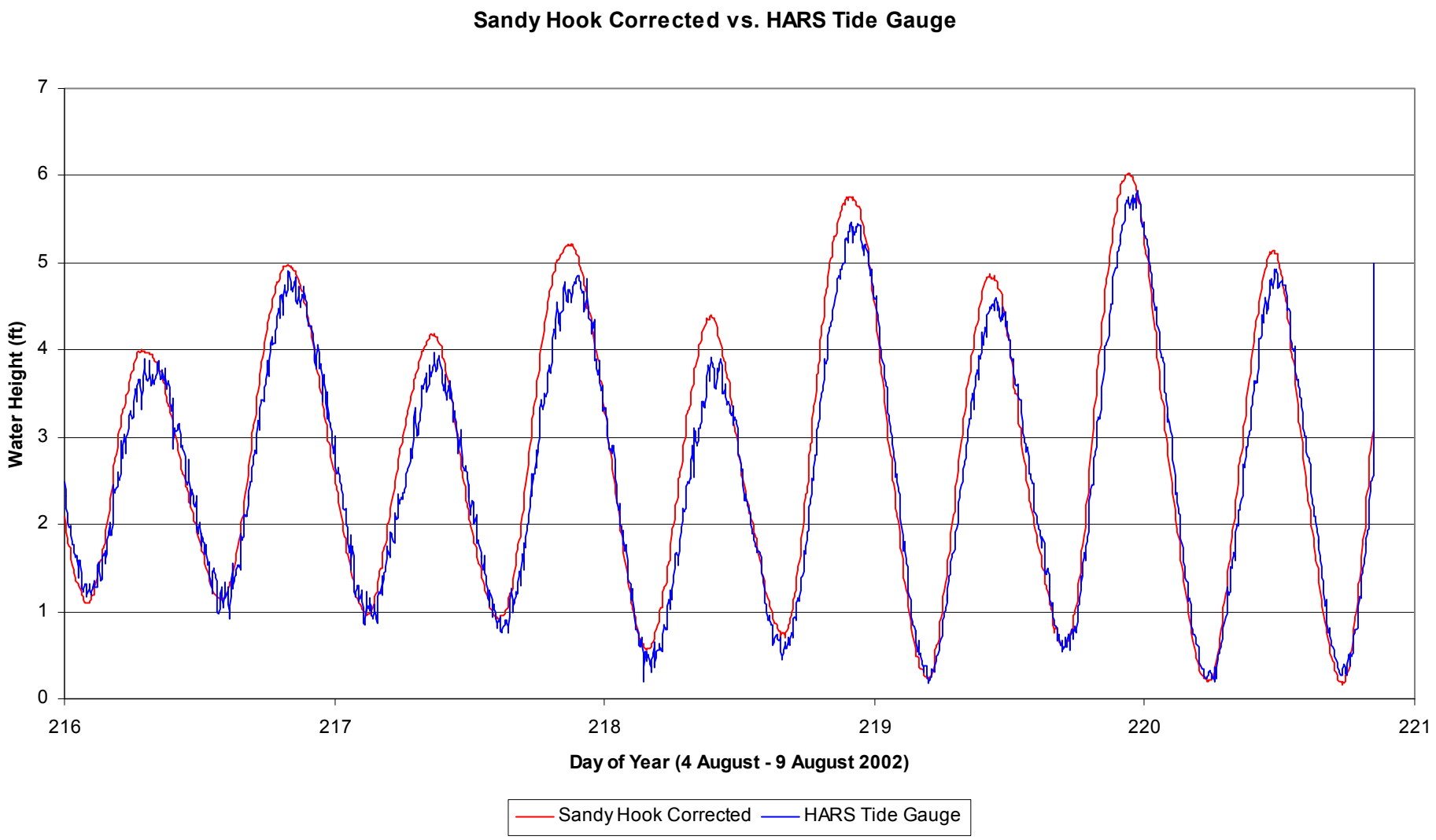

Sound Velocity 9/8/02
0
-10
-20
-30
Depth (m)
1490
1510
1530
Sound Velocity (m/s)

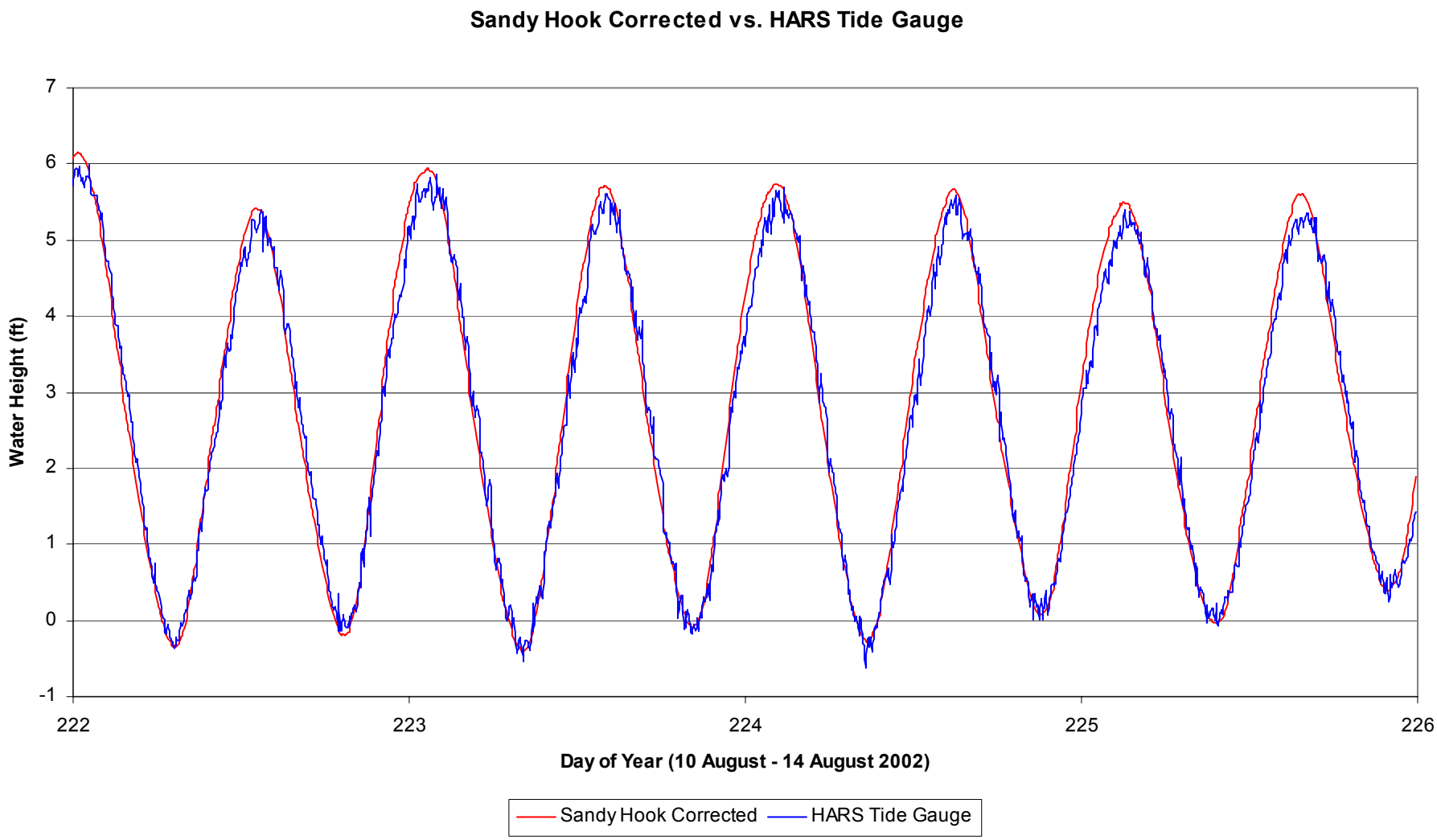

Sound Velocity 9/9/02
0
-10
-20
-30
Depth (m)
1490
1510
1530
Sound Velocity (m/s)

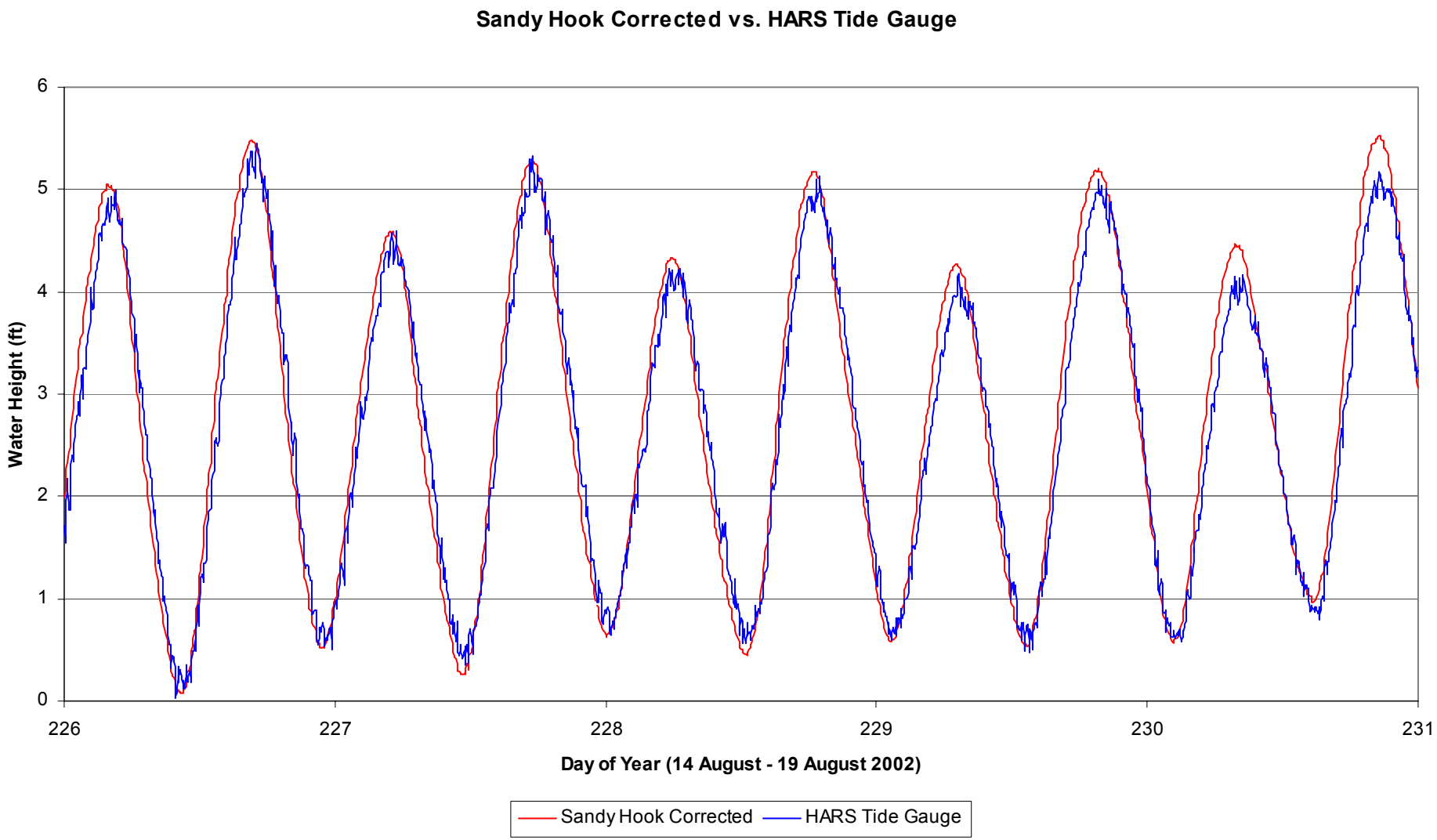
Appendix B
Tide Data

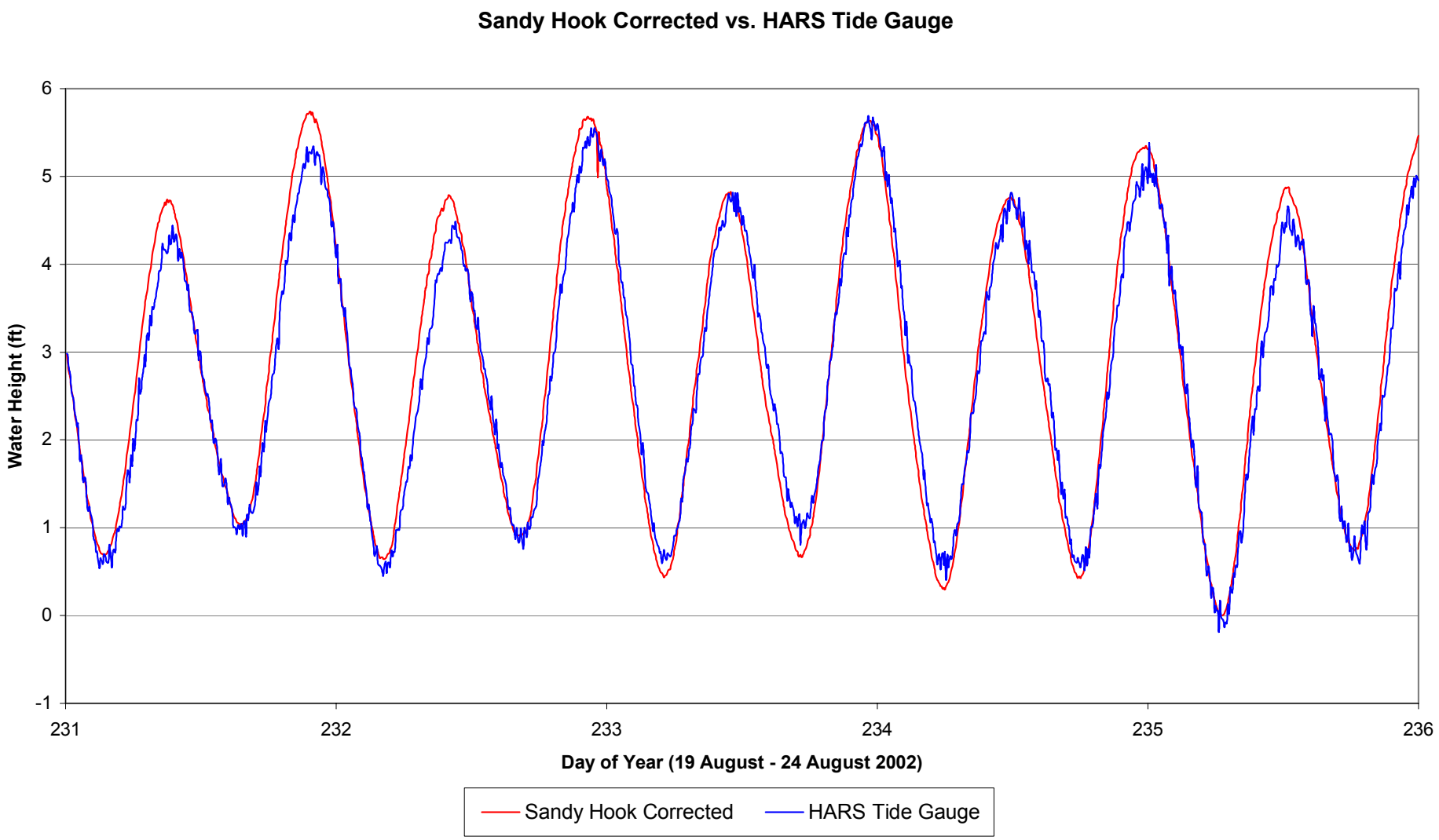

Sandy Hook Corrected vs. HARS Tide Gauge
Weather Delay
Weather Delay
Water Height (ft)
7
6
5
4
3
2
1
0
-1
210
215
220
225
230
235
240
245
250
255
Day of Year (1 August - 11 September 2002)
HARS Tide Gauge
Sandy Hook Corrected

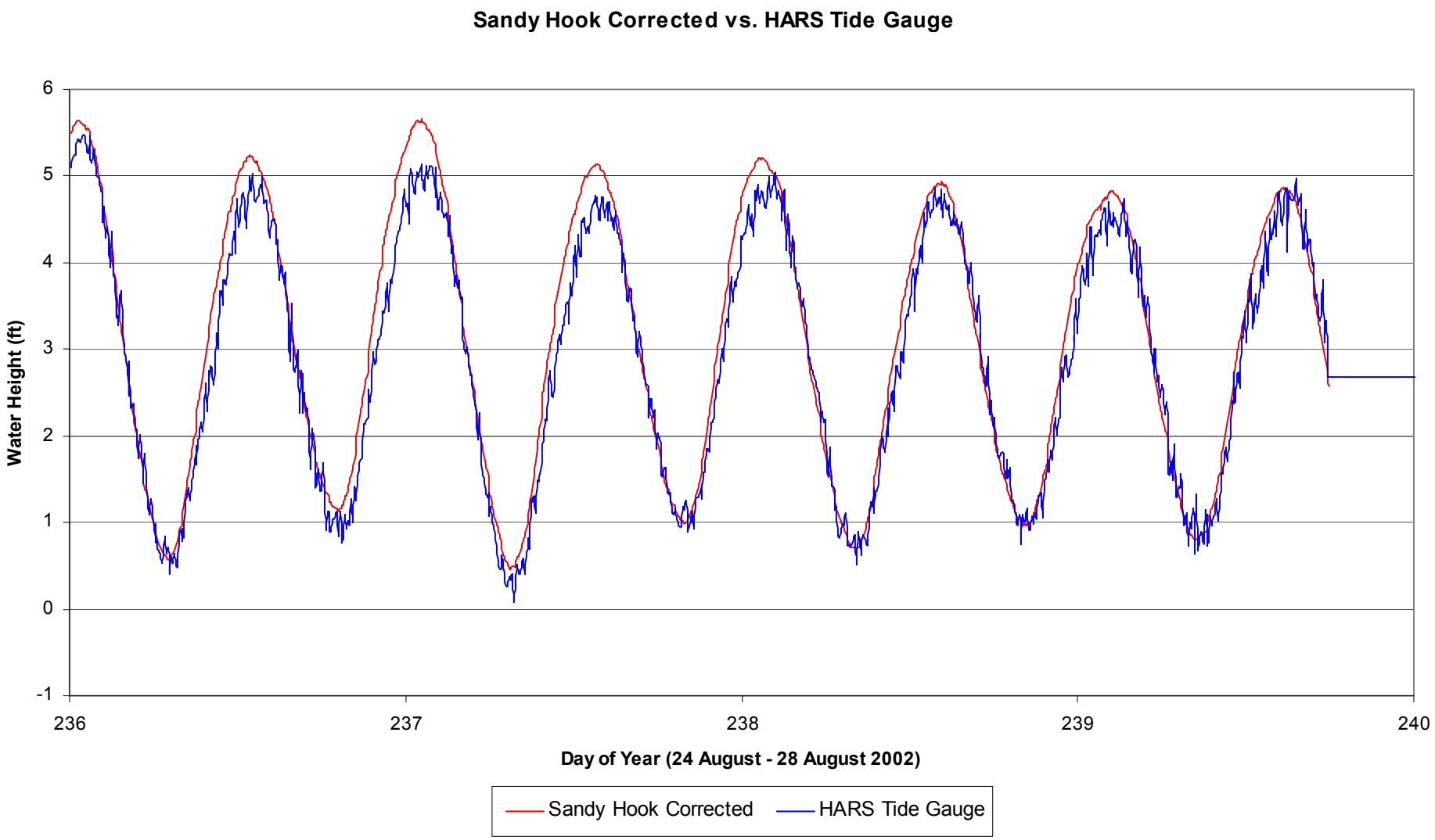

Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
0
1
2
3
4
5
6
213
214
215
216
Day of Year (1 August - 4 August 2002)
Sandy Hook Corrected
HARS Tide Gauge

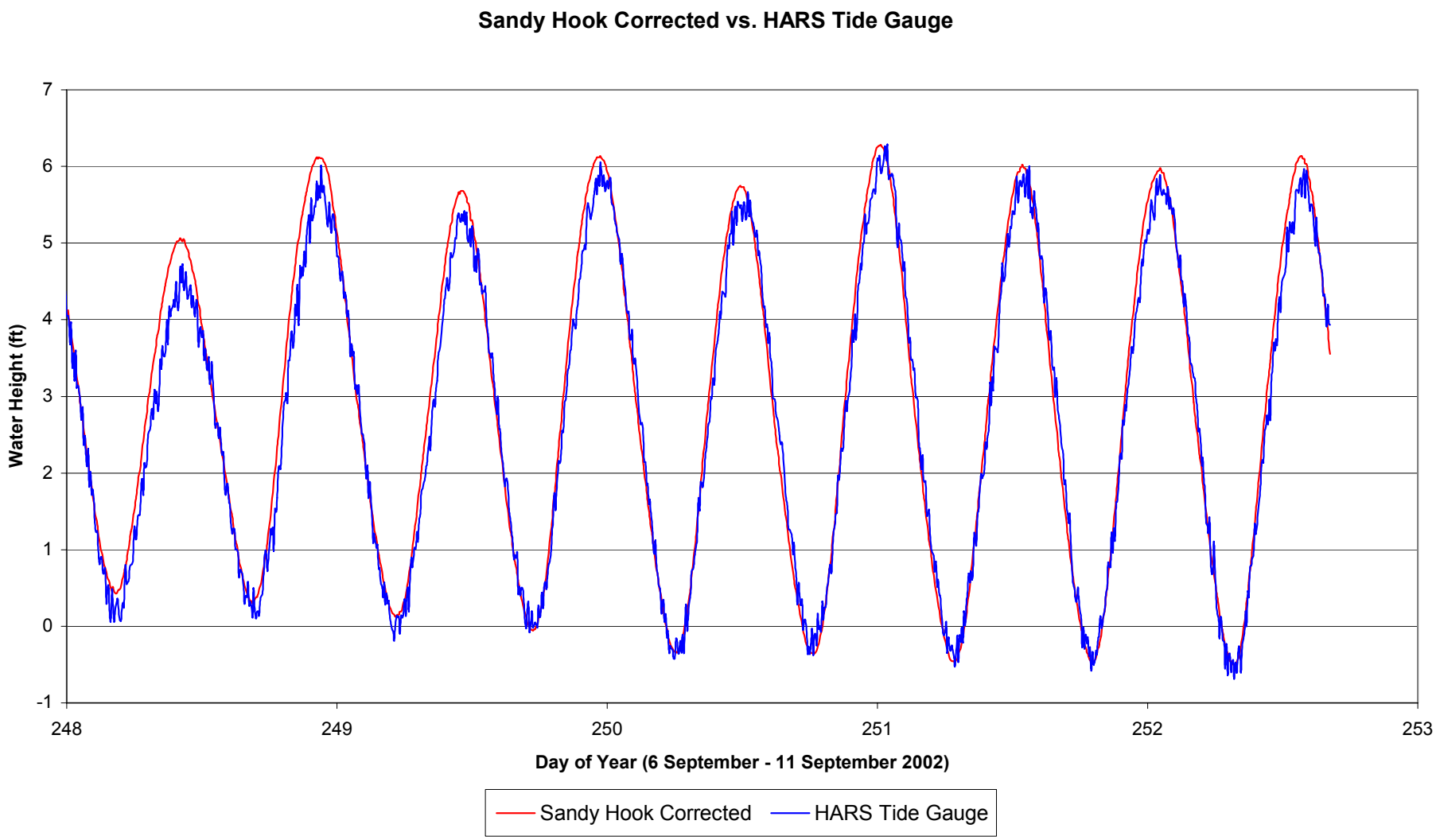

Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
0
1
2
3
4
5
6
7
216
217
218
219
220
221
Day of Year (4 August - 9 August 2002)
Sandy Hook Corrected
HARS Tide Gauge


Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
7
6
5
4
3
2
1
0
-1
222
223
224
225
226
Day of Year (10 August - 14 August 2002)
Sandy Hook Corrected
HARS Tide Gauge


Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
0
1
2
3
4
5
6
226
227
228
229
230
231
Day of Year (14 August - 19 August 2002)
Sandy Hook Corrected
HARS Tide Gauge


Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
6
5
4
3
2
1
0
-1
231
232
233
234
235
236
Day of Year (19 August - 24 August 2002)
Sandy Hook Corrected
HARS Tide Gauge


Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
6
5
4
3
2
1
0
-1
236
237
238
239
240
Day of Year (24 August - 28 August 2002)
Sandy Hook Corrected
HARS Tide Gauge


Sandy Hook Corrected vs. HARS Tide Gauge
Water Height (ft)
7
6
5
4
3
2
1
0
-1
248
249
250
251
252
253
Day of Year (6 September - 11 September 2002)
Sandy Hook Corrected
HARS Tide Gauge