RESULTS OF THE 2007 MULTIBEAM BATHYMETRIC AND BACKSCATTER SURVEYS AT THE HISTORIC AREA REMEDIATION SITE

FINAL DRAFT

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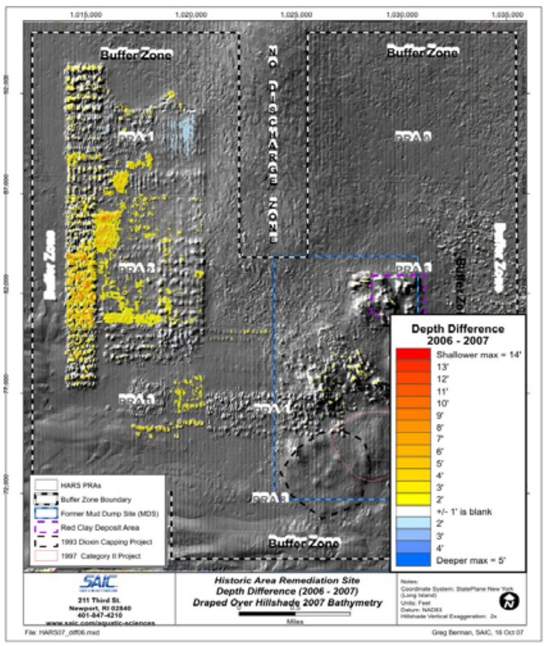

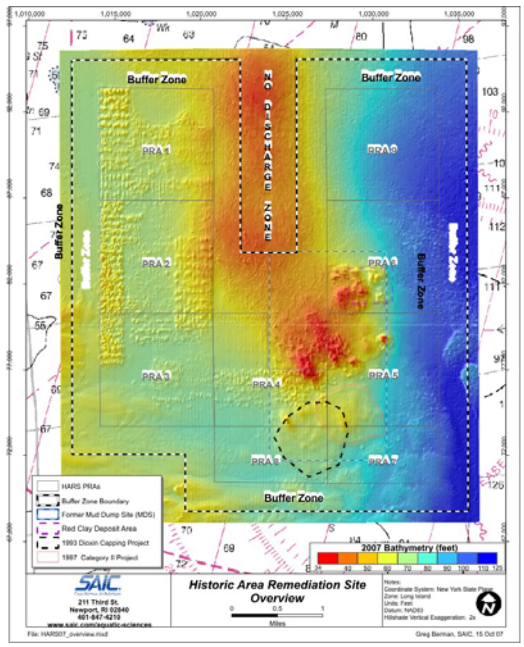

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1.0 INTRODUCTION

1.1 Background

Sediments dredged from New York/New Jersey Harbor Estuary 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 Site Management and Monitoring Plan (SMMP) serves as a guideline document for the monitoring of a series of nine Priority Remediation Areas (PRAs) during the course of remediation efforts (EPA-Region 2/USACE-NAN 1997). 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 focus of this report is on the multibeam bathymetric and backscatter imagery survey that was conducted over the HARS in early fall of 2007 to provide an updated broad-scale physical characterization of the entire area.

The 2007 survey results will be compared to the prior bathymetric surveys conducted at these sites over the past few years to document the progress of the on-going placement operations, as well as to evaluate the remaining capacity still within the PRAs.

1.2 Survey Objectives

The primary objective for this portion of the 2007 monitoring effort was to obtain an updated broad-scale physical characterization and seafloor topography map of the entire HARS (including the buffer areas and the no-discharge zone). The multibeam bathymetry acquired during this effort provided updated high-resolution data sets that will be used to monitor use of the site and plan future placement activity. In addition, the broad-scale characterization also provided multibeam backscatter imagery data that were used to help characterize the composition of the surface sediments.

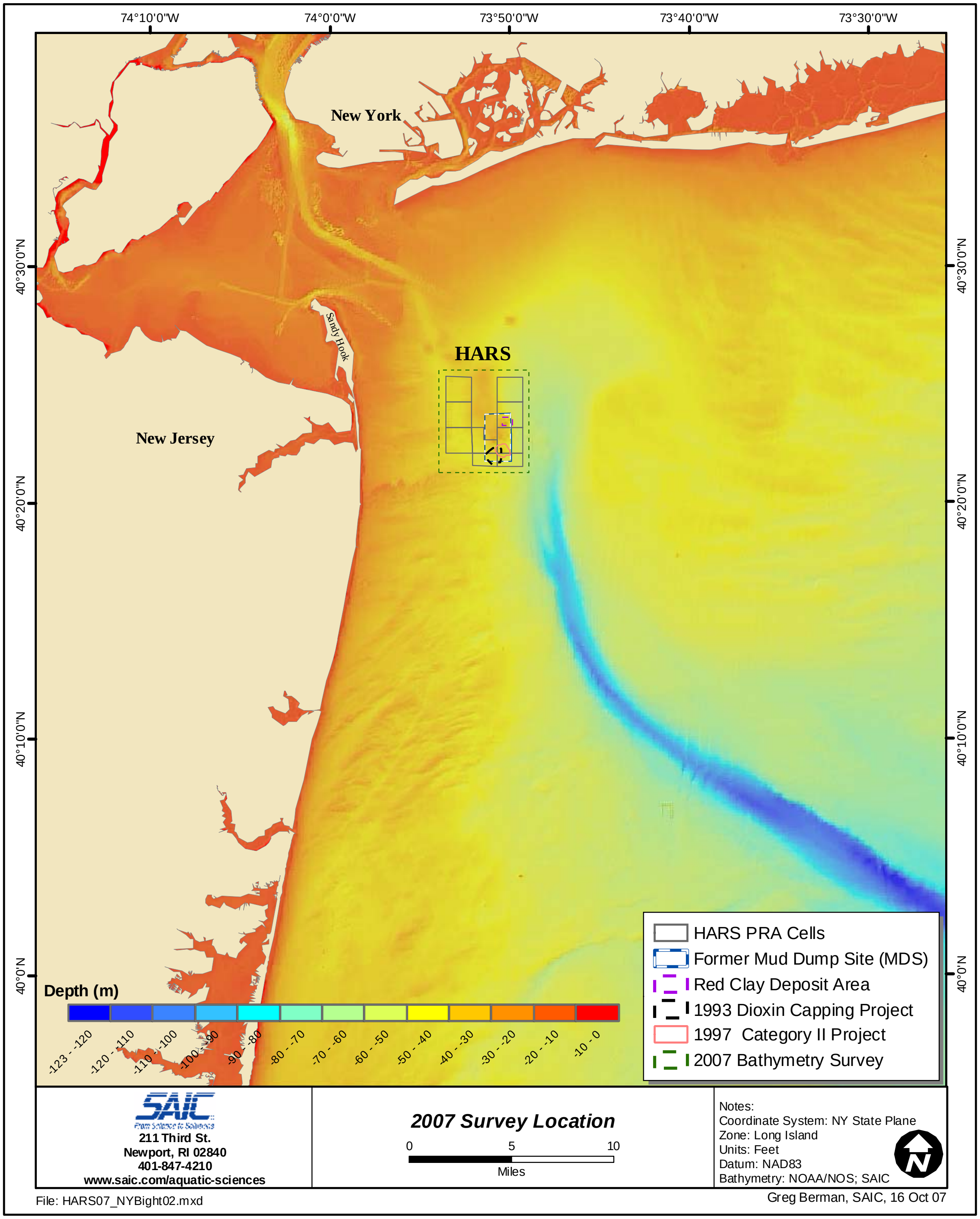


Figure 1.1-1. Location of the Historic Area Remediation Site (HARS) in the New York Bight

2.0 METHODS

2.1 Data Acquisition

The 2007 monitoring effort was comprised of a complete multibeam bathymetric survey over the entire HARS (including the buffer areas and the no-discharge zone). Concurrently with the multibeam data acquisition, multibeam backscatter imagery was also acquired over the site. A detailed description of the field data acquisition and processing techniques for each of the main survey elements is presented in the sections below. Survey operations at the HARS were conducted continuously on a 24-hour basis from 20 September through 24 September 2007.

All of the multibeam survey operations were conducted aboard the M/V *Atlantic Surveyor* home ported in Point Pleasant, New Jersey for the duration of these operations (Figure 2.1-1). In addition to the primary survey components installed by SAIC and identified in Figure 2.1-1, the vessel was equipped with an autopilot, echo sounder, differential Global Positioning System (DGPS), radars, and two 40 KW diesel generators.

Three 20-foot International Organization for Standardization (ISO) containers housing the multibeam data acquisition and processing electronics were secured on the aft deck. One was used as the real-time, survey data collection office, the second as a data processing office, and the third for maintenance and repairs, as well as spares storage. The multibeam transducer was mounted on the hull, 1.51 ft (0.46 m) port of centerline of the M/V *Atlantic Surveyor*. A Position Orientation System for Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) was mounted below the main deck of the vessel, 1.12 ft (0.34 m) port of centerline. Relative to the RESON 8101, the POS/MV sensor was located 1.12 ft (0.34 m) forward, 0.29 ft (0.12 m) starboard and 5.36 ft (1.64 m) above the multibeam transducer to monitor the attitude of the transducer head relative to the seafloor. Positioning data was acquired from external GPS antennas directly interfaced to the POS/MV system, as well as a separate Trimble 4000 DGPS receiver. A Trimble Probeacon Differential Receiver was used to obtain corrections to the GPS satellite data from a US Coast Guard, shore-based differential station located in Sandy Hook, NJ and applied to ensure horizontal position accuracy remained within the 10 to 16 ft (3 to 5 m) range. A Brooke Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted to the starboard stern quarter and used to acquire sound velocity profiles during the course of the survey.

Survey planning, data processing, and analysis were accomplished using SAIC's Survey Analysis and area Based Editor (SABER) software version 4.1.12.1 on a LINUX operating system. Data acquisition was carried out using the SAIC ISS-2000 software version 3.12.3 on a Windows XP operating system to control real-time navigation, data time tagging, and data logging. Position data were recorded from both the POS/MV system and the Trimble 4000. Data from the POS/MV was merged with multibeam data and was the primary navigation and positioning sensor. Vessel-positioning confidence checks were performed daily by comparing position data from the POS/MV to position data from the Trimble DGPS.

Vessel Name	LOA	Beam	Draft	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
M/V *Atlantic Surveyor*	110’	26’	9’	14 knots	Displacement 68 net tons	900	D582365

Primary On-Board Survey Systems by Manufacturer

	Manufacturer / Model Number	Subsystem
Multibeam Sonar	RESON SeaBat 8101	Transducer 8101 Processor
Side Scan Sonar	Klein 3000 Towfish	K-Wing Depressor, Transceiver/Processing Unit
Vessel Attitude System	TSS POS/MV Inertial Navigation System	
Positioning System	TSS POS/MV	
	Trimble 7400 GPS Receiver	
	Trimble Probeacon Differential Beacon Receiver	
	Leica MX41R Differential Beacon Receiver	
Sound Velocity System	Brooke Ocean Technology Ltd., Moving Vessel Profiler-30	Applied Microsystems Ltd. Smart SV and Pressure Sensor
	Sea-Bird Electronics, Inc. CTD Profiler	

Figure 2.1-1. Specifications for the M/V *Atlantic Surveyor* and an overview of the primary survey systems installed on the vessel

2.1.1 Multibeam Systems and Operations

The real-time multibeam acquisition system used for these surveys included the following primary components:

- Windows XP workstation (ISSC) for data acquisition, system control, survey planning, survey operations, and real-time quality control
- Reson 8101 multibeam transducer (240 kHz)
- Reson 81P sonar processor
- POS M/V version 4 Position and Orientation System with a Trimble Probeacon Differential Receiver
- Trimble 4000 GPS Receiver with a Trimble Probeacon Differential Receiver
- MVP 30 Moving Vessel Profiler with four interchangeable Applied Microsystem Smart Sound Velocity and Pressure Sensors and a Notebook computer to interface with the ISSC and the deck control unit
- Notebook computer for maintaining daily navigation and operation logs
- Uninterrupted power supplies (UPS) for protection of the entire system.

The user selectable range scale on the Reson 8101 multibeam system was adjusted appropriately depending upon the survey depth. Vessel speed was also adjusted to ensure an average of three 240 kHz ping footprints occurred within each 3.28 ft (1 m) segment of the survey lane in the along-track direction.

Confidence checks of the multibeam echo sounder were made using leadline comparisons during port calls. Multibeam bathymetric data, meeting the USACE Class I survey standards (USACE 2002), were acquired over each of the required survey areas by running a series of north-south, main-scheme survey lanes that were spaced at either 100 ft (30 m) or 200 ft (60 m) intervals, depending on the survey depth (and resultant swath coverage). In addition, several east-west lanes were also established in each area to provide the required cross-check comparisons with the main-scheme bathymetric data.

2.1.2 Sound Velocity Profiles

A Brooke Ocean Technology MVP 30 with an Applied Microsystems Smart Sound Velocity and Pressure sensor was used to collect sound speed profile (SSP) data. SSP data were obtained at intervals frequent enough to reduce sound velocity errors due to changing characteristics of the water column (i.e., temperature and salinity as influenced by tides). The frequency of casts was based on observed sound velocity changes from previously collected profiles and time elapsed since the last cast. Multiple casts were taken along individual survey lanes to identify the rate and location of sound velocity changes. Subsequent casts during the course of each survey day were made based on the observed trend of sound velocity changes. As the sound velocity profiles change, cast frequency and location are modified accordingly. Confidence checks of the sound velocity profile casts were conducted at the beginning and at the end of the survey by comparing two consecutive casts taken with different sound velocity and pressure (SVP) sensors. Over the course of these survey operations, a total of 66 SVP casts were acquired (Table 2.1-1).

Table 2.1-1.
Summary of sound velocity profiles (SVPs) taken aboard the M/V *Atlantic Surveyor* during the September 2007 survey operations at the HARS

Julian Day	Cast File Number	Cast Time (UTC)	Depth (m)	Position (NAD83)		Notes	Application Start Time (UTC)	Application End Time (UTC)
				Latitude (N)	Longitude (W)			
261	ASSVP07261.D01	01:14:15	4.00	38.949000	074.889167	APPLIED. USED FOR LEADLINE.	261/01:14:24	N/A
263	ASSVP07263.D01	17:33:14	21.22	40.378500	073.896500	APPLIED, USED FOR COMPARISON USING SENSOR 4523.	263/17:33:31	N/A
263	ASSVP07263.D02	17:38:31	22.66	40.379000	073.895333	APPLIED, USED FOR COMPARISON USING SENSOR 4880.	263/17:39:10	263/18:17:45
263	ASSVP07263.D03	18:16:54	30.06	40.374667	073.824833	APPLIED	263/18:17:45	263/18:41:22
263	ASSVP07263.D04	18:39:29	34.53	40.399167	073.814333	APPLIED	263/18:41:22	263/19:21:47
263	ASSVP07263.D05	19:20:40	21.87	40.424000	073.884000	APPLIED	263/19:21:47	263/20:02:19
263	ASSVP07263.D06	20:00:30	21.56	40.375333	073.899167	APPLIED	263/20:02:19	263/20:41:13
263	ASSVP07263.D07	20:39:53	22.63	40.410833	073.900667	APPLIED	263/20:41:13	263/21:51:39
263	ASSVP07263.D08	21:51:05	21.36	40.398333	073.898500	APPLIED	263/21:51:39	263/23:14:26
263	ASSVP07263.D09	23:12:33	22.28	40.407500	073.897833	APPLIED	263/23:14:26	264/00:41:36
264	ASSVP07264.D01	00:38:47	20.59	40.432500	073.893833	APPLIED	264/00:41:36	264/03:03:29
264	ASSVP07264.D02	03:03:09	23.61	40.406667	073.893500	APPLIED	264/03:03:29	264/06:18:07
264	ASSVP07264.D03	06:17:25	23.68	40.374833	073.888500	APPLIED	264/06:18:07	264/09:51:36
264	ASSVP07264.D04	09:51:02	19.54	40.432000	073.886000	APPLIED	264/09:51:36	264/13:01:24
264	ASSVP07264.D05	12:59:31	22.86	40.367667	073.882833	APPLIED	264/13:01:24	264/14:26:43
264	ASSVP07264.D06	14:25:35	21.24	40.360500	073.880667	APPLIED	264/14:26:43	264/15:02:20
264	ASSVP07264.D07	15:01:10	22.13	40.418500	073.879333	APPLIED	264/15:02:20	264/15:51:09
264	ASSVP07264.D08	15:50:25	22.19	40.391500	073.878000	APPLIED	264/15:51:09	264/16:17:00
264	ASSVP07264.D09	16:16:02	22.25	40.418667	073.878667	APPLIED	264/16:17:00	264/16:41:21
264	ASSVP07264.D10	16:40:37	24.36	40.366333	073.878667	APPLIED	264/16:41:21	264/17:20:55
264	ASSVP07264.D11	17:19:46	21.89	40.419000	073.877333	APPLIED	264/17:20:55	264/17:52:41
264	ASSVP07264.D12	17:51:19	23.76	40.381333	073.875833	APPLIED	264/17:52:41	264/18:56:57
264	ASSVP07264.D13	18:53:06	20.81	40.418500	073.875167	APPLIED	264/18:56:57	264/19:11:49
264	ASSVP07264.D14	19:11:11	24.49	40.379833	073.875167	APPLIED	264/19:11:49	264/20:30:03
264	ASSVP07264.D15	20:28:18	24.55	40.380667	073.874333	APPLIED	264/20:30:03	264/22:31:35
264	ASSVP07264.D16	21:11:33	20.81	40.418500	073.875167	NOT APPLIED	N/A	
264	ASSVP07264.D17	22:30:17	19.70	40.411333	073.872333	APPLIED	264/22:31:35	264/23:09:08
264	ASSVP07264.D18	23:06:12	22.78	40.379667	073.870833	APPLIED	264/23:09:08	264/23:48:41
264	ASSVP07264.D19	23:46:42	18.07	40.408833	073.869500	APPLIED	264/23:48:41	265/00:25:07
265	ASSVP07265.D01	00:23:50	22.88	40.380500	073.870167	APPLIED	265/00:25:07	265/02:08:27
265	ASSVP07265.D02	02:07:15	24.20	40.370667	073.868000	APPLIED	265/02:08:27	265/04:26:21
265	ASSVP07265.D03	04:26:14	24.54	40.364833	073.865833	APPLIED	265/04:26:21	265/09:53:30
265	ASSVP07265.D04	07:42:59	25.28	40.360167	073.859500	NOT APPLIED	N/A	
265	ASSVP07265.D05	09:53:13	25.28	40.440167	073.857500	APPLIED	265/09:53:30	265/12:34:25
265	ASSVP07265.D06	12:33:27	22.25	40.372667	073.856000	APPLIED	265/12:34:25	265/15:03:31
265	ASSVP07265.D07	15:02:35	22.91	40.357500	073.852500	APPLIED	265/15:03:31	265/15:50:20
265	ASSVP07265.D08	15:49:58	30.19	40.435667	073.819667	APPLIED	265/15:50:20	265/17:07:10
265	ASSVP07265.D09	17:06:19	35.98	40.362333	073.815667	APPLIED	265/17:07:10	265/18:28:01
265	ASSVP07265.D10	18:26:57	27.56	40.358667	073.836167	APPLIED	265/18:28:01	265/19:59:21
265	ASSVP07265.D11	19:58:13	30.18	40.407000	073.832667	APPLIED	265/19:59:21	265/22:09:43
265	ASSVP07265.D12	22:08:34	26.07	40.366333	073.835500	APPLIED	265/22:09:43	265/23:52:05
265	ASSVP07265.D13	23:50:40	25.27	40.400500	073.837667	APPLIED	265/23:52:05	266/01:58:40
266	ASSVP07266.D01	01:56:46	21.98	40.367167	073.839833	APPLIED	266/01:58:40	266/03:47:26
266	ASSVP07266.D02	03:45:21	24.56	40.406667	073.841167	APPLIED	266/03:47:26	266/05:45:15
266	ASSVP07266.D03	05:44:17	24.29	40.360500	073.845333	APPLIED	266/05:45:15	266/07:34:55
266	ASSVP07266.D04	07:33:52	22.89	40.417833	073.846167	APPLIED	266/07:34:55	266/09:25:44
266	ASSVP07266.D05	09:24:57	23.06	40.364500	073.850333	APPLIED	266/09:25:44	266/12:36:34
266	ASSVP07266.D06	12:35:40	27.55	40.357000	073.832000	APPLIED	266/12:36:34	266/14:15:35
266	ASSVP07266.D07	14:14:40	30.43	40.406833	073.829167	APPLIED	266/14:15:35	266/16:40:06
266	ASSVP07266.D08	16:39:44	28.93	40.377333	073.827000	APPLIED	266/16:40:06	266/19:01:52
266	ASSVP07266.D09	19:00:49	22.45	40.391500	073.880000	APPLIED	266/19:01:52	266/19:45:02
266	ASSVP07266.D10	19:44:16	31.37	40.407167	073.828167	APPLIED	266/19:45:02	266/22:26:08
266	ASSVP07266.D11	22:24:54	32.31	40.411500	073.824333	APPLIED	266/22:26:08	267/01:50:43
267	ASSVP07267.D01	01:49:58	28.92	40.432333	073.821000	APPLIED	267/01:50:43	267/04:08:43
267	ASSVP07267.D02	04:07:37	22.84	40.355833	073.848167	APPLIED	267/04:08:43	267/06:02:59
267	ASSVP07267.D03	06:02:15	17.91	40.393833	073.850000	APPLIED	267/06:02:59	267/09:07:55
267	ASSVP07267.D04	09:07:11	18.33	40.381500	073.840167	APPLIED	267/09:07:55	267/10:13:33
267	ASSVP07267.D05	10:12:49	18.05	40.393000	073.852833	APPLIED	267/10:13:33	267/12:48:57
267	ASSVP07267.D06	12:47:47	18.19	40.386333	073.857167	APPLIED	267/12:48:57	267/16:09:55
267	ASSVP07267.D07	16:08:38	17.99	40.390500	073.862667	APPLIED	267/16:09:55	267/18:02:53
267	ASSVP07267.D08	18:01:42	17.81	40.412833	073.866333	APPLIED	267/18:02:53	267/19:15:42
267	ASSVP07267.D09	19:14:44	20.66	40.432000	073.870667	APPLIED	267/19:15:42	267/20:22:27
267	ASSVP07267.D10	20:41:40	23.86	40.369333	073.884333	APPLIED	267/20:42:42	267/21:55:38
267	ASSVP07267.D11	21:55:29	26.35	40.358333	073.843833	APPLIED, USED FOR COMPARISON USING SENSOR 4880.	267/21:55:38	N/A
267	ASSVP07267.D12	22:02:20	26.53	40.358667	073.842167	NOT APPLIED, USED FOR COMPARISON USING SENSOR 4523.	N/A	N/A
268	ASSVP07268.D01	11:37:19	6.12	38.949000	074.889167	APPLIED. USED FOR LEADLINE.	268/11:37:26	N/A

2.1.3 Tidal (or Water-Level) Corrections

During prior bathymetric surveys at the HARS, a pressure tide gauge had often been deployed to acquire tidal height data in close proximity to the survey area. The primary purpose of the previous HARS tide gauge installations was to assess any observed differences in tidal range and phase between the HARS and the primary NOAA reference tide station located at the Sandy Hook Coast Guard Station (NOAA Station No. 8531680). Because the HARS gauges were deployed at an offshore location, they were not referenced to any tidal benchmarks or vertical datum (as is typically the case with shore-based tidal stations). However, by normalizing the HARS pressure gauge data about the mean tide level (MTL), it was possible to make direct comparisons between the non-referenced HARS tidal data and Sandy Hook tidal data referenced to Mean Lower Low Water (MLLW). Because the HARS pressure gauge data was not referenced to a true datum, tidal correctors for the HARS bathymetric data have typically been based on verified Sandy Hook observations with applicable phase and range offsets applied.

During the 2007 survey, a bottom-mounted instrument array equipped with a tide gauge to measure water level variation was deployed within the survey area (Figure 2.1-2). Pressure readings were obtained by a SeaBird Electronics SBE 26 Wave and Tide Recorder at a 6-minute interval to develop a continuous record of water level for the survey period. Deployment of the instrument array occurred prior to start of the multibeam bathymetry survey and the array was left undisturbed until the bathymetric data collection was complete. An acoustic release was utilized to facilitate recovery of the instrument following the completion of the survey operation. The array was deployed at 40° 22.757’ N, 73° 53.920’ W, between the western boundary of the HARS survey area and western boundary of PRA 3, at a water depth of approximately 69 ft (21 m; Figure 2.1-3). This position was selected to reduce the probability that the array would be impacted by on-going disposal at the HARS or fishing activity.

Upon recovery, the binary data were downloaded from the instrument using SeaBird Seasoft software and converted to ASCII text. These data were compared to NOAA water level observations obtained from the Sandy Hook, NJ tide station to develop accurate tidal corrections (time and height) for the 2007 HARS survey. These tidal correctors were then used to verify the accuracy of the values applied during the initial bathymetric data processing in order to reference the raw depth data to the vertical datum of mean lower low water (MLLW). Atmospheric pressure correctors were obtained from the Robbins Reef, New Jersey (NOAA Station ROBN4 – 8530973), since these correctors were unavailable from the Sandy Hook, New Jersey NOAA station at the time of the survey.

Processing and analysis of the 2007 HARS pressure tide gauge data followed the approach utilized for the 2006 data (SAIC 2006). As in 2006, the 2007 data pressure gauge data was adjusted to compensate for variable atmospheric pressure. This adjustment was shown to substantially improve consistency between the observed tidal level at the HARS and that predicted for the HARS based on the Sandy Hook tidal data. A more thorough discussion of the results of this tidal analysis is provided in Section 3.1.2.

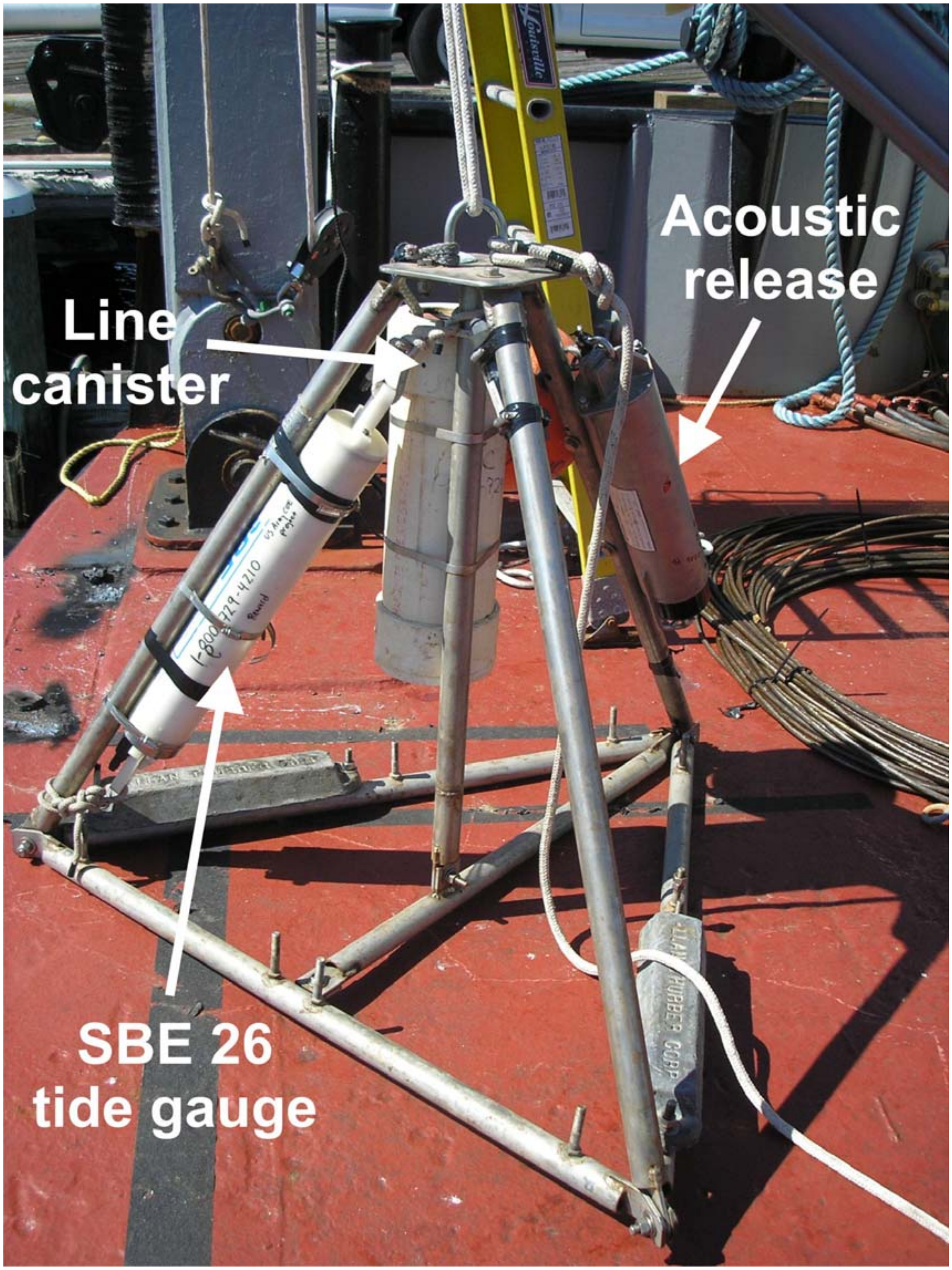


Figure 2.1-2. Configuration of the bottom mounted tide gauge array deployed at the HARS during the 2007 survey

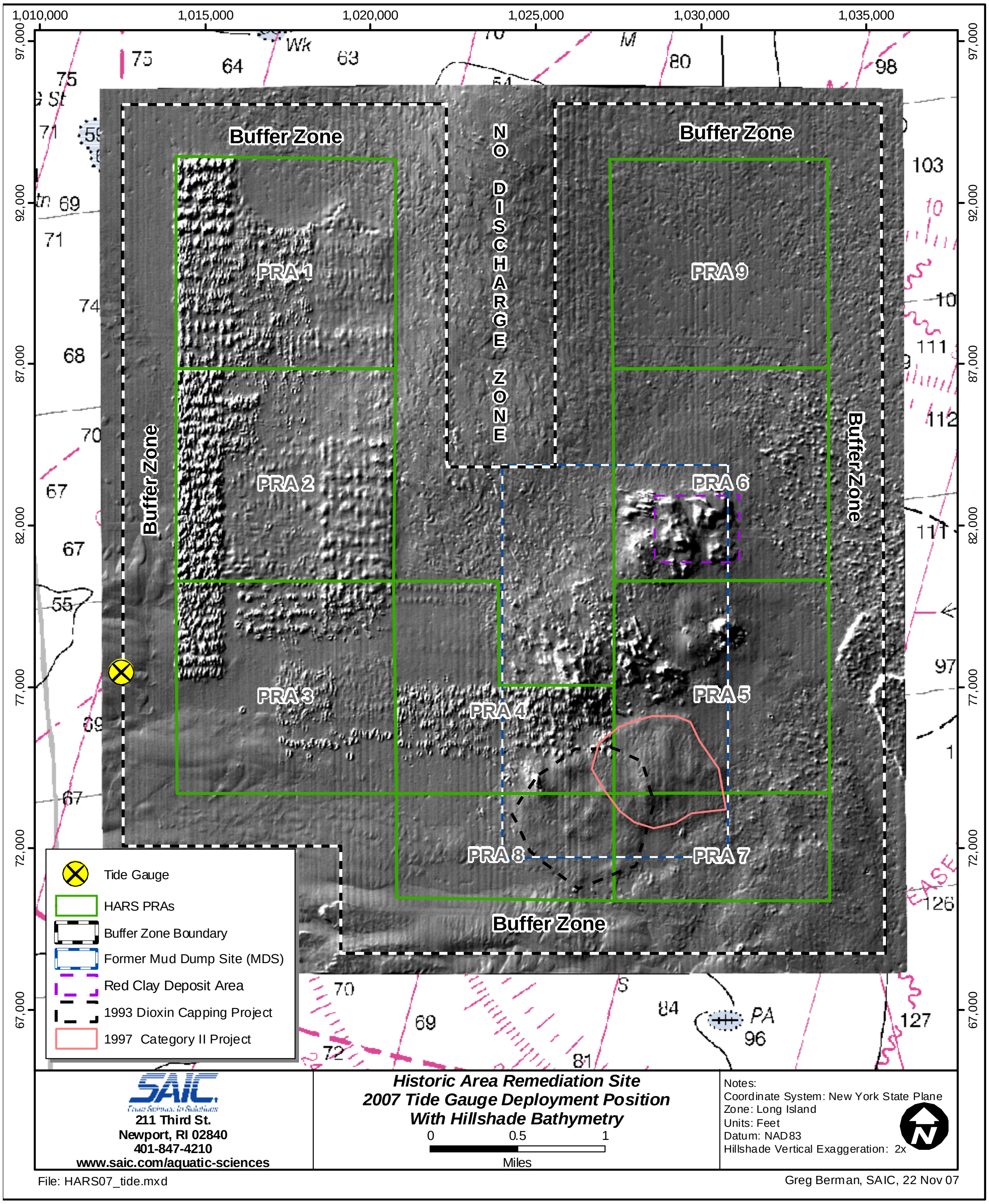


Figure 2.1-3. Location of the tide gauge instrument array relative to the various boundaries for HARS, the PRAs, and buffer zone. The shaded relief map of seafloor topography represents the extents of the 2007 multibeam survey area.

2.1.4 Quality Control

A systematic approach to tracking bathymetric data was employed during the survey to maintain data quality and integrity throughout the data acquisition and editing process. Several forms and checklists were used to identify and track the flow of data as it was collected and processed. During data collection, the watch-standers continuously monitored the systems, checking for errors and alarms. Thresholds set in the ISS-2000 system alerted the watch-stander by displaying alarm messages when error thresholds or tolerances were exceeded. Alarm conditions that compromised survey data quality were corrected and then noted in both the navigation log and the message files. Warning messages such as the temporary loss of DGPS, excessive cross-track error, or vessel speed approaching the maximum allowable survey speed were addressed by the watch-stander and automatically recorded into a message file. Approximately every 1 to 2 hours during data collection, the watch-stander completed checklists to ensure critical system settings and data collection were valid.

As the data collections were on-going, initial processing of the resulting multibeam bathymetric and imagery data began on the vessel, which included this first level of quality control:

- Initial swath editing of multibeam data flagging invalid pings and beams
- Second review and editing of multibeam data
- Turning unacceptable data "offline"
- Turning additional data "online"
- Track plots
- Cross-lane checks.

Upon completion of the survey a complete backup of all raw and processed multibeam bathymetry data and multibeam imagery data were archived and then sent to the Newport Data Processing Center during a scheduled port call. Analysis of the data at the Newport facility included the following steps:

- Generation of multibeam track lanes
- Swath editing and review of multibeam data (if not performed on the vessel)
- Calculation and application of verified tide correctors to multibeam data
- Bottom tracking of the multibeam side-scan files
- Coverage plots of multibeam data
- Cross-lane checks of multibeam data
- Final coverage mosaic plots of multibeam data
- Final quality control of all delivered data products.

The post-processing and quality control procedures for multibeam data acquisition are described in detail in the following section.

2.2 Data Processing

2.2.1 Multibeam Data Processing

At the end of each survey lane, all data files were closed and new files opened for data logging. The closed files were then auto-archived to the processing computer where track lines were generated and the multibeam data files were reviewed to flag erroneous data such as noise, fish, etc. using SAIC's Multi-View Editor (MVE) program. This tool is a geo-referenced editor, which can project each beam in its true geographic position and depth in both plan and profile views. At the end of each survey day, both the raw and processed data were backed up onto 4 mm tapes and a removable USB hard drive. The tapes and drive were later shipped to the Data Processing Center in Newport, RI.

Once the data were in Newport and extracted to the Network Attached Storage (NAS) system networked to the Data Processing Center (DPC), the initial step in processing was to create track lines from the multibeam data. Once created, the tracks were reviewed to confirm that no navigational errors existed and the tracks extended to the outermost boundaries of the survey area. Upon the completion of multibeam data reviews, verified tides were applied.

The observed, verified water level data from the NOAA Sandy Hook station (NOAA Station 8531680), modified with appropriate phase and range offsets, were initially used to reduce the HARS bathymetric data to MLLW and produce preliminary results. Preliminary and verified tide data for this station were downloaded from the NOAA CO-OPS web page (http://www.co-ops.nos.noaa.gov/hydro.html). The phase and range offsets were applied to the verified NOAA tide station data. Final water level files for each area were created from downloaded verified tide data using the SABER Create Water Level Files tool. Water level files contained water level heights that were algebraically subtracted from depths to correct the sounding for tides and water levels. These water level files were applied to the multibeam data using the SABER Apply Tides program. For quality assurance, the Check Tides program was run on all the Generic Sensor Format (GSF) files to confirm that the appropriate water level corrector had been applied. After confirmation that verified tides were applied to all multibeam data, grids were created and analyzed using various color-change intervals. The color intervals provided a means to check for significant, unnatural changes in depth across zone boundaries due to water level correction errors, unusual currents, etc. had they existed. No significant shifts were identified.

Following the application of verified tides, multibeam closest-to-cell-center depth grids were generated and reviewed for consistency. If any anomalies were detected, the edited multibeam files were re-examined and re-edited. When all of the multibeam files were determined to be satisfactory, the data were gridded to the required 16.4 ft ×16.4 ft (5 m × 5 m) cell size by populating the cell with sounding closest to the cell's center. The following three grids were created:

- Main scheme and gaps (+/- 60° from nadir)
- Cross lanes using only near nadir (+/- 5° from nadir)
- All survey lanes (main, cross, gaps).

The main scheme grid and cross-lane grid were used for subsequent cross-check analysis. The "all survey lanes" grid was used to export the final ASCII XYZ file.

2.2.2 Multibeam Backscatter Data Processing

As part of the 2007 data acquisition operation, digital acoustic multibeam backscatter intensity data returning to the 240 kHz transducers were also acquired during this survey, and recorded in two different data formats. For each multibeam survey lane, a separate Extended Triton Format (XTF) file was generated based on the Reson backscatter data. The XTF file format is an industry standard acoustic imaging format and is widely supported by most side-scan sonar and image processing vendors. In addition, SAIC's ISS-2000 data acquisition package also recorded the RESON "snippet" backscatter amplitude data format, where position, time and amplitude values for the individual beams of backscatter data are written directly within the raw multibeam GSF data files. This method of collection offers slightly better positional data than collecting backscatter as side-scan data (where the data is collected in XTF format) and can result in increased resolution and enhanced seafloor characterization data.

The raw backscatter XTF and "snippets" data were then processed in the same manner to generate a preliminary 240 kHz backscatter mosaic for the HARS based on a 16.4 ft ×16.4 ft (5 m × 5 m) grid cell size. Initially, the backscatter data were reviewed and bottom-tracked using image processing tools. A time-window file was then created to indicate imagery-range coverage for each of the sonar lanes. In addition, all sonar track lanes were viewed to evaluate navigation quality. Using SABER mosaic tools, a second 16.4 ft ×16.4 ft (5 m × 5 m) preliminary mosaic was created to verify swath coverage, bottom tracking, and gain changes by lane. After additional edits were made to the bottom tracking, time windows and gain settings, the final 16.4 ft ×16.4 ft (5 m × 5 m), as well as a 3.28 ft × 3.28 ft (1 m × 1 m) mosaic was generated, evaluated, and then exported as a georeferenced TIFF (geoTIFF) file. The "snippet" data were used to produce the final seafloor mosaic images for this report because they offered slightly better positional accuracy and also enhanced seafloor imagery.

2.3 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 multibeam bathymetric survey data covered the total seafloor area (approximately 100%), these analysis tools relied on minimal amounts of interpolation between the discrete survey data points in order to generate the subsequent three-dimensional seafloor surface model. This is in contrast to past single-beam surveys conducted over these same areas that often relied on a high-degree of interpolation to create the final surface models.

The fully edited multibeam datasets were initially gridded to a 16.4 ft ×16.4 ft (5 m × 5 m) grid cell size by selecting the sounding closest to the center of each cell. These thinned datasets were then imported into ArcGIS 9.1 for gridding to a continuous raster surface. The Spatial Analyst extension for ArcGIS was used to explore the variance of the bathymetric track-lane data and determine the optimal gridding parameters. Several gridding routines were investigated before final interpolation using Inverse-Distance Weight (IDW). The IDW method estimates grid cell values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. For the HARS dataset, a 150 ft (45.72 m) fixed search radius along with a power rating of two appeared to provide the best results. The resulting gridded dataset was based on a 25 ft × 25 ft (7.62 m × 7.62 m) grid cell size and was comprised of 1,111 rows and 971 columns. The final 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 against both the baseline and most recent prior bathymetric dataset. For the HARS, the baseline survey was from 1998 and the most recent prior survey was from 2006. Within ArcGIS 9.1, a bathymetric difference grid was generated between the 2007 and the 2006 datasets to illustrate changes in seafloor topography over the past year and evaluate the consistency of the prior survey results. In addition, a depth difference grid was generated between the 2007 and 1998 dataset to evaluate total accumulation within PRAs 1, 2 and 3 over time.

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

A Brooke Ocean Technology MVP with an Applied Microsystems Smart Sound Velocity and Pressure sensor was used to collect frequent SVP data throughout the survey. SVP data were obtained at intervals frequent enough to reduce sound velocity errors and generally spaced at not more than four-hour intervals throughout the survey day. Over the course of these survey operations, a total of 66 SVP casts were acquired (Table 2.1-1). A detailed review of the SVPs showed that the profiles were generally consistent throughout the survey period with no significant changes noted at anytime during the course of the survey operations (Figure 3.1-1).

3.1.2 Tidal Data Analysis

As discussed in Section 2.1.3, the tidal data analysis performed as part of the 2007 survey effort was quite similar to recent (2005 and 2006) survey efforts. The primary purpose of the previous HARS tide gauges was to assess any observed differences in tidal range and phase between the HARS and the primary NOAA reference tide station located at the Sandy Hook Coast Guard Station. The timing of high and low water level at Sandy Hook lags that at HARS, but the range is higher at Sandy Hook than at HARS. As a result, a tidal phase corrector of -30 minutes and a height corrector (multiplier) of 0.94 were applied to the 2005 and 2006 data to compensate for measured differences between HARS and the tidal station at Sandy Hook, NJ. In addition, these phase and height correctors were initially applied to the data obtained during the 2007 survey effort to generate preliminary bathymetric charts of the HARS.

The following discussion presents the processing steps employed to reduce the pressure data collected during the 2007 survey. Principal analyzed data consisted of NOAA verified water level observations at Sandy Hook and pressure measurements from the HARS tide gauge (Figure 3.1-2). Initially, all of the water level time series datasets were screened for statistical outliers and then, in accordance with the NOAA recommendations for tidal data analysis, smoothed to suppress noisy fluctuations with periods of less than one hour. This data smoothing was accomplished with an 8th order infinite impulse response Chebyshev filter.

Next, the time series of recorded atmospheric pressure were used to improve the conversion of the HARS pressure gauge measurements to depth units (Figure 3.1-3). This was necessary

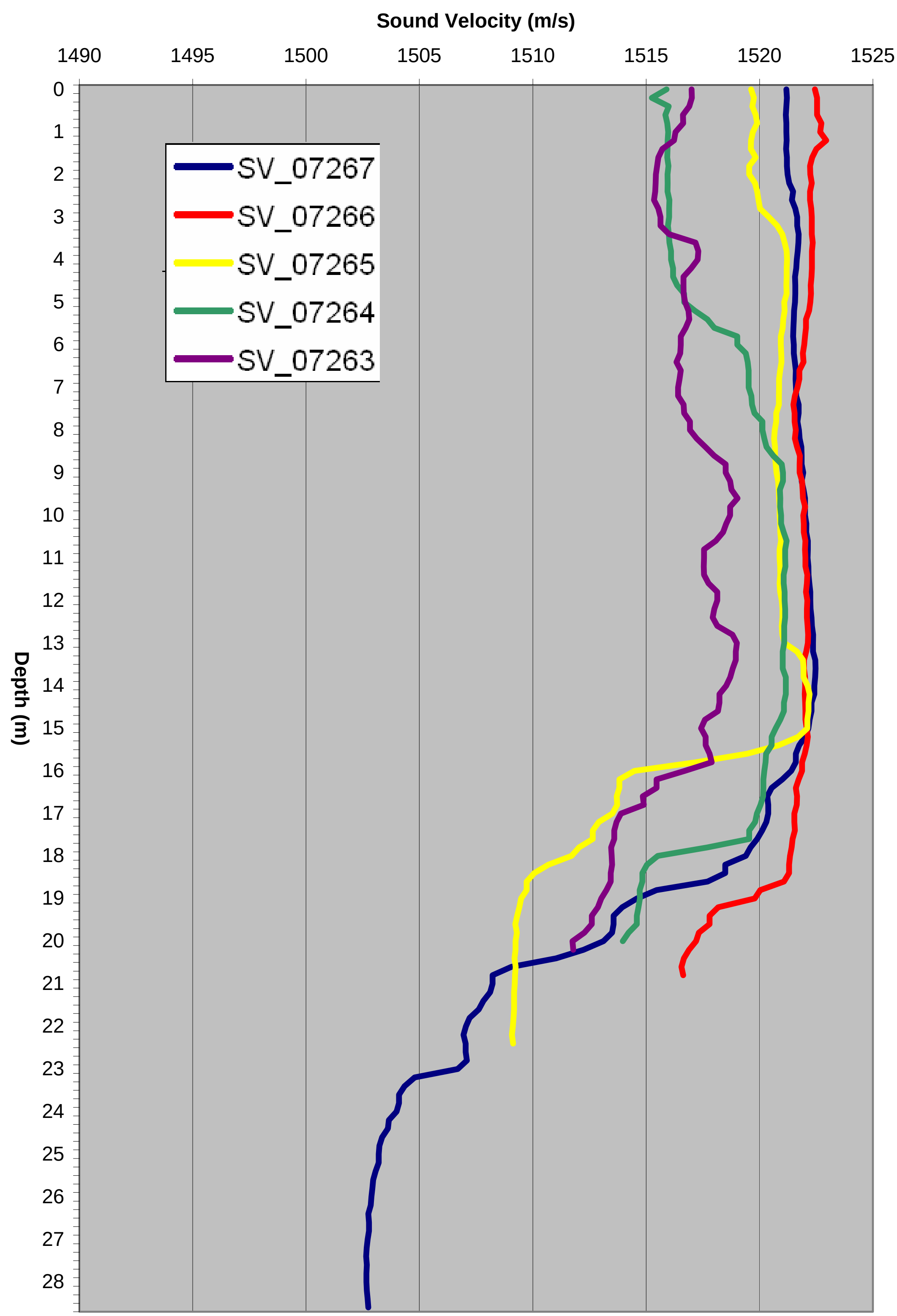


Figure 3.1-1. Sound velocity profiles representative of conditions at HARS

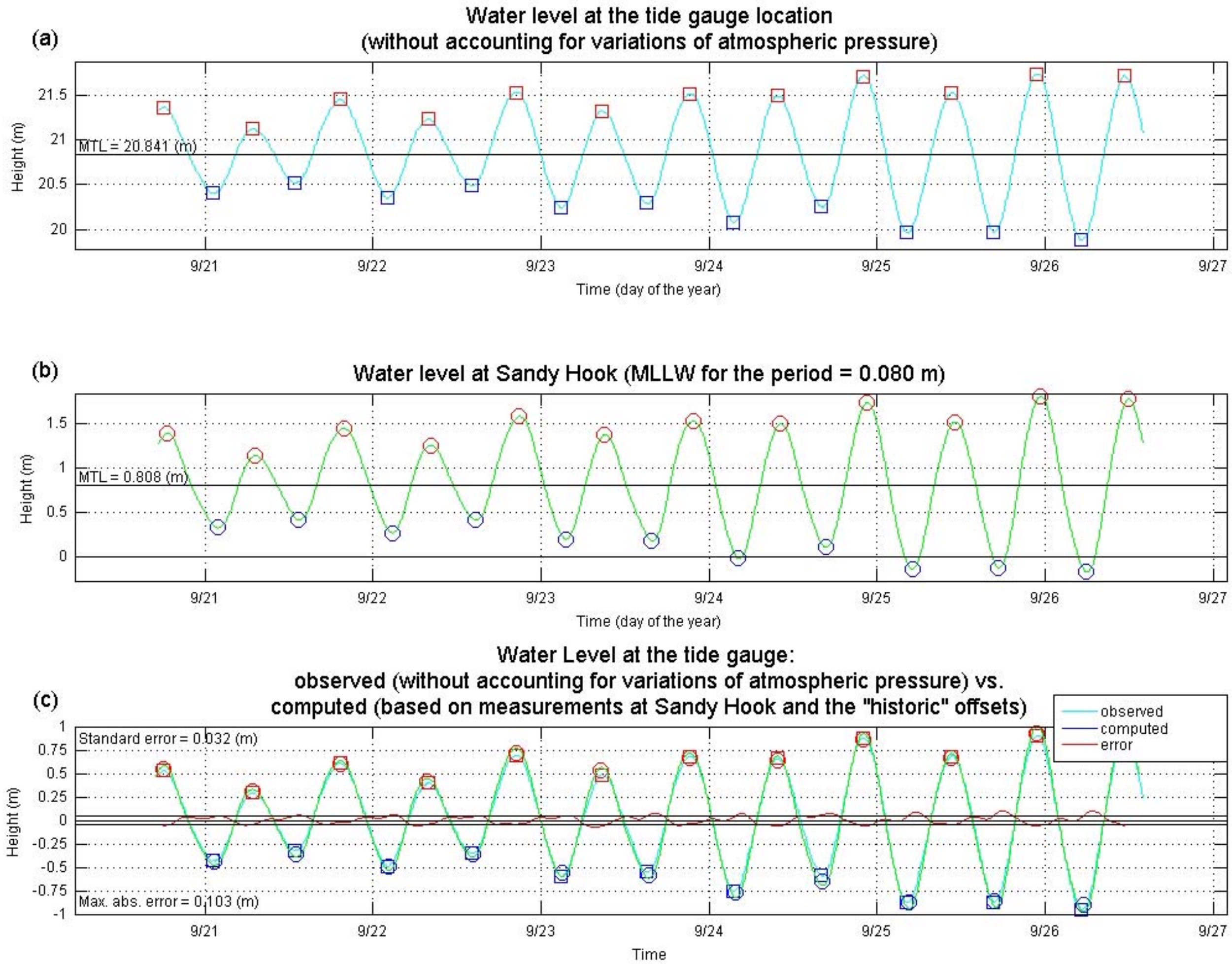


Figure 3.1-2. Time series of the observed water level at the HARS tide gauge and the Sandy Hook tide station during the September 2007 deployment. Panel (a) provides a time series of the observed water level at the HARS pressure tide gauge during a seven day measurement period in 2007; Panel (b) provides the verified MLLW tidal heights from the NOAA Sandy Hook tide gauge during the same time period; Panel (c) provides a time series of the observed differences between the HARS tide gauge data (normalized about the MTL) and the Sandy Hook tide gauge data (with historical range and phase offset correctors applied for the HARS). The observed standard error was 0.032 m and the maximum observed error was 0.103 m.

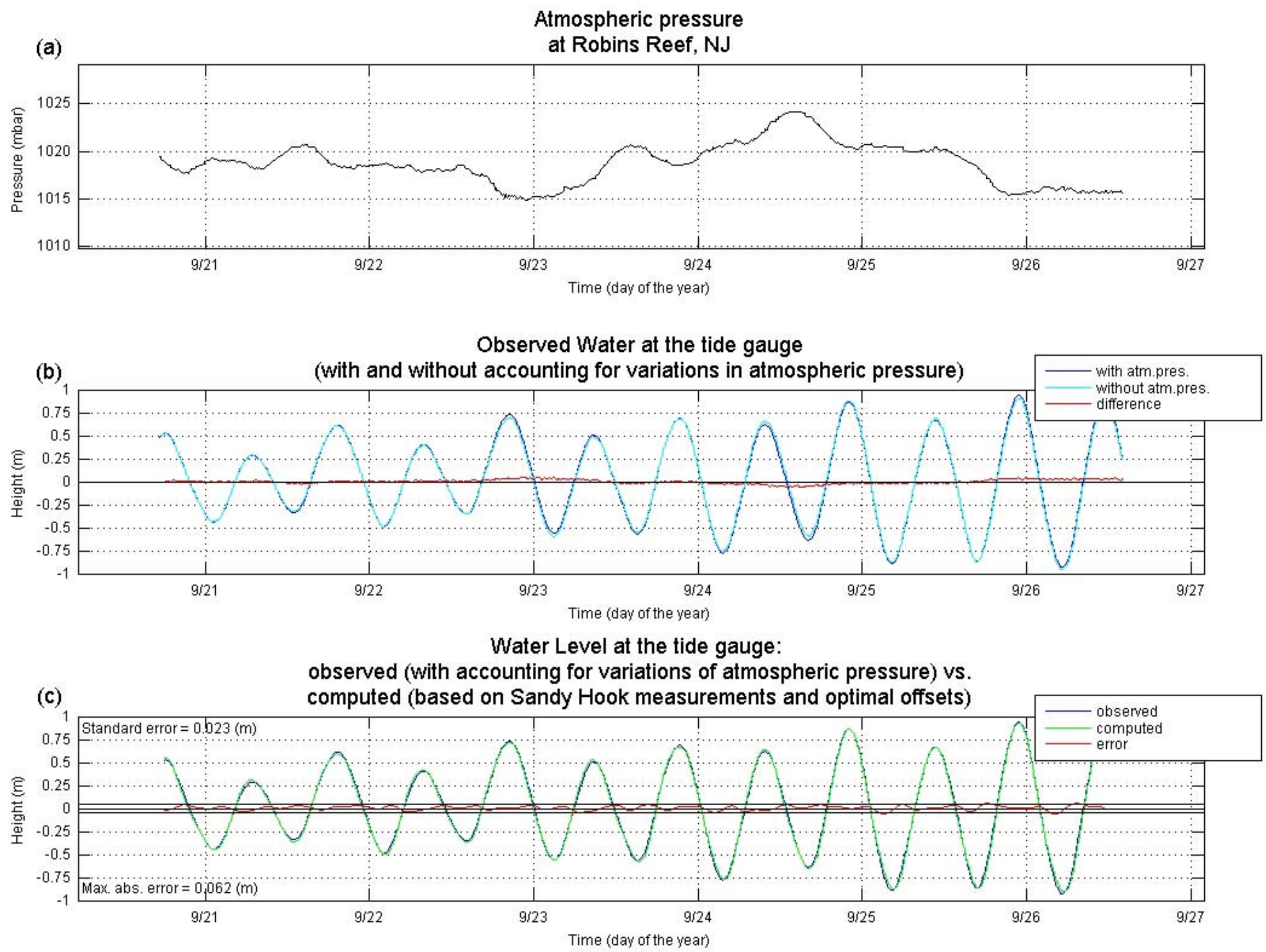


Figure 3.1-3. Time series of the observed atmospheric pressure and the corrected HARS tide data during the September 2007 deployment. Panel (a) provides the times series of the observed atmospheric pressure as measured at the Robins Reef tide station during the HARS pressure gauge deployment period in 2007; Panel (b) shows the times series of the observed HARS pressure gauge tide data with and without the atmospheric pressure correction, as well as the measured difference between these two measurements; Panel (c) provides a time series of the observed differences between the HARS tide gauge data (with the atmospheric pressure correction and normalized about the MTL) and the Sandy Hook tide gauge data (with historical range and phase offset correctors applied for the HARS). The observed standard error was 0.023 m and the maximum observed error was 0.062 m.

because the tide gauge recorded pressure exerted on the instrument by both the water column and the atmosphere. The time series of recorded atmospheric pressure was subtracted from the tide gauge pressure data to produce a time series of pressure exerted only by the water column on the gauge. To convert this pressure to water height, we used the hydrostatic relationship:

$$h = \frac{p}{g\rho}.$$

Where, p is the measured pressure of the water column (after subtracting the atmospheric pressure), g is the gravity acceleration, and ρ is the average water density. The average water density, ρ = 1022.0 kg/m^3, was selected based on the results of the SVP casts taken in the area during the survey operations. Application of the recorded atmospheric pressure data to the HARS pressure gauge data greatly improved the overall agreement between the observed Sandy Hook and HARS tidal results (Table 3.1-1). The noticeable range and phase differences were eliminated, and the observed tidal patterns were very consistent between the two stations. The computed standard error between the stations was reduced from 0.032 m to 0.023 m, and the maximum observed error was reduced from 0.103 m to 0.062 m.

The computed MLLW at the HARS pressure tide gauge location for the period of observation was 20.84 m. For the same period, the observed MLLW at the Sandy Hook station was 0.080 m relative to the verified MLLW datum. Therefore, the corrected MLLW datum at the location of the HARS tide gauge was:

MLLW(corrected) = 20.84 – 0.080 = 20.76 m (Figure 3.1-2).

The range offset (multiplier) is meant to be applied to deviations of the observed water level from the mean tidal level. According to this, the equation for transferring Sandy Hook tidal observations to HARS by using phase and range offsets is:

$$WL(time)_{MLLW}^{HARS} - MTL_{MLLW}^{HARS} = \alpha[WL(time + \Delta time)_{MLLW}^{SandyHook} - MTL_{MLLW}^{SandyHook}].$$

Here, *WL* stands for water level, *MTL* is the mean tidal level (the average of the observed highs and lows) for the period of observations, α is the range multiplier, and $\Delta time$ is the phase (or time) shift. For the analyzed data, the MTL was computed for the period between 21 September and 26 September 2007. The two calculated MTLs were subtracted from the corresponding time series and the resulting deviations were used to find optimal values for α and $\Delta time$ using a least squares procedure. For the 2007 bathymetric survey, the HARS tidal offsets applied to the verified Sandy Hook tidal data used to generate the final tidal correctors were α or range ratio of 0.934 and a $\Delta time$ of minus 30 minutes. Due to the similarity in the correctors initially applied to the 2007 data that were based on previous surveys (-30 minutes and of 0.94) to those derived from the 2007 tidal offset calculation exercise, no changes to the preliminary bathymetric data correctors were necessary to anchor the depth values to the vertical datum of MLLW.

Table 3.1-1.
Summary of optimal phase (time shift) and range offsets computed for different HARS tide gauge deployments

Deployment	Year	Duration (days)	Computed Optimal Offsets		Standard Error (cm)
			Range Multiplier (ratio)	Phase Shift (min)	
1	2007	6	0.93	30	0.03
2	2005	6	0.94	24	0.02
3	2002	7	0.92	24	0.02
4	2002	17	0.94	30	0.03
5	2002	4	0.95	30	0.03

Positive time shift indicates that water level at Sandy Hook lags that at HARS.

3.1.3 Cross-Check Comparisons

Junction Analysis

During post processing, two overlapping 16.4 ft ×16.4 ft (5 m × 5 m) cell sized grids were built for the HARS area, one of main scheme lane multibeam data and one of cross lane multibeam data. The main scheme grid was built from GSF files having the cut off angle set to 60˚. The cross lane grid was built from GSF files having the cut off angle set to 5˚, which allows the cross lane beams closest to nadir (transducer centerline) to be gridded. The two grids were used to create a third, depth difference grid that was used as the basis for the junction analysis routine. The cells of the depth difference grid contain the depth difference between overlapping cells from the cross lane grid and the main scheme grid.

The SABER Junction Analysis tool was used to perform the statistical analysis on all of the HARS overlapping gridded data. The result is an ASCII text file listing the total number of observations (count), the number of positive and negative differences for various depth ranges (0-5 cm, 5-10 cm, 10-15 cm, etc), and the percent of the total observations encompassed by each depth difference range (Table 3.1-2; note that the analysis results are in metric units).

This comparison of the cross lane soundings and main scheme soundings shows that 97.38% of the depth differences are less than 20 cm and that 99.32% of the differences are less than 30 cm. The comparisons larger than 50 cm (0.05%) are accounted for by normal small DGPS position scatter over areas within the survey area displaying bedforms or depressions in the seafloor.

Analyze Crossing Results

Beam by beam comparison of cross lane data to main scheme data was performed on three of the crossings for the HARS survey area (Figure 3.1-4 through 3.1-7). This two-step process begins by finding all beam to beam crossings that occur between the main scheme lanes and cross lanes within a given area. This was accomplished by running SABER’s Find Crossings utility on two file lists, one containing main scheme files and one containing cross lane files. The resulting ASCII file contains positional data for all crossings between the two file lists and can be displayed in SABER. The second step of the process was to compare the near nadir beams of one file to the associated full swath beams of another file for each crossing. Using SABER’s Analyze Crossings utility, a subset consisting of three identified crossings was analyzed (Figures 3.1-5 through 3.1-7). The subset of crossings was established by selecting crossings that were located in relatively flat areas of the seafloor. The selection of relatively flat areas for this crossing analysis reduces the variability of the beam to beam comparisons relative to “non-flat” areas comprised of disposal mounds, natural ridges or wrecks.

The ASCII file generated from SABER’s Analyze Crossings utility tabulates the number of comparisons, number and percentage of comparisons that meet an operator specified criteria for acceptable depth difference, maximum difference, minimum difference and statistics which include mean, standard deviation, and R95, for each beam to beam comparison. Each crossing generates two analysis reports. One report is for near nadir beams of the main scheme lane as

Table 3.1-2.
Summary of Junction Analysis Results for all crossings during the HARS Survey

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0->5cm	5213	41.84	2916	32.54	1673	58.19	624	100%
5->10cm	4240	75.87	3434	70.86	806	86.23	0	100%
10->15cm	2234	93.8	1962	92.76	272	95.69	0	100%
15->20cm	447	97.38	398	97.2	49	97.39	0	100%
20->25cm	173	98.77	142	98.78	31	98.47	0	100%
25->30cm	68	99.32	58	99.43	10	98.82	0	100%
30->35cm	34	99.59	23	99.69	11	99.2	0	100%
35->40cm	8	99.65	5	99.74	3	99.3	0	100%
40->45cm	15	99.78	9	99.84	6	99.51	0	100%
45->50cm	9	99.85	3	99.88	6	99.72	0	100%
50->60cm	13	99.95	8	99.97	5	99.9	0	100%
60->70cm	1	99.96	0	99.97	1	99.93	0	100%
70->80cm	1	99.97	1	99.98	0	99.93	0	100%
80->90cm	3	99.99	1	99.99	2	100	0	100%
90->100cm	0	99.99	0	99.99	0	100	0	100%
100cm->	1	100	1	100	0	100	0	100%

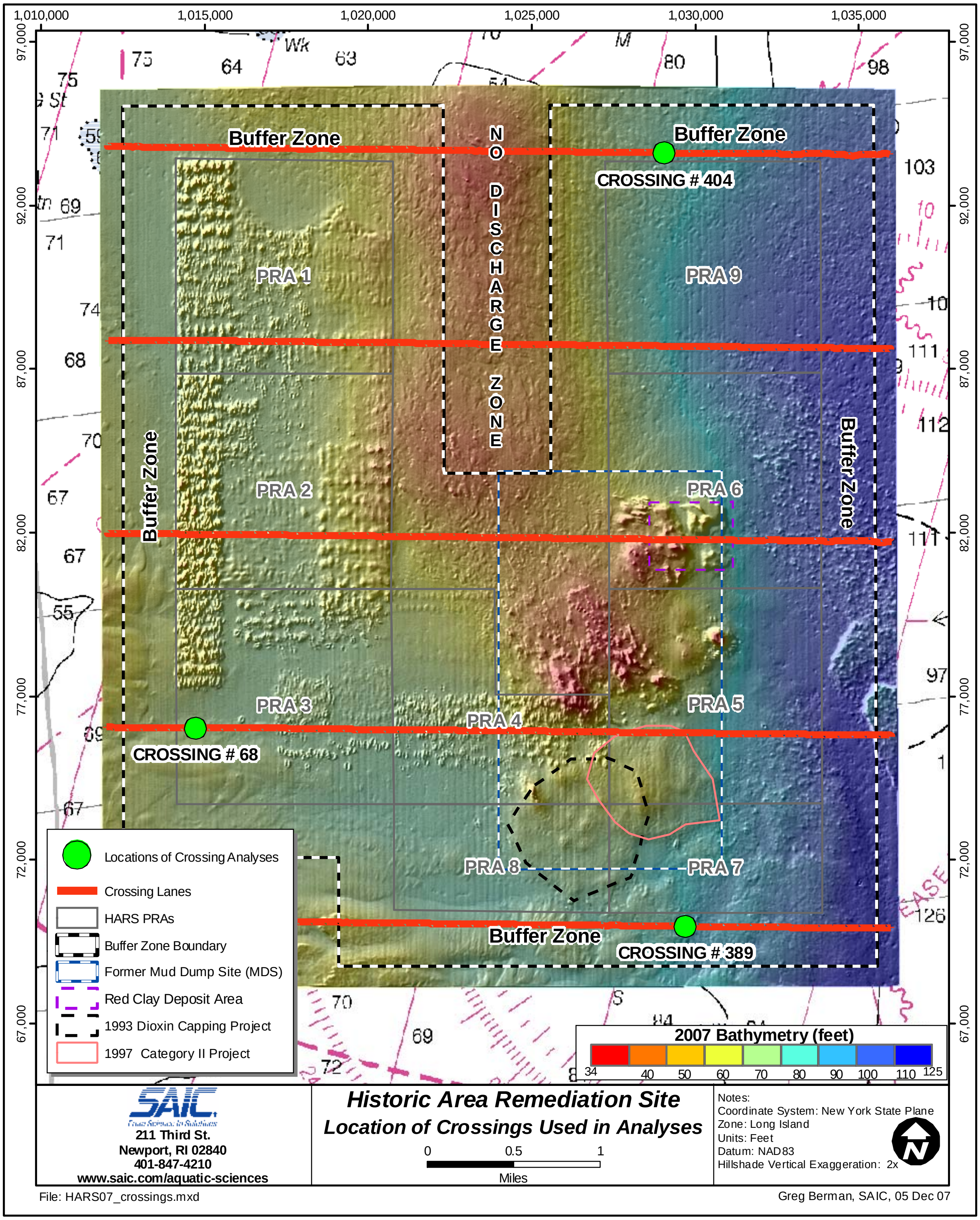
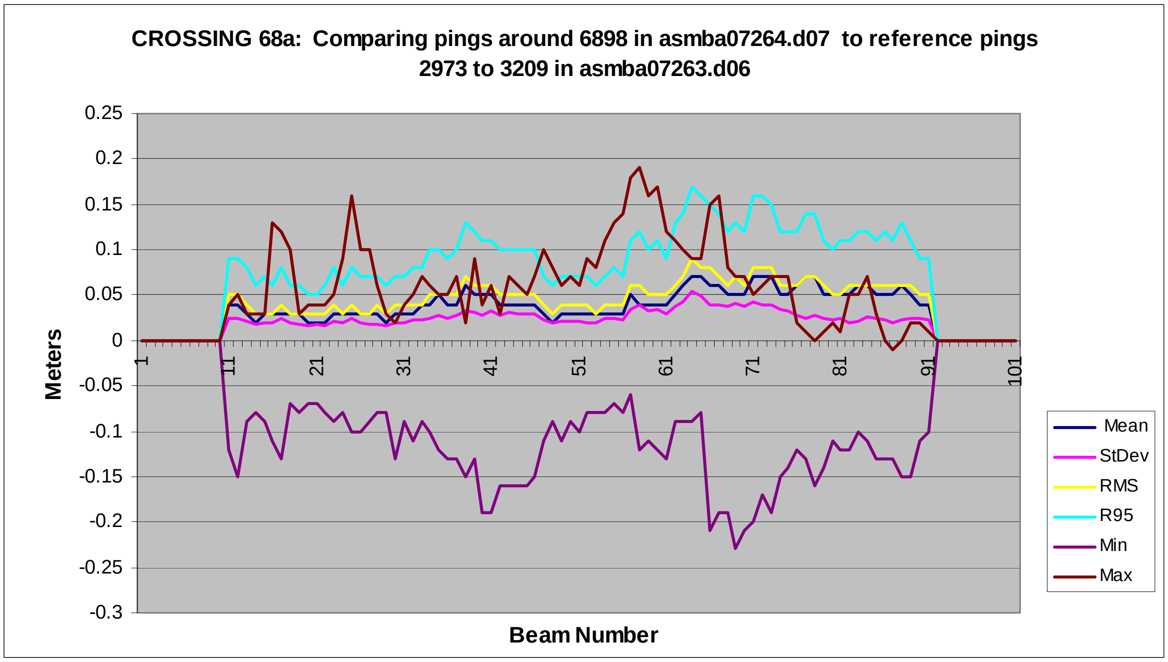


Figure 3.1-4. Locations of the three crossing beam to beam comparisons for a cross lane and main-scheme lane



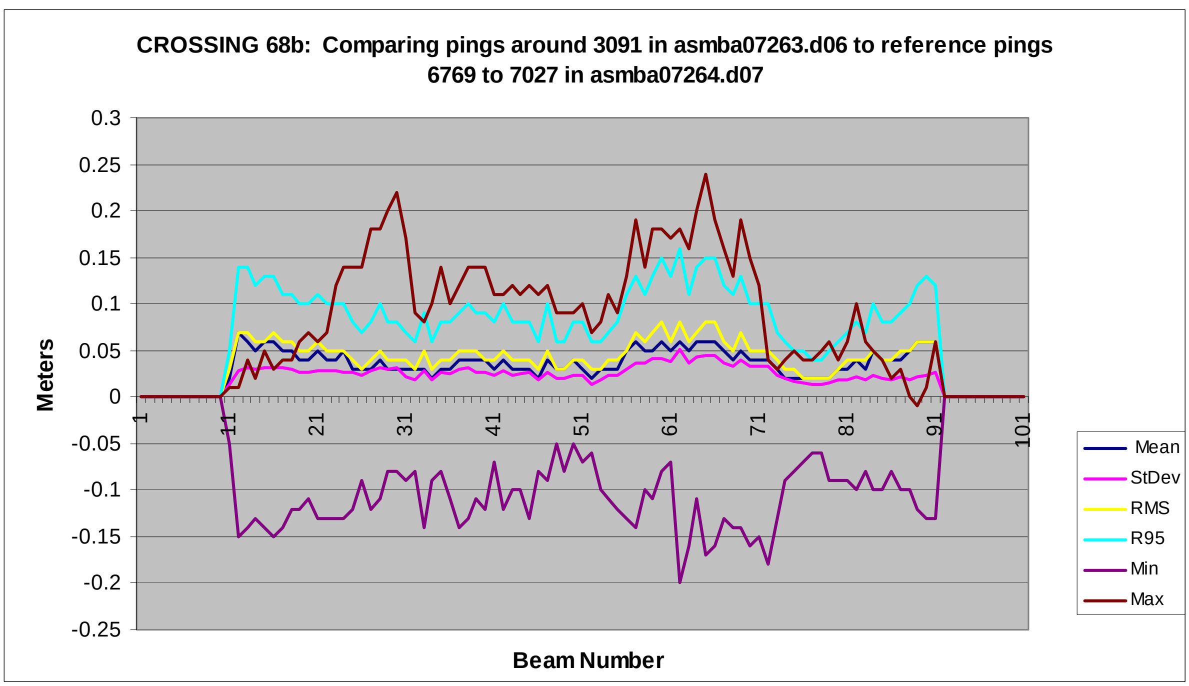
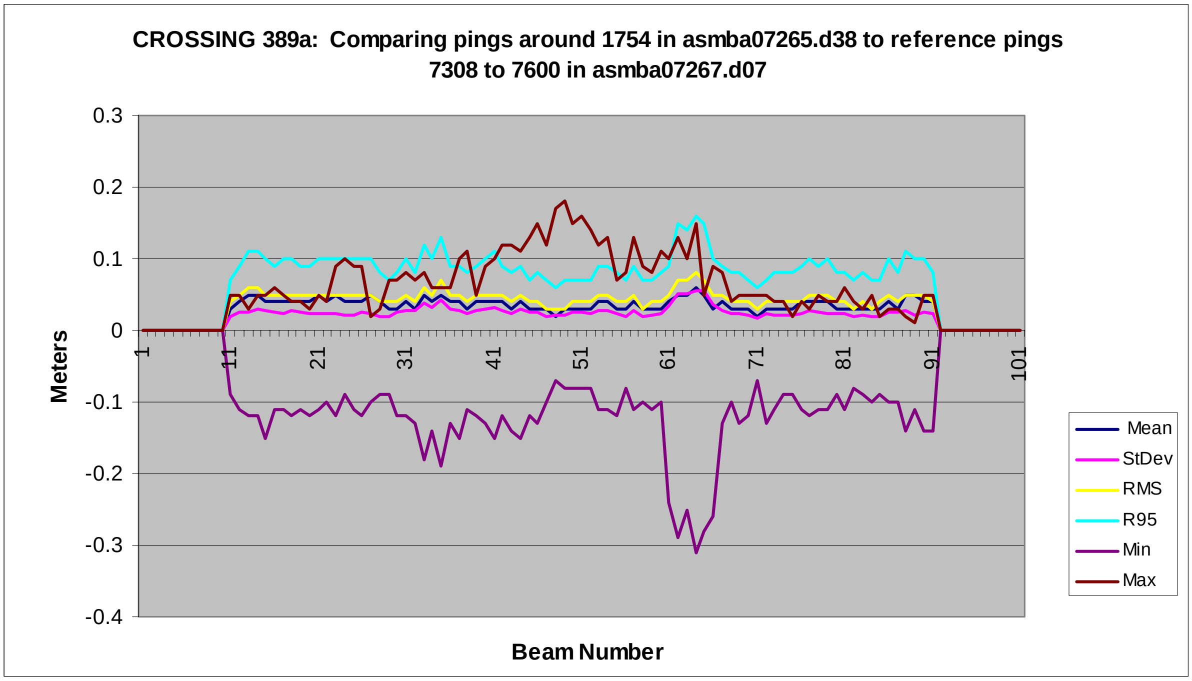


Figure 3.1-5. HARS Crossing 68 a/b: Beam to beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



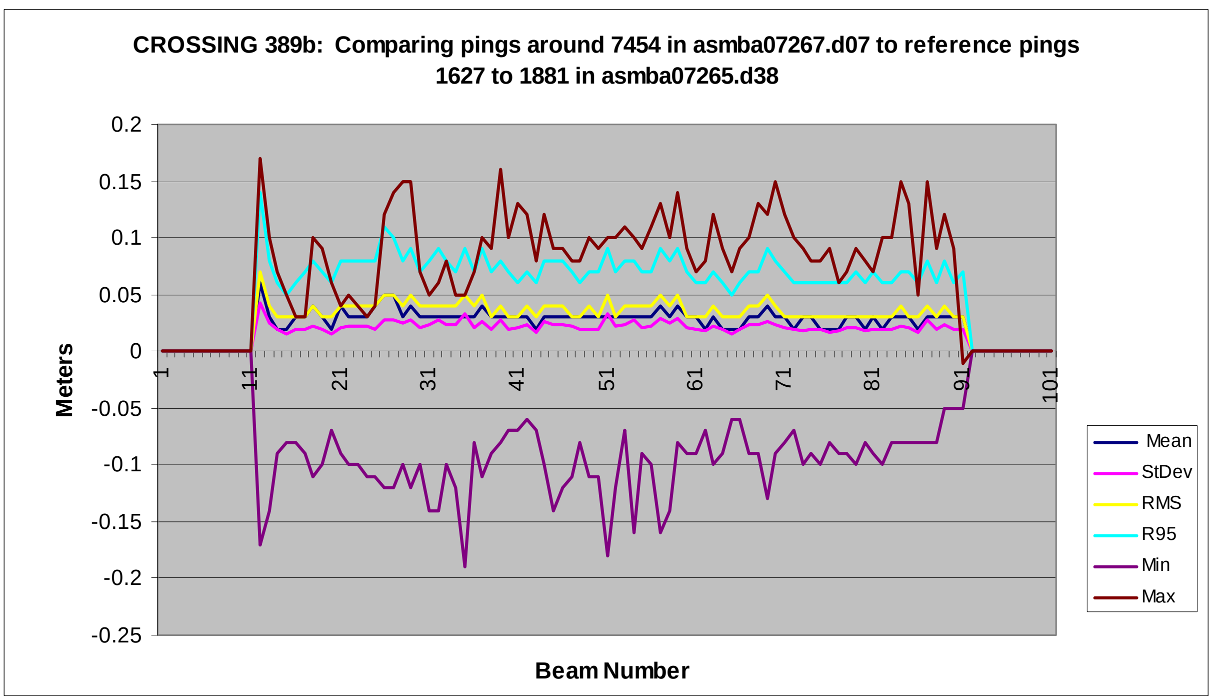
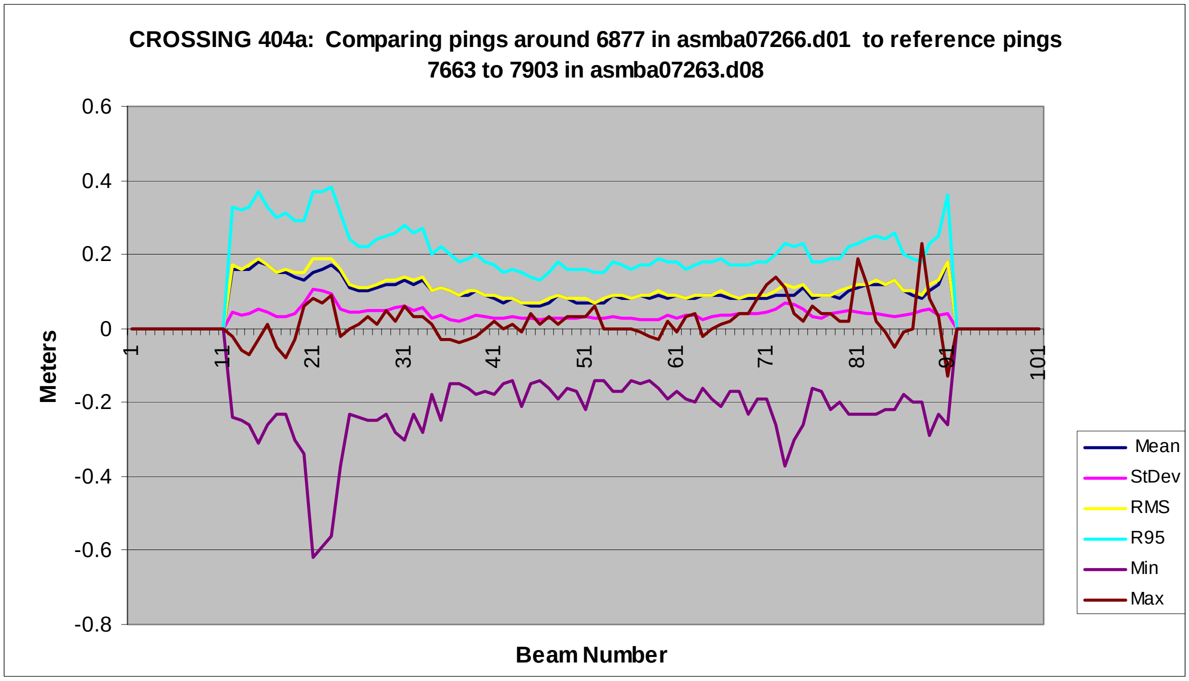


Figure 3.1-6. HARS Crossing 389 a/b: Beam to beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.



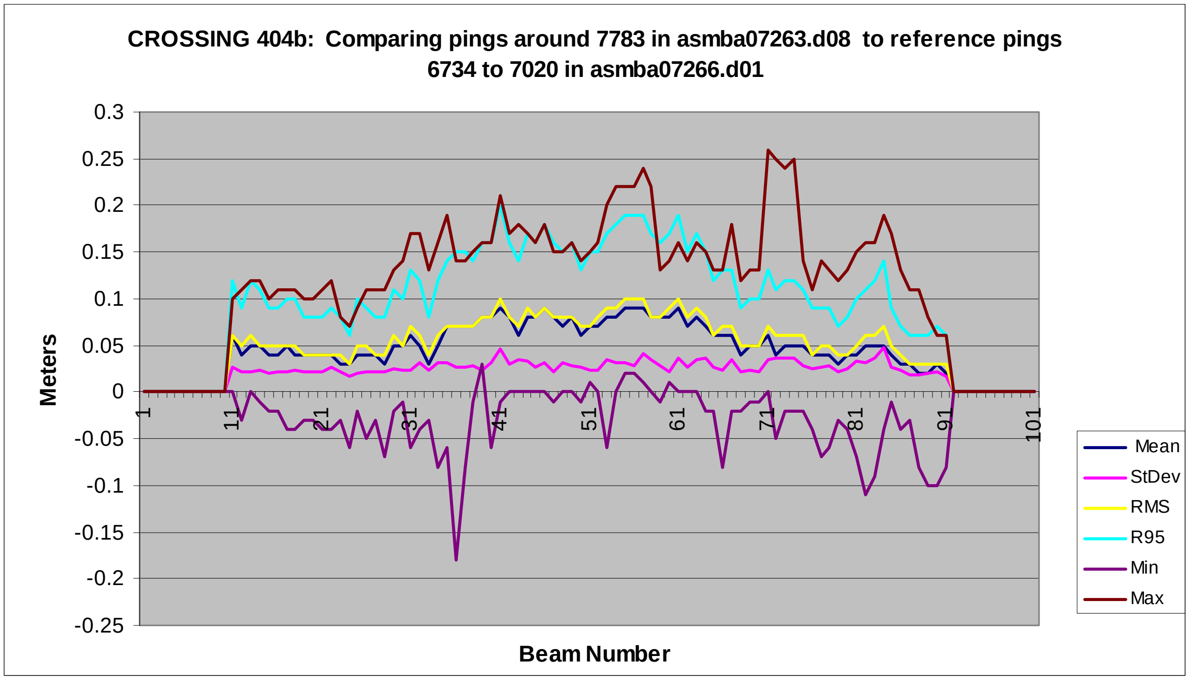


Figure 3.1-7. HARS Crossing 404 a/b: Beam-to-beam comparison between the nadir beams (reference pings) and all beams for a cross lane and a main-scheme lane in an area of overlap. Top panel uses the cross lane as the reference and the bottom panel uses the main-scheme lane as the reference.

compared to the full swath beams of the cross lane, and the second is for the near nadir beams of the cross lane compared to the full swath beams of the main scheme lane.

This beam to beam comparison of depths at the intersections of cross lanes with main scheme lanes can expose potential problems in sound velocity corrections, data biases, sensor offsets, draft, and water level application. The results of this survey suggest that there were no significant depth offsets or error introduced during acquisition and processing of the multibeam data.

3.2 Physical Characterization of the HARS

As discussed in the preceding section, no significant data problems were encountered during processing or analysis of the multibeam bathymetric data, and the entire HARS was well characterized based on these data. The color-coded gridded hill-shade model view shows 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 (Figure 3.2-1). 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 34.2 ft (10.4 m) MLLW and occurred near the center of the former Mud Dump Site. The maximum depth of around 124.5 ft (37.9 m) MLLW occurred in the southeast corner of the survey area.

Many individual disposal mounds were apparent within PRAs 1, 2, 3, and 4, which represent the products of continued dredged material placement within an established network of disposal cells over each PRA. This site management strategy was seen as the most efficient method of establishing a 3.3 ft (1 m) thick layer of remediation material over the entire HARS.

A 240 kHz acoustic image mosaic, representing 100% multibeam backscatter coverage, was also created for the entire survey area (Figure 3.2-2). Because the seafloor within this survey area was comprised of a wide range of sediment types, the imagery mosaic was useful for providing a relative indication of the bottom composition. In these mosaics, darker areas are generally represented as stronger acoustic returns (higher reflectance) and usually indicated harder seafloor surface materials such as well-consolidated sand or a seafloor comprised of cobble. A concentration of high reflectance areas was noticed along the western margin of PRA 2, indicating these dredged material deposits were quite consolidated or possessed different acoustic properties than the surrounding ambient sediment and dredged material. Although most of the dredged material deposited at HARS is principally composed of finer-grained sediments, the stronger sonar return in the backscatter image suggests a heterogeneous layer of material existed at the sediment-water interface of these dredged material deposits, potentially including some rock debris or dense clay.

The lighter areas of the 240 kHz image mosaic represented weaker acoustic returns (lower reflectance), indicative of a softer seafloor or material at the sediment-water interface that tends to attenuate the acoustic pulses, such as unconsolidated fine sand or silt. To assist with the site visualization, it was also useful to view the backscatter imagery draped over the multibeam hillshade view (Figure 3.2-3). Unconsolidated, finer-grained sediments were present at the

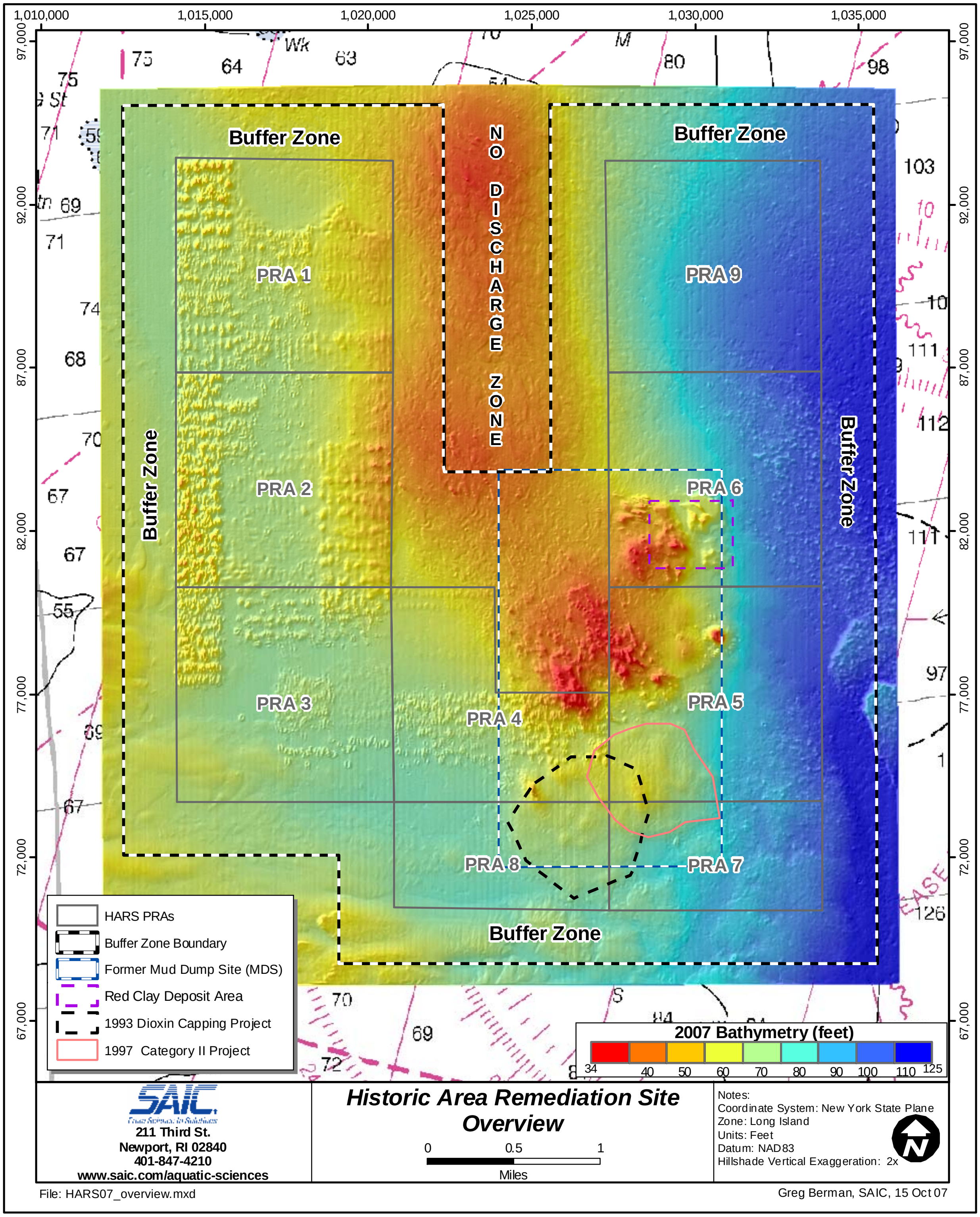


Figure 3.2-1. Hill-shaded relief model based on the 2007 multibeam bathymetric survey at the HARS

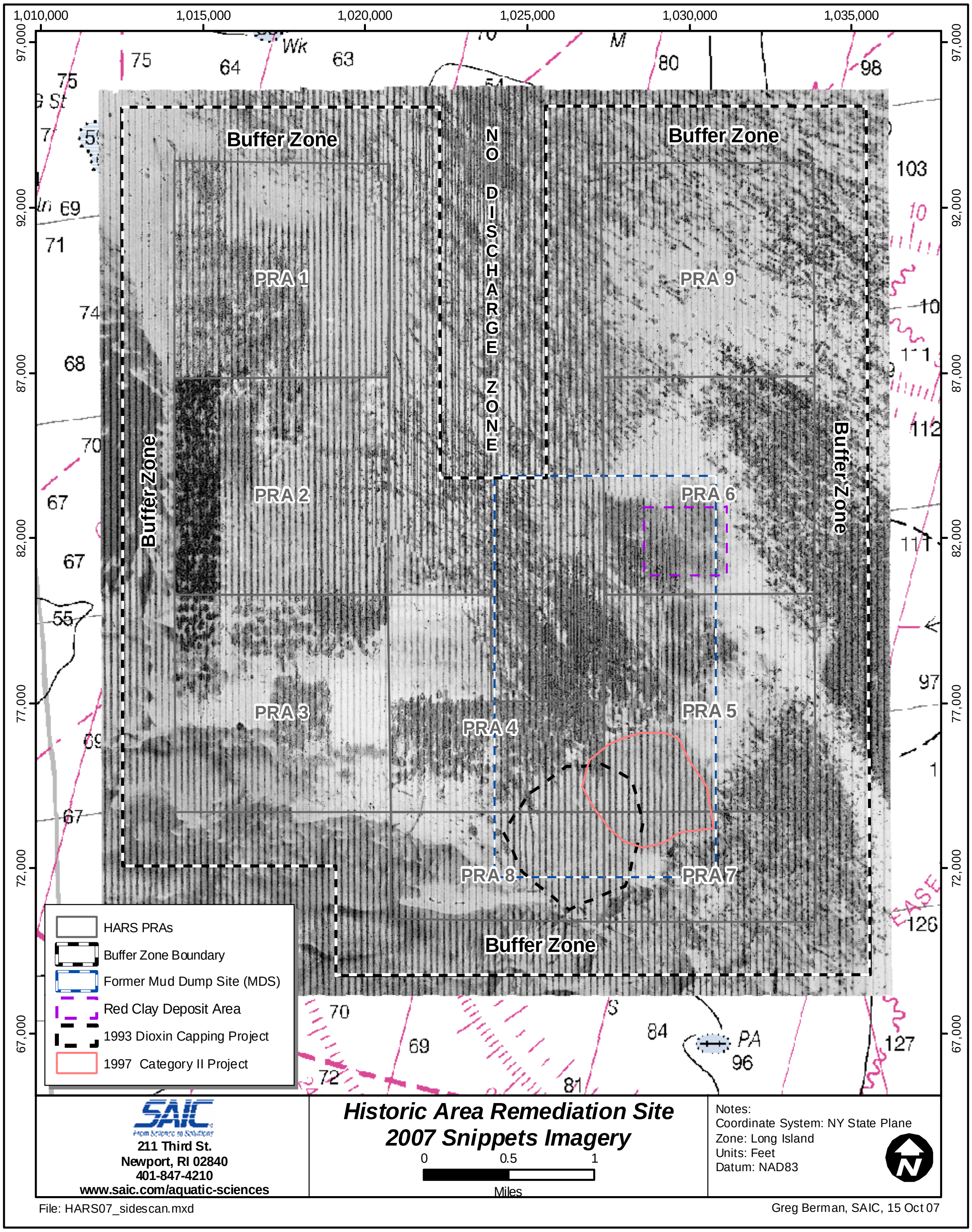


Figure 3.2-2. Multibeam backscatter imagery mosaic based on the 2007 bathymetric survey at the HARS

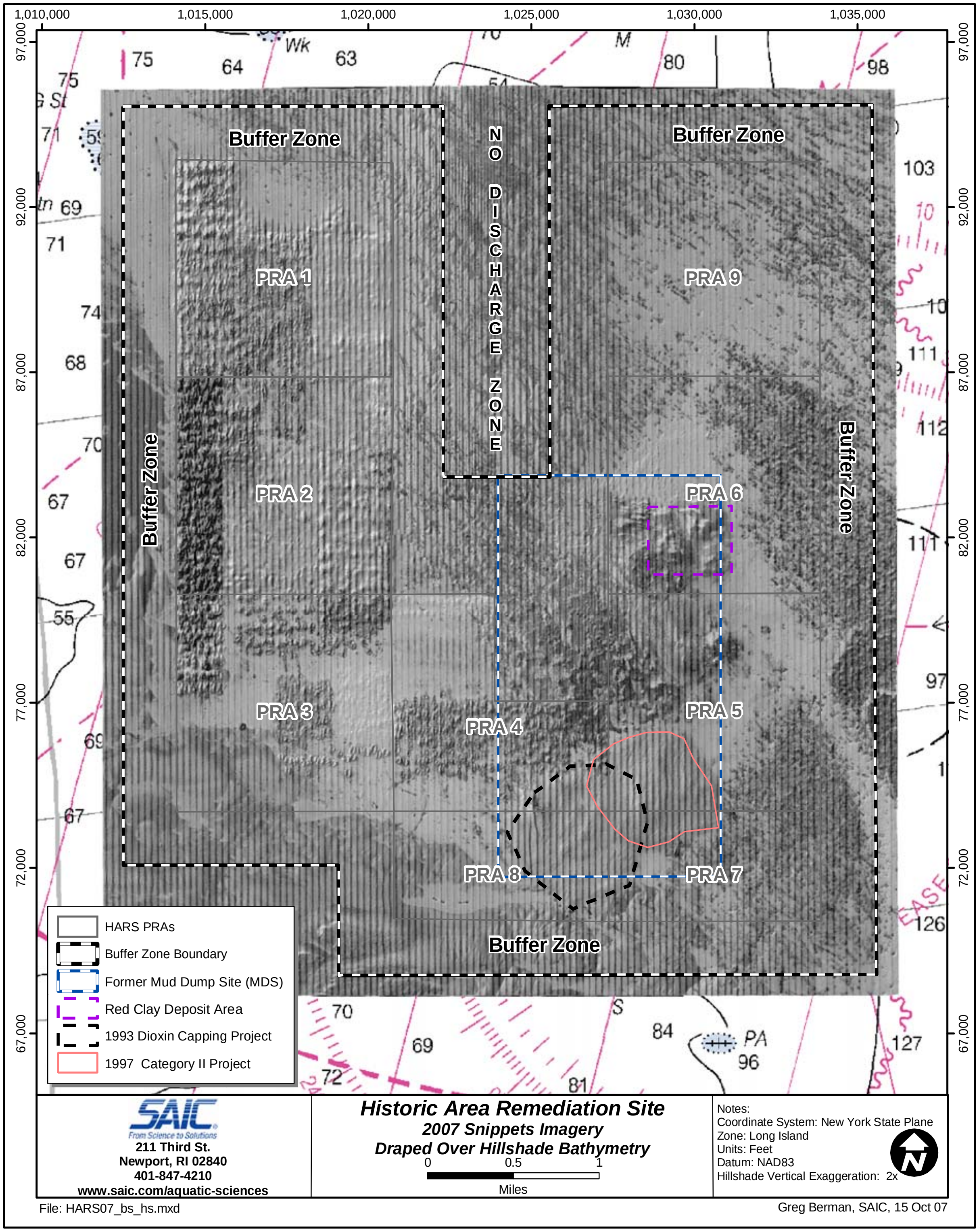


Figure 3.2-3. Multibeam backscatter imagery draped over the hill-shade multibeam bathymetry from the 2007 HARS dataset

sediment-water interface in a significant portion of PRAs 2 and 3, as well as the northwestern quadrant of PRA 4. In addition, the lighter returns acquired over the footprints of the 1993 and 1997 capped disposal mounds suggest the continued presence of a surface layer composed of fine sand (Figures 3.2-2 and 3.2-3). Remaining consistent with expectations, the surface of the seafloor within the Red Clay Deposit Area appears to be comprised of a denser material (consolidated clay), which serves as the basis for the stronger acoustic backscatter.

4.0 DISCUSSION

4.1 Existing Conditions

Prior to the 2007 survey, the most recent bathymetric dataset from the HARS originated from a multibeam survey conducted in September 2006. In order to evaluate recent deposition trends, a depth difference grid was also generated between the 2006 and 2007 datasets. The bathymetric depth difference grid generated between the 2007 and 2006 surveys showed dredged material accumulation (deposition) across different areas of PRAs 1, 2, 3 and 4 (Figure 4.1-1). Between the 2006 and the 2007 surveys, approximately 3,435,000 cubic yards (2,626,400 cubic meters) of material were placed across PRAs 1, 2 and 3, with an additional 48,000 cubic yards (36,700 cubic meters) placed within PRA 4. PRA 2 received the majority of the material (2,440,600 cubic yards/1,866,100 cubic meters), with the most significant accumulation occurring in the western portion of PRA 2, where one area of recent deposition measured nearly 13 ft (4 m) thick. The areas of accumulation noted in the depth difference comparison were in agreement with the Automated Disposal Surveillance System (ADISS) recorded disposal point information from the period between these two surveys (Figure 4.1-2). The few areas of minor deepening that were detected in eastern portion of PRA 1 were likely due to consolidation of the sediments that had been placed in these areas prior to the 2006 survey.

Because placement of remediation material at the HARS has been concentrated in PRAs 1, 2, 3 and 4 since 1998, subsequent analyses focused on evaluating the extent of dredged material accumulation based on comparisons between the recent 2007 and 1998 single-beam surveys. The September 1998 dataset originated from a series of north-south single-beam survey lanes that were spaced at 82 ft (25 m) intervals established over just PRAs 1, 2 and 3. This data set has been considered the baseline survey and used to evaluate dredged material accumulation through placement operations at the HARS over the past nine years.

A bathymetric depth difference grid generated between the comparisons of the 2007 and 1998 surveys clearly showed dredged material accumulation (deposition) throughout many areas of PRAs 1, 2, and 3, as well as some limited evidence of erosion or consolidation (Figure 4.1-3). The thickest deposits occurred in the western half of PRA 1, as well as in the western and eastern margins of PRA 2, where several deposits measured nearly 19 ft (5.8 m) thick.

A view of the ADISS-recorded disposal point information from the period between these two surveys generally coincided well with the areas of accumulation indicated by the depth difference plot (Figure 4.1-4). The blue tones, suggesting some apparent deepening, are quite linear in nature and likely align with the location of the single beam survey lanes associated with the 1998 survey (Figure 4.1-3). Since the data density, as well as the analysis and gridding routines employed for the 1998 single beam data and the more recent multibeam data sets are significantly different, this apparent small-scale deepening is likely attributable to minor error associated with the depth difference grid calculation. As a result, it can be assumed that the majority of this apparent loss of material can be considered an artifact and no widespread loss of sediment through resuspension and transport has occurred.

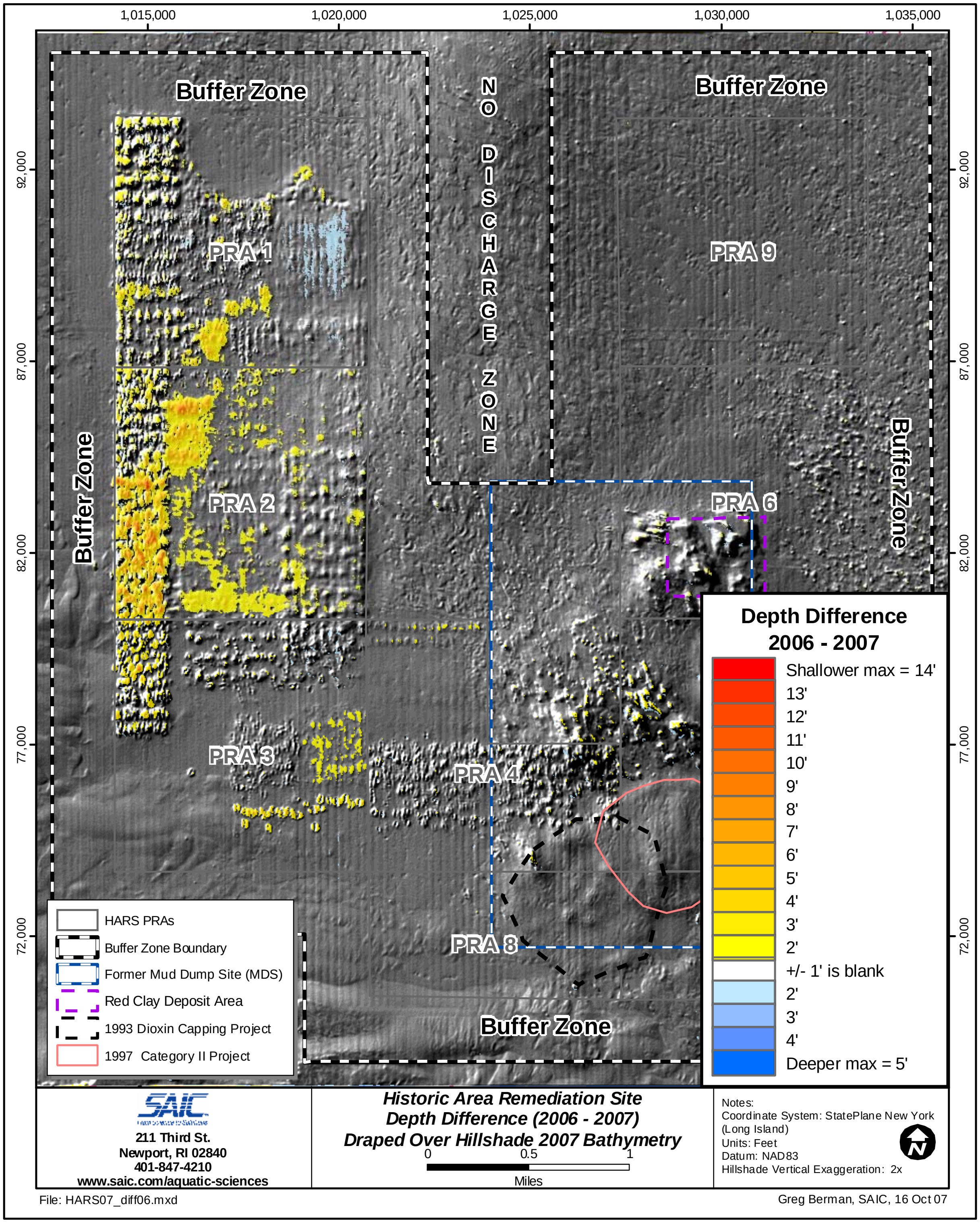


Figure 4.1-1. Bathymetric depth difference between the 2006 multibeam survey and the 2007 multibeam survey over the entire HARS. Yellow and red tones indicate apparent accumulation of dredged material through controlled placement, while blue tones indicate apparent consolidation or erosion.

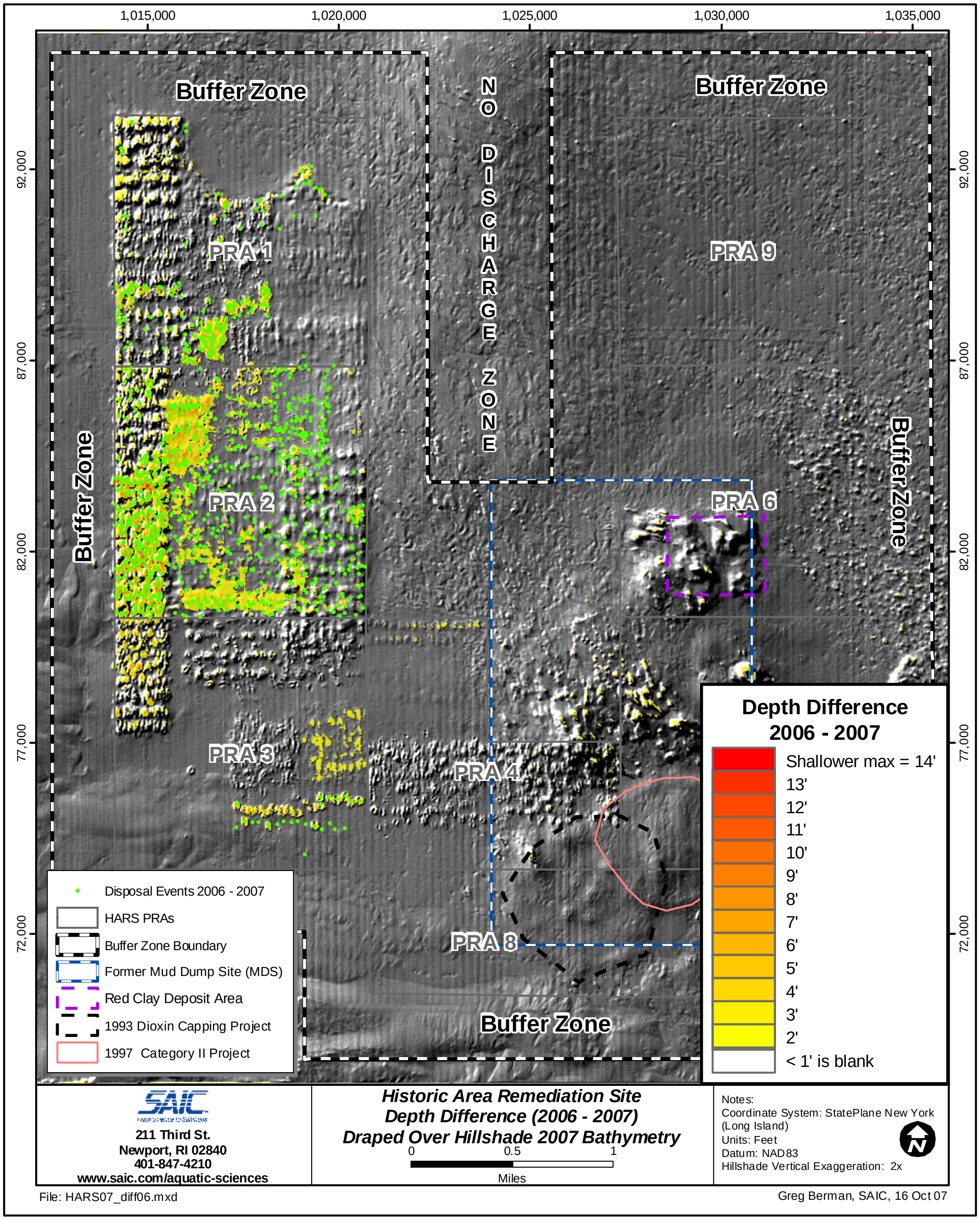


Figure 4.1-2. Disposal point data from the HARS from 2006 and 2007 depicted over the depth difference grid computed between multibeam surveys conducted in 2006 and 2007. The 2007 multibeam hillshade bathymetry and backscatter is included as the backdrop.

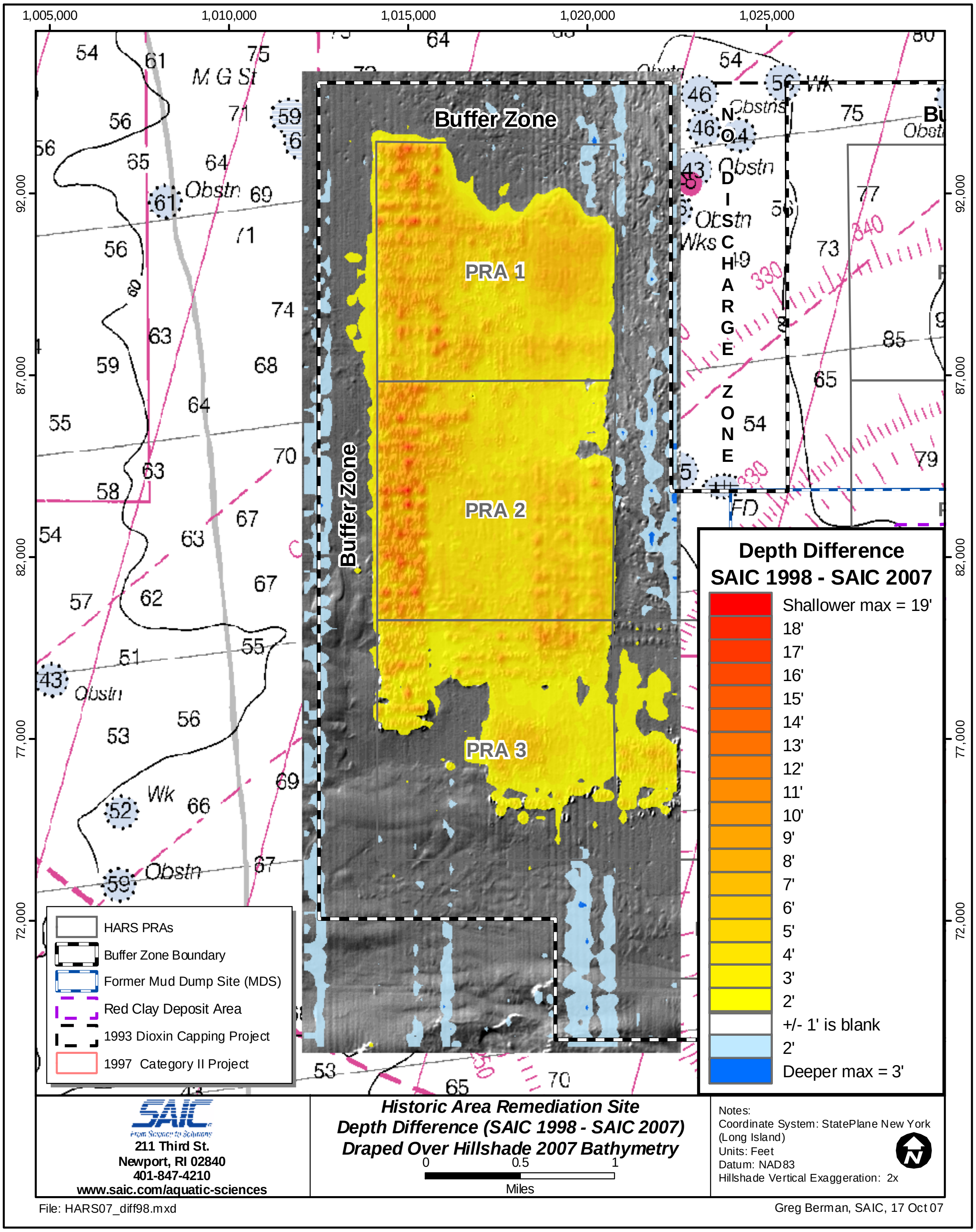


Figure 4.1-3. Bathymetric depth difference comparison between the 2007 multibeam and the 1998 single-beam surveys over PRAs 1, 2 and 3. Yellow and red tones indicate apparent accumulation of dredged material through controlled placement, while blue tones indicate apparent consolidation or erosion.

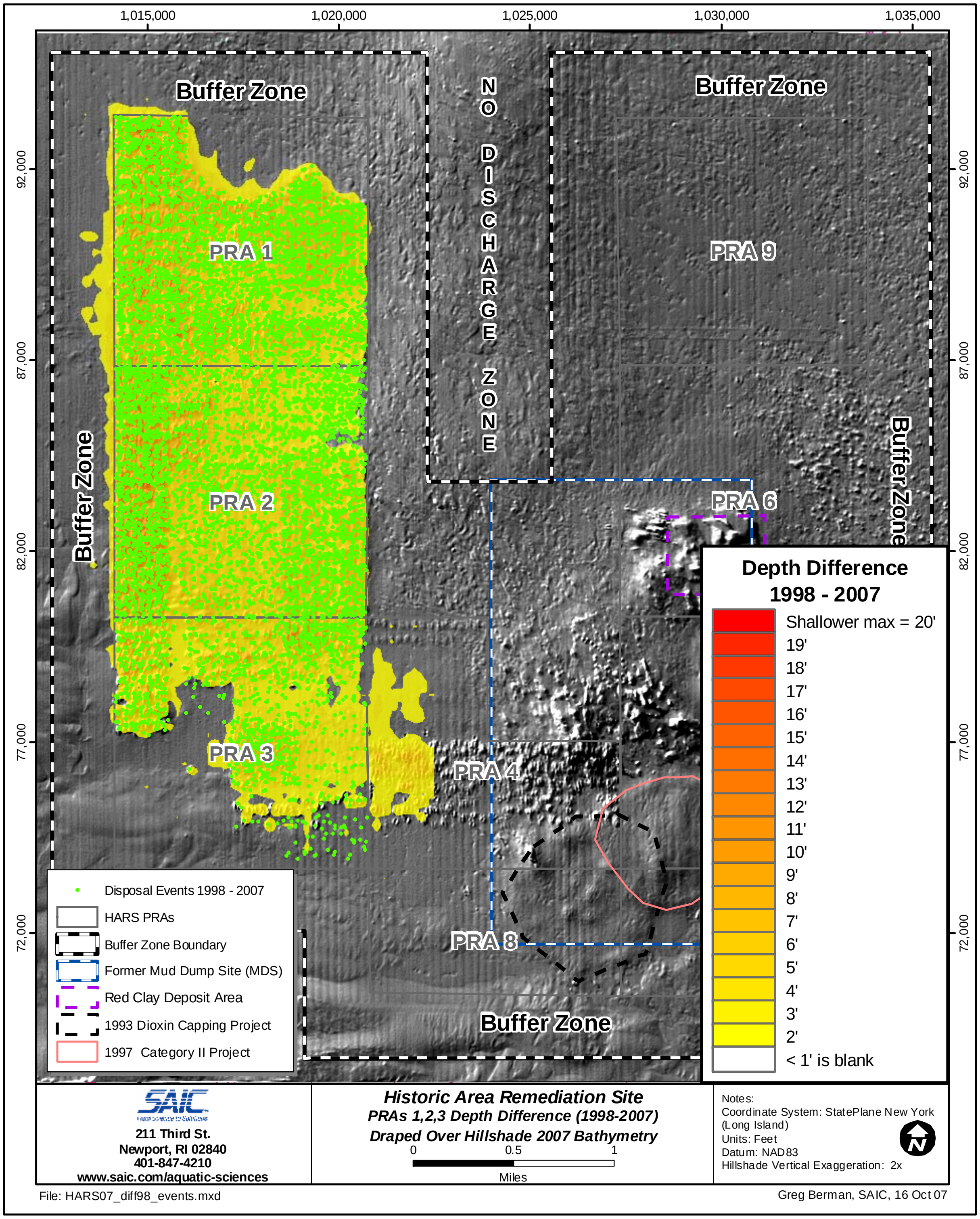


Figure 4.1-4. Disposal point data from the HARS from 1998 through 2007 depicted over the 1998 versus 2007 depth difference grid; the 2007 multibeam hillshade bathymetry and backscatter is included as the backdrop.

4.2 Future Placement

Estimates in the HARS SMMP indicate that approximately 40,548,000 cubic yards (31,003,000 cubic meters) would be required to establish a continuous layer of remediation material one meter thick over the nine PRAs established with the HARS (EPA Region 2/USACE-NAN 1997). A continuous layer of remediation material, or sediment cap, to a thickness of 1 m could be developed by evenly distributing a large volume of dredged material within each PRA. A total estimated barge volume of 28,106,600 cubic yards (21,490,300 cubic meters) has reportedly been placed at the HARS between September 1998 and September 2007, with disposal mainly concentrated in PRAs 1, 2 and 3.

When evaluating the accumulation of sediment in terms of establishing the continuous layer of remediation material over the HARS, the 1998 versus 2007 depth difference comparison indicates that greater than three feet (one meter) of remediation material now exists over most of PRAs 1 and 2 (Figures 4.2-1 and 4.2-2). The 1998 versus 2007 depth difference comparisons also indicate that a substantial area within PRA 3 and a smaller area of PRA 4 have begun receiving sufficient volume of dredged material to form a layer of remediation material greater than or equal to one meter in thickness. However, a significant portion of both PRAs 3 and 4 do not display any detectable thickness of remediation material as of September 2007 and should continue to be targeted for dredged material placement in the future.

Quantitative fill volume analysis indicates that the 1 m thick cover over PRA 1 is approaching completion. As of September 2007, nearly 71% of PRA 1 has been covered with remediation material to a thickness in excess of 3.28 ft (1 m). These estimates also suggest approximately 942,000 cubic yards of material is required to complete the cap, but disposal operations should target the northeastern and southeastern quadrants of the PRA.

The sediment cap over PRA 2 appears more complete than that over PRA 1, as much of the more recent disposal activity has occurred within PRA 2. In fact, with minimum water depths approaching 35 feet in some areas, future disposal operations should now avoid the western margins of PRA 2 to avoid developing discrete areas of shoal water and potential hazards to navigation for deep draft vessels. The fill volume calculations performed using the most recent bathymetry data suggest approximately 77% of the PRA 2 has been covered by a 1 m thick layer of remediation material. A minimum volume of 260,000 cubic yards of dredged material specifically targeting the northeastern quadrant and several disposal cells near the center of the PRA would be required to achieve the minimum desired cap thickness.

The overall thickness of material over both PRAs 3 and 4 had changed very little since the August 2005 bathymetric survey (SAIC 2005). As of September 2007, roughly 21% of the seafloor within PRA 3 has received a sufficient volume of sediment to form the desired 1 m cap, with the majority of this material existing along the northern margin of the PRA. In addition, disposal activity that occurred prior to August 2005 was concentrated near the center of PRA 3 and resulted in a remediation material deposit with a thickness in excess of 1 m. Fill volume estimates indicate that a minimum of 2,620,000 cubic yards strategically placed within PRA 3 will be required to construct an adequate cap.

Based on the limited amount of information pertaining to remediation material placement and accumulation available for PRA 4, qualitative estimates suggest that less than 10% of the sediment cap over PRA is at a thickness in excess of 1 m. Due to differences in configuration, the area of seafloor within the confines of PRA 4 is roughly 75% of the other active PRAs discussed above (Figure 2.1-3). As a result, less volume of remediation material will be necessary to construct a cap of the desired thickness in PRA 4.

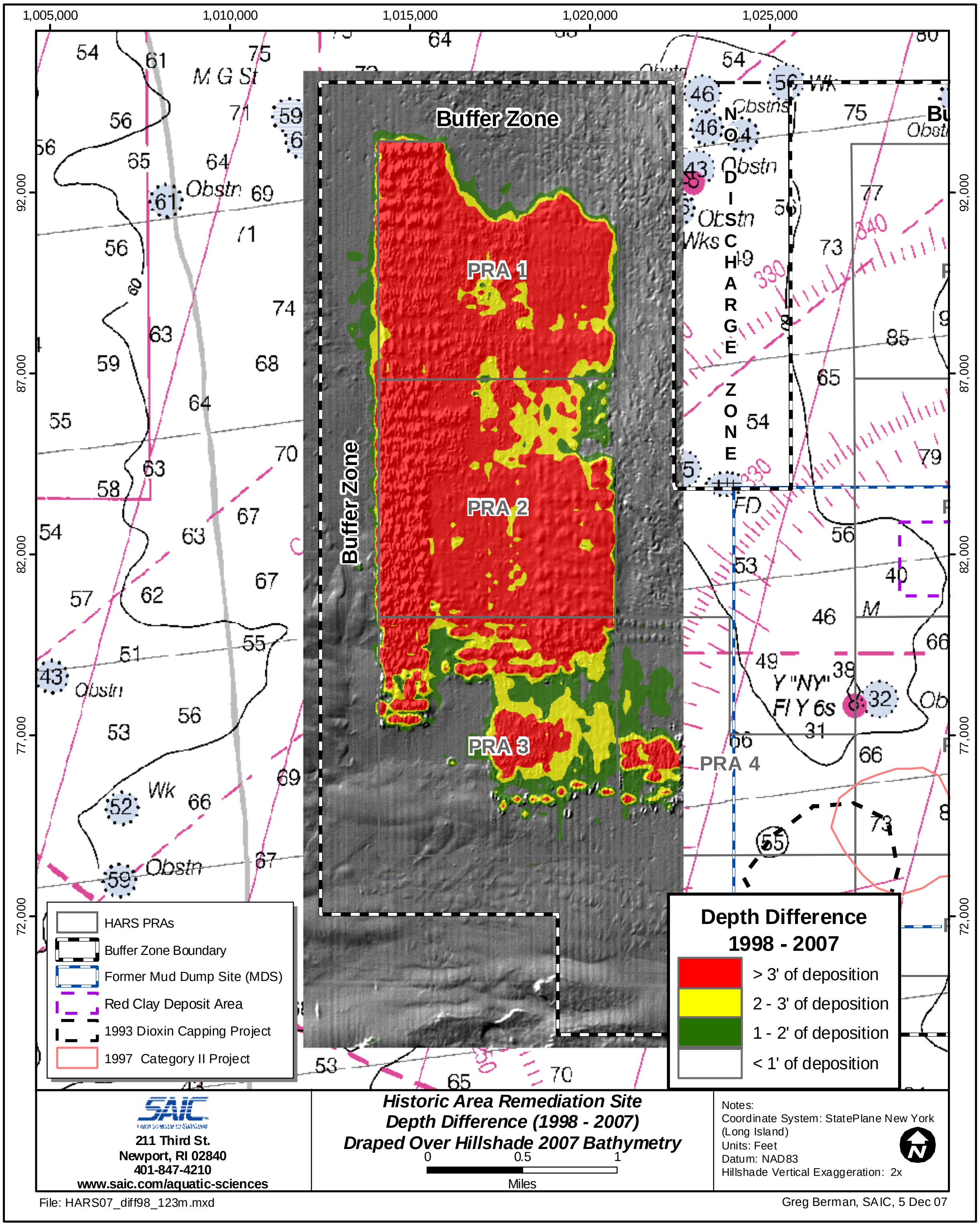


Figure 4.2-1. Bathymetric depth difference displaying areas of PRAs 1, 2 and 3 covered by remediation material at thicknesses exceeding 3 feet (red) between the 1998 and 2007 surveys

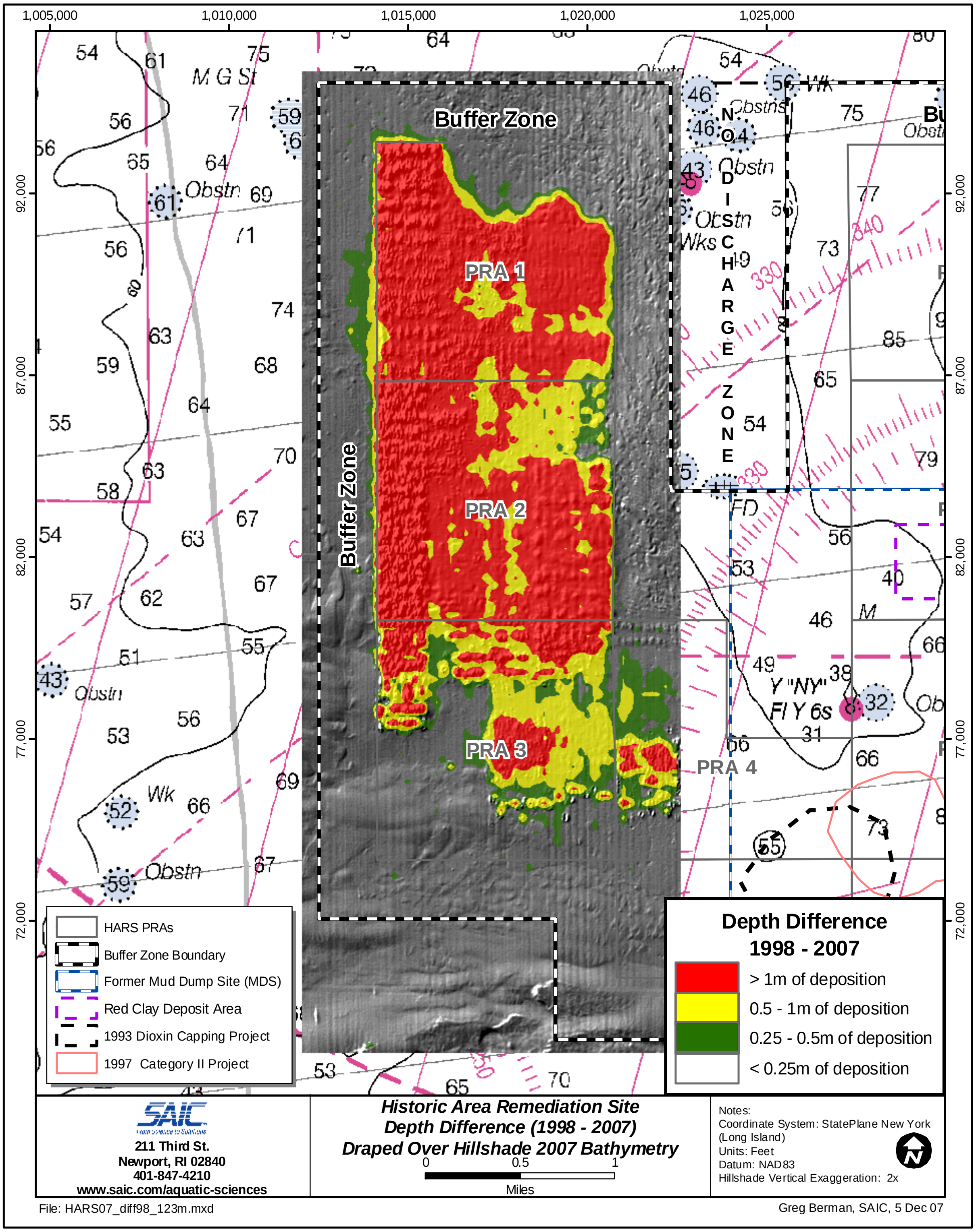


Figure 4.2-2. Bathymetric depth difference displaying areas of PRAs 1, 2 and 3 covered by remediation material at thicknesses exceeding 1 m (red) between the 1998 and 2007 surveys

5.0 REFERENCES

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