

APPENDIX F

Canaveral Harbor, FL— Establishing a PPCP and Tidal Datum Reference when Adequate NOAA Gage Data Exists (Jacksonville District)

F-1. Purpose and Background. This appendix illustrates the establishment of references to the NSRS and the NWLON for a typical navigation project. Figure F-1 depicts a Jacksonville District deep draft project that has been adequately referenced to a NOAA tidal datum and the NSRS. This project supports US Navy, commercial, and cruise ship interests. Underkeel clearances on the US Navy Trident portion of this project are considered critical. A shallow-draft barge canal exists west of the lock at the end of the deep-draft project. That portion of the project illustrates an application where the tidal range is small to negligible and a MSL reference datum is used.

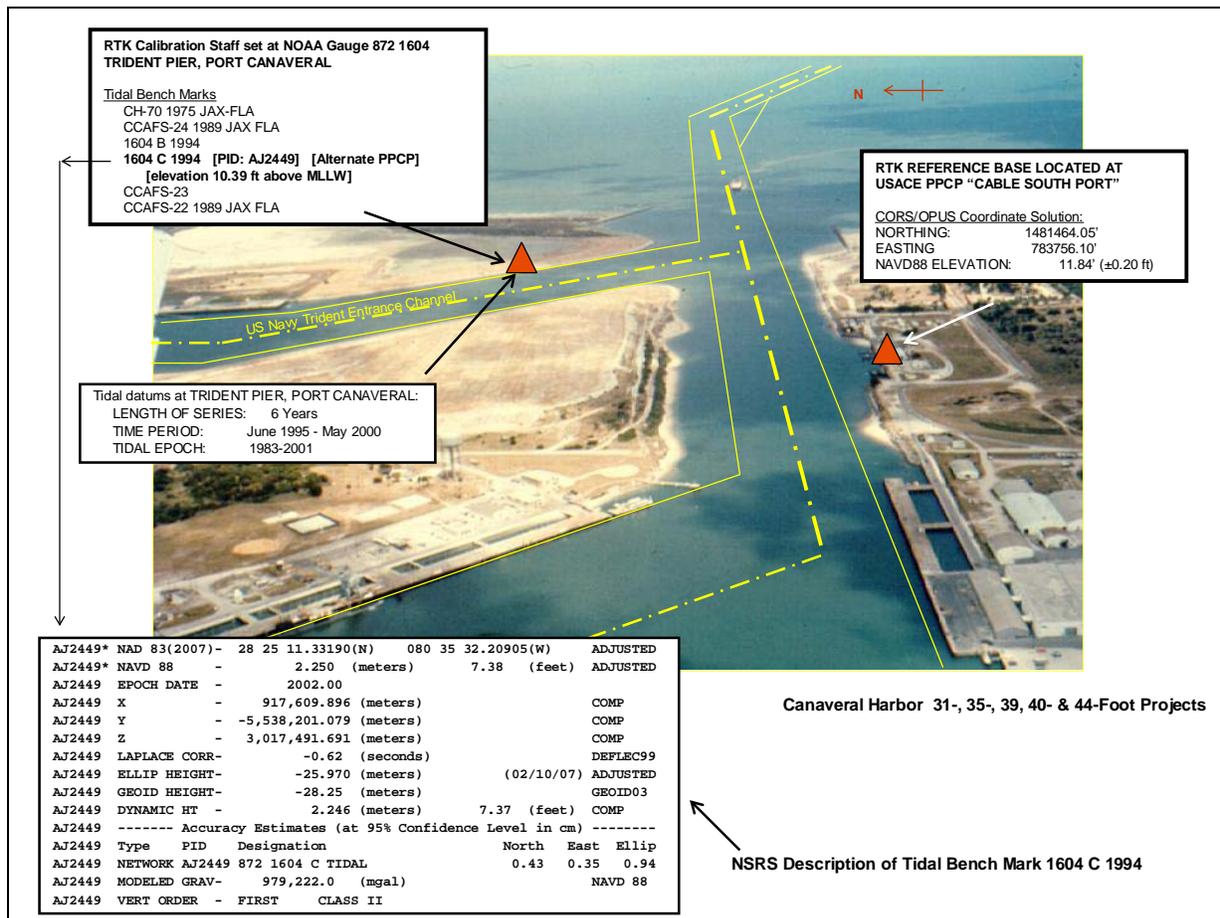


Figure F-1. Tidal PBM and RTK PPCPs established at Canaveral Harbor, FL. (Jacksonville District)

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This site contains an active NOAA gage (TRIDENT PIER, PORT CANAVERAL) on the north side of the entrance at the Trident Entrance Channel. This gage has six reference PBMs, one of which (1604 C 1994) is listed in the NSRS with adjusted First-Order NAVD88 vertical control. An existing USACE bench mark (CABLE SOUTH PORT) is located on the south side of the entrance channel. This bench mark had a NGVD29 elevation of uncertain origin and was previously used for tidal corrections at the project. A RTK base station situated on either side of the entrance will provide survey and dredge position coverage to the outer end of the project in the ocean.

F-2. Canaveral Harbor: Deep-Draft Tidal Project.

a. Project description. (See Figures F-2 and F-3). Maintenance of an entrance channel 41 feet deep and 400 feet wide; an inner channel 40 feet and 400 feet wide; a 1200 foot diameter turning basin 39 feet deep; a channel 39 feet deep and 400 feet wide for an 1800 foot length; enlargement of barge channel to 12 feet deep and 125 feet wide to the Intracoastal Waterway; a channel extension 31 feet by 300 feet by 1,500 feet dredged west of turning basin; and a barge lock 90 feet wide and 600 feet long west of the harbor dike; and two entrance jetties to the 12-foot contour. Length of project is about 11.5 miles. The entrance channel and part of the inner channel have been deepened to 44 feet for the Navy's TRIDENT Project.



Figure F-2. Canaveral Harbor project: Trident basin, cruise ship basin, and barge canal lock.

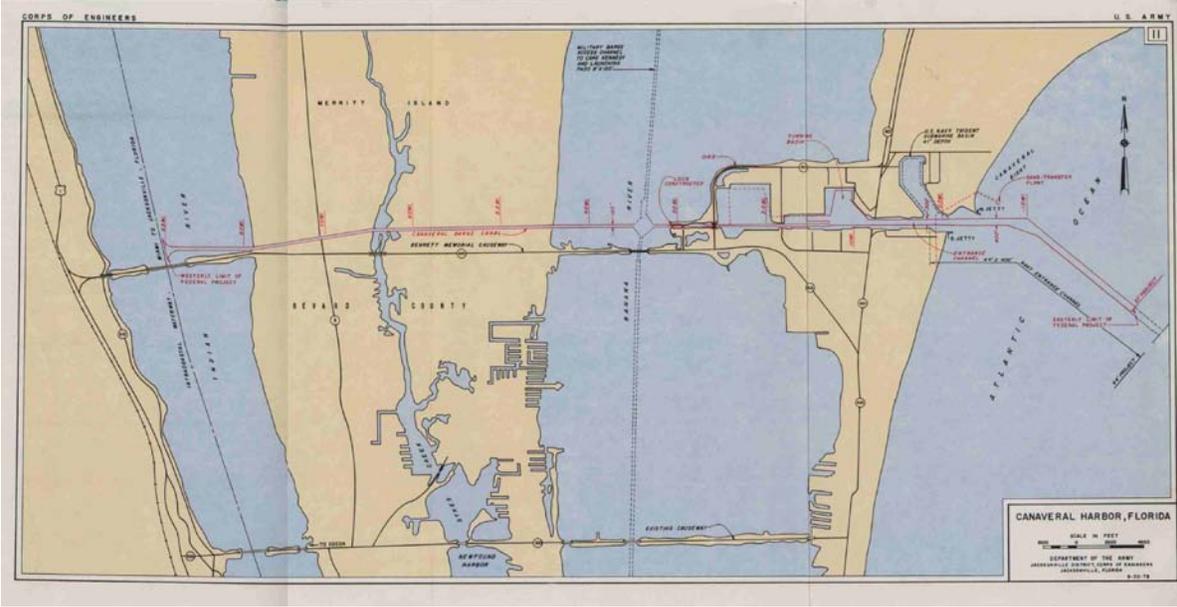


Figure F-3. Canaveral Harbor project map.

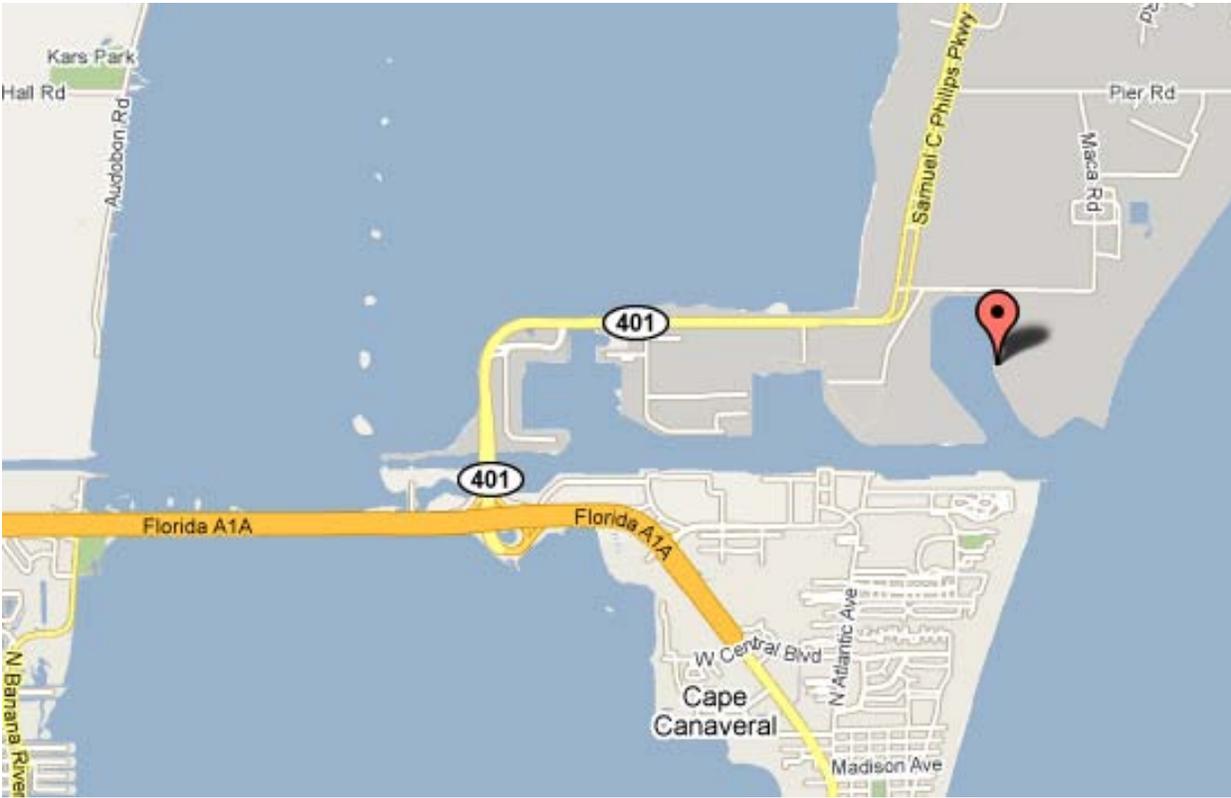


Figure F-4. NOAA gage "TRIDENT PIER" in Trident Basin.

b. Tidal datum reference. NOAA CO-OPS data for TRIDENT PIER gage (Figure F-4) indicates it is relatively current with a 6-year recording series from 1995 to 2000. No significant

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deepening or entrance modifications have been made since that period. Thus this NOAA gage was deemed as acceptable for the primary datum reference on this project. (Had an existing, or unsuitable, tide station not been located at this project site, then a short-term gage would have had to be installed to determine a reference datum following NOAA CO-OPS standards in "Computational Techniques for Tidal Datums Handbook" (NOAA 2003).

(1) Tidal reference bench marks. Three of the published tidal bench marks at the TRIDENT PIER gage were recovered and Third-Order level runs between these marks indicated they were stable internally to within 0.02 ft. Recovery notes on these tidal bench marks were transmitted to NOAA CO-OPS. (As above, had no reference tidal bench marks been recovered, then for all practical purposes, the gage is lost and new tidal observations would be required).

(2) Calibration tide staff. A tide staff was set at the TRIDENT PIER site relative to published MLLW datum on the tidal PBM. The staff zero was set at MLLW so visual readings were direct elevations of the water surface above MLLW.

c. Primary "PPCP" tidal reference mark. Tidal bench mark "1604 C 1994" at the TRIDENT PIER gage site has a solid First-Order (II) orthometric elevation and observed ellipsoid height observations—see the NSRS extract in Figure F-1. The estimated 95% confidence in the observed ellipsoid height is less than 1 cm. This tidal PBM, with published geodetic, ellipsoidal, and tidal reference elevations, is the obvious choice as the designated PPCP for this project. No additional field survey observations would be needed at this project if this point were used as an RTK base station. Since GPS observations were once made at this mark (per NSRS description), its use as an RTK base is presumed adequate. However, due to site access restrictions at this military site, an alternate RTK base station PBM was established on the south side of the channel at USACE PBM "CABLE SOUTH PORT."

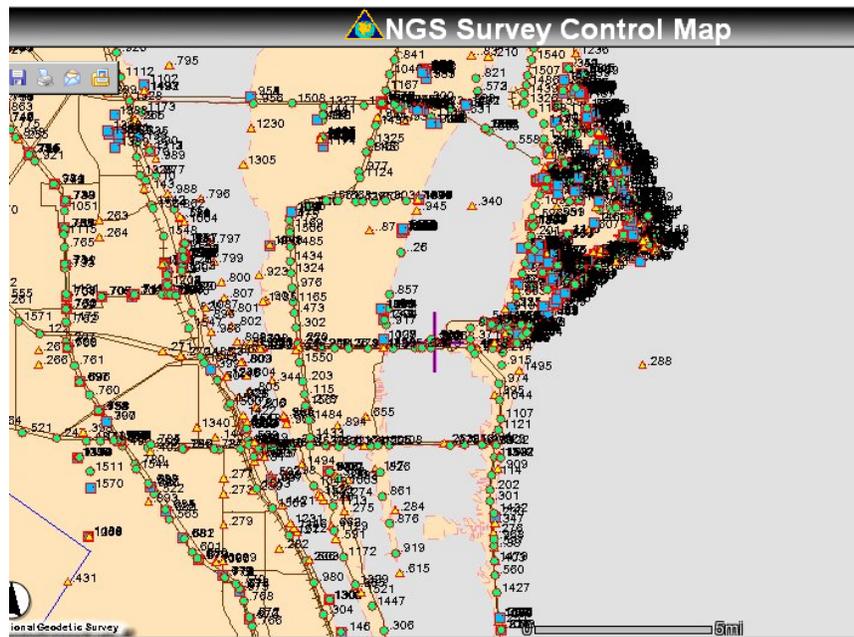


Figure F-5. NGS control network in Cape Canaveral area.

d. GPS surveys to position a primary RTK base station. Obtaining a PPCP for this project was not an issue at this site, given the dense NSRS network in the region—see Figure F-5. USACE PBM "CABLE SOUTH PORT" on the south side of the channel was positioned using CORS/OPUS techniques. An 8-hour session of CORS observations were recorded and transmitted to OPUS for reduction. The results along with descriptive data were transmitted through OPUS-DB for published input to the NSRS. A static baseline was simultaneously observed from tidal PBM 1604 C 1994 as a check on the CORS/OPUS solution. These observations were performed concurrently with hydrographic survey observations so no additional field effort was required to perform these control surveys. PBM "CABLE SOUTH PORT" is thus the designated PPCP for this project.

e. MLLW tidal model. Since VDatum coverage did not exist at this project site in 2009, an estimated tidal model was required. Based on comparisons in diurnal tide ranges between TRIDENT PIER and other NOAA gages in the surrounding offshore region (i.e., ocean pier gages north and south of Canaveral—see Figure F-6), there did not appear to be any significant tidal MLLW datum gradient between the ocean and the interior channels up to the Trident Basin. This may be due to the relatively wide entrance. A constant NAVD88-MLLW difference of 3.01 ft was therefore assumed constant throughout the project. This difference was computed using data at Tidal bench mark "1604 C 1994"—i.e., 10.30 ft NAVD88 - 7.38 ft MLLW. Future VDatum coverage is not expected to significantly modify this constant model since these NOAA gages would likely be used to develop the VDatum model.

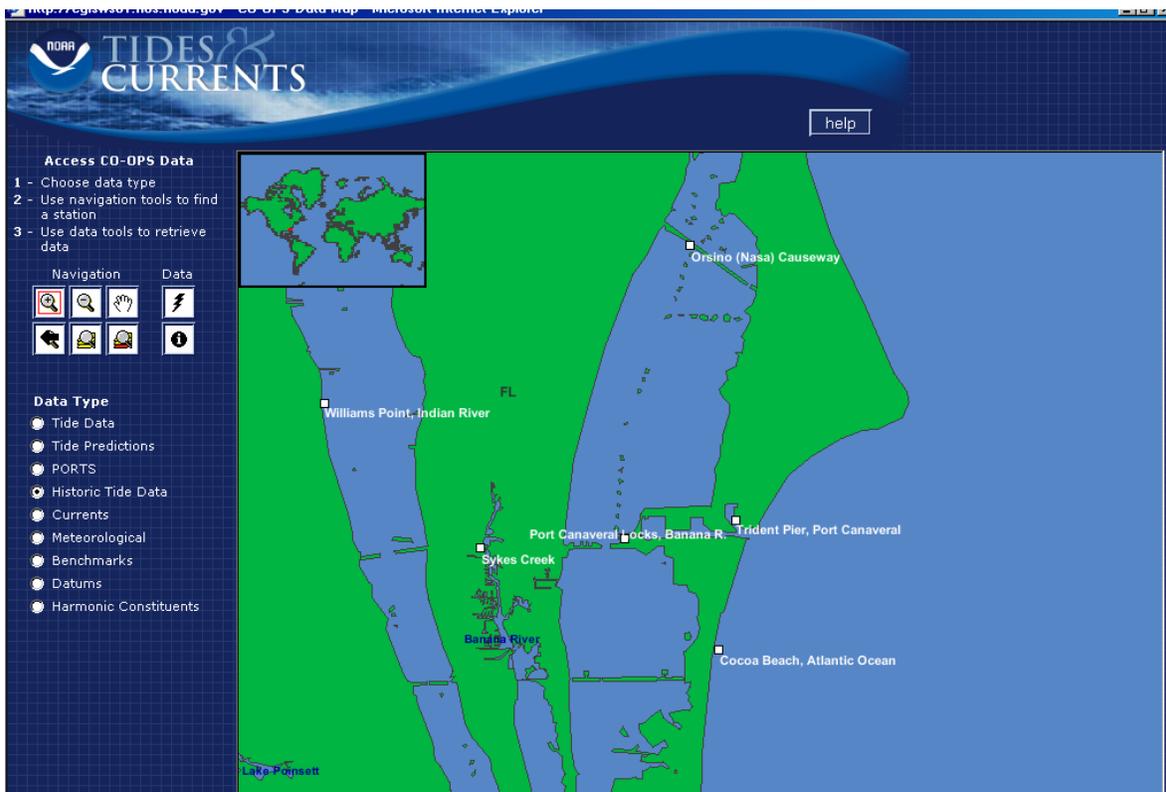


Figure F-6. NOAA tide gage data vicinity of Cape Canaveral.

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f. Measurement & payment survey procedures. The RTK base station is initialized at PBM "CABLE SOUTH PORT" using the newly NSRS published coordinates based on CORS/OPUS solutions. RTK observations are adjusted in the vessel positioning software to correct for the NAVD88-MLLW datum difference—i.e., the "K" term referenced Chapter 4. Likewise geoid height variations ("N") over the project are automatically adjusted in the GPS acquisition or processing software.

F-3. Canaveral Lock and Barge Canal to Banana River and Indian River: Non-Tidal. This section illustrates procedures for referencing construction datums in areas with little or imperceptible tide ranges. Tidal influences are small in the areas (Banana River and Indian River) west of the Canaveral Lock, given the nearest inlets north and south are over 20 miles distant. Figure F-7 depicts available tidal information from the Florida Department of Environmental Protection, Land Boundary Information System (LABINS). Survey reaches outside (west of) the Canaveral Lock are depicted as non-tidal, based on LABINS and NOAA gage data. It was decided that dredging elevations within these reaches shall be referred to Mean Sea Level (MSL) as the reference construction datum. Previously, dredging datums in this area were related to MLLW relative to NGVD29, as outlined in the 31 August 2007 CEPD Report for this project:

"Water surface elevation measurement tidal and geoid undulation corrections have not been hydrodynamically modeled or calibrated throughout the [Canaveral] project area. Portions of the project area may have not been converted from MLW to MLLW datum. Portions are still on NAD27 horizontal datum—Barge Canal. Currently, water surface elevation corrections for dredging measurement & payment are based on extrapolated staff gage readings set from unmodeled benchmarks that are set from benchmarks of uncertain origin, are not referenced to the NSRS, and are referenced to the superseded NGVD29 datum. Project framework and control documents do not define references or relationships between these benchmarks and NOAA tidal gages or tidal benchmarks."

"NOAA tidal PBM G 215 is used for extrapolating water surfaces in the Barge Canal, however the USACE 8.42 ft elevation differs from NGS published 9.92 ft (NGVD29). An unmodeled constant MLLW datum surface (0.5 ft below NGVD29) is assumed throughout the Barge Canal project area. The source of this corrector is uncertain. The tidal range in this project is small—a constant difference may prove to be valid once a model is developed."

a. The 2007 CEPD report made the following recommendation regarding the Canaveral Barge Canal:

"Tidal range gradients west of the Canaveral Lock should also be assessed and developed if significant, per [HQUSACE] guidance. NOAA gage data needs to be obtained up to the IWW (J—M) to determine the low water datum and whether any significant tidal gradient exists."

b. This section illustrates corrective actions taken based on the 2007 CEPD recommendation.

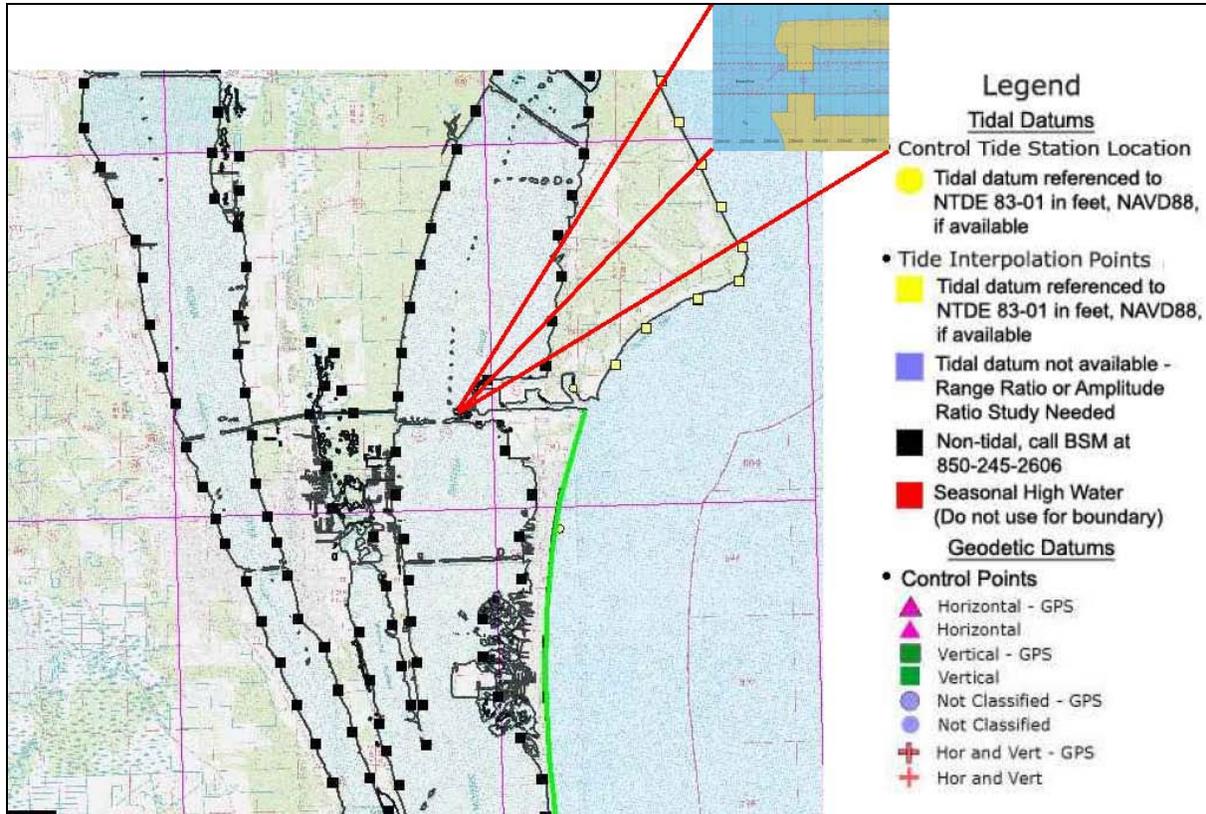


Figure F-7. Canaveral Barge Canal Datum Determination: Non-Tidal gages in Banana River and Indian River Region (Florida Department of Environmental Protection, Land Boundary Information System (LABINS)).

c. The NAVD88-MSL relationship was determined to be 0.70 ft within survey reaches west of the Canaveral Lock chamber (Station 235+00 of the Canaveral Barge Canal). This relationship was determined by performing a distance weighted interpolation from NOAA gages 872-1533 (Orsino Causeway), 872-1456 (Titusville, Indian River), and 872-1456 (Pineda, Indian River)—see Figures F-8 and F-9. Published NOAA gage information at these locations depicts the NAVD88 to MSL relationship—see NOAA datasheets in Figures F-10 and F-11 at the end of this section.

CANAVERAL BARGE CANAL DATUM							
NOAA GAGE	NAVD88-MSL ft (x)	DISTANCE MILES (d)	WEIGHT (1/d)	(x) * (1/d)	Weighted Variance	w * (x - x) ²	
8721533	0.690	7.414	0.093067	0.064216		0.000028	
8721749	0.730	13.717	0.053219	0.038850		0.000027	
8721456	0.702	17.41	0.040322	0.028306		0.000001	
MEAN (x)	0.707	SUM	0.186607	SUM	0.131372	SUM	0.000056
		weighted mean	0.704		weighted std dev	0.017	

Figure F-8. Computation of NAVD88-MSL difference west of Canaveral Lock.

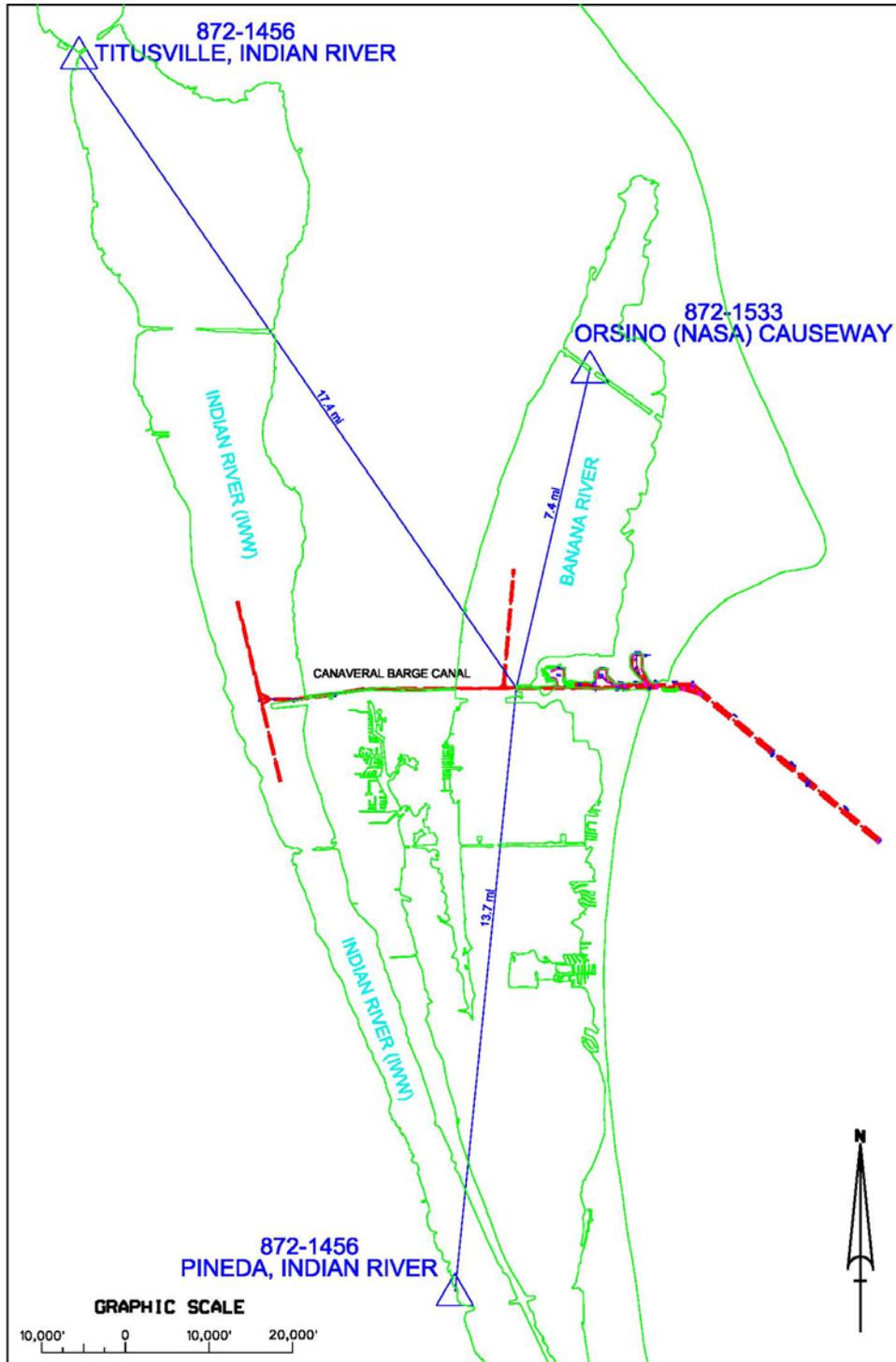


Figure F-9. Spatial interpolation of NAVD88-MSL relationship west of Canaveral Lock.

Mar 25 2010 13:17		ELEVATIONS ON STATION DATUM National Ocean Service (NOAA)		T.M.:	75 W
Station:	8721456			Units:	Feet
Name:	TITUSVILLE, INDIAN RIVER, FL			Epoch:	1983-2001
Status:	Accepted				
Datum	Value	Description			
MHHW		Mean Higher-High Water			
MHW		Mean High Water			
DTL		Mean Diurnal Tide Level			
MTL		Mean Tide Level			
MSL	4.01	Mean Sea Level			
MLW		Mean Low Water			
MLLW		Mean Lower-Low Water			
GT		Great Diurnal Range			
MN		Mean Range of Tide			
DHQ		Mean Diurnal High Water Inequality			
DLQ		Mean Diurnal Low Water Inequality			
HWI		Greenwich High Water Interval (in Hours)			
LWI		Greenwich Low Water Interval (in Hours)			
NAVD	4.71	North American Vertical Datum			
Maximum	5.08	Highest Water Level on Station Datum			
Max Date	19701020	Date Of Highest Water Level			
Max Time	00:00	Time Of Highest Water Level			
Minimum	2.41	Lowest Water Level on Station Datum			
Min Date	19780204	Date Of Lowest Water Level			
Min Time	00:00	Time Of Lowest Water Level			

Mar 25 2010 13:17		ELEVATIONS ON STATION DATUM National Ocean Service (NOAA)		T.M.:	75 W
Station:	8721533			Units:	Feet
Name:	ORSINO (NASA) CAUSEWAY, FL			Epoch:	1983-2001
Status:	Accepted				
Datum	Value	Description			
MHHW		Mean Higher-High Water			
MHW		Mean High Water			
DTL		Mean Diurnal Tide Level			
MTL		Mean Tide Level			
MSL	3.20	Mean Sea Level			
MLW		Mean Low Water			
MLLW		Mean Lower-Low Water			
GT		Great Diurnal Range			
MN		Mean Range of Tide			
DHQ		Mean Diurnal High Water Inequality			
DLQ		Mean Diurnal Low Water Inequality			
HWI		Greenwich High Water Interval (in Hours)			
LWI		Greenwich Low Water Interval (in Hours)			
NAVD	3.88	North American Vertical Datum			
Maximum		Highest Water Level on Station Datum			
Max Date		Date Of Highest Water Level			
Max Time		Time Of Highest Water Level			
Minimum		Lowest Water Level on Station Datum			
Min Date		Date Of Lowest Water Level			
Min Time		Time Of Lowest Water Level			

Figure F-10. NOAA datasheets for tide gages 872 1456 and 872 1533.

F-4. RTK Coverage. Figure F-12 depicts proposed RTK coverage for this projects. Base stations would be located at CABLE SOUTH PORT and CBC-101. The published NSRS datasheet for CABLE SOUTH PORT is shown on Figure F-13.

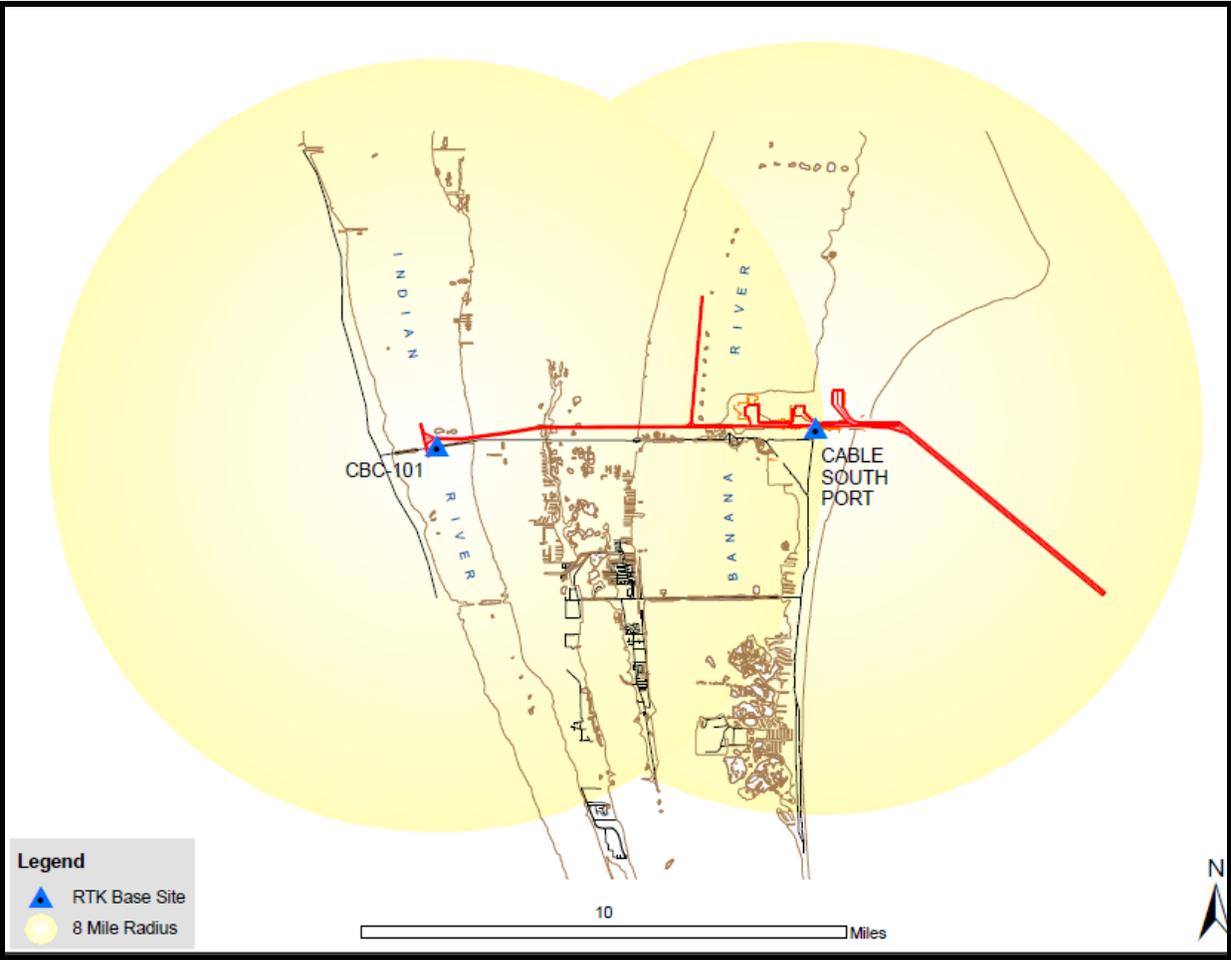


Figure F-12. RTK scheme for Canaveral Harbor.

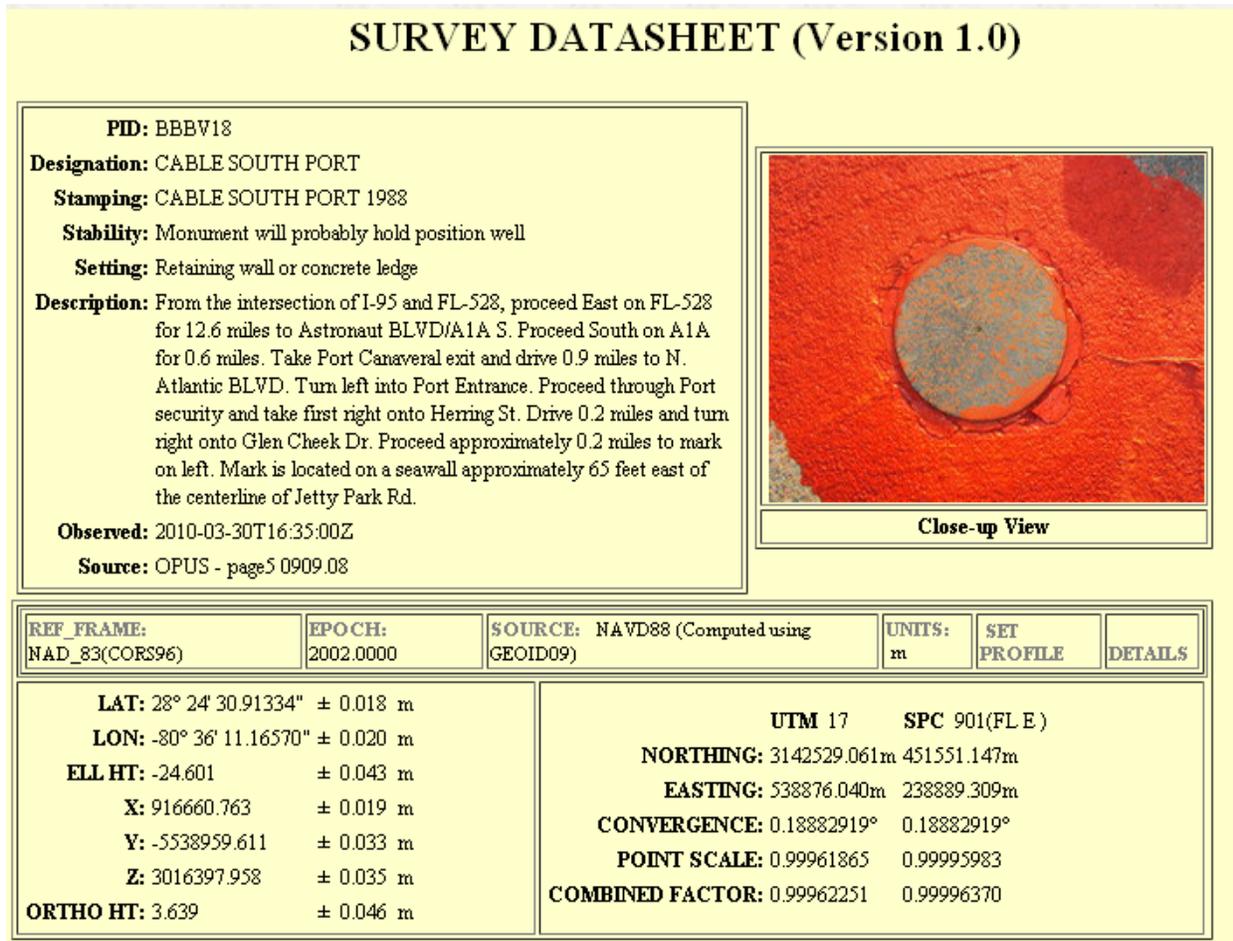


Figure F-13. Portion of NSRS Datasheet for USACE PPCP "CABLE SOUTH PORT."