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M E M O R A N D U M

TO: Utah Lake Science Panel

FROM: Nicholas von Stackelberg, P.E, and Scott Daly
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DATE: September 24, 2020

SUBJECT: Model Gaps and Limitations Summary
Utah Lake Water Quality Study

Final memo – Science Panel Approved December 14, 2020

The Utah Division of Water Quality has been collaborating with the University of Utah (UU) to develop the Utah Lake Nutrient Model in support of the Utah Lake Water Quality Study. The University is wrapping up its model development efforts and has submitted the *Utah Lake Hydrodynamic (EFDC) and Water Quality (WASP) Model Report* (Version dated 6/30/2020) prepared jointly between the UU and UDWQ. At previous Science Panel meetings, the capabilities and limitations of the model implementation have been presented and discussed. The purpose of this memorandum is to document the model gaps, limitations and performance issues identified by the Science Panel, and to recommend and prioritize approaches to resolve them in order for the model to be considered suitable for application to numeric nutrient criteria development. It is anticipated that a consultant will be procured by UDWQ to complete some or all of the recommended tasks.

Model Structural Limitations

Several structural limitations to the coupled EFDC-WASP model have been identified and discussed by the Science Panel. Structural limitations are considered inadequate representations of physical, biological or chemical processes, which were identified as potential significant mechanisms in Utah Lake that would require revisions to either the EFDC or WASP source code to incorporate. In no order of Science Panel priority, each limitation and proposed resolution is briefly noted in Table 1.

Model Performance

Based on review of the Model Report and associated model input and output files, the performance issues identified and recommended model refinement tasks are summarized in Table 2.

Table 1: Summary of model structural limitations and proposed resolution

Ref #	Limitation	Recommended Resolution/Justification	Existing/Ongoing Sources of Information	Additional Studies and Information Needs	Priority for EFDC and WASP Model Development*	Include as Model Scope of Work Task
1	Cyanotoxins: The water quality end point for the model is Chlorophyll a concentration of selected groups of phytoplankton. The model also simulates common Utah Lake cyanobacteria taxa, but does not simulate toxin production by cyanobacteria.	No modification required to EFDC/WASP model. Science is insufficiently advanced to incorporate toxin prediction into a mechanistic model. Empirical correlations can be external to the mechanistic model.	EPA cyanotoxin prediction models University of Utah HAB research	Develop literature review and strategy for determining empirical correlations between cyanobacteria taxa, environmental conditions and toxin production. Note that attempts at generating robust regressions between biomass and toxin concentration have not been widely successful, even in well-understood systems.	No	No
2	Food web: The model does not simulate nutrient cycling through the food web, such as primary and secondary consumers. The effect of zooplankton grazing on phytoplankton group biomass is specified through a rate constant.	No modification required to the EFDC/WASP model. Develop a stand-alone food web model that can be used to support specification of rate constants and existing coefficients in water quality model. Simulate effects of food web using existing model coefficients.	CNP study will quantify the standing stock and recycling rates of C, N, and P in food web components and/or identify these topics as knowledge gaps USU June sucker research Wasatch Front Water Quality Council	Incorporate results of CNP study to determine if additional food web modeling is needed.	Low	TBD - Separate Food Web Model RFP

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3	Bioturbation: The model does not simulate bioturbation and sediment resuspension resulting from the activities of benthivorous fish.	Evaluate relative importance of bioturbation on sediment resuspension. Alternative specifications of diffusion coefficients in model are possible in lieu of dynamic simulation of carp behavior.	Wind/turbidity analysis contained within the Analysis Report TSSD mesocosm study	Evaluate relative importance of bioturbation on sediment resuspension. Bioturbation identified as a priority for future research projects in Strategic Research Plan	Low	No
4	Microbes: The model does not simulate microbial biomass. The effect of microbes on organic matter decomposition is specified through rate constants.	No modification required to the EFDC/WASP model. Additional investigation of the effects of organic matter decomposition and nutrient mineralization rates. Potentially included as part of the food web model.		Additional investigation of organic matter decomposition and nutrient mineralization rates.	No	No
5	Calcite bound phosphorus: The formation of calcite and binding with phosphorus is not simulated by the model. Several approaches have been proposed to incorporate this mechanism into the model.	To be addressed through the Phosphorus Binding Strategic Research Project. Suggested approaches include: 1. Add calcite as a solids group and use partition coefficient for P. 2. Dynamically simulate calcite formation and P binding through addition of equilibrium chemistry.	Phosphorus Binding SRP. CNP Nutrient Budget		Mandatory	Future scope element based on SRP. Requires coordination with EPA model developers.

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6	Iron bound phosphorus: Phosphorus sorption to sediment is specified via a partition coefficient in the model that is not dependent on pH and redox conditions. Therefore, mineral bound phosphorus (iron, manganese, aluminum) sorption processes are not dynamically simulated. Several approaches have been proposed to incorporate this mechanism into the model.	To be addressed through the Phosphorus Binding Strategic Research Project. Suggested approaches include: 1. Modify partition coefficient for P to be dependent on pH and redox condition. 2. Dynamically simulate iron mineral formation and P binding through addition of equilibrium chemistry.	Phosphorus Binding SRP		Mandatory	Future scope element based on SRP. Requires coordination with EPA model developers.
7	Wetting/Drying: The effect of wetting and drying of shallow areas on sediment diagenesis and nutrient fluxes between the sediments and water column is not fully represented. The model only simulates sediment diagenesis and nutrient fluxes on cells that are wet throughout the simulation period.	Evaluate relative importance of wetting/drying on sediment diagenesis and nutrient fluxes through Strategic Research Project and use results of the research to determine any necessary modifications to the model.	Littoral Sediment SRP		High	Future scope element based on results of SRP to develop implementation strategy for model incorporation
8	Macrophytes: The model does not simulate macrophyte establishment and growth, including nutrient uptake from sediments, which has implications for simulating historical condition and lake restoration and management scenarios.	Defer consideration of macrophytes to future management scenarios. EFDC is capable of simulating hydrodynamic scenarios, but not nutrient uptake.	CNP Nutrient Budget. Paleolimnological Research Study		Medium	No

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9	Waves: The EFDC model does not simulate the effects of wave action on shear stress at the lake bottom.	Build and calibrate a wave model such as SWAN and couple with EFDC to simulate the effect of wave action on shear stress and sediment resuspension.	ADCP wave height measurement ongoing Wind-driven shear stress calculated from buoy and wind data in Data Analysis Report		Mandatory	Yes

*Prioritization key for addressing mechanistic model limitations:
Mandatory: Required for NNC development.
High: High importance.
Medium: Moderate importance.
Low: Low importance.
No: Not important.

Table 2: Summary of model performance and refinement recommendations

#	Model Performance	Recommended Refinement	Existing/Ongoing Sources of Information	Priority for EFDC and WASP Model Development*	Include as Model Scope of Work Task
	Data Gaps				
1	Incomplete flow and water quality concentration data from tributaries, as well as in-lake water quality data, was available for the calibration period (Water Year 2009-2013), which introduced significant uncertainty to the model inputs and limited model performance evaluation.	Validate and refine model calibration utilizing more data rich time period, i.e. post-2016. Select model application period and evaluate data for driving model (e.g, boundary conditions) and assessing model performance	Enhanced ongoing data collection initiated in 2017. C, N, P Mass Balance analysis.	Mandatory	Yes
	Run Time Issues				
2	Due to model run-time considerations, only a subset of wet cells were specified to simulate sediment diagenesis.	Resolve model run time issues and apply sediment diagenesis to all wet cells.		Mandatory	Yes – Coordinate with USEPA for resolution
3	Unreasonable values of several parameters were observed in cells that experience wetting and drying, although this does not appear to affect results in the continuously wet cells.	Only apply precipitation/evaporation to wet cells.		High	Yes
4	The model does not produce reasonable results for pH and alkalinity, but should have this capability.	Coordinate with EPA WASP model developers to resolve this issue.		Mandatory	No – UDWQ/SP coordination with EPA
	Performance Issues				
5	Phosphorus concentrations in the water column are consistently over-predicted by the model.	Refine model calibration utilizing more data rich time period, i.e. post-2016.	Enhanced ongoing data collection initiated in 2017. Phosphorus Binding SRP	Mandatory	Yes
6	Adequate characterization of light penetration and light extinction for algal growth prediction.	Incorporate CDOM and light extinction formulation and develop model implementation strategy	Light extinctions analysis from the Analysis Report	Mandatory	Yes

*Prioritization key for addressing mechanistic model limitations:
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High: High importance.
Medium: Moderate importance.
Low: Low importance.
No: Not important.