

Post-processing of Survey Data

Tidal Datum Determination

The NOS control tide station chosen to compute NTDE equivalent tidal datums for the project area is located at Fort Myers (Station ID: 8725520) on the Caloosahatchee River, and is part of the National Water Level Observation Network (NWLON). The tidal datums computed for Fort Myers are for the 1960-1978 Tidal Epoch, and are based on a series length of 18 years (1966-1984). The primary control tide station that was used to compute the Fort Myers tidal datums is located at St. Petersburg (8726520). The Fort Myers station was selected as the control station because it better reflects the local tidal influences within the Caloosahatchee River than does the St. Petersburg gauge. The NOS accepted tidal datums (feet), referenced to station datum, for the Fort Myers gauge are as follows (http://co-ops.nos.noaa.gov/data_res.html):

Station	MHHW	MHW	DTL	MTL	MSL	MLW	MLLW	GT	MN	DHQ	DLQ
8725520	5.44	5.24	4.85	4.81	4.82	4.37	4.25	1.19	0.87	0.2	0.12

NTDE equivalent tidal datums within the project area were determined by reducing water level data obtained from numerous tertiary water level stations that were installed by FSG personnel (Figure 4). The FSG stations operated anywhere from 6 to 119 days, depending on the time required to complete soundings in the vicinity of the gauge(s). Equivalent tidal datums were determined through “mathematical simultaneous comparison” of station high and low water levels with those recorded at the control station (Fort Myers). The siting of FSG gauges was such to cover “significant changes in tidal characteristics such as: changes in tide type, changes in tide range, changes in time of tide, changes in daily mean seal level.”

Water level data for the NOS Fort Myers gauge was obtained from the website maintained by the Center for Operational Oceanographic Products and Services (http://co-ops.nos.noaa.gov/data_res.html). NOS implements standard operating procedures to verify the quality of water level data published at the website. Verified water level data for the Fort Myers gauge is found under the link titled “Verified/Historical Water Level Data for U.S. and Global Coastal Stations.” As a control, an FSG gauge was installed in the same basin as the NOS Fort Myers gauge.

The following steps were taken to determine the NTDE equivalent tidal datums for each FSG gauges installed within the study area. The computational procedures followed are those specified by the NOS (Center for Operational Oceanographic Products and Services 2000). Since water levels at FSG gauges were recorded for less than a year, and since tides are mixed in the area, a comparison of simultaneous high and low waters (Tide by Tide Analysis) was performed. The steps followed to perform the tide-by-tide analysis are as follows.

For each FSG station, a spreadsheet application worksheet was constructed using the following format:

FSG Gauge Date/Time	Gauge Drop (Inches)	Gauge NGVD29 (Feet)	Slope	FSG Tide	NOS Tide	NOS Gauge Date/Time	NOS MLLW (Feet)
7/13/01 13:24	-67.93	1.095			L	7/13/01 21:06	0.63
7/13/01 13:36	-68.01	1.088	-		H	7/14/01 2:24	1.12

The primary purpose of the worksheet was to determine when specific high and low tide levels occur at each FSG station. Tide levels are designated as HH (higher high water), H (lower high water), L

(higher low water), or LL (lower low water). Tide levels at FSG gauges were determined using the designated high and low waters at the NOS gauge as a guide.

The information contained in each spreadsheet column is as follows:

- Col. 1: Dates and time, at 6 minute intervals, when a water level was recorded at the FSG gauge.
- Col. 2: The drop, in inches, from the FSG gauge transducer to the water level surface (i.e. station datum).
- Col. 3: The FSG gauge water level adjusted to the NGVD29 vertical datum (feet).
- Col. 4: Using an MS Excel formula [IF((C2-C1)<0,"-","")] the direction of water level change was determined. This was used as a visual aid to locate high and low waters.
- Col. 5: A tide designator (HH, H, L, LL) is entered for each FSG gauge record that corresponds to a high or low water.
- Col. 6: The tide designator (HH, H, L, LL) as assigned by NOS CO-OPS personnel, and downloaded from the CO-OPS web site.
- Col. 7: The date and time that high and low waters were recorded at the NOS primary station (Fort Myers). This entry is downloaded from the CO-OPS web site.
- Col. 8: The high or low water level, in feet, recorded at the NOS primary station (MLLW). This entry is downloaded from the CO-OPS web site.

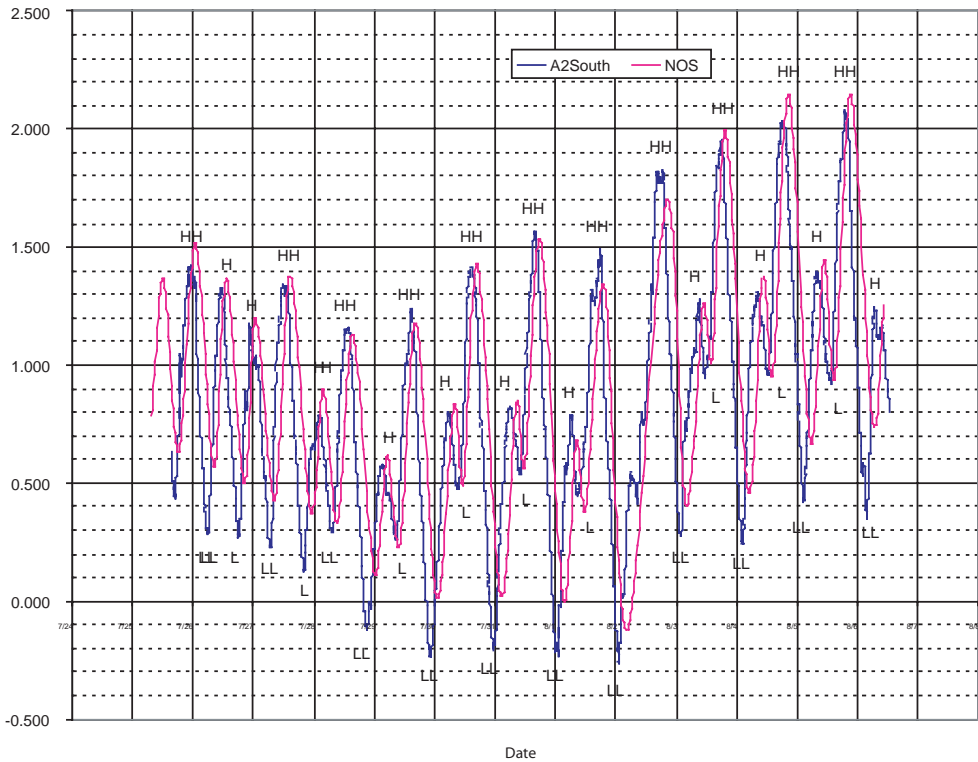
According to the published benchmark sheet for the Fort Myers station (<http://co-ops.nos.noaa.gov/bench.html>), the NGVD29 vertical datum and the MLLW tidal datum are at the same elevation. Therefore, recorded water levels at FSG gauges were adjusted to the NGVD29 geodetic datum prior to calculating tidal datums. High and low water levels referenced to the MLLW tidal datum were obtained for the Fort Myers gauge. This allowed for easy comparison of resulting tidal datums for the FSG gauges to the accepted tidal datums published for the Fort Myers station.

ELEVATIONS OF TIDAL DATUMS REFERRED TO MEAN LOWER LOW WATER (MLLW), IN FEET:	
HIGHEST OBSERVED WATER LEVEL (06/19/1972)	4.05
MEAN HIGHER HIGH WATER (MHHW)	1.19
MEAN HIGH WATER (MHW)	0.99
MEAN TIDE LEVEL (MTL)	0.56
MEAN LOW WATER (MLW)	0.12
NATIONAL GEODETIC VERTICAL DATUM-1929 (NGVD)	0
MEAN LOWER LOW WATER (MLLW)	0
LOWEST OBSERVED WATER LEVEL (01/16/1972)	-2.04

Once the spreadsheet worksheets were complete, corresponding time periods from the FSG gauge series and the Fort Myers gauge were plotted, as shown below. The plot was used to guide the determination of high and low waters at the FSG gauge, as outlined for column 5 above. The first step was to label the NOS tide curve with the high/low designators assigned by CO-OPS. Next, each high and low water for the FSG gauge was entered in column 5, using the same tide designator as the corresponding high or low water on the NOS tide curve.

Once high and low water designators were entered into column 5 for the FSG gauge, the results (columns 1 through 5) were pasted into database management software (MS Access) and that subset of FSG gauge records selected that consisted of high and low waters (HH, H, L, LL) that correspond to the NOS tide gauge. The subset was pasted into a second spreadsheet workbook with the following structure:

FSG GAUGE			NOS GAUGE			FSG Gauge minus NOS Gauge
Date/Time	NGVD29 (feet)			Date		NGVD - MLLW
7/13/01 17:54	0.39	L	L	7/13/01 21:06	0.63	-0.243
7/14/01 0:24	0.98	H	H	7/14/01 2:24	1.12	-0.143
7/14/01 7:06	0.54	L	L	7/14/01 9:00	0.65	-0.107



The information contained in each spreadsheet column was as follows:

- Col. 1: Date and time that high and low waters were recorded at the FSG station.
- Col. 2: The FSG gauge high and low water levels, in feet, referenced to the NGVD29 vertical datum.
- Col. 3: The tide designator (HH, H, L, LL) for each high and low water at the FSG gauge.
- Col. 4: The tide designator (HH, H, L, LL) as assigned by CO-OPS personnel for the NOS gauge.
This entry was downloaded from the CO-OPS web site.
- Col. 5: The date and time that high and low waters were recorded at the NOS primary station (Fort Myers). This entry was downloaded from the CO-OPS web site.
- Col. 6: The high or low water level, in feet, recorded at the NOS primary station (MLLW). This entry was downloaded from the CO-OPS web site.
- Col. 7: The difference between the water level recorded at the FSG gauge (column 2) and the corresponding water level recorded at the NOS gauge (column 6).

The worksheet data was then pasted into a database management program (e.g. MS Access) to generate the sums needed to calculate the tidal datums.

Tide Corrections

A specialized computer program, Survey Tide Correction (SURVCORR.exe), created by the University of Florida Coastal and Oceanographic Engineering Program, was used to correct soundings for the local state of the tides at the time each depth was recorded. The complete SURVCORR operator's manual, found in the Appendix, details the functionality of the program and specifies the required content and formatting for each input file.

SURVCORR output is a text file containing the raw depth, corrected depth, date/time, and XY coordinates for each sounding. This was used to generate an ArcView event theme and/or ArcInfo coverage of corrected depths. Figure 7 is a diagram of data flow from the tide gauge and sounder outputs through generation of tide-corrected ArcView GIS shapefiles.

Each SURVCORR session requires three ASCII-text-formatted input files: (1) uncorrected soundings (Survey Data File); (2) a "baseline" of georeferenced points, along which time and tide interpolation algorithms operate (Baseline Location File); and (3) tide gauge readings with interpolated time and location tags (Baseline Tide Data File). The program can correct soundings taken near a single tide gauge in the "one-gauge case" (with interpolation based only on time) or between pairs of gauges in the "two-gauge case" (interpolating over both time and distance).

Soundings Cleanup

Soundings processed using the procedures described above resulted in a distribution of data points suitable for display. Very rarely there were obvious errors in the DGPS positions, manifested by soundings that are displayed in the wrong place, perhaps on land. When present, such errors were not subtle, but readily apparent. The data collector looked carefully at the location of soundings over the entire study area and, if such anomalies were observed, re-surveyed the affected part of the study area. Note: Soundings collected in new canal systems or near inlets where storm events have caused shoreline changes since the background imagery was created may appear to be on land. These were verified,

Several error sources can affect depths measured by echo sounders. Common were excessively deep soundings caused by multiple bounces of the transducer signal from the bottom, back to the boat hull, and off the bottom again, which resulted in doubling (or even quadrupling) the true depth. If the sounder failed to record a depth for a position, it sent a zero reading to the survey software. Raw soundings (before boat squat/settlement corrections) of exactly zero are always bogus, because sounders have minimum operating depths greater than zero.

An initial step in cleaning up sounding data—after creating the shapefile with thinned data point and all attributes, but before creating text files for tide corrections—was to select and delete all data points with a raw depth value of zero. The appropriate ArcView queries were constructed and raw depths of less than approximately three feet were studied carefully and deleted if questionable, based on field notes and knowledge of actual minimum depths in a study area and the characteristics of the sounder(s) being used.

The maximum depth reasonably expected in an area was estimated, and a query built to select all depths deeper than that value. The selected soundings were examined and deleted if appropriate. A color-coded legend was applied to the depths to make changes in depth categories visually obvious. Depths were then carefully examined for sporadic, unlikely values. Simultaneously displaying depths from the two different sounders proved very useful, since, overall, the colors displayed from the sounders should be very similar. A series of points with differing colors from the two sounders were

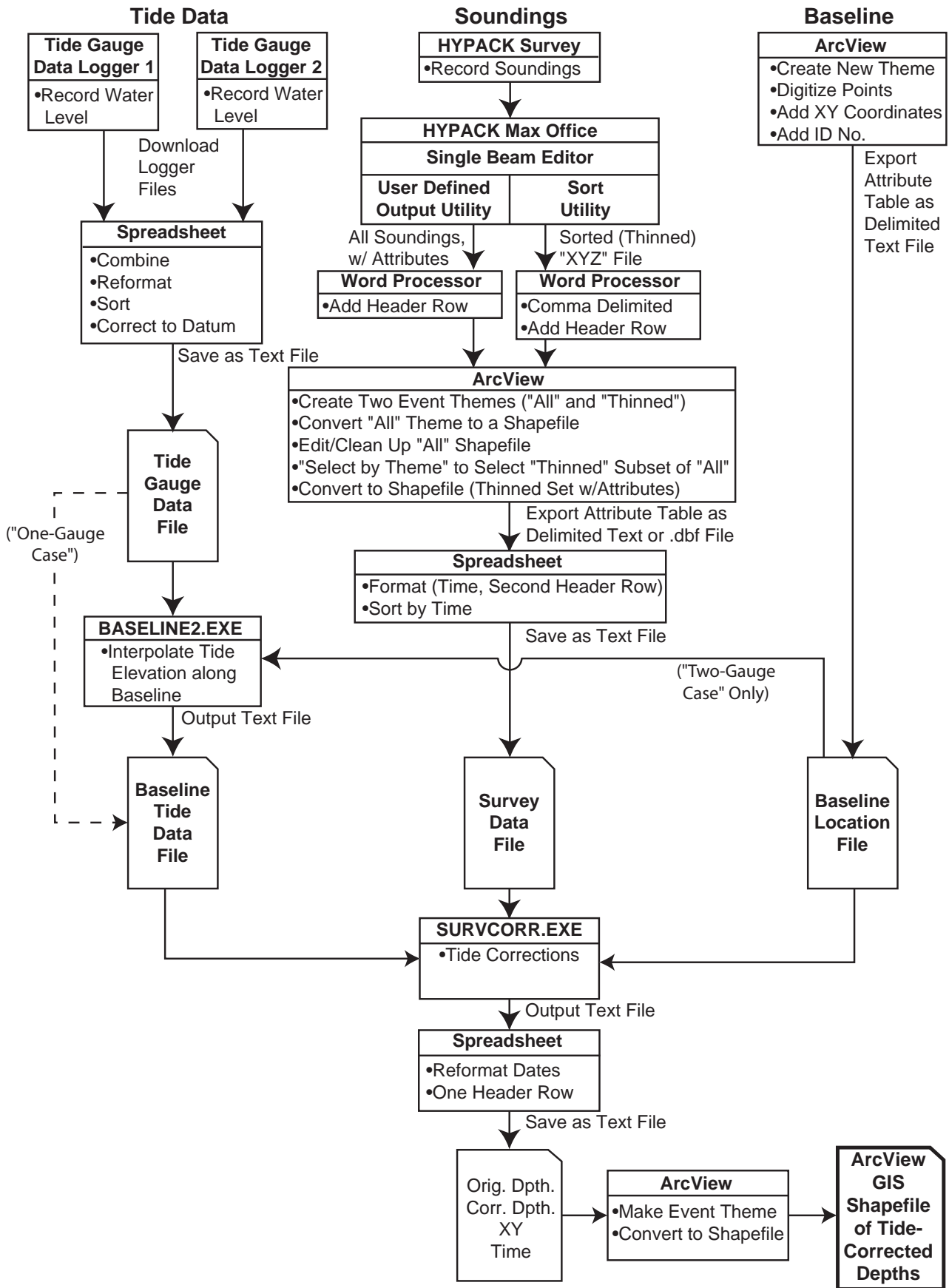


FIGURE 7. TIDE CORRECTION DATA FLOW

investigated. Normally, only one of the two sounders “doubled,” and the difference was obvious. Additionally, PERL and AML scripts were developed to automatically tag potentially anomalous soundings, which were then cleaned. With reference to field notes and aerial photo annotations, soundings were digitized to fill in gaps caused by shoals or loss of DGPS positions around buildings or under trees and bridges. Soundings were displayed along with a line shapefile of the waterways planned for surveying to ensure no areas had been missed.