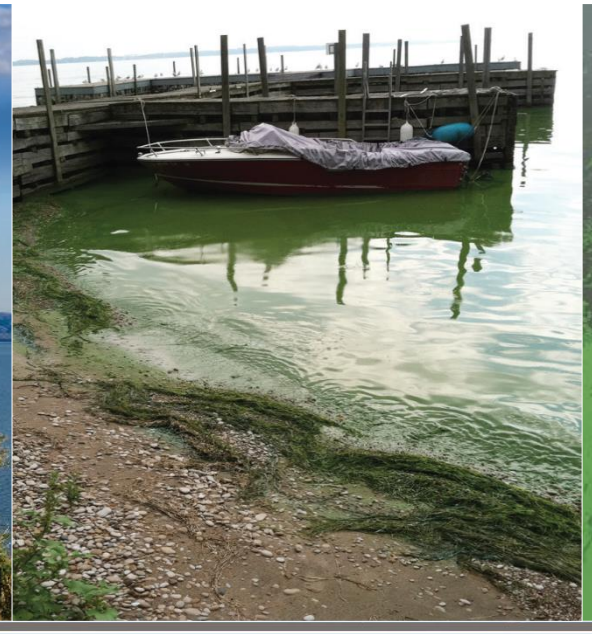
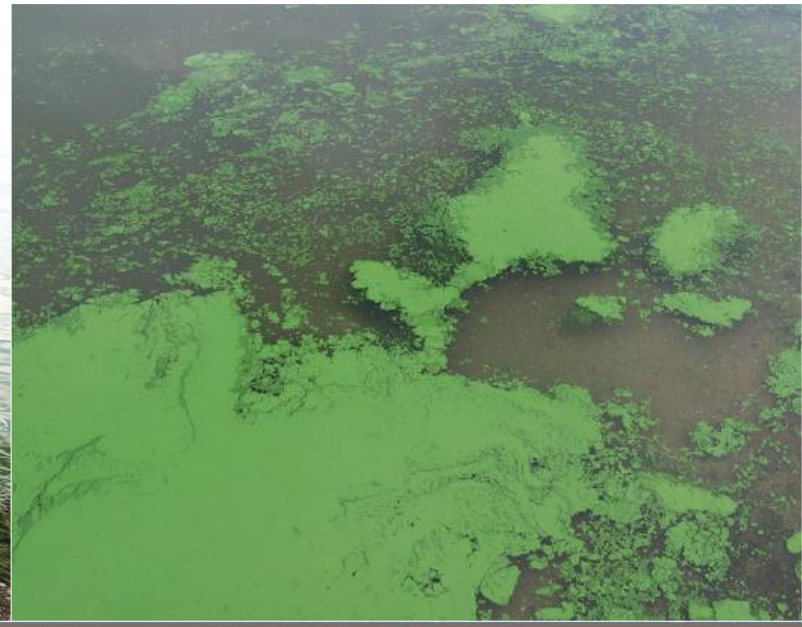
UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

TETRA TECH

Utah Lake Atmospheric Deposition

Science Panel Meeting | August 3, 2022





Goals

- Summarize atmospheric deposition work to date
- Apply Uncertainty Guidance Framework to evaluate sources of evidence
- Recommend atmospheric deposition estimates to EFDC/WASP modeling team

Tetra Tech Role: Synthesis Document

- Compile and review all sources of evidence
- Evaluate confidence using the SP's Uncertainty Guidance Framework
- Synthesize recommendations based on:
  - Previous SP recommendations
  - Third party review (David Gay)
- Worked alongside SP subgroup who provided edits

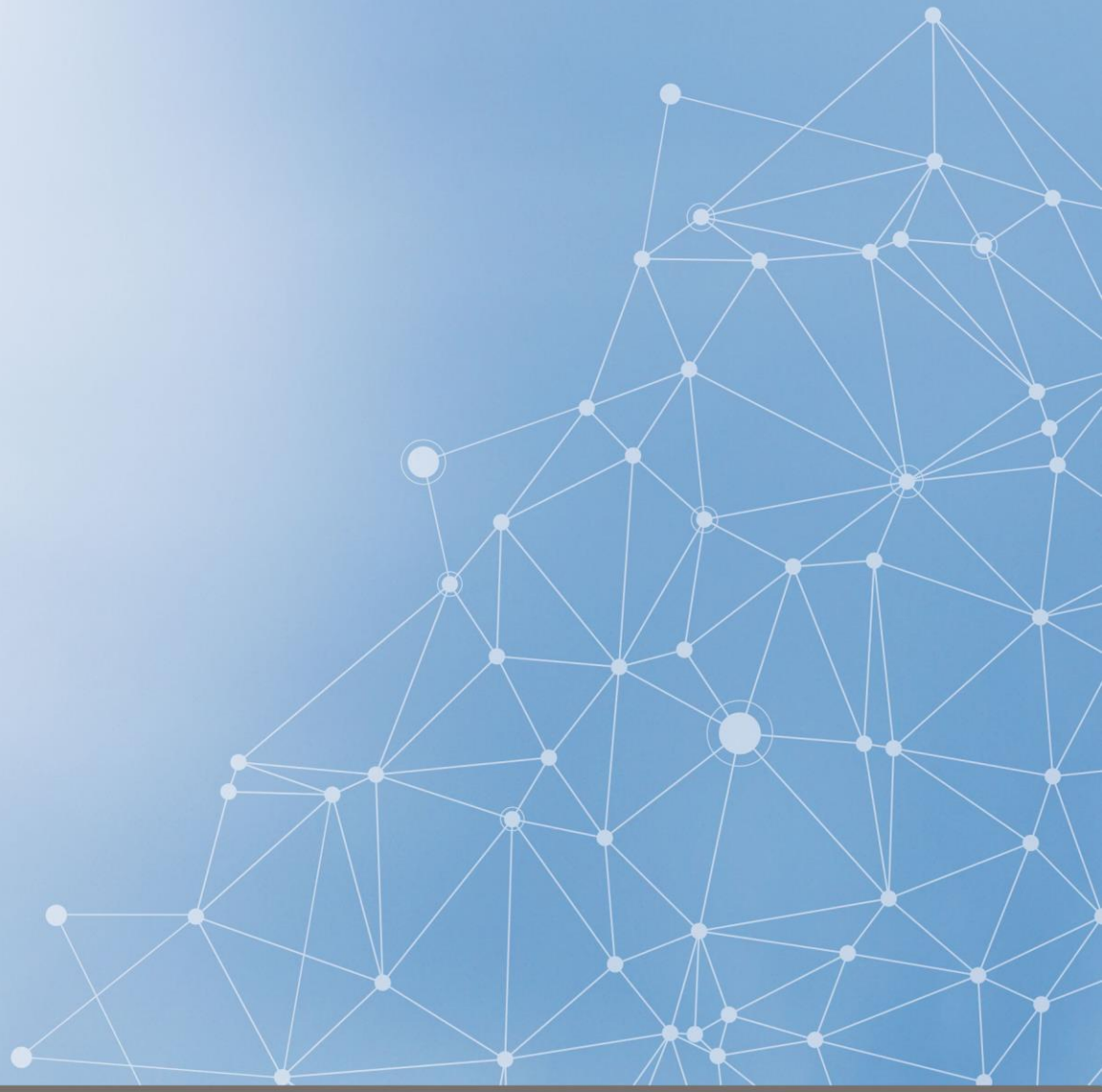
Note: Synthesis document represents a compilation of previous and current SP work, not a proposed recommendation from Tetra Tech

Comments on Period of Analysis from Theron Miller

- **AD estimates are relevant in relation to other nutrient sources to Utah Lake (e.g., POTW loads). Concern about using estimates from 2015-2020 rather than most up-to-date loads.**
  - EFDC/WASP model needs to be calibrated with known data for inputs and in-lake conditions
  - 2015-2020 is the period for which full datasets exist
  - Scenarios will be run with EFDC/WASP to simulate reductions in loads (current and future)
  - Mass balance analyses (e.g., Brett) use data from this same period because (a) data are available and (b) the time period is consistent with other analyses

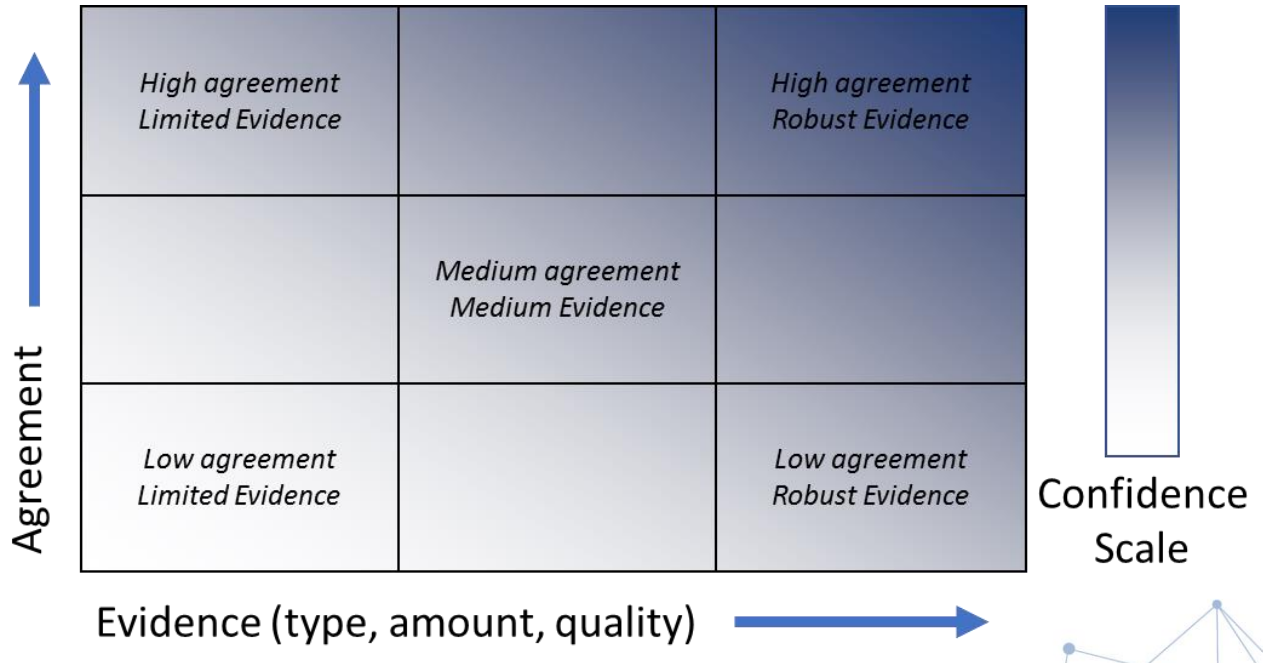
Decision Points

1. Uncertainty Framework
2. Areal Flux
3. Attenuation
4. Load
5. Speciation



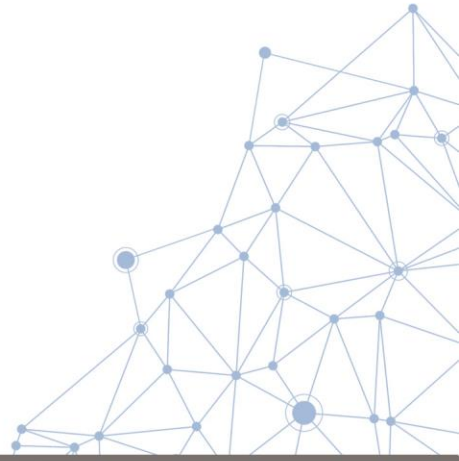
Uncertainty Guidance Framework

- ***Type***: derivation of evidence
- ***Amount***: quantity of independent evidence types
- ***Quality***: rigor with which the evidence was derived
- ***Agreement***: how results or conclusions among lines of evidence differ or concur



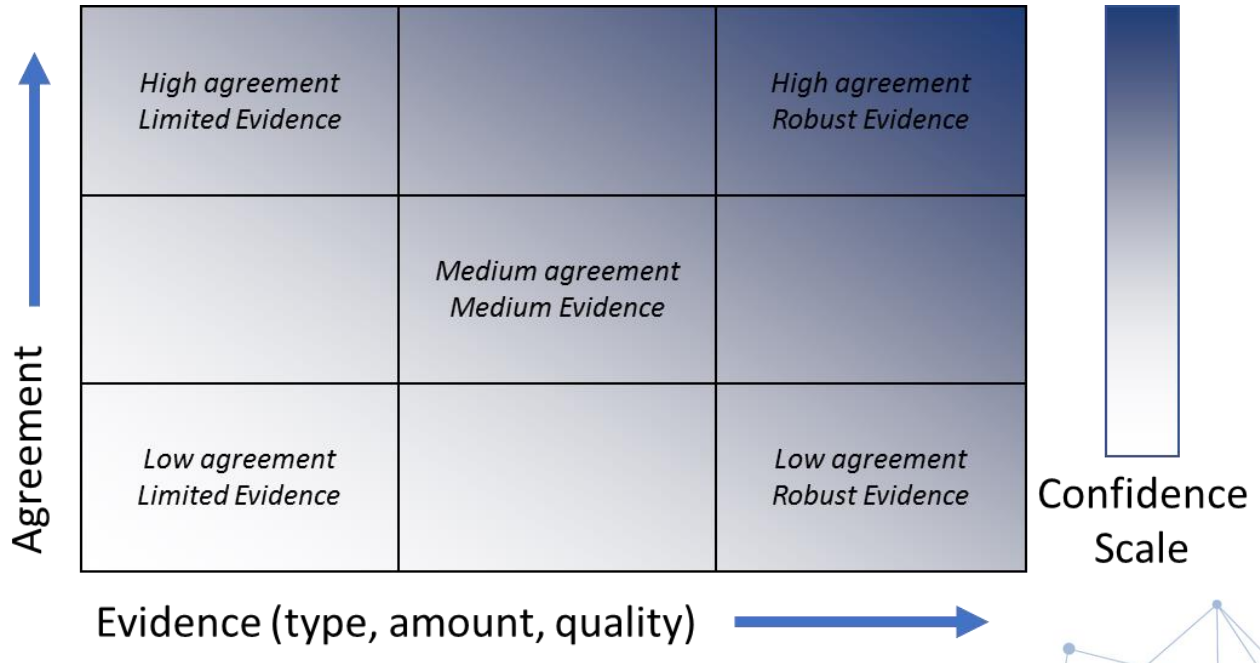
Review of Evidence

- Direct studies
  - Olsen et al. 2018
  - Reidhead 2019
  - Miller W. 2021
  - Barrus et al. 2021 (& data analysis by Hogsett 2022)
- Local & regional dust models
  - Brahney 2019, 2022
  - Carling 2022
- Mass balance & other constraining analyses
  - Brett 2022
  - Brahney 2022
- Global reviews



Uncertainty Guidance Framework

- *Type*
  - Direct, screened
  - Direct, unscreened
  - Dust measurements
  - Mass balance
  - Global review
- ***Amount*** (count)
- ***Quality***
  - Direct > indirect local (dust, mass balance) > global reviews
  - SP and third-party recommended methodology assigned higher quality
- ***Agreement*** (consistency within type and across types)



Study	Evidence Type	Sample Size/Period of Record	QA/QC Considerations	Consideration for Recommendation
Olsen et al. 2018	Direct Unscreened samples, analysis with and without contaminated samples	Weekly data at five shoreline sites May 2017-December 2017	Uses an unscreened sampler, though contaminated sample removal was tested. Raw data were not available for the SP to evaluate.	Not considered Note: estimates screened for contaminated samples are within range of other estimates
Reidhead 2019	Direct Unscreened samples	Weekly or biweekly data at five shoreline sites April 2018-November 2018	Uses an unscreened sampler. Raw data were not available for the SP to evaluate.	Not considered
Miller W. 2021	Direct Unscreened samples, analysis with and without outliers removed	Approximately weekly data at 9 shoreline sites January 2017-June 2020	Measurements based on a bulk precipitation sampler that was unscreened. Sampling plan and raw data not available for the SP to evaluate.	Not considered Note: estimates screened for outliers are within range of other estimates
Barrus et al. 2021	Direct Screened and unscreened samples	Unscreened: approximately weekly data at 4 shoreline sites January 2019-May 2020 Screened: approximately weekly data at 4 shoreline sites and at Bird Island June 2020-December 2020	2020 measurements are based on SP-recommended sampler design but include unscreened samples January-May.	Consider data only if estimates of screened data alone are provided
Hogsett 2022 (calculated from Barrus data)	Direct Screened and unscreened samples	Unscreened: approximately weekly data at 4 shoreline sites January 2019-May 2020 Screened: approximately weekly data at 4 shoreline sites June 2020-December 2020	2020 measurements are based on SP and third party-recommended sampler design and data QA	Consider screened 2020 data as upper bound of load (no attenuation assumed)

Analyses based on dust, mass balance, global reviews

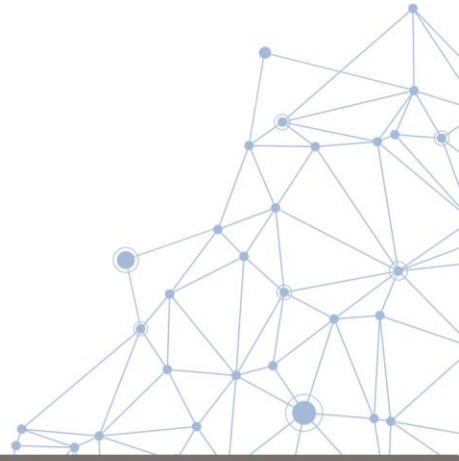
Study	Evidence Type	QA/QC Considerations	Consideration for Recommendation
Brahney 2019	Local & regional dust modeling	Uncertainty evaluated using bootstrapping Data available in report	Consider as lower bound
Brahney 2022	Local & regional dust modeling	Uncertainty evaluated using factorial application of variability Data available in report	Consider Constraining analysis
Carling 2022	Local & regional dust modeling	Uncertainty evaluated by applying upper value when relevant Data available in report	Consider as upper bound Constraining analysis
Brahney 2022	Mass balance	Uncertainty evaluated using factorial application of variability Data available in report	Consider Constraining analysis
Brett 2022	Mass balance	Uncertainty evaluated using factorial application of variability Data available in report	Consider as upper bound Constraining analysis
Brahney 2019, 2022	Global review	Based on global review, intended as comparison point	Not considered

Comments on Uncertainty Guidance from Theron Miller

- Concerns of treatment of outliers by Hogsett and assignment of baseline vs. total loads
- Concerns about leaving out W. Miller data from recommendations
- Concerns about leaving out Barrus data from recommendations
- Concerns of sample size used for mass balance and dust analyses
- Perception of double standard of SP's raw data request for BYU data

Uncertainty Guidance: Ideas for SP Recommendation

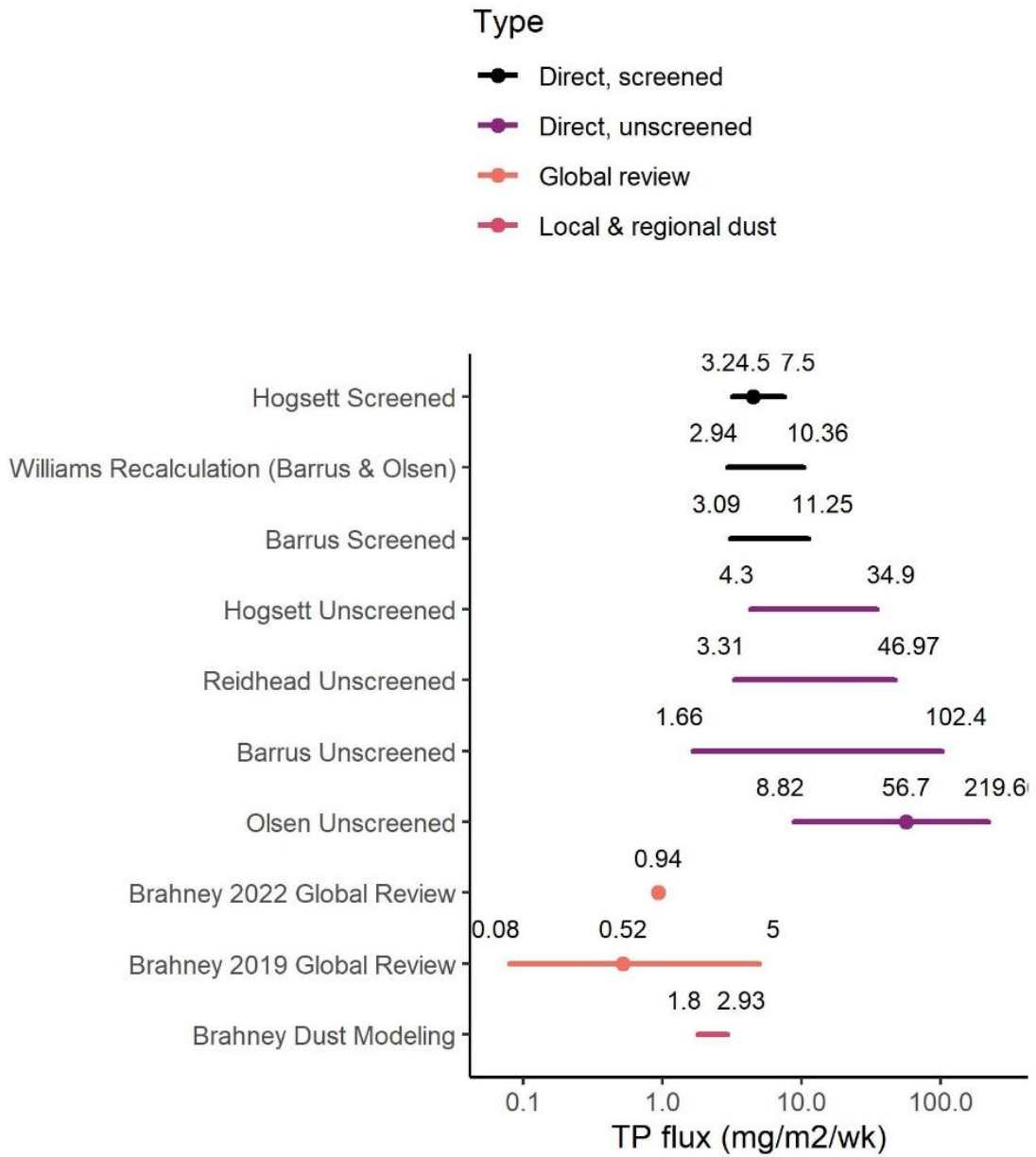
- **Consistency and overlap in estimates within and between evidence types**
- **High confidence that the true rate of atmospheric deposition to Utah Lake falls within the range estimated by lines of evidence**
  - Evidence types that directly measure atmospheric deposition and use methodology recommended by SP and third-party review have highest confidence.
  - Indirect estimates based on local data (mass balance, dust) have medium confidence and can be used as constraining analyses.



Science Panel Conclusions and Next Steps: Uncertainty Framework

Areal Flux

- Direct, screened measurements align with SP and third-party recommendations → highest quality
- Direct, unscreened measurements have limited quality per SP recommendation
- Global reviews (intended as comparative) and local & regional dust modeling overlap with low end of direct, screened fluxes



Comments on Areal Flux from Theron Miller

- Perception that effect of screening is mis-explained. Insects temporarily occurred at Mosida and Lakeshore and qualify as legitimate atmospheric deposition.

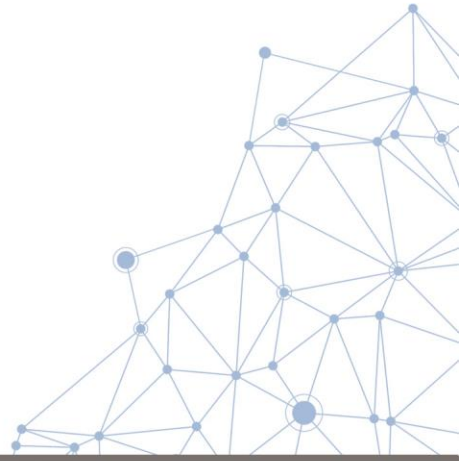
Areal Flux: Ideas for SP Recommendation

- **Calculate areal flux estimates based on direct measurements of screened samples that explicitly exclude sources of contamination**
- **Samples generated from most recent SAP be prioritized**
  - 2020 samples after screens were installed
  - Incorporate recommendations of SP and third-party review

Science Panel Conclusions and Next Steps: Areal Fluxes

Attenuation

- **Concept: fluxes may reduce (attenuate) moving from shoreline to mid-lake**
- **Options:**
  - Mathematical averaging across monitored locations, no attenuation
  - Spatial interpolation across monitored locations (kriging), with or without attenuation
  - Attenuate based on decay equation to background levels



Attenuation

Potential advancement: Bird Island sampler

- Directly sample at mid-lake to see how much attenuation occurs
- BUT fluxes were greater here than at shoreline sites
- Implies that there is a nutrient source to Bird Island Sampler beyond what is observed at shoreline sites

Hypotheses to account for increased flux at Bird Island

1. Shoreline source that wasn't sampled (NW side of Utah Lake?)
2. Lake source that does not represent atmospheric deposition

Comments on Attenuation from Theron Miller

- Description of Kriging is wrong and incomplete
- Concern about exclusion of Bird Island data

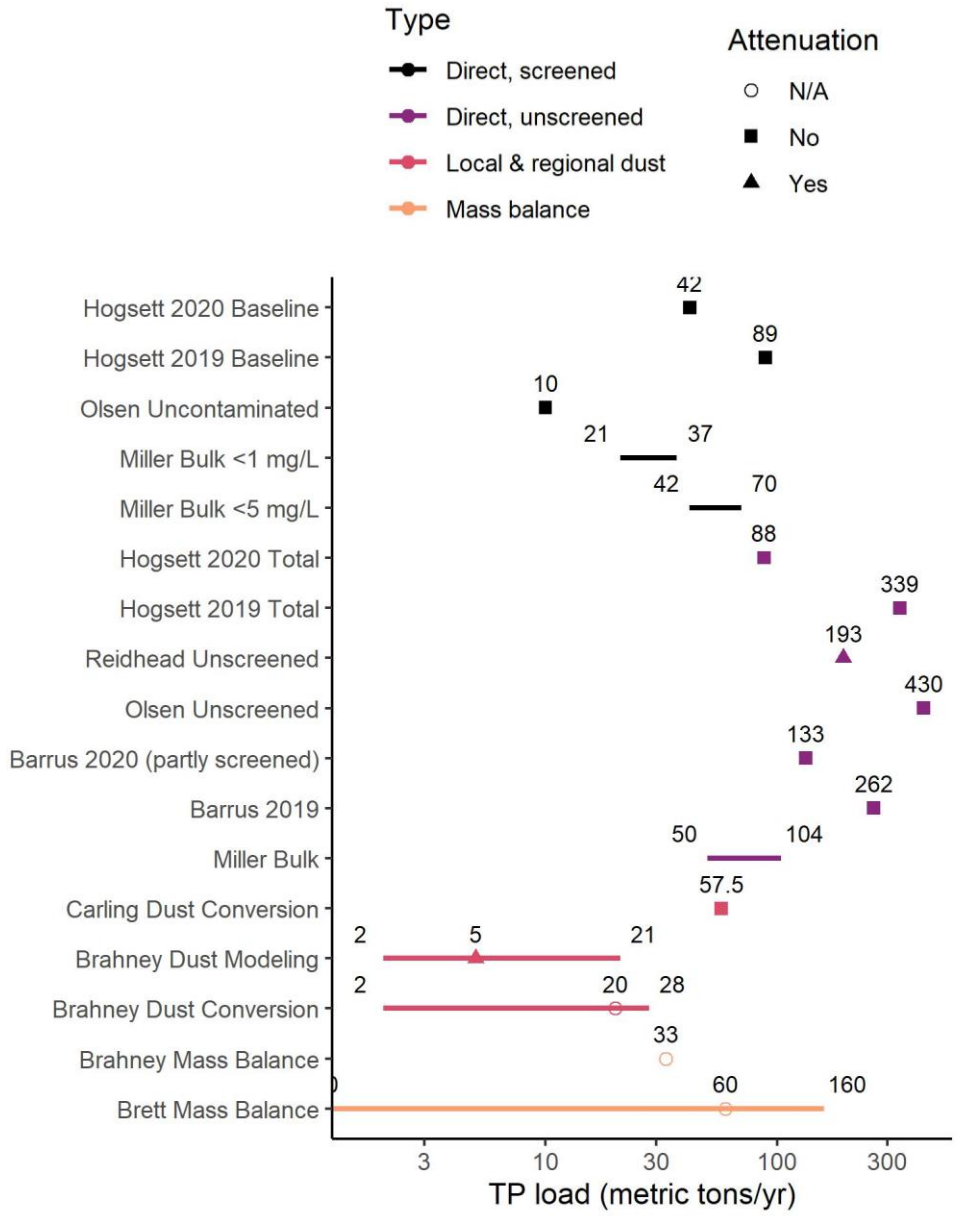
Attenuation: Ideas for SP Recommendation

- Exclude Bird Island for the time being while hypothesis testing occurs
- Assume zero attenuation of areal fluxes as upper bound of potential load
- Assume attenuation approaching regional background levels as lower bound

Science Panel Conclusions and Next Steps: Attenuation

Load to Utah Lake

- Combine areal fluxes and attenuation to calculate load
- Direct, screened measurements align with SP and third-party recommendations → highest quality
- Direct, unscreened measurements have limited quality per SP recommendation
- Local & regional dust modeling and mass balance analyses overlap with direct, screened loads



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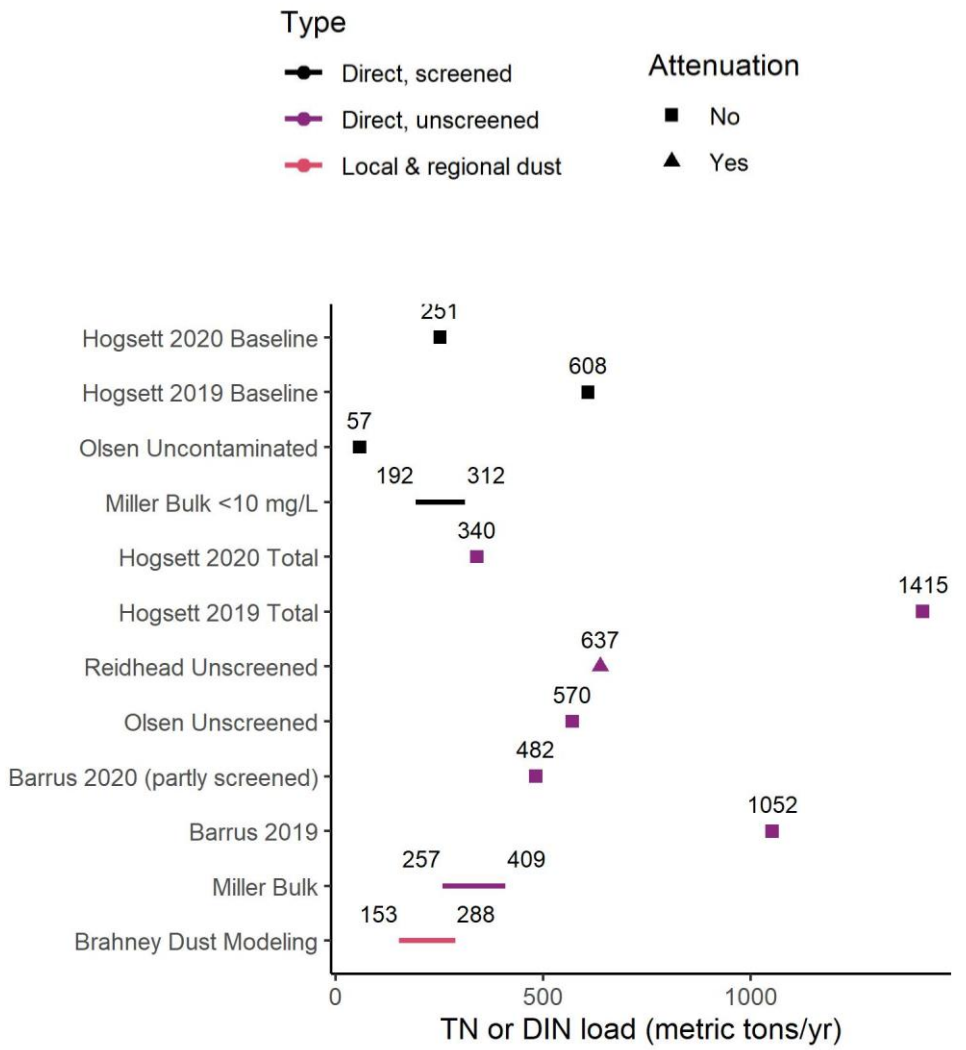

Load: Ideas for SP Recommendation

- **Eligible load estimates**
- **Upper bound:**
  - Non-attenuated loads
  - Upper bounds of constraining analyses
- **Lower bound:**
  - Attenuated loads by Brahney (2019)
- **Middle estimate:**
  - Estimate between upper and lower bounds
  - New attenuation factor calculated from fluxes

Constituent	Load (tons/yr)	Context	Source
TP	42	**Direct measurement** SP-recommended sampling design No attenuation	Hogsett 2022, calculated from Barrus 2021
	60	**Mass balance** Constraining analysis	Brett 2022
	57.5	**Local & regional dust conversion** No attenuation	Carling 2022
	33	**Mass balance** Constraining analysis	Brahney 2022
	20	**Local & regional dust conversion** Constraining analysis	Brahney 2022
	5	**Local & regional dust conversion** Attenuation	Brahney 2019
TN	251	**Direct measurement** SP-recommended sampling design No attenuation	Hogsett 2022, calculated from Barrus 2021
	153-288	**Community Multiscale Air Quality Model**	Brahney 2019

Science Panel Conclusions and Next Steps: Load

Chemical Speciation of Atmospheric Load

- **Total atmospheric loads are comprised of different chemical forms**
- **EFDC/WASP model takes atmospheric loading inputs as speciated loads rather than total loads**
- **Direct measurements indicate TP load is ~1/3 SRP**
  - Reidhead 2019: 37%
  - Miller W (2021): 32%
  - Consistent with regional dust bioavailability estimate by Brahney (2019): 34%
- **Direct measurement of N fluxes is already divided into nitrate and ammonium**

Chemical Speciation: Ideas for SP Recommendation

- Use a proportional factor to TP loads to estimate SRP (~1/3)
- Calculate ammonium and nitrate loads from directly sampled data

Science Panel Conclusions and Next Steps: Speciation