W00287

NOAA FORM 76-35A

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

DESCRIPTIVE REPORT

Type of Survey	**Hydrographic Lidar Survey**
Project No.	**OSD-AHB-14**
Registry No.	**W00287**

LOCALITY

State	**Florida**
General Locality	**Lake Worth**
Sub-locality	**Lake Worth Inlet**

2014

CHIEF OF PARTY

HYDROGRAPHER

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DATE **August 12, 2014**

NOAA FORM 77-28 (11-72)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGISTRY NUMBER: W00287

HYDROGRAPHIC TITLE SHEET

FIELD NUMBER: Sheet G

State: Florida

General Locality: Lake Worth

Locality: Lake Worth Inlet

Scale: 1:10,000

Date of Survey: 28 Sept 2014 - 1 Oct 2014

Instructions Dated: 12 Aug 2014

Project Number: OPR-K379-KR

Vessels: NOAA Twin Otter Aircraft (Tail N48RF)

Chiefs of Party:

Surveyed by: National Geodetic Survey - Remote Sensing Division

Soundings taken by echosounder, hand lead line, or pole: Riegl VQ-820-G lidar system

Verification by: Atlantic Hydrographic Branch

Soundings in: Feet: ____ Fathoms: ____ Meters: X at MLW: ____ MLLW: X

Remarks:

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charts. All separates are filed with the hydrographic data. Any revisions to the Descriptive Report (DR) generated during office processing are shown in bold red italic text. The processing branch maintains the DR as a field unit product, therefore, all information and recommendations within the body of the DR are considered preliminary unless otherwise noted. The final disposition of surveyed features is represented in the OCS nautical chart update products. All pertinent records for this survey, including the DR, are archived at the National Geophysical Data Center (NGDC) and can be retrieved via http://www.ngdc.noaa.gov/.

National Geodetic Survey
Remote Sensing Division

Topobathy Lidar Survey Report:

Project: FL1423 Lake Worth Inlet, FL

OCS Project Number: OSD-AHB-14
Survey Number: W00287

November 5, 2014

Contents

1.0 Area Surveyed

NGS/RSD conducted topbathy lidar operations along the Lake Worth, Florida vicinity in accordance with NGS/RSD FL1423 Lake Worth Inlet, FL Project Instructions, August 12, 2014.

1.1 Survey Limits

Survey Limits were established based on a request for topobathy data by MCD for updated hydrography. Planned flight lines are shown in Figure 1.

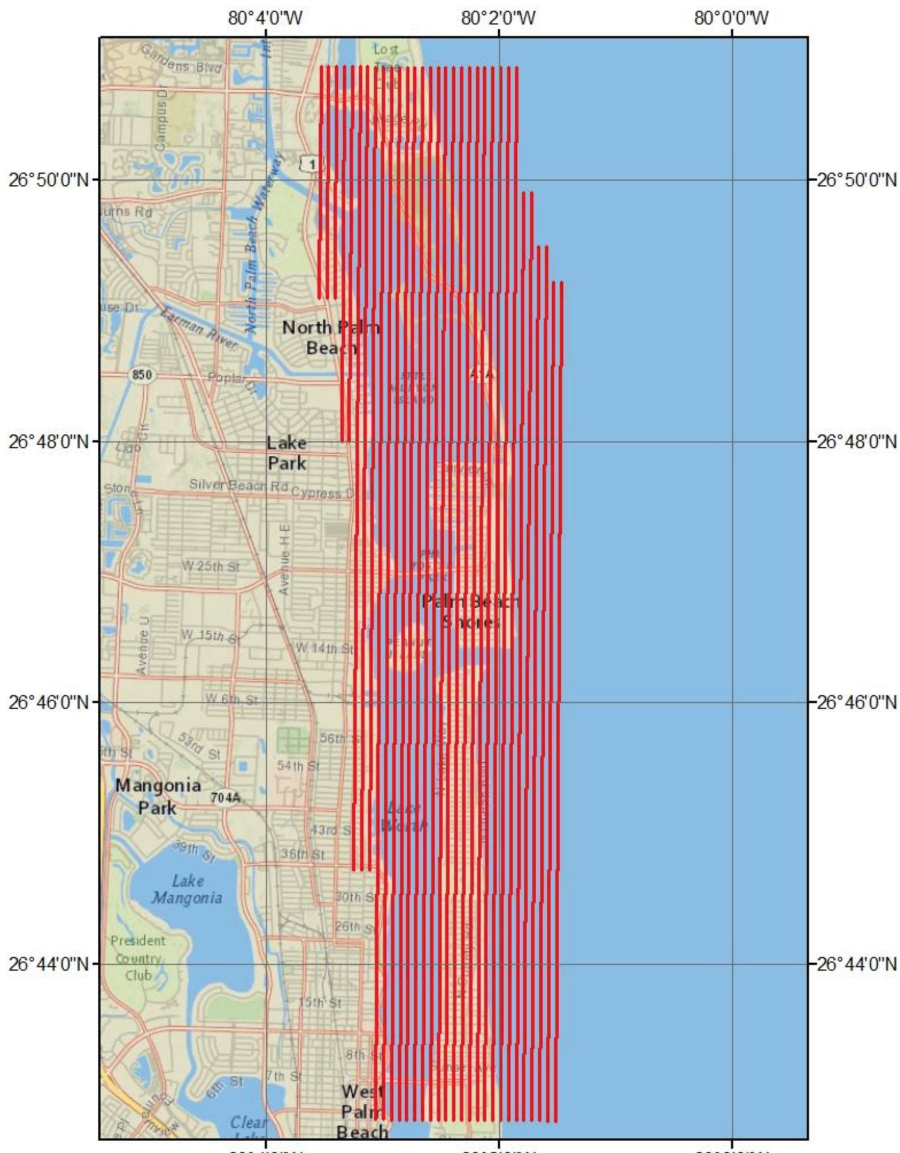

Figure 1. Flight Lines for FL1423.

1.2 Survey Purpose

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products. Specifically these data will address the need for updated bathymetry.

1.3 Survey Quality

The entire survey is adequate to supersede previous surveys

1.4 Survey Coverage

The project instructions specified 50% sidelap between flight lines, which assures the same location, is surveyed in two passes of the aircraft. The parameters used to conduct this survey produce a planned nominal point density of 8 points per square meter, for an individual topobathy flight line and a ground sample distance of 15 centimeters for the rectified imagery mosaic. All areas were flown with 50% sidelap to the topographic extent of the project boundary and out to the extent of the topobathy lidar capabilities under the conditions encountered. The extent of bathymetric lidar coverage is shown in Figure 2.

1.5 Survey Statistics

The following table lists the following statistics for this survey:

Number of Flight Lines:	32
Number of Photo Emulsions (RGB):	2,034
Area of Survey:	34 Square miles

Table 1. Survey Statistics

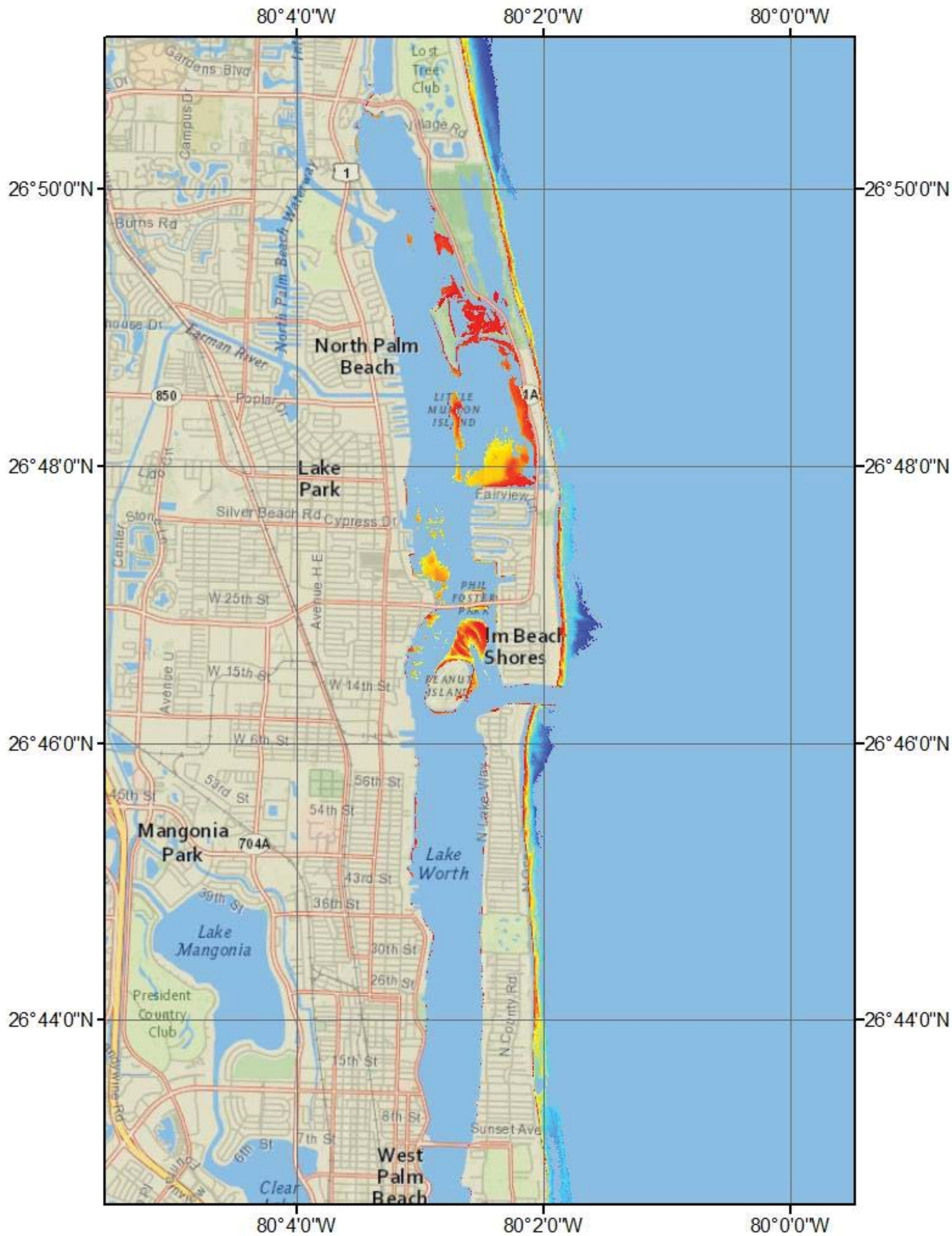

Figure 2. Bathymteric coverage for FL1423.

2.0 Data Acquisition and Processing

2.1 Equipment

This survey was collected with a Riegl VQ-820-G lidar system and Applanix Digital Sensor System (DSS) RGB Imager on a NOAA Twin Otter Aircraft (Tail N48RF).

Instrument	Manufacturer	Model	Function
VQ-820-G	Riegl	Version 1	Topographic and Bathymetric lidar sensor (520 kHz)
POSAV	Applanix	Version 6	Flight Control Software and Positioning System
DSS	Applanix	439	Digital RGB 39 MP Camera (5412 x 7216)
POSAV	Applanix	Version 5	Flight Control Software and Positioning System
GNSS Receiver and Antenna	Trimble	R7 and TRM41249.00	GNSS Base Station
GNSS Receiver and Antenna	Trimble	R8 and TRMR8_GNSS	GNSS Base Station

Table 2. Equipment Hardware

2.2 Calibration

Immediately following system installation, a calibration flight was conducted over the NOAA Sun City Calibration site. The calibration site was selected in a suburban environment with many houses that have pitched roofs and open flat surfaces, such as cul-de-sac roads. The GPS baseline between the base station and aircraft are kept to a minimum, so that the uncertainties associated with the trajectory file are minimized (Figure 3). The raw data was initially processed to a point cloud referenced to an appropriate coordinate system. The average density of the laser measurements was around 40 measurements per square meter (#/m^2), and certain areas of the calibration site with high overlap had up to 180 points/m^2 (Figure 8.17). The initial boresight angles were calculated and verified in a three-step procedure. First, an initial examination of the relative offset between adjacent scan lines is performed. This offset observed is utilized to assist in finding tie objects between different scans. A tie object is a planar surface, point, or sphere found in a scan. Observations consist of the matching of two similar objects in overlapping scans. Between 30,000 to 70,000 observations are typically identified for a geometric calibration flight. Second, the distances of the observations and a standard deviation are calculated for estimation of the current fit. Third, an adjustment is calculated for optimal boresight angles to achieve a best fit between all scans in the data set. The data is then reprocessed with the newly calculated boresight angles. The third step was repeated until the standard deviation of distances between objects converges to a value between 1 to 3 cm and further adjustment iterations are providing negligible differences. Various techniques are utilized to analyze the results from qualitative examination of intensity data and hillshade images to examine for unusual scan or geometrical artifacts to quantitative differences between flat surfaces in overlapping scans. The results from the Boresight Calibration procedure were verified using control points measured in cul-de-sacs areas determined with rapid static GNSS field-surveys. The average difference from the comparison between the ALB survey to the control points was -0.012 cm vertical difference with a standard deviation of 0.039 m.

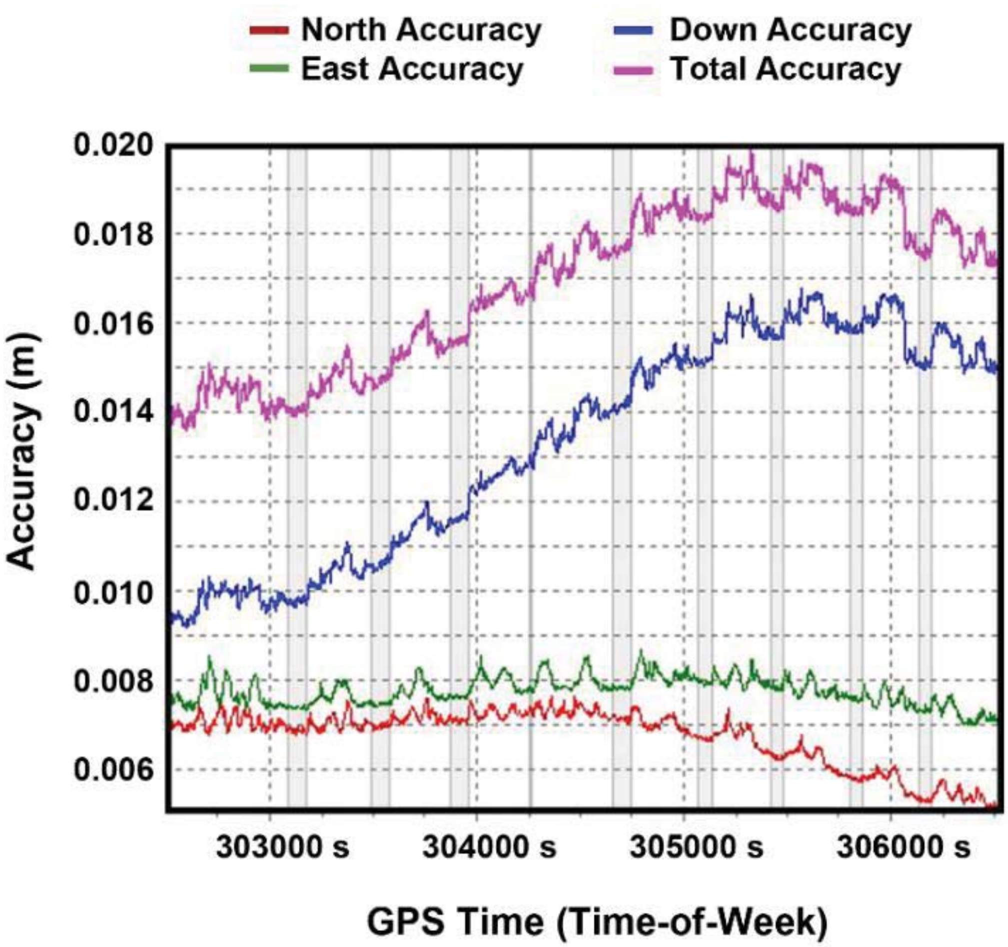

Figure 3. Uncertainties associated with the aircraft trajectory.

2.3 Acquisition

The Riegl VQ-820-G acquired topobathy lidar and digital camera imagery on September 28th, 29th, and October 1st in the Lake Worth Inlet, Florida vicinity. Data was acquired +/- 2 hours of low tide, from an altitude of 1000 feet at approximately 100 knots, resulting in an average swath width of 300 meters.

2.4 Data Processing and Software

Data were initially processed in the field for coverage review. Raw airborne data were combined with preliminary processed trajectory information in the Riegl Lidar Processing Suite to produce a point cloud. Field data were reviewed for coverage and also to ensure there were not potential system issues.

A list of processing software used during the project is provided in Table 3.

Description	Manufacurer	Version	Description
Tracker 32	Track-Air	3.04	Flight Planning
POSPac	Applanix	6.2	Trajectory/Inertial Processing
Riegl Lidar Processing Suite	Riegl	1.6.1	Airborne Lidar Data Processing
GeoCue	GeoCue	2013.1.45.2	Lidar Editing and Workflow Management
Microstation v8i	Bentley	08.11.09.357	Lidar editing with Terrascan
Terrascan	Terrasolid	14.018	Lidar editing
VDatum	NOAA	3.3	Vertical Datum Transformation
ArcGIS	ESRI	10.2.2	Iterim QC, Product Review
LP360	GeoCue		
RapidOrtho	Applanix	1.5	Orthorectify Images
OrthoMaster	Inpho	4.6	Mosaic Orthorectified Imagery

Table 3. Processing Software

Final data processing was conducted in the office after field operations were completed. An overview of the current topobathy workflow is diagrammed in Figure 4. Final trajectory processing was completed in POSPac once the precise ephemeris was available. The Riegl Lidar Processing Suite was used to combine the raw airborne data, final trajectories, and calibration information into a georeferenced point cloud. During this process, QC is performed to check stability of calibration values. Once confirmed, a noise filter is applied and water surface classification is performed on a flight line by flight line basis. Individual flight lines are examined to determine if classification of the water surface is correct and sufficient. Refraction correction is then applied within the Riegl Lidar Processing Suite. A LAS file for each flight line in 1.2 format is exported and ingested into the GeoCue workflow management system for editing. Lidar was tiled into 500 meter x 500 meter blocks. Spatial algorithms were developed and run to remove erroneous high and low points, classify bare earth topo points as ground, and to ground the seabed to a bathymetric point class.

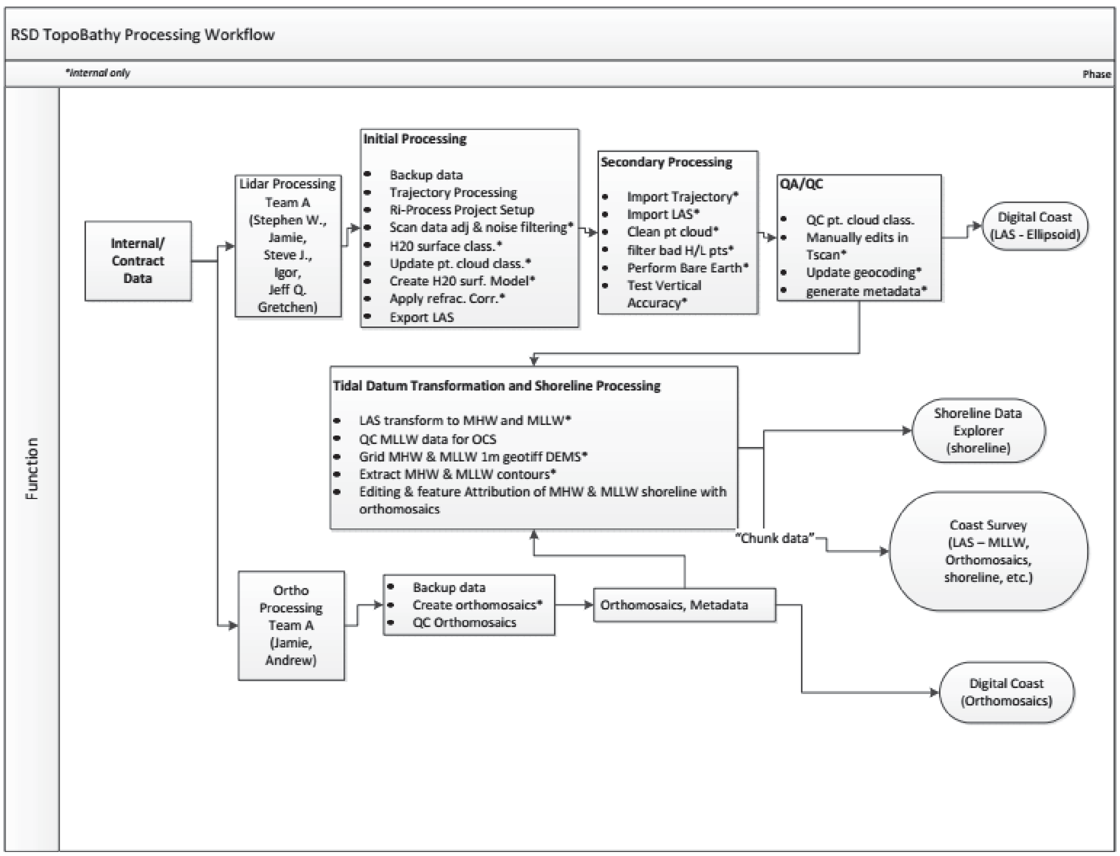

Figure 4. Topobathy Workflow

RGB imagery was acquired during each flight concurrent with the lidar. The imagery was utilized to assist in lidar data editing and quality control. These images were used to generate orthorectified mosaics at a 0.15 meter ground sample distance with an accuracy less than 0.50 meters at a 95% confidence level.

2.5 Vertical and Horizontal Control

There were no specific vertical and horizontal control requirements for this project.

All horizontal and vertical data for this project were acquired on NAD83 (2011) ellipsoid. During processing, data were transformed to Universal Transverse Mercator Zone 18N in meters and to MLLW. The vertical transformation was conducted using VDatum and GEOID12A.

Twenty-eight GPS check points were established for use during project acquisitions tied to the CORS network. The coordinates for the base station utilized in positioning of the aircraft trajectory and RTK base station for check point collection were computed via the NGS OPUS.

2.6 Quality Control

Internal consistency of the data was checked using the sidelap between adjacent strips, while absolute checks were conducted using ground control. Results from all QC checks indicated good internal consistency. Table 4 provides the results from computing the elevation difference between a surface from individual strips and a mean surface, with an overall average magnitude of 0.045 meters between all strips. Average magnitude is the mean value of absolute elevation difference values. Magnitude is the absolute value of the elevation difference between a strip and the mean surface. Dz is the mean value of the elevation difference between a strip and the mean surface. Additional qualitative reviews are performed with Terrascan and ArcGIS/LP360 for detection of geometrical or scan artifacts, misclassification, and any other unusual issues that may be present in the data.

Absolute vertical accuracy checks were also conducted using 28 ground check points collected on the topographic portions of the survey area and results are shown in Table 5.

2.7 Corrections to Soundings

VDatum 3.3 was used to convert data from NAD83 (2011) elevations to Mean Lower Low Water (MLLW), which made use of GEOID12A. Uncertainties associated with both the source data and each transformation used during the conversion within VDatum is computed. The Cumulative uncertainty was calculated to be 10.24 centimeters with each associated individual uncertainty component illustrated in Table 6.

Flight Line	Magnitude	Dz
1	0.0788	0.068
2	0.053	0.012
3	0.0706	0.051
4	0.0544	0.002
5	0.0782	0.060
6	0.0542	-0.026
7	0.0514	-0.005
8	0.0512	-0.004
9	0.0498	-0.020
10	0.0509	0.022
11	0.0427	0.003
12	0.0378	0.006
13	0.0291	-0.013
14	0.0369	0.011
15	0.0426	-0.024
16	0.0417	-0.011
17	0.0442	-0.005
18	0.0371	-0.004
19	0.0352	-0.029
20	0.0254	-0.013
21	0.022	0.000
22	0.0258	0.004
23	0.0616	0.048
24	0.0277	-0.012
25	0.038	0.034
26	0.0253	-0.013
27	0.0322	0.027
28	0.0216	-0.001
29	0.0215	0.008
30	0.0175	-0.010
31	0.0218	0.011
32	0.0426	-0.040

Table 4. Magnitude and Delta Z (meters) calculated from overlapping sidelap of adjacent flight lines

Average Dz:	0.012
Average Magnitude:	0.028
Root Mean Square:	0.036
Standard Deviation:	0.036

Table 5. Statistics (cm) calculated from ground control points

Transform	Std. Deviation (cm)	Std. Deviation ^ 2
NAD83 to NAVD88	5	25.00
NAVD88 to LMSL	5.9	34.81
LMSL to MLLW	3.1	9.61
Transform Error:		8.332
Source	Std. Deviation (cm)	Std. Deviation ^ 2
NAD83	2	4.00
NAVD88	5	25.00
LMSL	1.8	3.24
MLLW	1.8	3.24
Source Error:		5.957
Cumulative VDatum Uncertainty:		10.242

Table 6. VDatum Uncertainty Components

2.8 Delivery and Formats

Since OCS/HSD currently experiences issues with loading several LAS classes into CARIS, all relative LAS classes, such as bathymetric data and any other notable features identified within and above the water column, horizontally seaward of the MHW line are combined into class 26 (bathymetric point) and provided as a deliverable.

- **Lidar:** LAS 1.2 (all relative classes merged to class 26)

- **Ortho Imagery Mosaics:** *.tiff format

APPENDIX I

TIDES AND WATER LEVELS

No tide information submitted for W00287

APPENDIX II

SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

No supplemental survey records or correspondence sumbitted for W00287.

APPROVAL PAGE

W00287

Data meet or exceed current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in the common area.

The following products will be sent to NGDC for archive

- W00287_DR.pdf
- Collection of depth varied resolution BAGS
- Processed survey data and records
- W00287_GeoImage.pdf

The survey evaluation and verification has been conducted according current OCS Specifications, and the survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Approved:____

Lieutenant Commander Matthew Jaskoski, NOAA
Chief, Atlantic Hydrographic Branch