

# Horizontal and Vertical Control Report

## Project Metadata

<b>Project Name</b>	Cold Bay, AK
<b>Project Number</b>	OPR-P377-RA-17
<b>General Locality</b>	Cold Bay, AK
<b>State or Territory</b>	Alaska
<b>Field Unit</b>	NOAA Ship <i>Rainier</i>
<b>Chief of Party</b>	Benjamin K. Evans, CDR/NOAA
<b>Project Start Date</b>	2017-07-12
<b>Project End Date</b>	2017-08-30
<b>Field Year</b>	2017
<b>DAPR Version</b>	2017 RA-DAPR Final

**Horizontal and Vertical Control Report**

**NOAA Ship *Rainier* (S221)**

OPR-P377-RA-17

Survey of Cold Bay, AK

H13024, H13027, H13031

Hydrographic Letter Instructions dated 06/07/2017

Chief of Party: Commander Benjamin K. Evans, NOAA

**A. VERTICAL CONTROL**

**I. Project**

The tidal datum for this project was Mean Lower Low Water (MLLW). The operating National Water Level Observation Network (NWLON) station at **King Cove, AK (945-9881)** served as datum control for the survey area and provided preliminary water level reducers during data acquisition. Project Instructions required no subordinate tide stations to be installed for project OPR-P377-RA-17.

**II. Tidal Zoning Application**

A preliminary Tidal Constituent and Residual Interpolation (TCARI) grid based on **King Cove, AK (945-9881)** was provided by CO-OPS in file P377RA2017.tc. On the following dates, CO-OPS provided Final Tide Note accepting the preliminary TCARI grid as the final grid for registry numbers in project OPR-P377-RA-17:

Registry Number	Date Final Tide Note Received
H13024	15 Sept 2017
H13027	18 Oct 2017
H13031	15 Sept 2017

**III. Ellipsoid Referenced Zoned Tides**

OPR-P377-RA-17 Project Instructions required acquiring survey data vertically-referenced to the ellipsoid. This was accomplished through the creation of Ellipsoid Referenced Zoned Tides (ERZT) models. A 1000m resolution separation model was generated for each survey sheet using Smoothed Best Estimate of Trajectory (SBET) data combined with final approved TCARI grid P377RA2017.tc. For further details and results of ERZT for each sheet, see individual Descriptive Reports and for details about the process, see the DAPR submitted for this project.

**B. HORIZONTAL CONTROL**

**I. Horizontal Positioning Control**

For project OPR-P377-RA-17, horizontal control was managed by a combination of

- 1) Applanix SmartBase processing/virtual base station network
- 2) Applanix SingleBase processing using an installed GNSS base station (Trimble NetR9 Receiver).

Site ID	Base Station ID
AB06	FALSEPASS_AK2005
AB07	SANDPOINT_AK2004
AB13	CHIGNIKLGNAK2006
AC10	CPSARICHEFAK2008
AC25	King_Cove_AK2005
AC42	SANAKISLNDNAK2007
AV40	BrownPeak_AK2008
CDB8	COLD BAY WAAS 8
9715	Foxy

Table 1. CORS/UNAVCO and Base Stations used for this project.

## II. Soundings and Detached Positions

Applanix POSPac SingleBase Processing and SmartBase Processing were the methods used for horizontal positioning and kinematic correction on all hydrographic survey data acquired during OPR-P377-RA-17. SingleBase processing was the preferred method and SmartBase processing was used as a secondary method when SingleBase data were missing, incomplete, or causing spurious results. SingleBase solution processing utilizes an installed GNSS base station “Foxy” (Figure 1) to calculate corrections in the form of a Smoothed Best Estimate of Trajectory (SBET) for a roving receiver (e.g. ship and survey launches). The data were processed through the GNSS-Inertial Processor in the Forwards, Backwards and Combine mode with the Roll, Pitch and Heading Initialization set to initialize from the real time solution and the Lever Arm Standard Deviation ideally known to three centimeters or better.

In accordance with the 2017 HSSD Section 3.5 “Ellipsoid Referenced Survey Control”, a hybrid GPS-GLONASS (e.g. GNSS) solution was utilized to improve positional accuracy of SBET solutions. SBET positional dilution of precision (PDOP) values for this survey project were generally less than 2.0 which was well within desired specifications and was a marked improvement over earlier 2017 survey projects in which a GPS only solution was obtained.

All data were then processed using Applanix POSPac MMS 7.1.5. Post-processed position correctors were not applied to any detached positions acquired in this project.

*Rainier’s* POS MV systems are configured to use WAAS and GLONASS for improving GPS accuracy. DGPS was not available in the assigned project area. Local WAAS Reference Station (WRS) data was acquired by the Cold Bay Airport (PACD) receive site which was approximately 16 nautical miles North-North West of the survey area. WAAS satellite reception was enabled on all ship and survey launch POS MV units during survey acquisition.

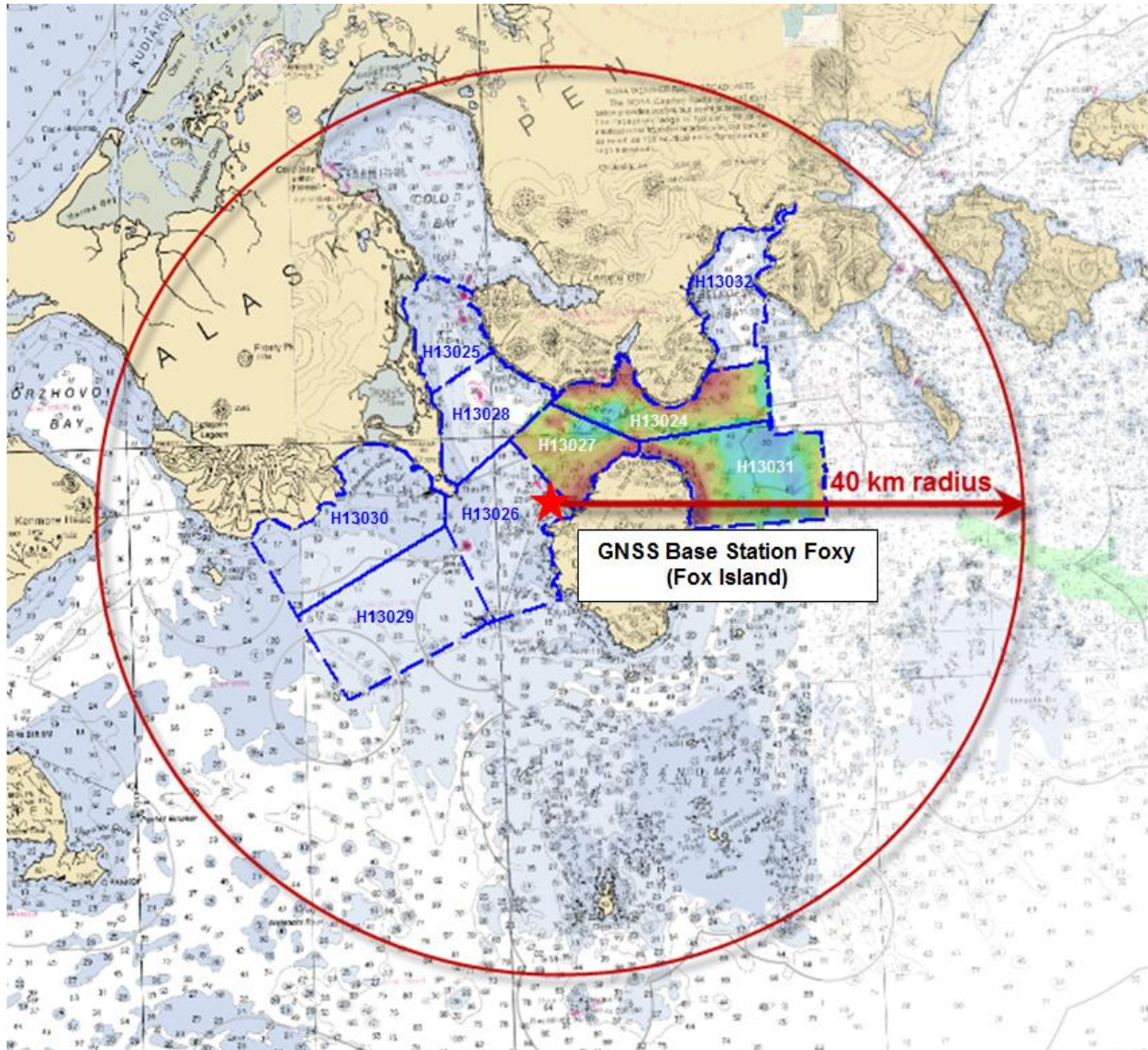


Figure 1. Location of installed GNSS base station with 40 km radius.

### III. Quality Control

All data were processed using Applanix POSPac MMS version 7.1.5. To ensure compliance with the positional accuracy requirements of Sections 3.1 and 3.2 of the *NOS Hydrographic Surveys Specifications and Deliverables Manual* (HSSD, April 2017) the following checks were conducted:

- North, east and down position error Root Mean Square (RMS) time series plots of the vessel data were reviewed, and the max values were recorded. A majority of the data acquired by the survey launches and ship were found to have a max RMS value of less than 0.07m. Values of higher than 0.07m were specifically logged.
- The vessel altitude time series plot was reviewed for anomalous jumps. If a spike or anomaly was found in the altitude or accelerometer bias time series, they were compared against one another and noted in the log. For additional details see corresponding Descriptive Reports.
- Calibrated installation parameters (i.e. the lever arm from the IMU to the primary GPS antenna) were checked for consistency. These offsets were evaluated on a daily basis and compared to all other data sets acquired by a given vessel for a given survey sheet.
- The processed Positional Dilution of Precision (PDOP) for each vessel file was nominally less than 3. For the most part, each vessel had a maximum daily PDOP of 1.75 to 2.40 with some larger spikes momentarily during drops in GPS satellite reception. The minimum number of satellites and maximum PDOP were recorded for each vessel day. Instances in which the PDOP values exceeded 3 or the number of satellites was less than 5 were noted in the QC logs.
- Sounding data positioned with files that had issues noted above were reviewed following application to verify they did not introduce any artifacts.

### IV. Aids to Navigation

While no fixed aids to navigation were assigned within the limits of the survey, the following lights were observed, and appear to be in their charted position and serving their intended function.

Light Name	Number
Stag Point Light	27180
South King Cove Harbor Light 1	27181
King Cove Deep Water Docks Lights (2)	27182
King Cove Harbor Entrance Light 1	27185
King Cove Harbor Entrance Light 2	27190
Morgan Point Light	27195
Fox Island Light	27230

**Table 2. Charted lights adjacent to the project area.**

## V. Horizontal Control Activities

A GNSS base station was installed by Rainier personnel at a central location within the project area to ensure sufficient coverage. The base station (Foxy, Table 2) was installed on Fox Island, located just northwest of Deer Island in Deer Passage, AK. Base station installation was completed on day number (DN) 193 with two external 12V batteries and six solar panels in parallel providing power. The extensive CORS and UNAVCO base station network permitted Smart-Base solutions with near equivalent quality solutions, compared to Single Base solutions, and short baselines. The base station remained set on Fox Island after the completion of the Cold Bay survey project due to inclement weather preventing retrieval prior to departure. The NOAA Ship Fairweather recovered base station Foxy on day number (DN) 249. The data acquisition rate was set to one sample every second.

<i>Foxy</i> , Fox Island		Serial Number
Receiver	Trimble Net R9	5034K69715
Antenna	Trimble Zephyr GNSS	1441031030

**Table 3: Equipment installed at Fox Island**

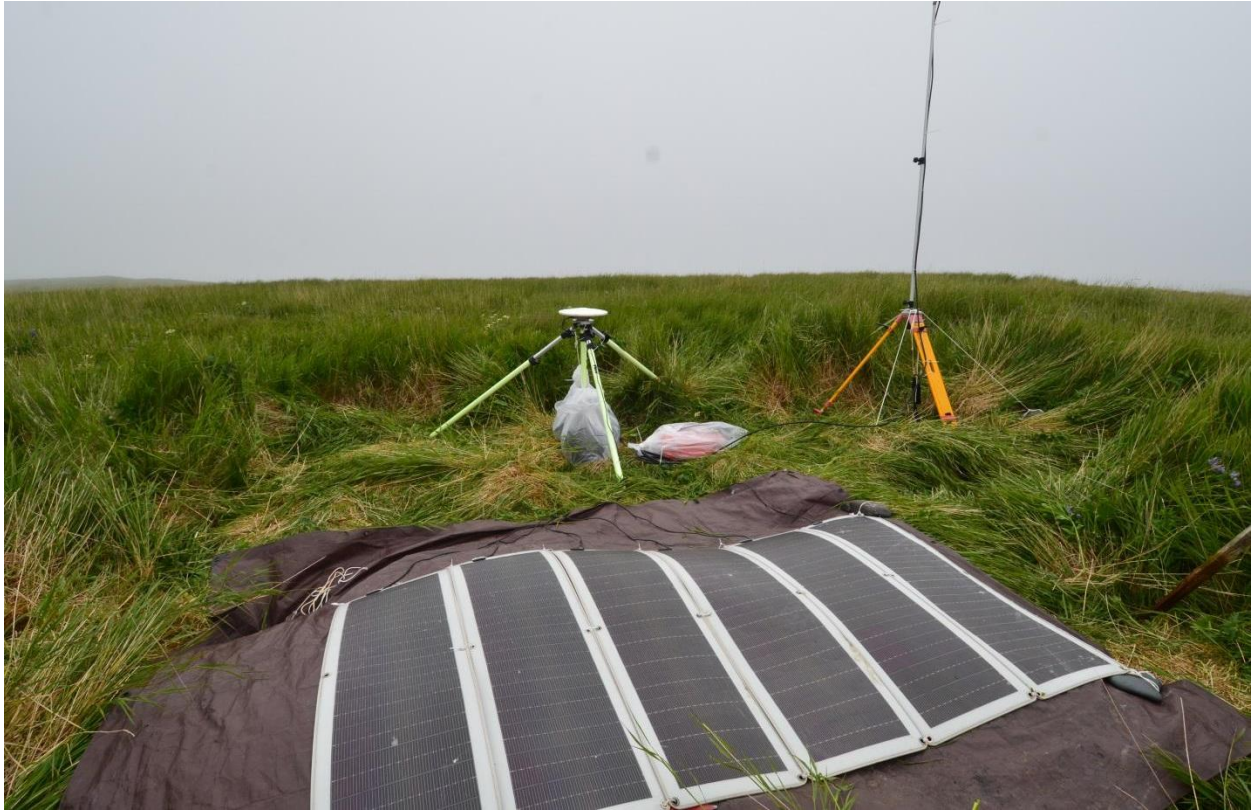
Table 3 shows the latitude, longitude, and ellipsoid height of each base station established for this project in IGS08 coordinates. The coordinates were obtained using NGS OPUS processing performed on a 24-hour observation file.

Station Name	N. Latitude (Err (m))	W. Longitude (Err (m))	Ellipsoidal Height (Err (m))
<i>Foxy</i>	54° 56' 51.24188 " " (0.024)	162° 25' 26.62363 " " (0.004)	82.319 (0.010)

**Table 4: Base Station coordinates at Fox Island**

## VI. Site Descriptions

*Foxy* horizontal control station was established at the high point on Fox Island. The site was selected as it provided a safe location well out of the tidal range, acceptable access by small boat, clear views of the sky in all directions, and at a location central to anchorage and survey operations which allowed near daily Freewave Data Modem (UHF) download of Trimble .T02 files (Figures 2-6). Established NGS bench mark "FOX 2" (PID: UW0320) was located and recovered for use at the base of the GNSS antennae with the height between the bench mark and the antennae center fixed at 1.5 meters.



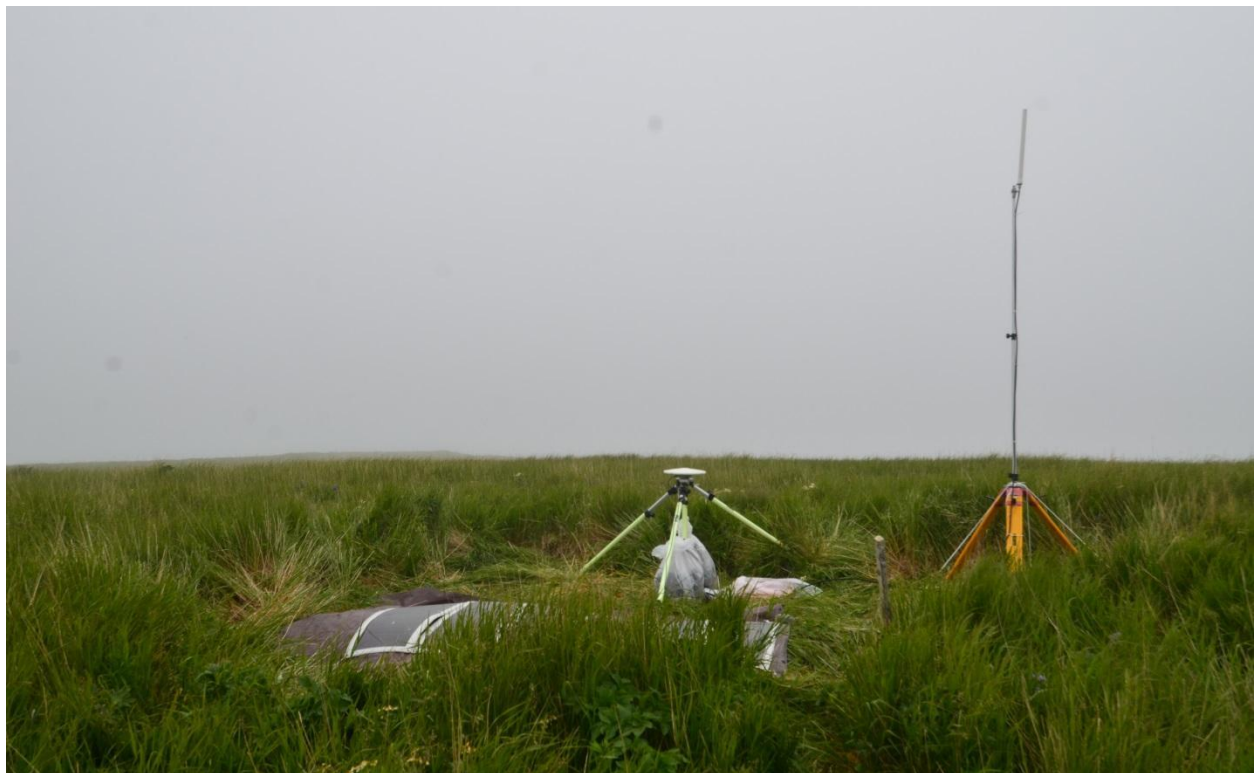
**Figure 2.** Foxy GNSS Antenna and solar panel array.



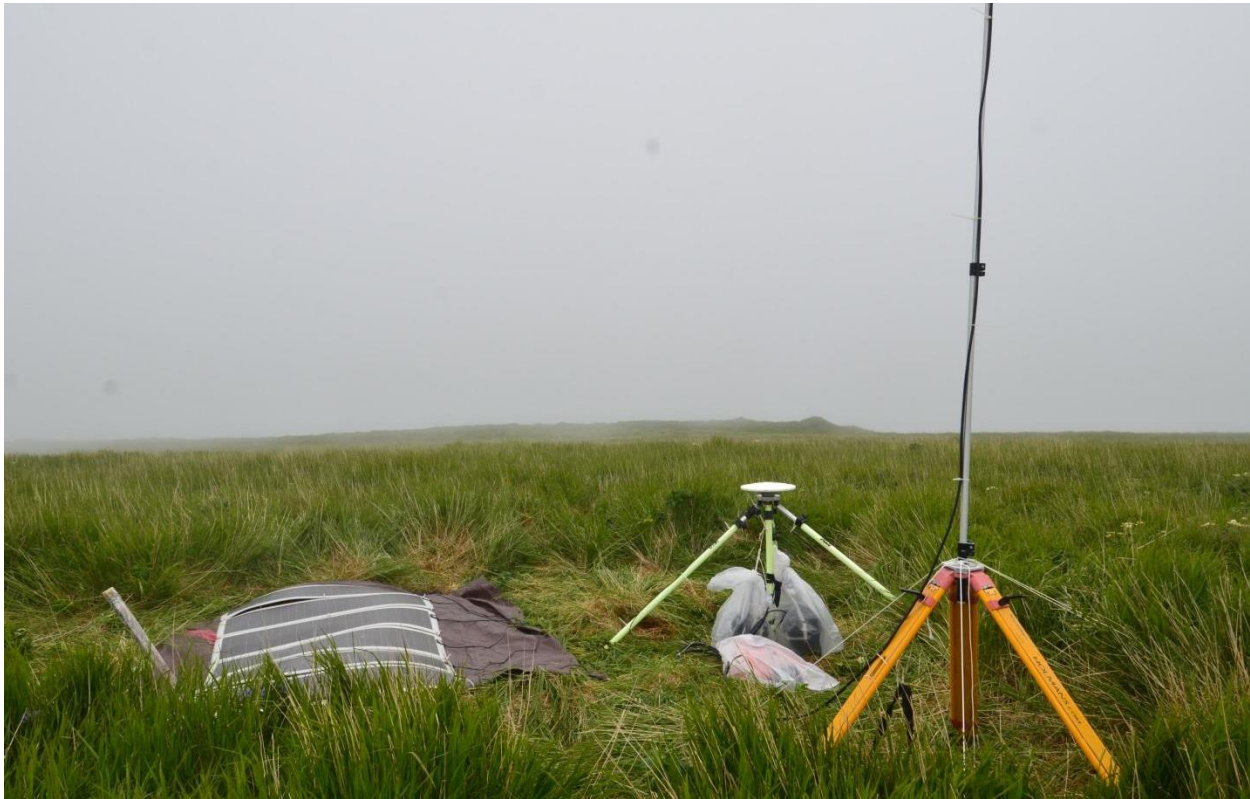
**Figure 3.** Foxy antenna looking south.



**Figure 4.** *Foxy antenna looking east.*



**Figure 5.** *Foxy antenna looking north.*



**Figure 6.** *Foxy antenna looking west.*

### C. APPROVAL

As Chief of Party, I have ensured that the field surveying and processing procedures used during this project meet the requirements of the National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (HSSD), dated April 2017, and Office of Coast Survey (OCS) Field Procedures Manual (FPM), dated April 2014.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Approved and Forwarded: \_\_\_\_\_  
Benjamin K. Evans  
Commander, NOAA  
Commanding Officer, NOAA Ship *Rainier*

In addition, the following individuals were also responsible for overseeing horizontal and vertical control operations for this project:

Control Officer:

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Collin Walker  
Ensign, NOAA

Control Officer:

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Gregory Gahlinger  
Hydrographic Senior Survey Technician, NOAA Ship *Rainier*

Chief Survey Technician:

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James B. Jacobson  
Chief Survey Technician, NOAA Ship *Rainier*

Field Operations Officer:

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Scott Broo  
Lieutenant, NOAA