Concluding Comments on the WRAP Hydrodynamic Model for the Los Angeles/Long Beach Harbors Toxics TMDL

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From August to December 2016, I have reviewed the technical report "WRAP Model Development" and supporting materials, participated in a series of conference calls with the technical team, provided several rounds of comments, and participated in a in-person meeting with the technical team, the Ports, and other stakeholders that was held at Long Beach, CA on December 8, 2016. Through these engagements, I have known the WRAP model and the related issues. I have not found any fatal flaws in the model, data, parameters, and results. The technical team has demonstrated a credible commitment in developing, calibrating and validating the model. My concluding comments on the WRAP model are given below.

General Comments:

The WRAP model is developed based on EFDC, which has been widely applied in similar studies. The model is able to simulate the hydrodynamic, sediment, and pollutant transport processes in estuarine systems. The runoff, sediment and pollutant loadings from watershed are estimated reasonably. The model calibrations and validations are comprehensive and appropriate. The used data are basically enough to calibrate and validate the model. The model results of flow, sediment, and chemicals (TPCB and TDDX) agree generally well with the measured data. The sensitivity and uncertainty analyses are conclusive and have identified the important inputs for chemicals in the study system. The WRAP model can be used to simulate the hydrodynamic processes that drive the bioaccumulation processes, and evaluate the TMDL management strategies in Los Angeles and Long Beach Harbor Waters.

Specific Comments:

My initial and detailed comments submitted previously have been adequately responded by the technical team. I have the following specific concluding comments, which are just for reference and use by the Ports, agencies and stakeholders and do not need further response from the technical team.

<u>1. Model Development and Setup</u>. The WRAP model is based on the well-developed EFDC model, which is a surface water modeling system developed and distributed by EPA. It solves the 3-D shallow water flow equations using a finite difference scheme. It has a sediment transport module handling the cohesive and noncohesive sediment transport and bed changes by size classes. It also has a pollutant transport module handling multiple constituents and considering sediment adsorption/desorption and mass exchange between water column and bed sediments. The model has been used in numerous similar TMDL studies. The available source code helps the technical team to add the necessary functions and improve the model for the specific situations of the study problem. For example, the team has implemented the capabilities to calculate the chemical volatilization and the vessel propeller induced erosion.

The mesh used in the present study is slightly coarse, particularly in the adjacent channels. This is understandable, because it is still very time consuming to use a 3-D hydrodynamic model to simulate the long-term (20 years) processes in such a large water body. Considering that the adjacent channels are mostly not in the TMDL study region and they are man-made channels with narrow widths and regular boundaries, use of coarse mesh there can be justified.

The bed bathymetry data are complete, even though the data in different zones were measured in different years. It is normal to rely on different sources of bathymetry data to get a complete coverage of such a large study domain. The team has used dredging information to update the bathymetry when needed.

The modeling team considered about 200 inflows into the domain as upstream boundary conditions. It is very good to have such details when handling the storm water inflows from such large, highly urbanized watersheds. The open sea boundary is appropriately imposed with tidal water levels. The wind effects are considered in the model. The wave effects are ignored, because the harbors are enclosed by wave breakers and dikes on the sea side. However, there may be some wave effects near the northern shorelines of the San Pedro Bay and several other places, but this can be left for future study when such details are needed.

2. Watershed Loadings. Flows, sediment, and organic chemical concentrations in the 14 years from 2002 to 2015 were specified at the nearly 200 boundary locations as watershed loading conditions. The 14 year time series should be long enough to represent the hydrological and sediment characteristics of the watershed.

The inflow discharges were estimated based on measured data. For those locations without continuous measured data, the regression relations between the water volumes at gage locations were used to fill the data gaps. This handling is appropriate.

The team tried to establish the rating curves of flow discharge and sediment transport rate or concentration, but they could not succeed. The reason might be that the majority of sediments are wash load from watershed, which is independent on flow conditions. However, the team found that the TSS concentrations in dry weather, first flush and wet weather have different behaviors and can be represented separately by the average TSS concentrations under these three weather conditions. This finding is very important and helps to determine the sediment loads from watersheds.

The organic chemical (TPCB and TDDX) loads were estimated by using nice rating curves of chemical concentration and sediment concentration separately for dry and wet weathers. This handling is reasonable and is often used in other similar studies.

3. Validation of Hydrodynamic Model. In addition to the validation previously done using data of Feb 2005-March 2006 in an earlier study, the flow model has been calibrated and validated using newly collected ADCP data in the POLA outer harbor in a three-month period of 2010, in the West Basin during 2/23/09-3/10/09 and in Cabrillo Marian during 1/12/11-3/14/11, as well as velocity profile data in Cabrillo Marina in 5/27-6/12, 2009. The calibrated parameters include bed roughness height and mixing coefficients. The estimated bed roughness height is 0.02-0.03 m, which are reasonable for such water system. The temporal variations of simulated water levels and velocity profiles agree well with the measured data at the measurement stations spatially distributed over the POLA harbor area.

4. Validation of Mixing and Transport Model. Dye and salinity data were used to test the WRAP mixing and transport model, which is used for modeling sediment and pollutant transport. This validation also further tested the flow model because the flow model drives the transport model. The calculated dye concentration and salinity agree generally well with the measured data.

5. Validation of Sediment Transport Model. The used bed sediment size composition data cover the entire domain spatially, which provides a good basis for the sediment transport model. Even though some data were collected in years ago, this is normal because collecting bed sediment data in such a large domain is quite expensive. Compromise is often needed between project cost and data accuracy.

For the cohesive sediment size class (clay), the floc settling velocity, erosion rate coefficient and critical shear stress for erosion and deposition were calibrated by comparing the calculated and measured sediment concentrations and bed changes. One of the key parameters for this study is the critical shear stress for erosion, which determines the bed sediment erosion or resuspension. Its calibrated value is 0.05 N/m^2. To my knowledge, this value is typically for newly deposited sediments. It is reasonable for the top surface layer of bed sediment, which has not gone through significant consolidation. Considering that sediment deposition is the dominant trend in the LA/LB port areas, the bottom consolidated sediments will rarely be eroded, so a critical erosion shear stress of 0.05 N/m^2 is acceptable. It is on the safe side for the TMDL study because a larger value of critical erosion shear stress will give a smaller amount of sediment entrainment.

The calculated sediment concentrations and bed changes agree generally well with the measured data. The sediment tracer transport in the LAR and San Pedro Bay, the deposition rates in the Consolidated Slip and in the LAR estuary were well reproduced by the sediment transport model. This also tested the flow model because the sediment transport model has to be driven by the flow model.

6. Validation of PCB and DDX Transport Model. The initial bed sediment chemical concentration data was carefully prepared. The team has done a wonderful job to compile many data to cover the entire study domain. The chemical loadings from watershed were converted from suspended load concentration by using the established rating curves. The chemical condition on the ocean boundary was estimated using measured data. The mass transfer coefficient and the particle mixing coefficient were estimated using literature values and then calibrated by comparing the calculated and measured chemical concentrations. The model reproduced reasonably well the measured suspended load, TPCB and TDDX concentrations.

7. Sensitivity and Uncertainty Analyses. The team conducted a very impressive sensitivity and uncertainty analyses, through which the key controlling factors for the study system were identified. It has been found that the ocean boundary, sediment bed concentration and watershed loadings are the three key controlling inputs for the pollutant transport in LA/LB harbors. This provides useful guidance for the TMDL management strategies. This implies that the LA/LB harbor water body is an open system and reducing the watershed and ocean boundary contaminant loadings may be as important as capping or dredging the harbor contaminated sediments in order to meet the TMDL targets.