

## **C1. Vertical Control**

The vertical datum for this project is the CRD, an adopted low-water gradient datum relative to NAVD88. There are known problems in the NGS level lines between Oregon and Washington due to the long level runs without the ability to run tie lines across the Columbia River. GPS observations have documented large vertical differences in published bench mark elevations across the Columbia River. Whereas CO-OPS water level gauges are located in Oregon and Washington and are directly referenced to NGS published bench mark elevations, and the known issue with the level lines between Oregon and Washington, a decision was jointly made by the USACE and NOAA to use NGS OPUS solutions to establish vertical consistency in the relationship of CRD relative to NAVD88. The USACE, Portland District (designated stewards of CRD) conducted surveys that established OPUS derived NAVD88 elevations on historic bench marks referencing CRD. A result of these surveys was a profile of CRD relative to OPUS derived NAVD88 elevations which were consistent across the Columbia River. The profile defined CRD relative to NAVD88 for each River Mile (RM) from RM 23 to RM 145 on the Columbia River and RM 0 to RM 26 on the Willamette River. This profile is used by the USACE, Portland District for hydrographic surveys and dredging operations to maintain the Federal Channel on the Columbia and Willamette rivers.

To improve vertical accuracy of this survey, soundings were reduced to CRD using GPS water levels measured at the survey vessel. Water levels were derived from post processed GPS heights and application of a separation model of the CRD to NAD83 ellipsoid relationship. Data reduction procedures, including detailed discussions of the CRD model generation and GPS water levels computations, for survey H11854 are detailed in the *OPR-N338-KR-08* DAPR.

To verify GPS water levels, a comparison was made by vessel static observations in the vicinity of the CO-OPS water level station 9440569 located in Skamokawa, WA, and CO-OPS water level station 9439099 located in Wauna, OR. To obtain water levels relative to the CO-OPS

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defined CRD, the Hydrographer selected Station Datum when downloading data from the CO-OPS web site. This is consistent with obtaining CRD values for any CO-OPS station on the Columbia River above RM 23. Adjustments were required to correct CO-OPS water level data to CRD based on the updated USACE CRD profile used to maintain the Columbia and Willamette rivers. CO-OPS is aware of this issue and is working toward resolving the problem.

It should be noted that these adjustments were applied to CO-OPS water level data for comparison purposes of water level data relative to the revised USACE profile relative to OPUS derived NAVD88 elevations. This method was approved for project OPR-N388-KR-08 by the Office of Coast Survey, Hydrographic Surveys Division Chief as it is consistent with the USACE, Portland District, methods for maintaining the Federal Channel in the Columbia and Willamette rivers. Further, CO-OPS should adjust water level stations on CRD and part of the Columbia PORTS® system to be consistent with the defined CRD profile by the USACE, Portland District. Tables 5 and 6 list corrections to be applied to CO-OPS data to be consistent with the USACE, Portland District CRD profile.

**Table 5. Corrections Applied to 9440569 Skamokawa, Washington**

Description of Adjustment	Adjustment (m)
Revised CRD Value to 0.286m NAVD88 from CO-OPS 0.371m NAVD88	-0.085
Adjustment to OPUS elevation for Tidal Bench Mark No 3 1940	0.103
<b>Total Adjustment to CO-OPS Data in Skamokawa, WA</b>	<b>0.018</b>

**Table 6. Corrections Applied to 9439099 Wauna, Oregon**

Description of Adjustment	Adjustment (m)
Revised CRD Value to 0.398m NAVD88 from CO-OPS 0.469m NAVD88	0.071
Adjustment to OPUS elevation for Tidal Bench Mark 9099H 1994	-0.033
<b>Total Adjustment to CO-OPS Data in Wauna, OR</b>	<b>0.038</b>

Water level observations, OPUS position results and gauge comparison data may be found in Appendix IV. No configurations used during data acquisition deviated from those described in the OPR-N338-KR-08 DAPR.

## C2. Discussion of GPS Tides

The coordinates of the GPS base stations used during acquisition and processing of H11854 are included in Table 7. The reference base stations used for both RTK and post processing are listed in the survey acquisition logs and POSPac processing logs included in Separate I *Acquisition and Processing Logs*.

**Table 7. H11854 NAD83 Base Stations Positions**

RTK Base Station	Latitude (N)	Longitude (W)	Ellipsoid Height
BEVR	46 10 13.97257	123 09 26.40353	-15.766 m
CATH	46 11 27.70015	123 25 24.15551	-12.127 m

As discussed in the *OPR-N338-KR-08 DAPR*, the use of GPS water levels eliminated large errors associated with discrete zoning and significantly reduced vertical uncertainty for this survey. Typical tide zoning artifacts for the survey area could exceed 30 centimeters, but as a result of using GPS water levels there are no visual tidal artifacts present in this survey.