

Utah Lake Water Quality Study (ULWQS)
Atmospheric Deposition Subgroup
Meeting Outcomes
August 18, 2022, to February 23, 2023

The Utah Lake Water Quality Study Atmospheric Deposition Subgroup met from August 18, 2022, to February 2, 2023, to develop atmospheric deposition loading recommendations for the ULWQS. Following each meeting, Peak Facilitation Group distributed a summary of the meeting outcomes within a week. Please use the following links to quickly access meeting outcomes:

- [August 18 Meeting Outcomes](#)
- [September 8 Meeting Outcomes](#)
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August 18, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards and Gus Williams

Facilitation Team: Heather Bergman and Samuel Wallace

ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	<ul style="list-style-type: none"> Share the table that outlines the data needs for the atmospheric deposition analysis plan. Convert non-detects in Wood Miller's and Barrus (2021) datasets to half the value of the minimum detection limit. Calculate the interquartile range to identify outliers in the dataset. Identify the surface area of the bulk deposition sampler in the methodology of Wood Miller's report. (Reach out to Theron Miller if the sampler surface area is unavailable in the report.) 	Sep 1	
Gus Williams and Theron Miller	<ul style="list-style-type: none"> Provide a date when the research team added screens to collection buckets. Provide raw data for paired sampler design experiments, if available, to cross-reference with other datasets. Provide raw sampler data from 2021 if available. Provide data or metadata on the presence of insects or other observed sources of contamination cited in Barrus 2021 if available. 	Aug 29	

DRAFT ATMOSPHERIC DEPOSITION ANALYSIS PLAN

Kateri Salk, Tetra Tech, provided an overview of the draft atmospheric deposition analysis plan. Her comments are summarized below.

- The analysis plan aims to lay out a series of discussions for the Science Panel to develop a recommendation for atmospheric deposition load. The draft analysis plan is a starting point for discussion and can be revised based on Science Panel feedback.

- Task 1 in the analysis plan is to review the raw data from Gus Williams and Wood Miller. As part of this task, the Science Panel will evaluate the data quality assurance/quality control (QA/QC) and distributions and compare spatial and temporal variability across sampling sites.
- Task 2 in the analysis plan is to evaluate outlier samples for potential explanations. This task will involve identifying and reviewing existing and relevant information and David Gay's recommendations to inform the forthcoming analysis approach. Discussion topics will include sampler screening, sampler data QA/QC, potential contamination, sampler height, wet/dry versus bulk sampler design, attenuation, nutrient speciation, and consideration of multiple lines of evidence. The next step in the task will be to evaluate outlier samples to investigate potential causes. There may be multiple causes that impact samples that the Science Panel will investigate.
- Task 3 is to evaluate the spatial interpolation among sites and the attenuation of fluxes. This task involves the evaluation of temporal aggregation and spatial interpolation across sites. This task will culminate with the analysis of the impact of assumptions for no attenuation and rapid attenuation of loads moving from shoreline to mid-lake.
- Task 4 is to evaluate the speciation. This task will involve assessing the loads of individual chemical species of nitrogen and phosphorus as needed and identifying the relative proportions and absolute amounts of nitrogen and phosphorus constituents that make up the total atmospheric loads.
- Task 5 is to consider other analyses to compare to the direct atmospheric deposition estimates.
- Task 6 is to synthesize all the available lines of evidence to recommend an estimate of atmospheric loading that includes fluxes, attenuation, total load, and speciation of chemical constituents.
- This analysis plan is not finalized, and the Science Panel can modify the analysis plan as needed throughout the process.

TASK 1 DISCUSSION

Meeting participants discussed task 1 of the draft atmospheric deposition analysis plan. Their comments are summarized below.

Overview Discussion

- The purpose of task 1 is to consolidate the information from all the datasets into one place for review and discussion. The first step in task 1 is to impute non-detects, convert raw data to areal flux, and flag outliers.
- The high bulk deposition sample values should not be considered outliers. Those samples are due to natural variability related to high wind events.
- The purpose of flagging outliers is only to identify them. Flagging outliers does not mean they will be removed from the dataset.
- The Wood Miller dataset has precipitation data associated with it, and the Barrus (2021) dataset has wind events associated with it. In 2020, there was a dramatic reduction in atmospheric deposition, likely due to the low level of precipitation that year. According to recent papers, the screens that researchers installed on the samplers likely did not significantly reduce atmospheric deposition values.
- The metadata would help the Subgroup assess the datasets for potential contamination. The metadata is primarily the student's notes. The primary investigators normally do not archive those notes.

- Insects in the samplers may also be an additional source of nutrients to the lake, depending on whether they are from the water or land.
- The Barrus (2021) analysis includes the data from previous studies (Olsen and Reidhead). The Barrus (2021) study is the most recent dataset and analysis.

Raw Data and Analysis Discussion

- It would be helpful to access the raw dataset from the paired experiments that compared the impacts of sampler height and screens on atmospheric deposition. The raw dataset would allow Science Panel members to examine the relative influence of screens/no screens and weather on the sampling results. The statistics comparing the paired sampler data are available in Barrus (2021).
- Theron Miller and Gus Williams provided the Barrus dataset to the Science Panel. That spreadsheet has one data value for each sampling event, so it is unclear whether the dataset includes the data from the paired sampler experiments. It would also be helpful to know the date when screens were installed on the samplers.
- The Wood Miller dataset contains concentration data from the bulk deposition samples. After every precipitation event, Wood Miller collected the rainfall in the sampler and sent it to a laboratory for nutrient analysis. The results are reported in concentrations. He then calculated the average load from the bulk deposition samples on Utah Lake. In that averaging calculation, he gave more weight to storm events with higher precipitation. He did not measure volume or flux.
- Part of task 1 is to take the concentration and precipitation (in inches) from Wood Miller's dataset and multiply it against the sampler surface area to calculate flux. Wood Miller only calculated concentration. He used the official weather stations in Orem or Lindon Marina for annual precipitation data. The Wood Miller study identifies the sampler model in the methods section.
- Utah State University manages several precipitation stations for agricultural producers. These stations provide local wind and precipitation data, which would be helpful to match with the bulk deposition data.
- Wood Miller's dataset is episodic. Distributing Wood Miller's results into a weekly flux may require making too many assumptions to be useful. It is better to use the data to calculate annual loads.
- Wood Miller's sampler had very little visible dust on it. This result may be due to the re-mobilization of dust on the sampler between storms. This result would suggest that the bulk deposition sample underestimates atmospheric deposition.
- It may not be appropriate to calculate fluxes using Wood Miller's dataset. Since Barrus (2021) dataset is reported as fluxes, it is not possible to compare Wood Miller's dataset with the Barrus (2021) dataset. Identifying a way to compare datasets would help the Subgroup discuss atmospheric deposition loading. Having the data reported in fluxes will help inform discussions on spatially interpolating fluxes across the lake to calculate loads.
- As a thought exercise, the Science Panel will calculate fluxes using the data from Wood Miller and the sampler surface area. If the Science Panel decides that it is not useful to calculate fluxes using Wood Miller's dataset, then that is a useful finding. Some meeting participants were not confident that calculating fluxes using the sampler surface area would yield useful results. The Science Panel will continue discussing how to interpret the data at the next meeting.
- The Atmospheric Deposition Subgroup should focus on discrete sites to understand the influence of localized weather and sources. A better understanding of localized sites and the

nutrient fluxes associated with those sites will inform a Science Panel discussion on how to characterize fluxes spatially.

- It may be helpful to consider how each study tracks different mechanisms for depositing dust on the lake (e.g., precipitation, dry dust, urban sources). Adding Janice Brahney's estimate on dust deposition from urban sources to Wood Miller's bulk deposition data would be equivalent to the total load.
- Interannual variability in the atmospheric deposition datasets can be large. Seasonal variability is more consistent.

Non-Detect Discussion

- There are several non-detects in the Wood Miller data, particularly for orthophosphate data.
- There are several ways to impute non-detects. One way is to use the $\frac{1}{2}$ detection limit. Tetra Tech could also calculate a statistical imputation. Meeting participants agreed to impute non-detects using half the detection limit.

Missing Data Discussion

- The Barrus (2021) dataset primarily contains weekly data, but there are times when there is a gap of two or three weeks between sampling events. It was not the intention of the study to measure weekly fluxes.
- The atmospheric deposition results in the Barrus (2021) dataset reflect the cumulative deposition between sampling events. It would be beneficial to standardize the dataset using a weekly timestep.
- When there is "N/A" in the Barrus (2021) dataset, that assumption should be that the next sampling event reflects the cumulative data. If there are many "N/A"s in a row, then the assumption should be that the sampler buckets were removed for that timeframe (e.g., the 2017-2018 winter at the Orem sampling site).

Identifying Outlier Discussion

- The distribution of the dataset is not normal; it is episodic. It is not appropriate to flag outliers assuming a normal distribution and standard deviation approach. A log-Pearson or interquartile method is appropriate to identify outliers with a non-normal dataset.
- The purpose of identifying outliers is not to remove them from the dataset. It is simply to identify them for further discussion.
- Meeting participants supported using the interquartile range approach to flag outliers. This approach involves identifying the range between the 25 and 75 percentile data points and multiplying that range by 1.5. The interquartile range expands and shrinks based on the spread of the data.

Data Needs Discussion

- The data needs for task 1 include the date when the research team added screens to collection buckets, raw data for the paired sampler design experiments, raw sampler data from 2021, and metadata.
- The researchers already used the Barrus (2021) dataset to compare the influence of screens and sampler height on atmospheric deposition results. The Science Panel should not re-do the analyses researchers have already completed using the paired sampler data. The request for the paired sampler data is to cross-reference it with other datasets (e.g., weather datasets) to understand the relative influence of different mechanisms on atmospheric deposition.

- The researchers removed data points with insect contamination from the Barrus (2021) dataset. For example, they did not use much of the data from the Mosida sampling station and did not use data from Saratoga Springs. The Subgroup will discuss how to process potential insect contamination at future meetings.

NEXT STEPS

The Subgroup will continue to discuss the atmospheric deposition analysis plan. Samuel Wallace, Peak Facilitation Group, will contact Subgroup members to find a regular meeting time.

September 8, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Samuel Wallace

9/8 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Identify low outliers in the dataset. Identify the specific dates and samples for the high and low outliers.	Sep 15	
Theron Miller	<ul style="list-style-type: none">Confirm with Gus Williams the detection limit for the Barrus (2021) study data.Confirm with Gus Williams that measurements listed as 0 mg/m² in the Barrus (2021) datasets should be assigned ½ minimum detection or reporting limit rather than zero.	Sep 12	
Subgroup Members	Review the studies Barrus et al. (2021) and Richards (2022).	Sep 15	

9/8 DECISIONS

- Daily fluxes from the Barrus (2020) dataset were calculated based on interval between samples. Weekly fluxes from the Barrus (2020) dataset were calculated based on fractional week interval between samples.
- Samples from Central Davis and Ambassador were compiled but not included in the analysis because those sites are related to the Salt Lake City area and not Utah lake.

9/8 NEXT STEPS

At the next meeting, the Subgroup will discuss whether there are any additional approaches they would like to take to identify outliers. They will also discuss the next steps for exploring and understanding outliers.

September 15, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

9/15 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk and Theron Miller	Determine the detection limit for the Gus Williams' dataset by converting the concentration detection limit into an areal flux detection limit.	Sep 22	
Kateri Salk	Calculate the frequency of outliers before and after screens were installed on the samplers.	Sep 22	
Subgroup Members	Add sticky notes to the ULWQS decision tree to share their perspectives on what to do if metadata are not available or if insects are present in a sample.	Sep 22	

9/15 DECISIONS

- Tetra Tech will convert the Wood Miller dataset from mg/L to mg/m² by assigning precipitation from the gauge closest to the sampler and multiplying the concentration by the depth of precipitation to get the area flux.
- Tetra Tech will flag low and high outliers using the interquartile range approach. They will use the entire dataset to set the interquartile range. In the future, subgroup members can decide to look more closely at specific sites of interest.

9/15 NEXT STEPS

At the next meeting, the Subgroup will review the summary results of the Wood Miller dataset and outlier identification exercise. They will then discuss the next steps for how to review and analyze outlier data.

September 22, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

9/22 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk and Theron Miller	Determine if there is volume data for the Williams' dataset to calculate the flux for samples below the detection limit.	Sep 22	
Subgroup Members	Add sticky notes to the ULWQS decision tree to share their perspectives on what to do if metadata are not available or if insects are present in a sample.	Sep 22	

9/22 DECISIONS

- Tetra Tech will calculate the flux value for samples below the detection limit using the volume from Gus Williams' dataset. If the volume data from Gus Williams' dataset is not available, Tetra Tech will assign non-detect values at 0 mg/meter squared.
- For the Wood Miller dataset, each atmospheric deposition station will be matched with the following primary and secondary weather stations to calculate flux:
 - Orem Waste Water Treatment Plant sampler
 - Primary station: I-15 at Orem
 - Secondary station: Provo Airport
 - Mosida sampler
 - Primary station: SR-68 at MP 16 Mosida
 - Secondary station: Genola Mid
 - Pelican Point sampler
 - Primary station: SR-68 at MP 16 Mosida
 - Secondary station: Utah Lake at Lehi
 - Saratoga Springs sampler
 - Primary station: SR-68 at MP 16 Mosida
 - Secondary station: Utah Lake at Lehi

9/22 NEXT STEPS

- Tetra Tech will calculate fluxes using the Wood Miller dataset and the nearby weather stations. The Atmospheric Deposition Subgroup will review the fluxes from the Wood Miller and Gus Williams' datasets at the next meeting.
- At the next meeting, Subgroup members will go through the atmospheric deposition decision flowchart to decide how they want to address insects and samples.

September 29, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

9/29 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Heather Bergman, Samuel Wallace, Scott Daly	Reach out to Olsen, Reidhead, and Barrus to determine if they have the metadata for their respective studies.	Oct 6	
David Richards	Share the data from Barrus' study with Peak Facilitation and DWQ.	Oct. 6	
Tetra Tech	Create a map that shows the location of gravel pits and agricultural production occurring around Utah Lake.	Oct 6	

9/29 DECISIONS

- The Atmospheric Deposition Subgroup will consider insects as contamination in samples.
- If metadata is not available, the Atmospheric Deposition Subgroup will only use atmospheric deposition data after screens were installed in the samplers.
- For datasets where metadata is available, the Atmospheric Deposition Subgroup will exclude sampler data where insects are present.

9/29 NEXT STEPS

- At the next meeting, Tetra Tech will share the summary of the Wood Miller and Gus Williams' datasets.
- Tetra Tech will create a map that shows the location of gravel pits and agricultural production occurring around Utah Lake. The purpose of this map is not to exclude samples but rather create a better understanding of potential localized sources to Utah Lake.

October 6, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

10/6 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Compare the precipitation data at the Lehi and Genola weather stations to determine how different or similar the datasets are to each other.	Oct. 20	
	Calculate the number of events during which the bulk deposition sampler would have overflowed.	Oct. 20	
	Review Wood Miller's publication to verify that Wood Miller measured total inorganic nitrogen and orthophosphates.	Oct. 20	
	Update the graphs of Miller's and Williams' datasets by: <ul style="list-style-type: none"> • Using a consistent y-axis across graphs (preferably in logarithmic notation) • Creating a cumulative time series graph • Creating a time series that puts all the data collected on one graph (in the interactive version only) 	Oct. 20	
Kateri Salk and Scott Daly	Share the interactive version of the Miller's and Williams' graphs with Atmospheric Deposition Subgroup members.	Oct. 13	
Samuel Wallace and Scott Daly	Send Reidhead's phone number to Theron Miller.	Oct. 7	Oct. 7
Theron Miller	Contact Reidhead to see if the Subgroup can obtain his raw data.	Oct. 7	

10/6 DECISIONS

- Tetra Teach needs all data from the studies by Friday, October 7 to proceed with the analysis.

- The Atmospheric Deposition Subgroup will not meet on Thursday, October 13. The Subgroup will reconvene on October 20. The Subgroup will move their meeting times to 1pm MST except for the one Thursday a month when Mike Brett has a previous commitment.

10/6 CLARIFICATIONS

- If the data is labeled as “NADP” in the Barrus dataset, this label indicates that there was not a screen on the sampler. If the data is not labeled with “NADP,” this data is from a sampler with a screen.

10/6 NEXT STEPS

- Tetra Tech will calculate the number of times Wood Miller’s bulk deposition samplers would have overflowed due to precipitation. At the next meeting, the Atmospheric Deposition Subgroup will use that information to discuss how to approach overflown samples.

October 20, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly and John Mackey

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman

10/20 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Compare precipitation data across samplers using cumulative precipitation plots.	Oct. 27	
	Add y-axis lines to the atmospheric deposition data visualizations.	Oct. 27	
Kateri Salk and Scott Daly	Share the interactive version of the Miller's and Williams' graphs with Atmospheric Deposition Subgroup members once ready.	Oct. 27	

10/20 DECISIONS

- Atmospheric Deposition Subgroup members supported comparing dissolved inorganic nitrogen values from the Williams dataset and the total nitrogen values from the Millers dataset with the understanding that total nitrogen will be higher than the dissolved inorganic nitrogen (DIN) values.
- Atmospheric Deposition Subgroup members supported comparing soluble reactive phosphorus (SRP) values from the Williams dataset and the orthophosphate values from the Millers dataset.
- Atmospheric Deposition Subgroup members supported moving forward with the atmospheric deposition analysis with the caveats that:
 - Precipitation overflow of the sampler would impact nutrient fluxes; although, it is uncertain whether the overflow would result in an overestimation or underestimation of the flux
 - Evaporation of samples would result in the overestimation of nutrient fluxes
 - Dry deposition blowing off the sampler would result in the underestimation of nutrient fluxes
 - Differences in sampler cleaning would impact flux accuracy, with Wood Miller reporting that he cleaned samplers “quite well” and National Weather Station observers reporting that they cleaned samplers “now and then”
- The Reidhead raw data is not available. The Atmospheric Deposition Subgroup will proceed with the analysis using the decision tree they developed at the previous meeting.

10/20 NEXT STEPS

- Tetra Tech will create a cumulative precipitation plot.

- Tetra Tech will incorporate the relevant metadata information into the Wood Miller and Gus Williams data visualization. They will also add the Wood Miller orthophosphate and total nitrogen data to the SRP and DIN data plots.
- At next week's meeting, the AD Subgroup will:
 - Review the cumulative precipitation plots
 - Review the updated Gus Williams and Wood Miller data visualization

October 27, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly and John Mackey

Technical Consultants: Kateri Salk

Facilitation Team: Samuel Wallace

10/27 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Track which data points are derived as a result of the linear interpolation approach for filling in data gaps.	Nov. 3	
	Track the frequency of events in which there was a time gap between a precipitation event and the sampling date.	Nov. 3	
	If there are a significant number of events where there is a time gap between a precipitation event and sampling, calculate evaporation loss impacts on samples.	Nov. 3	
	Compare outlier fluxes with precipitation, PM2.5, and PM10 data.	Nov. 3	
Theron Miller	Reach out to Gus Williams' to clarify the meaning of the different wind expressions in his dataset.	Nov. 3	

10/27 DECISIONS

- The Atmospheric Deposition Subgroup supported continuing to analyze the Gus Williams dataset using screened data and data that was determined to not have insect parts based on the metadata for the Barrus and Olsen studies.
- The Atmospheric Deposition Subgroup supported using a linear interpolation method to fill in data gaps in the Gus Williams datasets. Kateri will track which data points are derived as a result of applying the linear interpolation approach.
- The Atmospheric Deposition Subgroup supported tracking the frequency of events in which there was a time gap between a precipitation event and the sampling date. The Subgroup supported having Kateri calculate the evaporation loss if there are a significant number of events where there is a time gap between a precipitation event and sampling date.

10/27 NEXT STEPS

- At next week's meeting, the AD Subgroup will:
 - Review the preliminary comparisons between precipitation events, PM2.5, and PM10 with outlier fluxes
 - Discuss how to compare wind events with outlier fluxes

November 3, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly and John Mackey

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

11/3 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Create cumulative flux graphs that include Bird Island data by setting the flux at 0 for all sites at the first day of Bird Island sampling.	Nov. 10	
	Track the frequency of events in which there was a time gap between a precipitation event and the sampling date for the Wood Miller dataset.	Nov. 10	
	If there are a significant number of events where there is a time gap between a precipitation event and sampling, calculate evaporation loss impacts on samples.	Nov. 10	
	Share the intermediate spreadsheet that pairs Wood Miller's sampling events with precipitation.	Nov. 10	
	Identify seasonal differences in the graphs comparing precipitation, PM2.5, and PM10 with fluxes.	Nov. 10	
	Conduct a multiple regression on the impacts of precipitation, temperature, wind, PM2.5, and PM10 on atmospheric deposition fluxes.	Nov. 10	
Theron Miller	Follow up with Gus Williams' to clarify the meaning of the different wind expressions in his dataset.	Nov. 10	

11/3 DECISIONS

- There were two sampling events at Mosida with relatively high values. The interpolated data between these two datapoints were relatively high as a result. In a past meeting, the Subgroup agreed to use linear interpolation to analyze the data in between sampling events. The Atmospheric Deposition Subgroup will continue with the outlier analysis with the intent to revisit the interpolated data once they have completed the weather analysis. Additionally, the interpolated data can be compared to the contaminated samples and Wood

Miller samples over the same period to help the AD Subgroup discuss an approach for addressing those interpolated values.

11/3 NEXT STEPS

- At next week's meeting, the AD Subgroup will:
 - Review the results of the evaporation analysis
 - Review the results of the outlier analysis

November 10, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly and John Mackey

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

11/10 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Create box-and-whisker plots comparing the Wood Miller and Gus Williams datasets that: <ul style="list-style-type: none"> Break the datasets out by year (noting the Williams dataset does not have values for 2018 and 2019) Display the <i>mean</i> daily fluxes Combine the data across sites into one box-and-whisker figure 	Nov. 17	
	Gather data on specific outlier events to see if there is a pattern in weather and consistency between the Wood Miller and Gus Williams' datasets	Nov. 17	
Theron Miller	Follow up with Wood Miller to get clarity on when National Weather Service staff cleaned samplers between collections.	Nov. 17	

11/10 DECISIONS

- The Atmospheric Deposition Subgroup supported using Wood Miller's dataset to corroborate statistical outliers found in Gus Williams' dataset and not to use Miller's dataset to calculate an average flux.
- The evaporation analysis indicated that for most samples, evaporation would impact the flux value by a second or third significant figure, but for some samples, evaporation has a potentially more significant impact. The Atmospheric Deposition Subgroup supported continuing the outlier analysis and cross-referencing any individual outliers with the evaporation analysis results.

11/10 NEXT STEPS

- At next week's meeting, the AD Subgroup will:
 - Look into specific outlier events to see if there is a pattern in weather and consistency between datasets

- Discuss how to interpolate missing sampling events between high flux events using weather relationship

November 17, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman

11/17 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Analyze the ratio of total nitrogen to total phosphorus for the Williams' dataset.	Dec. 1	
	Analyze the ratio of soluble reactive phosphorus to total phosphorus for the Williams' dataset.	Dec. 1	
	Identify the ratio of soluble reactive phosphorus to total phosphorus found in literature.	Dec. 1	
	Calculate the cumulative flux using a linear interpolation approach and regression analysis approach.	Dec. 1	
Theron Miller	Check with the ChemTech lab manager to determine the methods they used to measure nitrogen and phosphorus concentrations for Wood Millers' samples.	Dec. 1	
	Check with Wood Miller to obtain a description of the field collection methods in respect to the analytical methods.	Dec. 1	

11/17 DECISIONS

- The Atmospheric Deposition Subgroup supported calculating cumulative annual loads from Wood Millers' and Gus Williams' datasets separately to later discuss how to generate a single annual load.
- The Atmospheric Deposition Subgroup supported calculating the cumulative flux using a linear interpolation approach and regression analysis approach.

11/17 NEXT STEPS

- At next week's meeting, the AD Subgroup will:
 - Discuss the cumulative flux using a linear interpolation approach and regression analysis approach
 - Discuss the cumulative annual loads from Wood Millers' and Gus Williams' dataset

December 1, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly and John Mackey

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

12/1 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk and Mitch Hogsett	Share the existing Wood Miller data through 2020.	Dec. 8	
Kateri Salk and Scott Daly	Create a map with sampling locations to facilitate a discussion on potential sources.	Dec. 8	
Theron Miller	Reach out to ChemTech lab to obtain a written description of the methods they used to measure nitrogen and phosphorus concentrations for Wood Millers' samples.	Dec. 1	
	Check with Wood Miller to obtain a written description of the field collection methods in respect to the analytical methods.	Dec. 1	

12/1 DECISIONS

- The Atmospheric Deposition Subgroup supported using a weather regression approach to fill in missing data between sampling events.

12/1 NEXT STEPS

- At next week's meeting, the AD Subgroup will:
 - Discuss the approach to computing attenuation, including how to integrate Bird Island data.

December 8, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

12/8 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Update the Wood Miller data visualizations with new data through June 2022.	Dec. 22	
	Review the atmospheric deposition study on Lake Taihu and Jassby's study on Lake Tahoe.	Dec. 22	
	Analyze the variability of atmospheric deposition across the sampling sites.	Dec. 22	
Theron Miller	Check on the wind rose data from the Mosida sampling site to determine if the wind patterns are oriented correctly.	Dec. 22	
	Prepare data results from measuring nutrient input from bird droppings.	Dec. 22	

12/8 DECISIONS

No decisions were made at this meeting.

12/8 NEXT STEPS

- On December 22, the AD Subgroup will:
 - Continue the discussion computing attenuation, including how to integrate Bird Island data.

December 22, 2022 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, and Hans Paerl

Division of Water Quality (DWQ) Staff: Jodi Gardberg and John Mackey

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

12/22 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Reach out to Greg Carling and Janice Brahney to determine if there is data on aerosol particle sizes.	Jan. 5	
	Send the updated Wood Miller and Bird Island visualizations to the Subgroup.	Jan. 5	
	Prepare the speciation data for the next meeting.	Jan. 5	
	Prepare a table that compares the estimated atmospheric load to Utah Lake (once calculated) to the estimated results from constraining analyses.	Jan. 12	
Atmospheric Deposition Subgroup	Consider the upper and lower boundaries of potential atmospheric deposition scenarios for future sensitivity analyses.	Jan. 5	

12/22 DECISIONS

Subgroup members in attendance supported retaining the Bird Island data as a representation of point source nutrient input and not using it to estimate external atmospheric deposition.

12/22 NEXT STEPS

- At the next meeting, the AD Subgroup will:
 - Review any data on aerosol particle sizes and discuss attenuation rates
 - Review atmospheric deposition speciation data

January 5, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Other Attendees: David Richards

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

1/5 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Compare wet deposition fluxes from regional data from the National Trends Network to the fluxes from the sampler data.	Jan. 10	
Peak Facilitation Group	Distribute the Goodman et al. paper, Greg Carling’s memo, and Kateri Salk’s slide deck from today’s meeting to the Subgroup.	Jan. 5	Jan. 5
Atmospheric Deposition Subgroup	Review the Goodman et al. paper, Greg Carling’s memo, and Kateri Salk’s slide deck, and be prepared to discuss how these studies apply to calculating attenuation at the next Subgroup meeting.	Jan. 10	

1/5 DECISIONS

- Subgroup members supported rescheduling the next Subgroup meeting to Tuesday, January 10, from 12pm to 1pm MST.
- Subgroup members discussed several different approaches to calculating attenuation rates for Utah Lake. The Subgroup did not decide on a final approach and indicated they wanted to review Goodman et al. paper and Greg Carling’s memo before deciding how to calculate attenuation.

1/5 NEXT STEPS

- At the next meeting, the AD Subgroup will:
 - Discuss Carling’s memo and the Goodman et al. paper and agree on an approach to attenuation rates
 - Review atmospheric deposition speciation data and agree on an approach to speciation

January 10, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Other Attendees: David Richards

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

1/10 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Compute the decay rate for attenuation based on particle size distribution.	Jan. 19	
	Work with the Tetra Tech GIS team to generate raster layers according to the agreed upon methodology (below in <i>1/10 decisions</i>).	Jan. 19	
Peak Facilitation Group	Distribute Kateri Salk's slide deck from the 1/5 meeting to the Subgroup.	Jan. 18	Jan. 18
Atmospheric Deposition Subgroup	Review the table with information on the proportions of different chemical species in the 1/5 slide deck.	Jan. 19	

1/10 DECISIONS

- Subgroup members supported using the following methodology to incorporate attenuation into the atmospheric deposition loading calculation:
 - Create a raster layer of shoreline flux by interpolating between shoreline samplers (e.g., inverse distance weighted interpolation)
 - Assign a regional flux over Utah Lake
 - Use Carling and Goodman et al. (2019) to assign a regional flux for total phosphorus
 - Use the Community Multiscale Air Quality (CMAQ) model to assign a regional flux for total nitrogen
 - Assign decay rate of shoreline flux moving toward mid-lake
 - Use the regional flux values for total phosphorus and total nitrogen for the “floor” of the decayed shoreline flux
 - Calculate the decay rate based on particle size distribution

1/10 NEXT STEPS

- At the next meeting, the AD Subgroup will:
 - Review the results of the atmospheric loading calculation following the application of the methodology for incorporating attenuation and finalize the approach for attenuation
 - Review atmospheric deposition speciation data and agree on an approach to speciation

January 19, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly

Technical Consultants: Kateri Salk

Facilitation Team: Samuel Wallace

1/19 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk	Calculate the regional flux from the Putman et al. 2022 study.	Jan. 26	
	Calculate nutrient loading using the Goodman grain size and Van Curen attenuation rates by grain size to model attenuation of shoreline samples	Jan. 26	
	Calculate nutrient loading using multiple attenuation rates to use as a range for a sensitivity analysis.	Jan. 26	
	Calculate speciation using two approaches: a) use the average of proportions across sites for annual fluxes, and b) assume 1/3 of total phosphorus is soluble reactive phosphorus and assume 2/3 of dissolved inorganic nitrogen is ammonium	Jan. 26	
Peak Facilitation Group	Re-distribute the Putman et al. 2022 to the AD Subgroup	Jan. 24	

1/19 Decisions

- Subgroup members supported having Tetra Tech calculate the regional flux from the Putman et al. 2022 study.
- Subgroup members supported using the total phosphorus regional bulk flux calculated from Carling 2022 & Goodman et al. 2019 over the total phosphorus regional bulk flux calculated using nitrogen:phosphorus ratios from Gus Williams’ study.
- The majority of subgroup members in attendance supported using the Goodman grain size and Van Curen attenuation rates by grain size as the primary method to model attenuation of shoreline samples. One subgroup member supported using the attenuation rates calculated from the Wilson and Serre North Carolina concentrated animal feeding operation (CAFO) study to model attenuation.
- Subgroup members supported having Tetra Tech calculate speciation using two methods: a) the average of proportions across sites for annual fluxes, and b) assume 1/3 of total phosphorus is soluble reactive phosphorus and assume 2/3 of dissolved inorganic nitrogen is ammonium. Subgroup members will discuss the results of the calculations at the next meeting.

1/19 Next Steps

- At the next meeting, the AD Subgroup will:
 - Review the results of the atmospheric loading calculation following the application of the methodology for incorporating attenuation
 - Review atmospheric deposition speciation data and agree on an approach to speciation
 - Review and compare the total nitrogen values at Mosida to the total nitrogen values at other sites

January 26, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, and Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly, Jodi Gardberg, and John Mackey

Other Attendees: David Richards

Technical Consultants: Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

1/26 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk and Scott Daly	Check in with the Tetra Tech modeling team to understand what spatial and temporal data they need to incorporate atmospheric deposition into the model.	Jan. 27	Jan. 27
Mitch Hogsett	Calculate the amount of dust depositing onto Utah Lake by subtracting dissolved phosphorus from total phosphorus.	Feb. 2	
Peak Facilitation Group	Reach out to Hans Paerl and Mike Brett to confirm their availability for the February 2 meeting.	Jan. 27	
AD Subgroup Members	Reach out Kateri Salk if they have any clarifying questions on the attenuation methodology.	Feb. 2	

1/26 Next Steps

The subgroup did not make any decisions at this meeting.

1/26 Next Steps

At the next meeting, the AD Subgroup will discuss and come to an agreement on the values the modeling team needs to incorporate atmospheric deposition into the model.

February 2, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly, Jodi Gardberg, and John Mackey

Technical Consultants: Kateri Salk

Facilitation Team: Samuel Wallace

2/2 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Theron Miller	Develop a one-page memo outlining the reasoning for the alternative phosphorus and nitrogen loading recommendations.	Feb. 16	Feb. 20
Tetra Tech and Peak Facilitation Group	Draft the atmospheric deposition report summarizing the process, methodology, and diverging perspectives for review by the subgroup.	Feb. 16	Feb. 17
Tetra Tech Modeling Team	Develop an approach for incorporating phosphorus speciation into the model for review by the subgroup in the atmospheric deposition report.	Feb. 16	
Samuel Wallace	Distribute meeting recordings to the Atmospheric Deposition Subgroup.	Feb. 9	Feb. 9

2/2 Decisions

- The majority of subgroup members supported the following atmospheric deposition loading recommendations:
 - The **main** total phosphorus (TP) and dissolved inorganic nitrogen (DIN) loading recommendations for model calibration are the values of the analysis when assuming attenuation occurs at 200 meters
 - TP: 32 metric tons/year
 - DIN: 220 metric tons/year
 - The **low** TP and DIN loading recommendations for the sensitivity analysis are the values of the analysis when assuming attenuation occurs at 100 meters
 - TP: 31 metric tons/year
 - DIN: 218 metric tons/year
 - The **high** TP and DIN loading recommendations for the sensitivity analysis are the values of the analysis when assuming attenuation occurs at 2,000 meters
 - TP: 45 metric tons/year
 - DIN: 249 metric tons/year
- One subgroup member did not support these atmospheric deposition loading recommendations. Their proposed alternative atmospheric deposition loading recommendations are as follows:
 - The **main** TP loading recommendation for model calibration is 150 metric tons/year

- The **low** TP loading recommendation for the sensitivity analysis is 93 metric tons/year (the value that assumes no attenuation)
- The **high** TP loading recommendation for the sensitivity analysis is 200 metric tons/year
- Recommended atmospheric loading values for DIN are forthcoming
- Subgroup members supported letting the Tetra Tech modeling team develop an approach for incorporating phosphorus speciation into the model since the model can only partition phosphorus into orthophosphate and organic phosphorus. Subgroup members will provide feedback on the documented approach in the atmospheric deposition report.

2/2 Next Steps

- Theron Miller will develop a one-page memo outlining the reasoning for the alternative phosphorus and nitrogen loading recommendations. This one pager will include the recommended dissolved inorganic nitrogen atmospheric deposition loading values.
- Tetra Tech will begin drafting the Atmospheric Deposition report. The Subgroup will review the report and meet again to provide feedback on either February 16 or 23, depending on when the report will be complete.

February 23, 2023 - Virtual Meeting

ATTENDANCE:

Science Panel Members: Mike Brett, Mitch Hogsett, Theron Miller, Hans Paerl

Division of Water Quality (DWQ) Staff: Scott Daly, Jodi Gardberg, and John Mackey

Technical Consultants: Kateri Salk

Other Attendees: David Richards

Facilitation Team: Heather Bergman and Samuel Wallace

2/23 ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Kateri Salk and Samuel Wallace	Incorporate the following edits into the ULWQS Atmospheric Deposition Subgroup Report: <ul style="list-style-type: none"> • Abbreviate nitrogen and phosphorus throughout the document • Add data visualizations for ammonium, nitrate, and soluble reactive phosphorus to the appendix of the report • Include the graphs from Wilson and Serre (2007) and VanCuren (2012) in the attenuation of fluxes section • Revise the speciation section of the report to reflect the Subgroup decision that the modeling team determine how to integrate organic nitrogen values into the model in the absence of data 	Feb. 24	Feb. 24
	Prepare a slide deck for the March 2 Science Panel meeting that highlights the outcomes from the Subgroup meetings and the minority and majority perspectives of the decision points.	Mar. 2	Mar. 2
Theron Miller	Send Dr. David Richards' report comparing screened sample data to non-contaminated unscreened sample data Kateri Salk and Samuel Wallace to integrate into the Atmospheric Deposition Subgroup Report.	Feb. 24	Feb. 27
Mike Brett, Hans Paerl, Mitch Hogsett	Send their feedback on Theron Miller's minority perspective memo to be considered by Theron.	Feb. 23	Feb. 25

2/23 Decisions

- The Subgroup supported making the following changes to the Atmospheric Deposition Subgroup Report:
 - Abbreviate nitrogen and phosphorus throughout the document
 - Add data visualizations for ammonium, nitrate, and soluble reactive phosphorus to the appendix of the report
 - Include the graphs from Wilson and Serre (2007) and VanCuren (2012) in the attenuation of fluxes section
 - Revise the speciation section of the report to reflect the Subgroup decision that the modeling team determine how to integrate organic nitrogen values into the model in the absence of data
- The Subgroup previously recommended speciating the dissolved inorganic nitrogen (DIN) into 0% organic nitrogen, 30.25% as nitrate, and 69.75% as ammonium. After discussion, the Subgroup reached the conclusion that the organic nitrogen portion of DIN is unknown, but it is also not 0%. The Subgroup supported having the Tetra Tech modeling team determine how to incorporate organic nitrogen into the DIN speciation in the model. Samuel Wallace and Kateri Salk will edit the final report to reflect this decision.

2/23 Next Steps

- Mike Brett, Hans Paerl, and Mitch Hogsett will provide feedback on Theron Miller's diverging perspective memo for his review and consideration.
- Kateri Salk and Samuel Wallace will prepare a slide deck for the March 2 Science Panel meeting that will highlight the outcomes from the Subgroup meetings and the minority and majority perspectives of the decision points.