# Vertical and Horizontal Control Report

## Columbia River Hydrographic Survey

***Clover Island and Benton-Franklin Intercounty Bridge***

Vessel: ***R/V Kvichak Surveyor***

Survey: **Columbia River Hydrographic Survey**

State: **Washington**

General Locality: **Hanford Reach**

Sublocality: **River Miles 325-343**

Survey Dates: **August 11, 2011 to August 18, 2011**

Project Lead: **Gunnar E. Forsman, USN-NUWC**

Lead Hydrographer: **Steven S. Intelmann, NOAA-AFSC**

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## APPENDICES

## A. HORIZONTAL CONTROL

The horizontal control datum for the survey was the North American Datum of 1983 (NAD 83). Data were projected to Universal Transverse Mercator (UTM) Zone 11 North.

During survey, sounding position control was determined using a Global Positioning System (GPS) incorporated into the POSM/V with RTCM beacon corrections being supplied by a Trimble Ag332. As a quality control measure, independent POSM/V and Trimble Ag332 positions were compared to a common node (the IMU) at various instances. The difference in the Northing and Easting values were calculated and graphed. Positions did not exceed 5 meters + 5 percent of the depth of the given line, as stated in section 3.1 of the NOAA HSSD. Results of the GPS confidence check are provided in the Descriptive Report, *Separates I: Acquisition Logs and Confidence Checks.*

Final processing, however, was accomplished using post-processed kinematic (PPK) techniques using a single Continuously Operated Reference Station (CORS) located in Richland, WA. See Appendix I of this document for the NGS data sheet describing the Richland, WA CORS station. PPK horizontal processing was accomplished using Applanix Mobile Mapping Suite (MMS), in accordance with the single-base procedures documented in the NOAA ellipsoidally referenced survey (ERS) standard operating procedure (SOP).

Sixteen projects were created in MMS, resulting in 16 Smooth Best Estimate Trajectory (SBET) and associated error files (*.smrmsg) being created for application in HIPS. CARIS Field Sheets were used to easily organize lines for matching the appropriate SBET/error files (Table 1).

**Table 1. Listing of SBET and associated HIPS files. Times are UTC.**

| POSPac SBET | HIPS_FieldSheet | SBET StartTime | SBET EndTime |
|---|---|---|---|
| sbet_2011-223 | JD223 | 8/11/2011 8:29:38 PM | 8/12/2011 3:09:57 AM |
| sbet_2011-224 | JD224 | 8/12/2011 4:14:56 PM | 8/13/2011 1:39:38 AM |
| sbet_2011-225_1 | JD225a | 8/13/2011 2:56:21 PM | 8/13/2011 3:49:23 PM |
| sbet_2011-225_2 | JD225b | 8/13/2011 3:52:32 PM | 8/13/2011 11:58:47 PM |
| sbet_2011-225_3 | JD225b | 8/14/2011 12:01:14 AM | 8/14/2011 1:40:28 AM |
| sbet_2011-226_1 | JD225b | 8/14/2011 1:57:33 PM | 8/14/2011 3:14:43 PM |
| sbet_2011-226_2 | JD225b | 8/14/2011 3:21:27 PM | 8/14/2011 4:09:36 PM |
| sbet_2011-226_3 | JD226 | 8/14/2011 4:14:02 PM | 8/15/2011 1:04:18 AM |
| sbet_2011-227 | JD227a/JD227b | 8/15/2011 1:46:36 PM | 8/16/2011 12:32:19 AM |
| sbet_2011-228_1 | JD228 | 8/16/2011 1:47:02 PM | 8/16/2011 3:31:15 PM |

| POSPac Project | HIPS_FieldSheet | SBET StartTime | SBET EndTime |
|---|---|---|---|
| sbet_2011-228_2 | JD228 | 8/16/2011 4:48:22 PM | 8/16/2011 11:38:59 PM |
| 2011-228_2 | JD228/JD229 | 8/16/2011 11:55:42 PM | 8/17/2011 12:52:16 AM |
| 2011-229_1 | JD229 | 8/17/2011 2:36:02 PM | 8/17/2011 8:40:58 PM |
| 2011-229_2 | JD229 | 8/17/2011 9:37:20 PM | 8/18/2011 12:25:44 AM |
| 2011-230_1 | JD230 | 8/18/2011 3:12:07 PM | 8/19/2011 1:00:12 AM |
| 2011-230_2 | JD225b | 8/19/2011 2:03:48 AM | 8/19/2011 2:27:10 AM |

## B. VERTICAL CONTROL

As mentioned above, the project was conducted as an ERS where the vertical relationship between the ellipsoid (GRS80) and NGVD29 was used to reduce ellipsoidally referenced survey soundings to a non-tidal chart datum, defined as 340 feet above "Mean Sea Level" (NGVD29).

POSView was configured to capture POSPac data packets during acquisition, where GPS antenna heights (to the ellipsoid) were logged with the raw sounding data. Since no VDATUM model exists for this non-tidally influenced survey area, the GEOID09 model (http://www.ngs.noaa.gov/PC_PROD/GEOID09/dnpc09u.shtml) was used to convert logged ellipsoid heights to NAVD88 orthometric heights and the VERTCON model (http://www.ngs.noaa.gov/PC_PROD/VERTCON/) was then subsequently applied to compute modeled differences between NAVD88 and NGVD29 orthometric heights. Another shift of 340 feet placed the soundings at a chart datum above Mean Sea Level (NGVD29).

Figure 1 provides a schematic of the various datum relationships used in a separation model to convert ellipsoid heights to chart datum. Values provided on the Figure 1 schematic, including the Final Corrector, would be relative to the CORS site only, and are merely shown in this figure to provide context for the model calculations which were ultimately applied to all soundings in the form of a grid, thus essentially working as "micro-tide zones". A single corrector was not applied to all the soundings since the geoid varies by nearly 10 centimeters over the survey area. As such, a grid model was used to apply a range of correctors to the soundings according to the variation of the geoid in space.

ARCMap was used in a step-wise fashion to create individual grids of the GEOID09 model (Figure 2) and associated VERTCON relationship (Figure 3). By using the various datum relationships outlined in Figure 1, a series of raster calculations were then performed on the GEOID09 and VERTCON "working" grids to produce a final grid of modeled height correctors for the survey area (Figure 4). Final grid model resolution was inherent to the cell size of the GEOID09 model, which was 1-arcminute (0.0166667 degrees). The final raster grid was ultimately converted to a point feature and input into

CARIS HIPS as an XYZ text file (see Appendix II of this report for the correction data) during the Compute GPS Tide function. GPS Tide corrections ranged from 82.908 to 83.005 for the model cells intersecting the survey area.

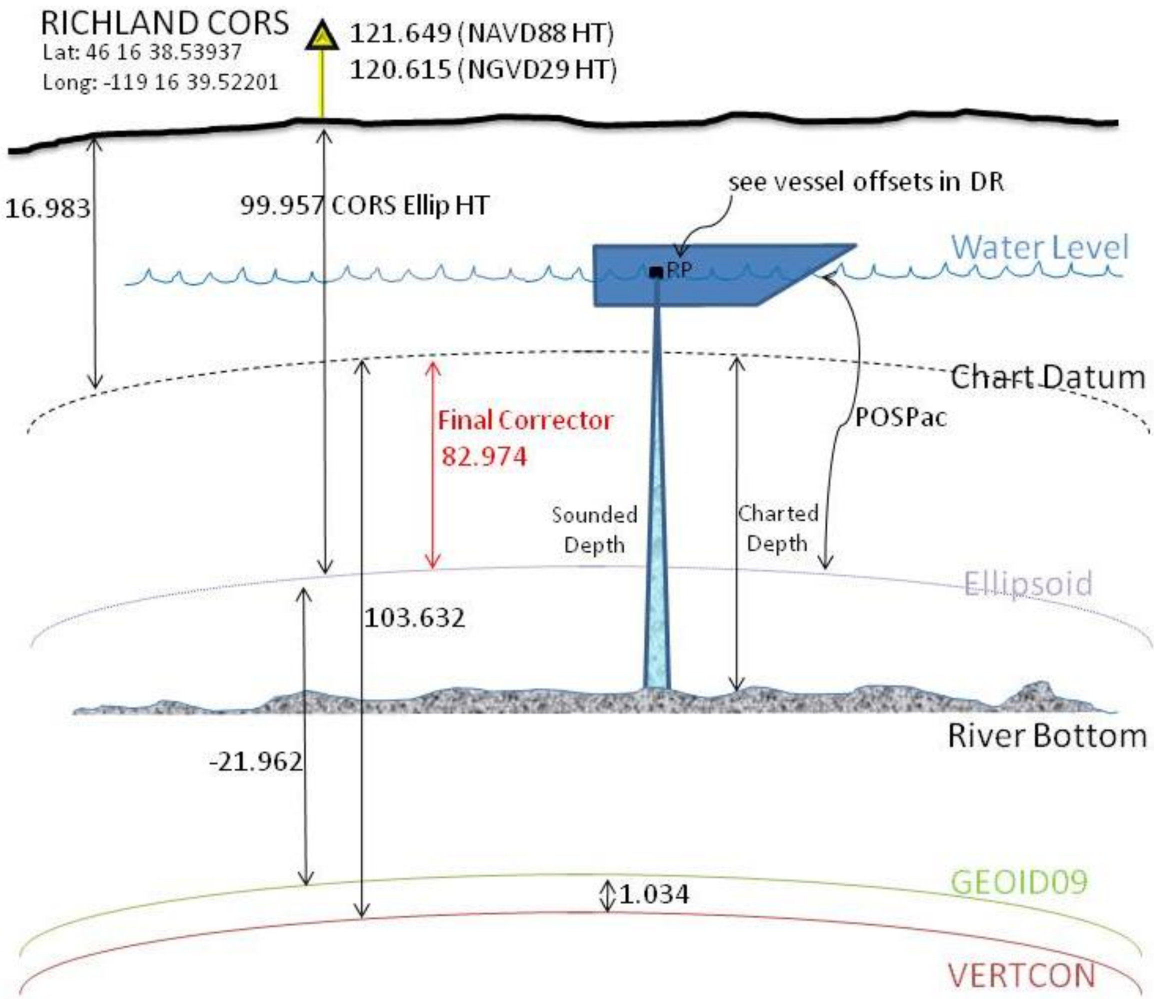


**Figure 1. Schematic of the various datum relationships used to reduce sounded depths to chart datum through the ellipsoid referenced process.**

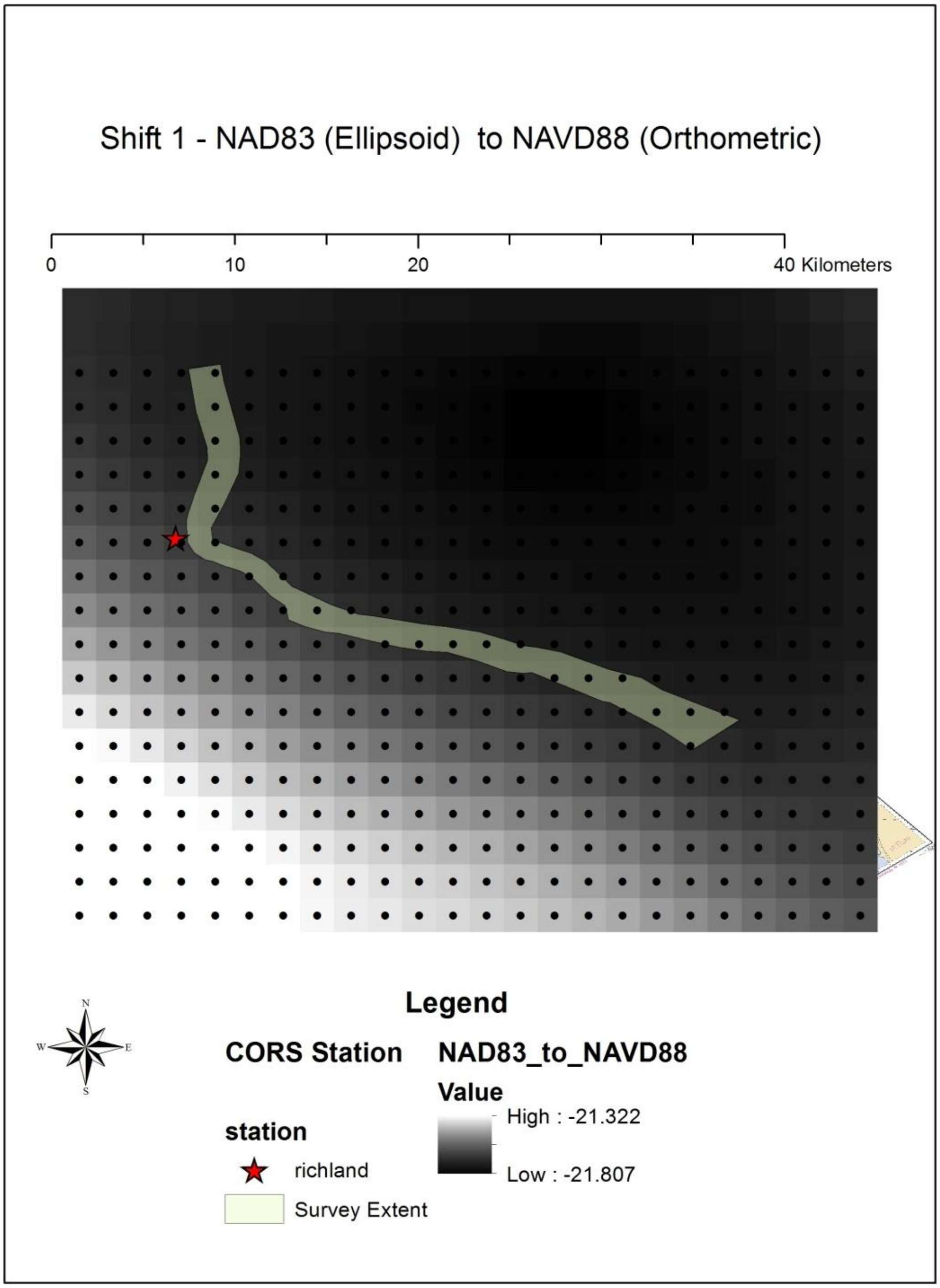


**Figure 2. Raster grid of the GEOID09 model which was used to transform ellipsoid heights (GRS80) to orthometric heights based on NAVD88 datum. Green polygon represents a generalized extent of the survey area. The red star indicates the location of the Richland CORS. Cell size is 1 arcminute.**

 

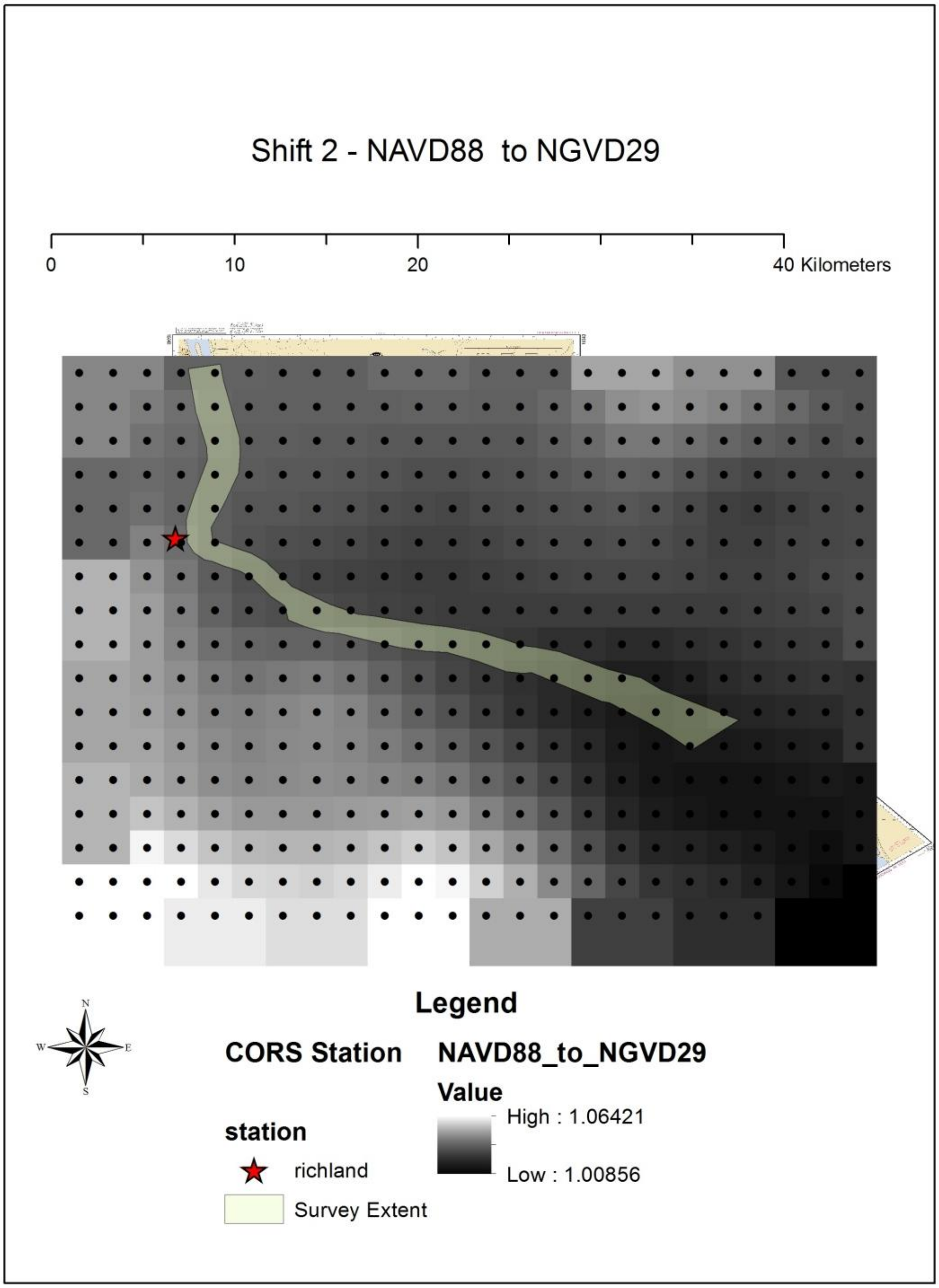


**Figure 3. Raster grid of the VERTCON model which was used to transform orthometric NAVD88 heights to NGVD29. Green polygon represents a generalized extent of the survey area. The red star indicates the location of the Richland CORS. Cell size is 1 arcminute.**

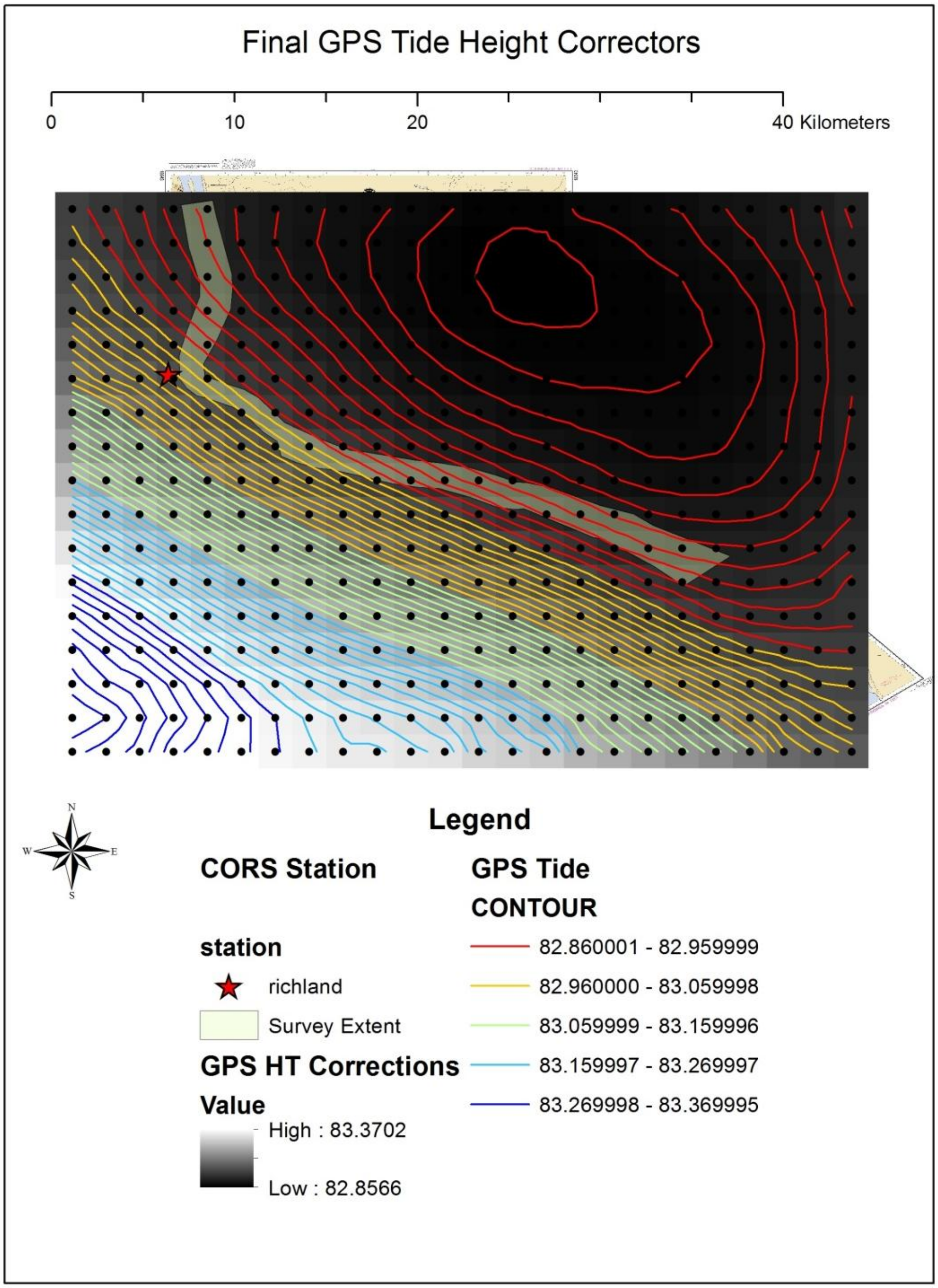


**Figure 4. Raster grid of final height corrections (meters) used to reduce soundings of GPS based ellipsoid heights to the local chart datum of 340 feet above Mean Sea Level (or NGVD29). Local variation in the geoid is clearly visible in the contour lines, which essentially represent "micro-tide zones". Green polygon represents a generalized extent of the survey area. The red star indicates the location of the Richland CORS used in the PPK processing. Black spheres represent the individual nodes which were imported into CARIS HIPS as a separation model during the Compute GPS Tide application. Cell size is 1 arcminute.**

# Vertical and Horizontal Control Report

## Columbia River Hydrographic Survey

All information contained in this Vertical and Horizontal Control Report for the Columbia River Hydrographic Survey has been reviewed and approved by me and is hereby respectfully submitted.

**Steven S. Intelmann, Physical Scientist**
**NOAA**

Date 9 December 2011