UTAH LAKE C, N, AND P PROJECT UPDATE

ULWQS Science Panel Meeting

2021-07-26

Presented by Kateri Salk, Tetra Tech

GOALS

1. Update on new data and calculations for external mass balance
2. Present completed analyses for SedFlux modeling

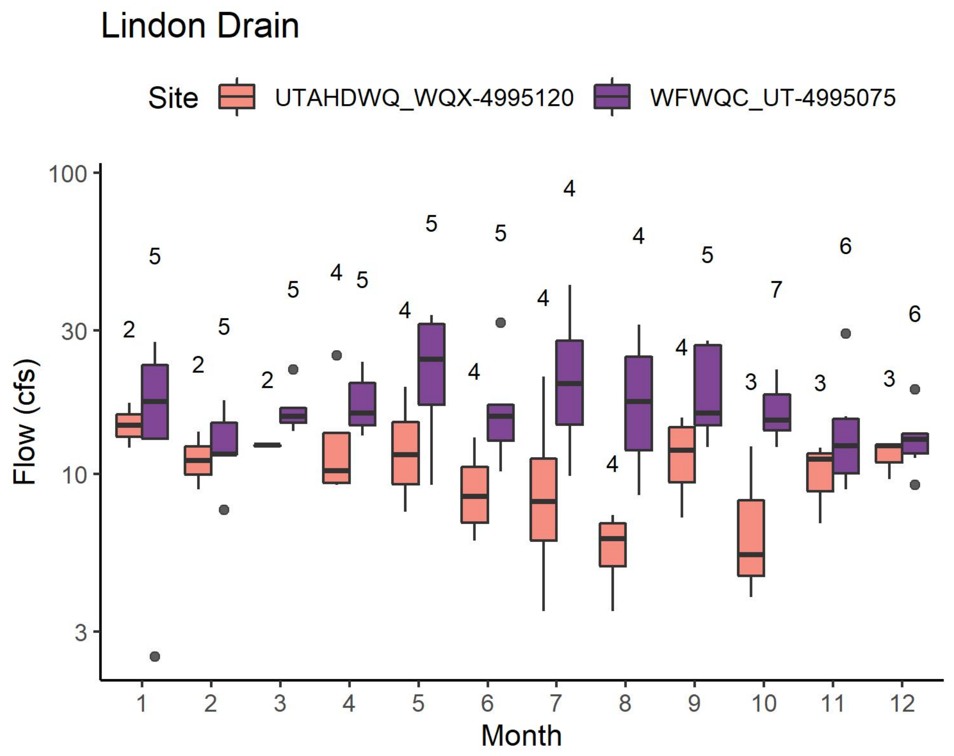
EXTERNAL MASS BALANCE MODEL

UPDATES SINCE LAST TIME

- WFWQC uploaded new flow data to Water Quality Portal week of 6/10
  → incorporated new data for 2018 forward and re-ran analysis
- Flagged sub-catchments w/
  - Previous flow inconsistencies
  - New flow inconsistencies

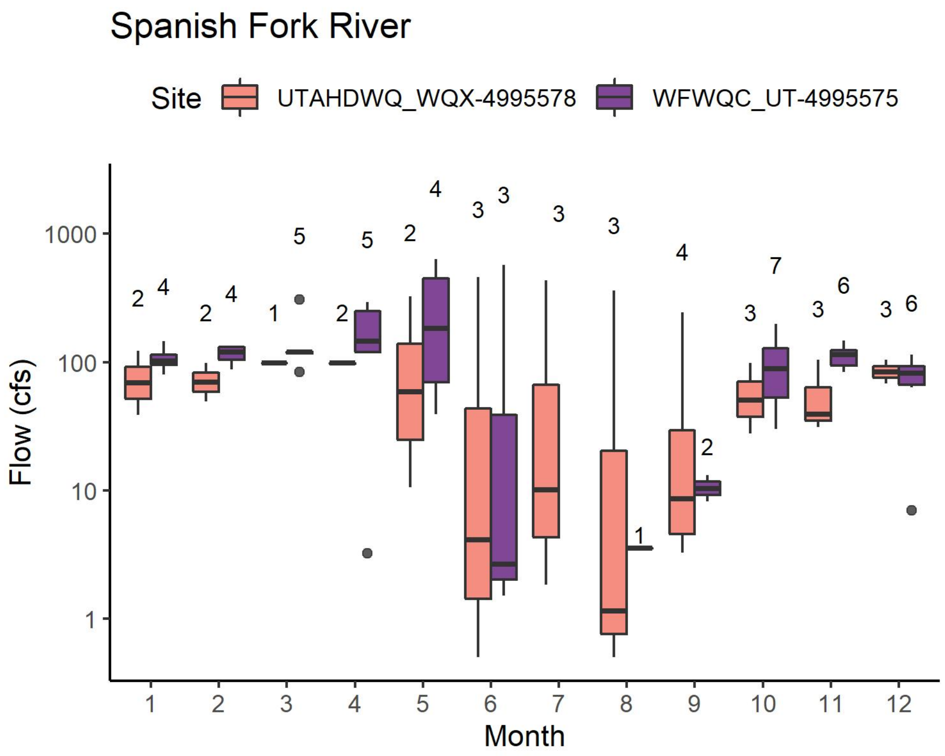
LINDON DRAIN

- Recall: WFWQC flow > DWQ flow
- Field site visit:
  - DWQ site located upstream of PacifiCorps Energy discharge site
  - WFWQC located downstream of PacifiCorps Energy discharge site
  - →WFWQC site represents total load, DWQ site + DMR represents total load → combine all
- PacifiCorps Energy
  - Flow: 1.7-2.6 cfs
  - TP load: 0.17-0.33 ton/mo



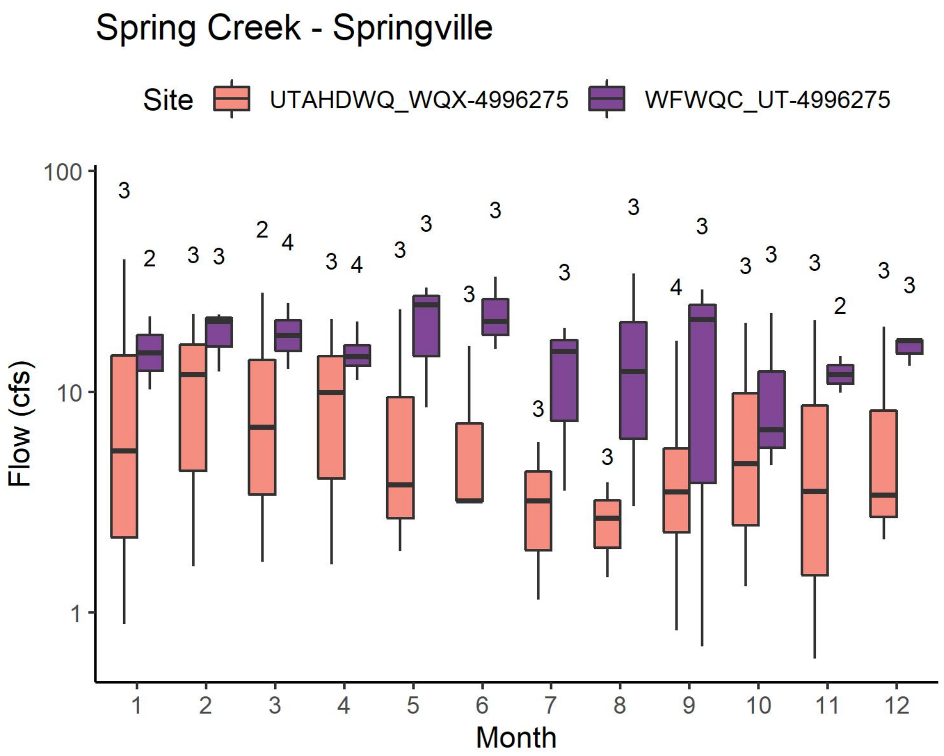
SPANISH FORK

- New WFWQC flow data → filled in previous lack of summer samples
- Flows now comparable
- Used both entities for loading calculations



SPRING CREEK - SPRINGVILLE

- New WFWQC flow data indicate flow discrepancy between entities (same site)
- Proceeded with using both entities
- Impacts to TP loading estimates (ton/yr)
  - Both: 12.82
  - DWQ: 8.83
  - WFWQC: 17.68
- Impacts on TN loading estimates (ton/yr)
  - Both: 55.12
  - DWQ: 50.91
  - WFWQC: insufficient data



UPDATES TO LOADING CALCULATIONS

Sub-Catchment	Summary of changes	TP load (old)	TP load (new)	TN load (old)	TN load (new)
Lindon Drain	Added DMR TP load (3.04) Included WFWQC data	0.87	3.65	29.09	36.09
Spanish Fork	Flagged lack of flow discrepancy Included WFWQC data	7.83	12.71	48.89	53.43
Spring Creek - Springville	Flagged flow discrepancy between entities – no action	9.44	12.82	55.12	55.12
Mill Race	Used tributary rather than DMR to estimate loads	51.88	27.29	318.31	257.41
Total tributary loading		**267**	**268**	**1787**	**1723**

NEXT STEPS

- Full results presented in technical report
- Additional detailed data for each sub-catchment included in appendix
- Report will be circulated to SP subgroup for review

SEDFLUX MODEL

SEDFLUX MODELING

- Organic matter settling rates
  - Data exist for Utah Lake for sediment content & accumulation
  - UL data lack density needed to generate areal input rates
  - UL data are for sediment, not sinking OM
  - → estimate from literature, run several scenarios across probable range

- Water column depth
  - Main basin observed: 1.9-3.5 m
  - Main basin scenario: 2.0 m ("shallow")
  - Provo Bay observed: 0.2 m
  - Provo Bay scenario: 1.5 m ("deep")

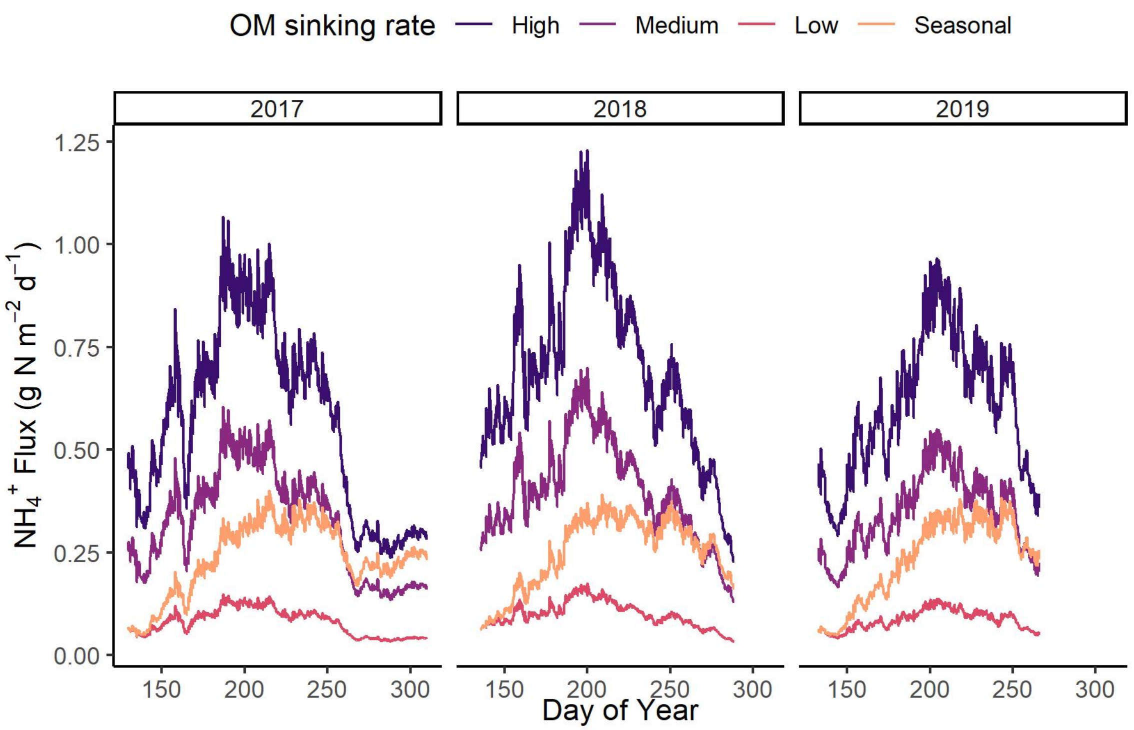
SEDFLUX COMPARISONS TO OTHER STUDIES

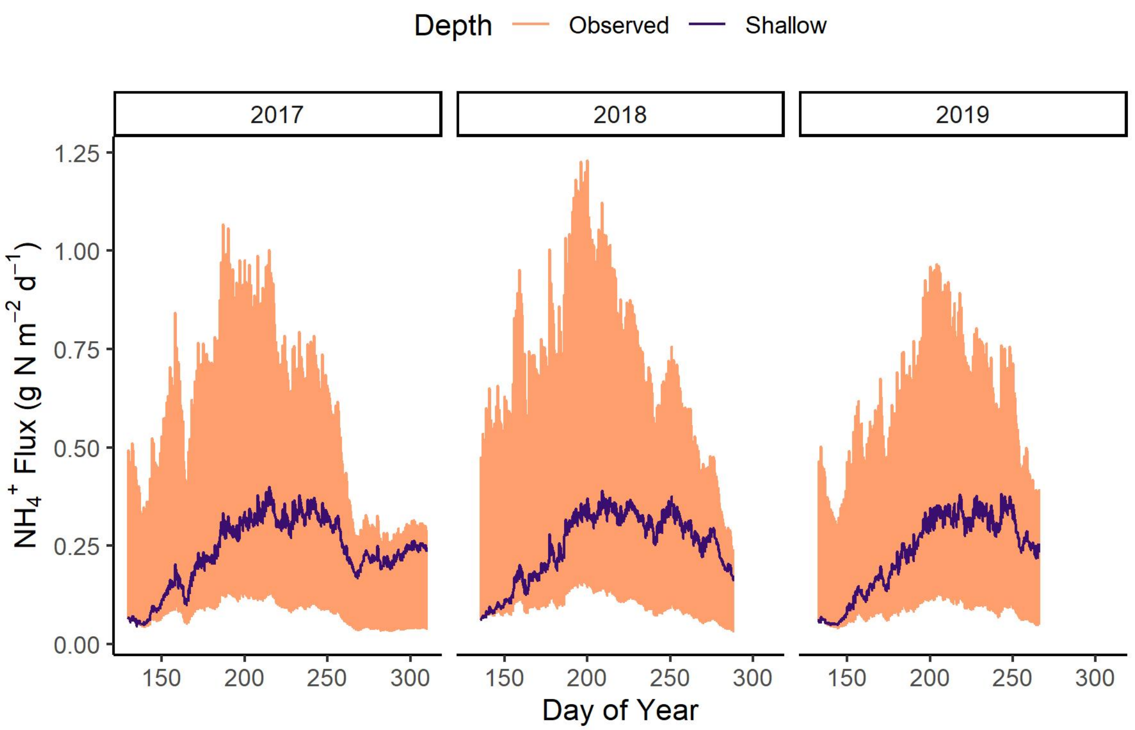
- SRP, NH_4^+, NO_3^- comparable to other studies
- SOD higher than other studies

Rate ($g\ m^{-2}\ d^{-1}$)	Main Basin This Study	Hogsett et al. 2019	Goel et al. 2020	Provo Bay This Study	Hogsett et al. 2019	Goel et al. 2020
SRP Flux	0.006-0.20	-0.004-0.071	-0.0024 ± 0.0042	0.005-0.17	0.01	-0.012 ± 0.0097
NH_4^+ Flux	0.03-1.23	-0.033-0.141	-0.0098 ± 0.0034	0.005-0.89	1.442	-0.017 ± 0.01
NO_3^- Flux	-0.01-0.01	-0.008-0.08	--	-0.13-0.009	0	--
SOD	**4.90-14.38**	**0.9-2.04**	**2.97**	**1.91-14.58**	**4.61**	**0.05**

NH_4^+ FLUX

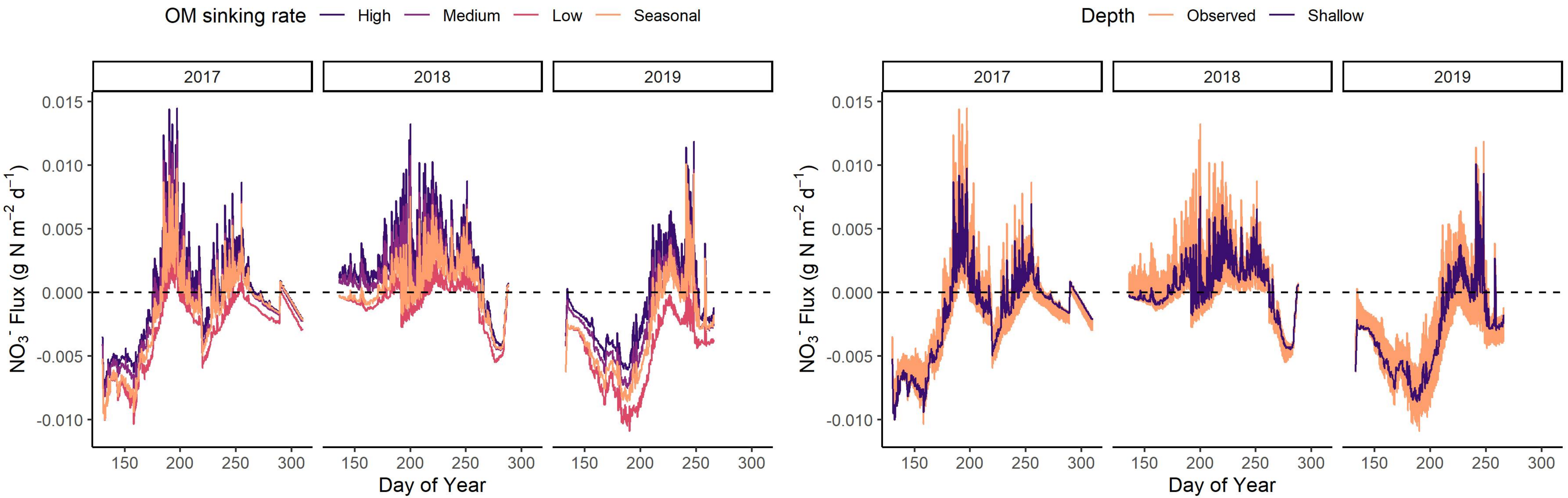
- Flux to water column (+)
- Highest under high OM sinking rate
- Variability: observed > shallow depth





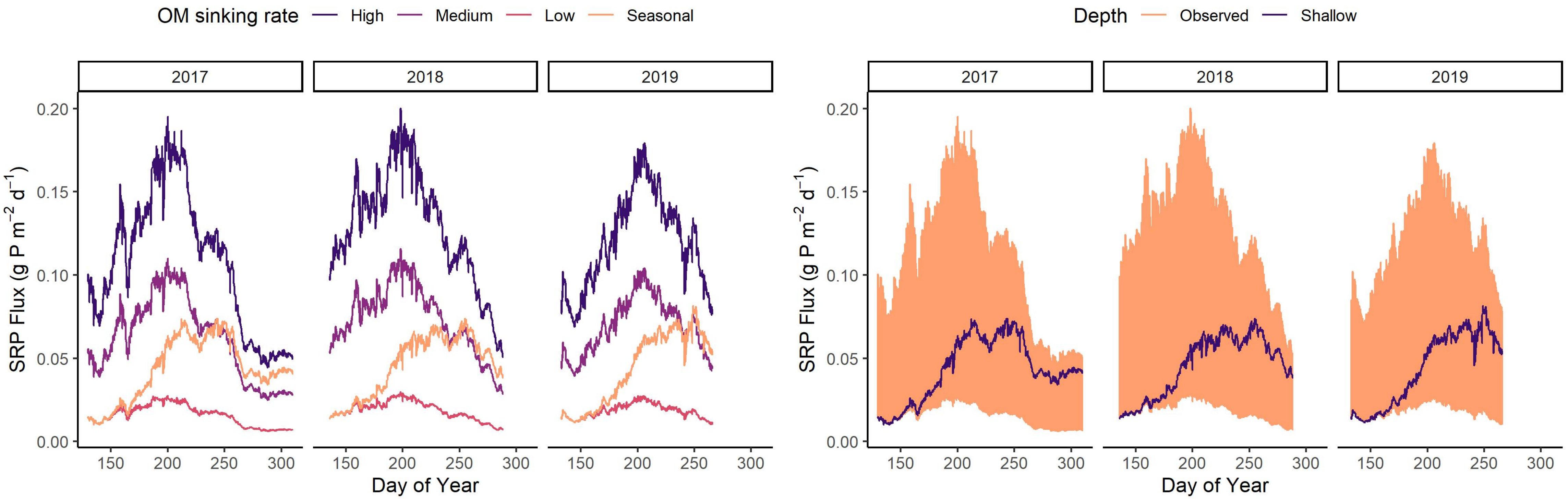
NO_3^- FLUX

- Flux to water column in summer (+), to the sediment in spring & fall (-)
- Highest under high OM sinking rate
- Variability: observed > shallow depth



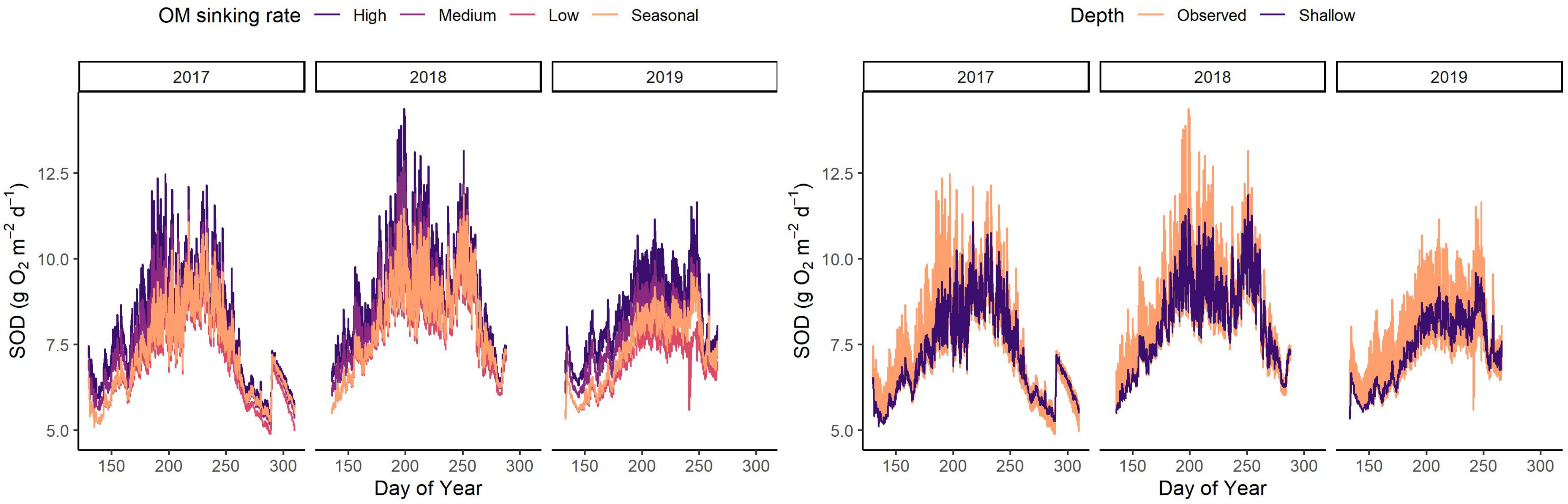
SRP FLUX

- Flux to water column (+)
- Highest under high OM sinking rate
- Variability: observed > shallow depth



SEDIMENT OXYGEN DEMAND (SOD)

- Highest under high OM sinking rate
- observed > shallow depth



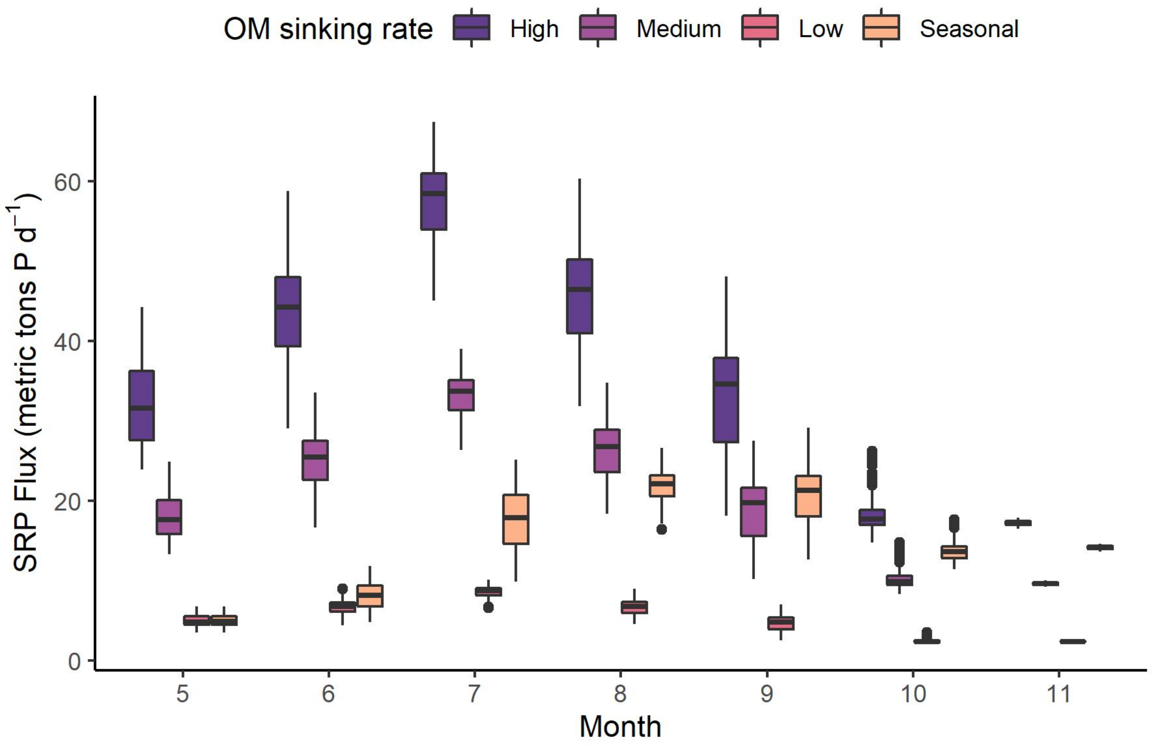
SOD EXPLORATION

- SOD not particularly sensitive to reaction network parameters
- SOD is sensitive to:
  - Water column DO concentration (accurate)
  - Settling rate of POC (inaccurate?)
- Hypotheses…
  - Sediment dilutes incoming POC
  - Frequent resuspension → does SOD become BOD?

→ SedFlux may not capture important factors driving SOD

ADDITIONAL SEDFLUX RESULTS

- Provo Bay
  - Similar response as main basin to OM levels
  - Rates: observed < deep
- Lakewide rates
  - Multiplied rates by daily lake area
  - Highly dependent on OM sinking rates
  - Seasonally variable
  - Lack of winter data → extrapolating to yearly rates not recommended, would likely overestimate true rates



NEXT STEPS

- Full results presented in technical report
- Additional detailed data for each sub-catchment included in appendix
- Report will be circulated to SP subgroup for review

UTAH LAKE CHARGE QUESTIONS UPDATE

ULWQS Science Panel Meeting
2021-07-26
Presented by Kateri Salk, Tetra Tech

CHARGE QUESTION REPORTING

- SP to report out on charge questions to SC
- Last meeting: chose option to have SP subgroups work with Tetra Tech to evaluate evidence for each question
- Since last meeting:
  - Tetra Tech grouped questions into 6 themes
  - SP members signed up for subgroups

SUBGROUPS

Subgroup	Name
Criteria Development	Theron Miller
Fish, Aquatic Life, Birds	Michael Mills
	Soren Brothers
	Theron Miller
Harmful Algal Blooms	Hans Paerl
	Janice Brahney
	Theron Miller
Historical Condition	Michael Mills
	Greg Carling
	Soren Brothers
	Hans Paerl
	Janice Brahney
Macrophytes and Diatoms	Soren Brothers
	Janice Brahney
	James Martin
Sediments	Greg Carling
	Janice Brahney
	James Martin
	Theron Miller

NEXT STEPS

- Tetra Tech to assist in assembling evidence w/ subgroups
- Items to include in charge question response
  - Evidence evaluation
  - Confidence evaluation
  - Likelihood evaluation (pending sufficient confidence)
- Response also includes
  - Summary
  - Traceable account (type, amount, degree of agreement, uncertainty)

CHARGE QUESTIONS

(Subsequent slides not presented but are included for informational purposes and/or in response to possible questions during the presentation)

I. HISTORICAL CONDITION

1.1. What does the diatom community and macrophyte community in the paleo record tell us about the historical trophic state and nutrient regime of the lake?

> **1.1.i.** Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?
>
> **1.1.iii.** How have environmental conditions changed over time?

1.2. What were the historic phosphorus, nitrogen, and silicon concentrations as depicted by sediment cores? (add calcium, iron, and potentially N and P isotopes)

1.4. What do photopigments and DNA in the paleo record tell us about the historical water quality, trophic state, and nutrient regime of the lake?

4.1. What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources? This question may require the identification of primary sources of nutrients.

2. MACROPHYTES AND DIATOMS

1.1.ii. What were the environmental requirements for diatoms and extant macrophyte species?

2.2 What are the environmental requirements for submerged macrophytes currently present at Utah Lake?

> **2.2.i.** What is the role of lake elevation and drawdown in macrophyte recovery? Are certain species more resilient to drawdowns and nutrient related impacts? Can some species establish/adapt more quickly?
>
> **2.2.ii.** What is the relationship between carp, wind, and macrophytes on non-algal turbidity and nutrient cycling in the lake? What impact could macrophyte reestablishment have?

3. FISH, AQUATIC LIFE, AND BIRDS

1.3. What information do paleo records (eDNA/scales) provide on the population trajectory/growth of carp over time? What information do the paleo records provide on the historical relationship between carp and the trophic state and nutrient regime of the lake?

2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

- **2.1.i.** What contribution do carp make to the total nutrient budget of the lake via excretion rates and bioturbation? How much nutrient cycling can be attributed to carp?
- **2.1.ii.** What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?
- **2.1.iii.** How much non-algal turbidity and nutrient cycling is due to wind action versus carp foraging? How much does sediment resuspension contribute to light limitation, and does wind resuspension contribute substantially in the absence of carp?

2.5. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife: i. Where and when in Utah Lake are early life stages of fish present? ii. Which species are most sensitive and need protection from nutrient-related impacts?

4.2. Assuming continued carp removal and current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30¬50 years)?

HARMFUL ALGAL BLOOMS

2.3. What are the linkages between changes in nutrient regime and Harmful Algal Blooms (HABs)?

- **2.3.i.** Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources? Data analysis
- **2.3.ii.** Which nutrients are controlling primary production and HABs and when?
- **2.3.iii.** If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?
- **2.3.iv.** How do other factors affect HAB formation in Utah Lake (e.g., climate change; temperature; lake stratification; changes in zooplankton and benthic grazers and transparency)
- **2.3.vi.** What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?

4.3. If the lake stays in a phytoplankton-dominated state, to what extent can the magnitude, frequency, and extent of harmful and nuisance algal blooms be reduced through nutrient reductions?

SEDIMENTS

2.3.v. What is the role of calcite "scavenging" in the phosphorus cycle?

2.4. How do sediments affect nutrient cycling in Utah Lake?

- **2.4.i.** What are current sediment equilibrium P concentrations (EPC) throughout the lake? What effect will reducing inputs have on water column concentrations? If so, what is the expected lag time for lake recovery after nutrient inputs have been reduced?
- **2.4.ii.** What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions?
- **2.4.iii.** Does lake stratification [weather patterns] play a result in anoxia and phosphorus release into the water column? Can this be tied to HAB formation?

CRITERIA DEVELOPMENT

3. What additional information is needed to define nutrient criteria that support existing beneficial uses?

- **3.1.** For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife
- **3.2.** For primary contact recreation
- **3.3.** For agricultural uses including irrigation of crops and stock watering

UTAH LAKE WATERSHED MODEL SELECTION PROCESS

ULWQS Science Panel Meeting
2021-07-26
Presented by Kevin Kratt, Tetra Tech

UTAH LAKE WATER QUALITY MODELING - OVERVIEW

- Contract signed July 21, 2021
- Study objectives:
  1. Provide technical expertise to the Science Panel in the areas of mechanistic hydrodynamic, water quality and watershed modeling.
  2. Further refine and develop the Utah Lake Nutrient Model (ULNM) so that it is a scientifically defensible decision support tool for establishing Numeric Nutrient Criteria (NNC).
  3. Quantify the uncertainty of the ULNM in predicting nitrogen and phosphorus concentrations, and associated algal and cyanobacterial biomass response in order to build confidence in model outputs and application to NNC.
  4. Apply ULNM to support determination of NNC concentrations.
  5. Develop and calibrate a watershed model to be used as a scientifically defensible decision support tool for evaluating nutrient load reduction scenarios.
  6. Apply watershed model for evaluation of nutrient load reduction scenarios.

UTAH LAKE WATER QUALITY MODELING - SCHEDULE

Tasks		2021					2022												2023											
		A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1A	Review existing lake model documentation	■	■																											
1B	Application of existing lake models		■																											
2	Lake model enhancements			■	■	■	■	■	■	■	■	■																		
3	Lake model validation/calibration refinement			■	■	■	■	■	■	■	■	■																		
4	Lake model uncertainty analysis												■																	
5	Lake model application to NNC development											■	■	■	■	■														
6	Lake model documentation and training																■	■												
7	Watershed model selection and approach	■	■																											
8	Watershed model QAPP			■	■																									
9	Watershed model development					■	■	■	■	■	■	■	■	■	■															
10	Watershed model application to scenarios														■	■	■	■	■											
11	Watershed model documentation and training																						■	■						
12	ULWQS reports																			■	■	■	■	■	■	■	■			
13	SC and SP interaction	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
14	Project management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

TASK 7 – WATERSHED MODEL SELECTION

1. Tetra Tech will develop and circulate proposed watershed selection criteria and candidate watershed models
2. Science Panel and Steering Committee will review and propose edits to the criteria and candidate models
3. Tetra Tech will proceed with evaluation and recommend top model(s)
4. Science Panel and Steering Committee will review the evaluation and will select and approve a final watershed model(s)

PROPOSED MODEL CRITERIA

Technical Criteria

- Processed-based hydrology and water quality simulation
- Simulates erosion and sediment transport
- Simulates build-up and wash-off of nutrients on the landscape and stream transport
- Simulates nutrients and represents species for nitrogen and phosphorus as well as particulate, dissolved, and total forms
- Simulates DO, BOD, algae, and water temperature
- Simulates pH/alkalinity and/or important cations (Ca)
- Simulate carbon (dissolved organic carbon and total organic carbon)
- Includes explicit representation of plant growth on the watershed

PROPOSED MODEL CRITERIA (continued)

Source Representation Criteria

- Temporal and spatial resolution supports identification of targeting priorities (e.g., model time step; heterogeneity in conditions like weather across the landscape)
- Uniquely represents loads from land uses/covers in the watershed (agriculture, developed, forest) to support Load Allocation (LA) development
- Capable of supporting assignment of Waste Load Allocations (WLAs) to permitted stormwater and wastewater dischargers
- Simulates lawn/landscape and crop irrigation
- Simulates atmospheric deposition of nutrients to the landscape and waterbody surfaces
- Able to model imported water (flow and water quality)
- Simulates nutrient contributions to the lake from surface runoff and active shallow groundwater

PROPOSED MODEL CRITERIA (continued)

Usability Criteria

- Feasible to link to EFDC-WASP
- Includes landscape/upland and stream reach outputs
- Allows for assessment of natural conditions, future land use, and climate change
- Capable of predicting potential reductions for management/implementation actions
- Computational time step is not overly restrictive to model calibration
- Availability of tools for model calibration and sensitivity/uncertainty tests
- Historically used for TMDL development
- Ease of use and active user base
- Data availability for model population and calibration

PROPOSED MODEL CRITERIA (continued)

<u>General Platform Criteria</u>

- Sufficient documentation on model theory and user guide
- Open-source code
- Freeware with no licensing fee
- Stable code during runtime
- Ease to modify the model source code

CANDIDATE MODELS

- Hydrologic Simulation Program – FORTRAN (HSPF)
- Soil and Water Assessment Tool (SWAT)
- Agricultural Policy / Environmental eXtender (APEX)
- Generalize Watershed Loading Functions model (GWLF)
- Loading Simulation Program C++ (LSPC)
- Stormwater Management Model (SWMM)
- Hydrologic Modeling System (HEC-HMS/RAS)
- Regional Hydro-Ecologic Simulation System (RHESSys)/Distributed Hydrology-Soils-Vegetation Model (DHVSM)
- Gridded Surface/Subsurface Hydrologic Analysis (GSSHA)
- Watershed Analysis Risk Management Framework (WARMF)

QUESTIONS/DISCUSSION

Atmospheric Deposition to Utah Lake