9-1-2012

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Engineering – Hydrology – Stream Restoration – Water Resources

TECHNICAL MEMORANDUM

Date: 18 September 2012

To: Aldaron Laird, Environmental Planner
Trinity Associates
980 7th Street, Suite K
Arcata, CA 95521

From: Jeffrey K. Anderson, M.S, P.E.

Re: Estimates of Mean Monthly Maximum Water Surface Elevations in Humboldt Bay, Humboldt County, CA

Introduction

This technical memorandum briefly summarizes the methods and results used by Northern Hydrology & Engineering to provide estimates of mean monthly maximum water surface elevations in Humboldt Bay to support your Humboldt Bay Shoreline Inventory and Mapping Project for the California Coastal Conservancy. All work in this memo is referenced to the North American Vertical Datum of 1988 (NAVD88).

Humboldt Bay Hydrodynamic Model and Tidal Boundary Condition

Water surface elevation estimates were determined using a previously semi-calibrated three-dimensional hydrodynamic model (3D model) of Humboldt Bay that predicted water levels, salinity and temperature (Anderson 2010). Estimates of mean monthly maximum water elevations in Humboldt Bay were made using the 3D model and a simple tidal curve boundary condition that varied between mean monthly maximum water and mean lower low water.

Model Domain and Parameters

The 3D model domain encompasses Humboldt Bay, the larger slough systems, and a small portion of the open ocean immediately outside of the entrance channel (Figure 1). The model was orientated to the NAD83 horizontal coordinate system. For this work the 3D model was configured to simulate water levels and salinity only. Temperature and wind stress effects were not simulated. Initial conditions consisted of a horizontal water surface elevation at 1 m, and a constant salinity of 31 ppt. The model was run for an 8-day period using a generated tidal boundary condition (described below) with the first few days used for model spin-up. Table 1 lists the data and sources used for model boundary condition forcing and model input assumptions. The current model calibration (Anderson 2010) has the bottom roughness height at $Z_0 = 0.005$ m, and the sub-grid scale horizontal mixing coefficient $C_s = 0.05$ (Smagorinsky's parameter).

Table 1. Summary of 3D model boundary condition sources

Parameter	Data Description	Data Source	Notes
Ocean tidal boundary condition	North Spit simple tidal curve generated between MMMW and MLLW	NOAA CO-OPS	Repeating tidal curve for simulation period
Ocean salinity boundary condition	Assumed constant at 31 ppt		Held constant for simulation period
Streamflow for Humboldt Bay tributaries	Scaled Little River mean annual flow, held constant for simulation period	USGS	Scaled Little River flow by tributary watershed area
Salinity for Humboldt Bay tributaries	Assumed constant at 0.1 ppt		Held constant for simulation period

Tidal Boundary Condition

Tidal datum relative to the 1983-2001 tidal epoch are listed in Table 2 for the North Spit tide gage (NOAA Station 9418767). Also listed in Table 2 is the mean monthly maximum water (MMMW) for North Spit, which is the average of the maximum measured tide levels each month. This is not a NOAA published tidal datum such as mean higher high water (MHHW), but was the tidal reference elevation selected for this work.

Table 2. North Spit (NOAA Sta. 9418767) tidal datum and other reference elevations for the 1983-2001 Tidal Epoch

Tidal Data	Tidal Elevation (m, NAVD88)	Tidal Elevation (ft, NAVD88)
Maximum Observed Water Level	2.862 (1/26/1983)	9.39
Mean Monthly Maximum Water (MMMW)	2.356	7.73
Mean Higher High Water (MHHW)	1.987	6.52
Mean High Water (MHW)	1.770	5.81
Mean Low Water (MLW)	1.025	3.36
Mean Sea Level (MSL)	1.025	3.36
Mean Tide Level (MTL)	0.280	0.92
Mean Lower Low Water (MLLW)	-0.103	-0.34

Generation of MMMW to MLLW Tidal Curve

The ocean boundary condition for the 3D model was a simple tidal curve generated between MMMW and mean lower low water (MLLW) for North Spit (Figure 2) using the following equation (FHWA 2004):

$$\mathbf{Ht\ (t) = a \cos (360t/T) + Z}$$

where Ht (t) = tide at time t, a = tidal amplitude, t = time, T = tidal period, and Z = vertical offset or datum adjustment. For this tidal curve the tidal amplitude was 1.230 m (MMMW to MLLW) with a tidal period of 12.42 hours (half of 24.84 hour tidal day).

Mean Monthly Maximum Water Surface Elevation Results

To provide estimates of mean monthly maximum water elevations in Humboldt Bay, the maximum predicted water surface elevation were extracted from each cell of the 3D model grid on the last day of the 8-day simulation period (Figure 3). Model predictions show how the maximum water levels from the MMMW to MLLW tidal boundary condition (Figure 2) propagate in Humboldt Bay.

The extracted maximum water surface elevation points were imported into ArcGIS and a triangulated irregular network (TIN) surface of predicted mean monthly maximum water elevations was developed and distributed. The TIN surface was then used to assist in mapping existing shoreline conditions in Humboldt Bay.

References

Anderson, J. 2010. *A Three-Dimensional Hydrodynamic and Transport Model of Humboldt Bay*. Poster presented at the 2010 Humboldt Bay Symposium.

Federal Highway Administration (FHWA) 2004. *Tidal Hydrology, Hydraulics and Scour at Bridges, First Edition.* U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, VA. FHWA-NHI-05-077, Hydraulic Engineering Circular No. 25.

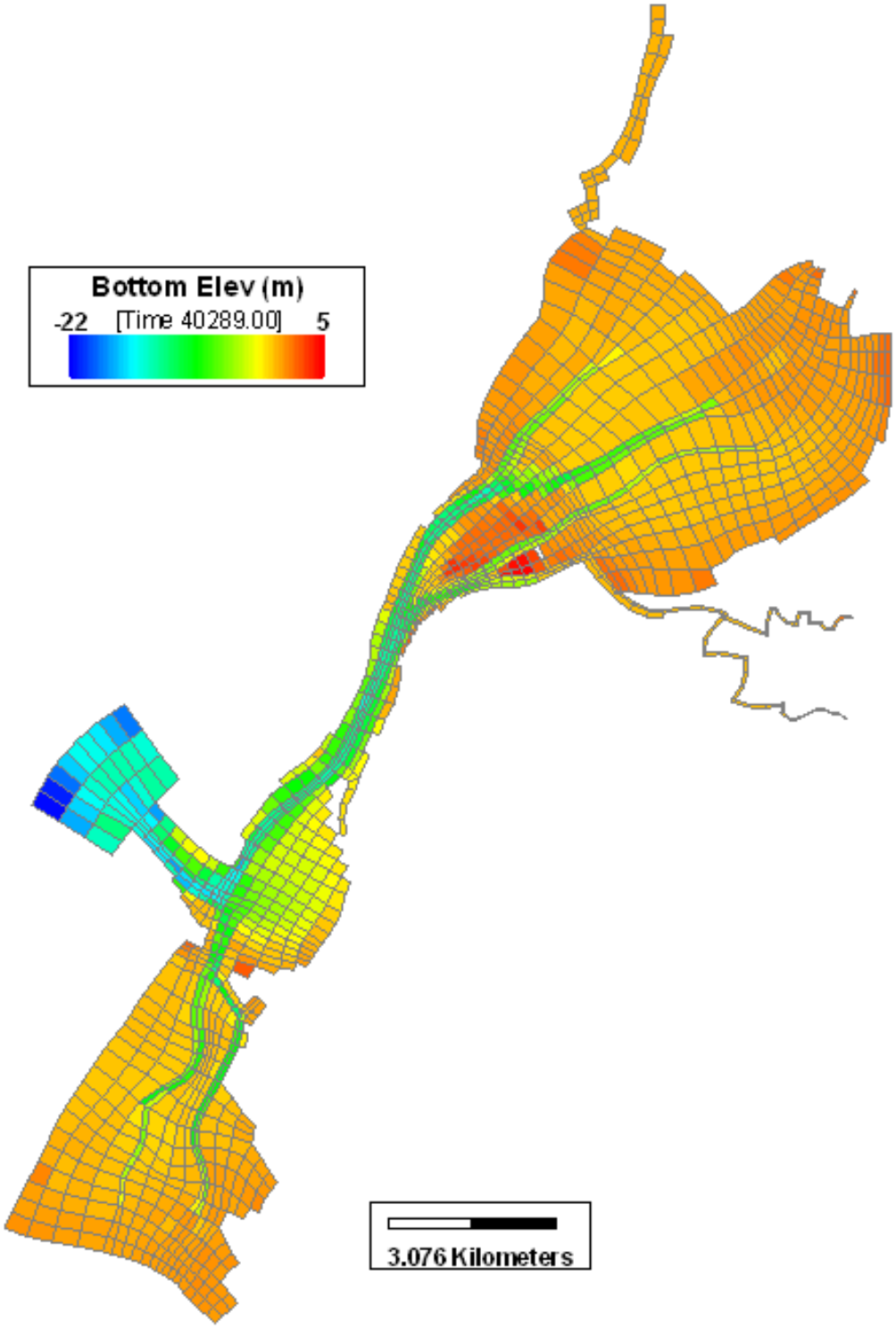

Figure 1. Humboldt Bay 3D hydrodynamic model grid and bottom elevations.

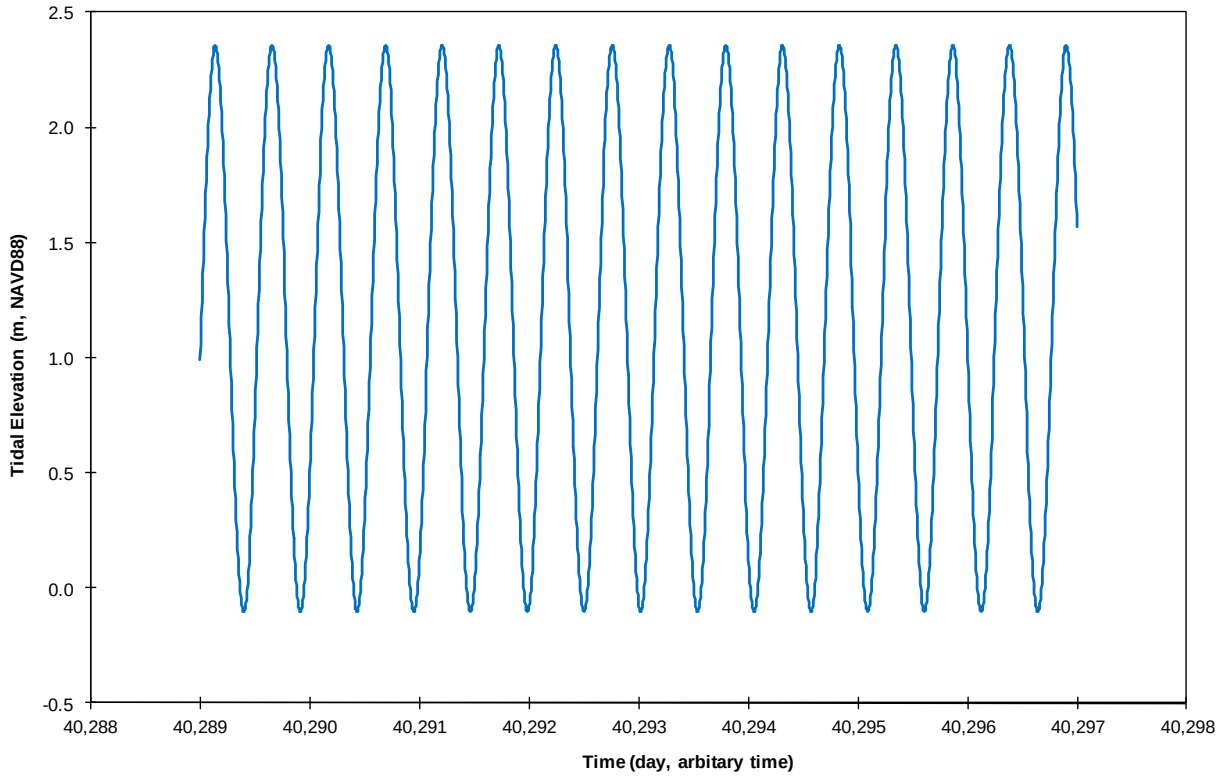

Figure 2. **North Spit simple tidal curve generated between mean monthly maximum water (MMMW) and mean lower low water (MLLW).**

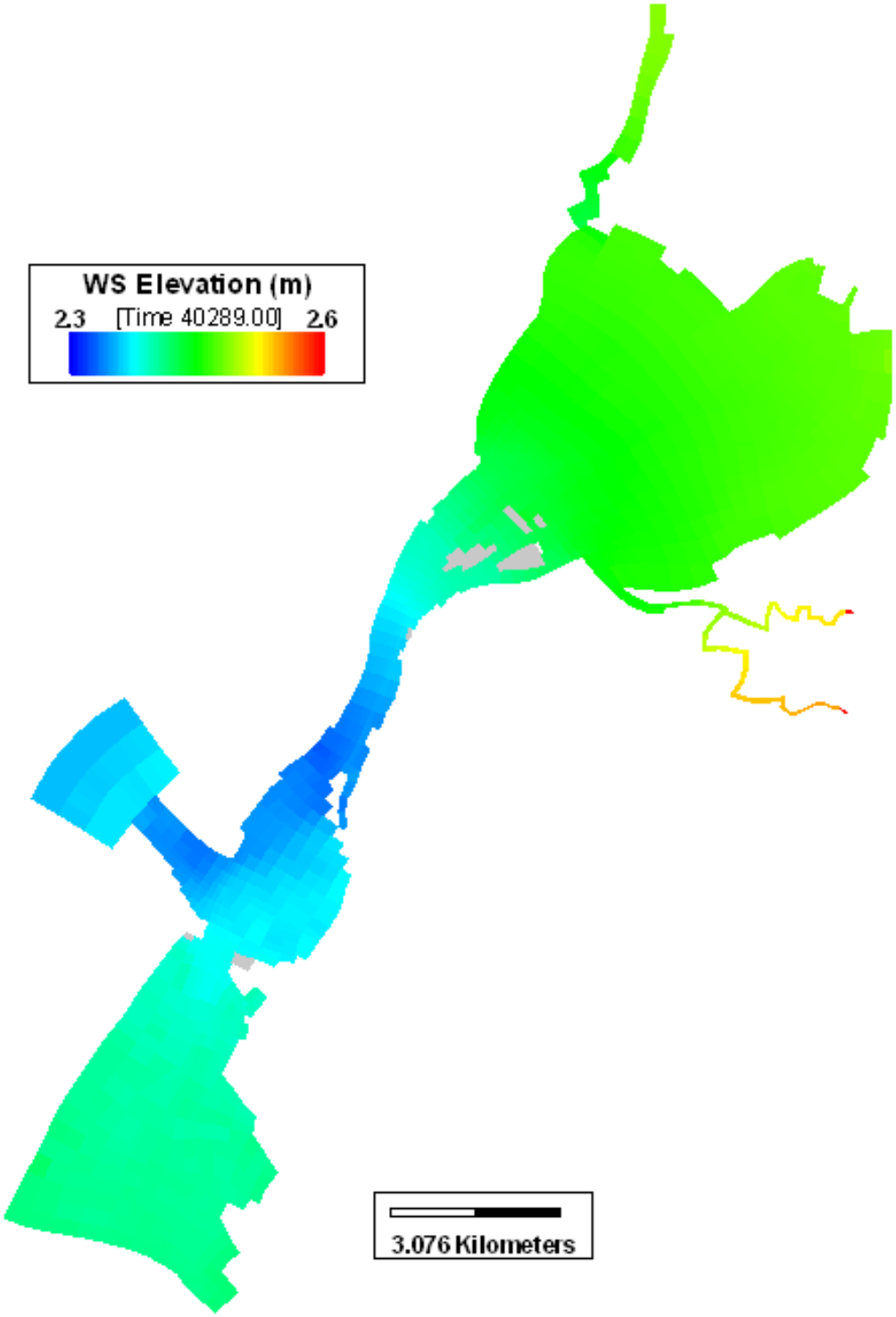

Figure 3. **Estimated mean monthly maximum water (MMMW) in Humboldt Bay predicted from the 3D model.**