

Executive Summary

Nature-Based Solutions (NBS) are sustainable alternatives to conventional wastewater treatment plants due to their much lower cost and easy installation process. This study incorporates mainly two parts.

1. Pollutant removal percentage data is collected from various papers and online databases, and subsequently, conducting meta data analysis.
2. SWAT+ modeling is integrated in the study to evaluate the effectiveness of different NBS in the removal of different nutrients from wastewater.

Background

- Due to the rapid urbanization and increased runoff, water pollution has become a global issue.
- The conventional wastewater treatment system is very costly, and sometimes these are very difficult to set up, especially in rural areas.
- NBS, like constructed wetland, bioretention systems, filter strips, grassed waterways, and permeable pavements, are sustainable alternatives to the traditional systems.
- Studies based on individual NBS have been conducted a lot.

Research Gap: Limited studies considering multiple NBS and their overall removal efficiencies, and also considering their effectiveness at the watershed level.

Methods and Data Analysis

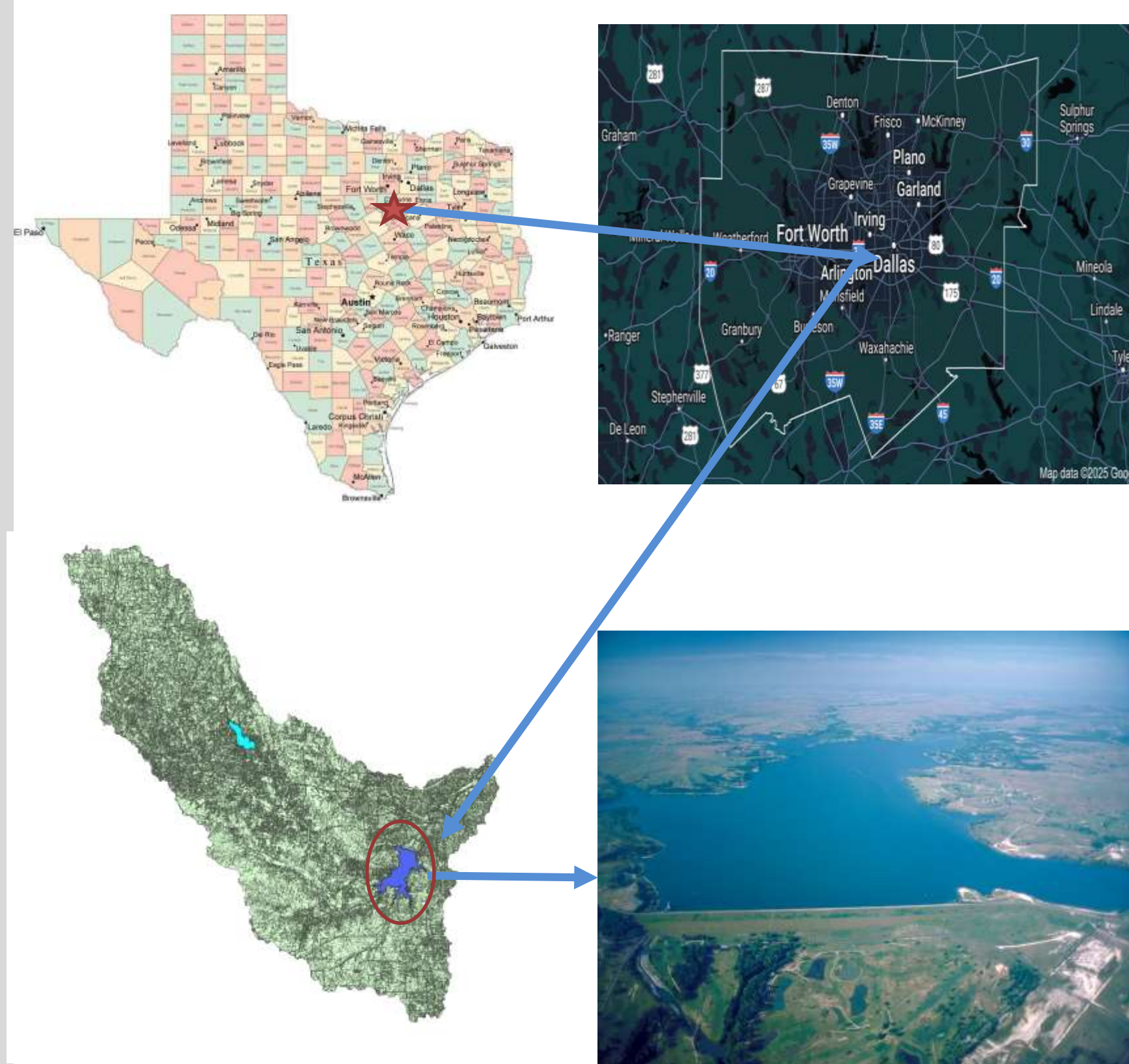
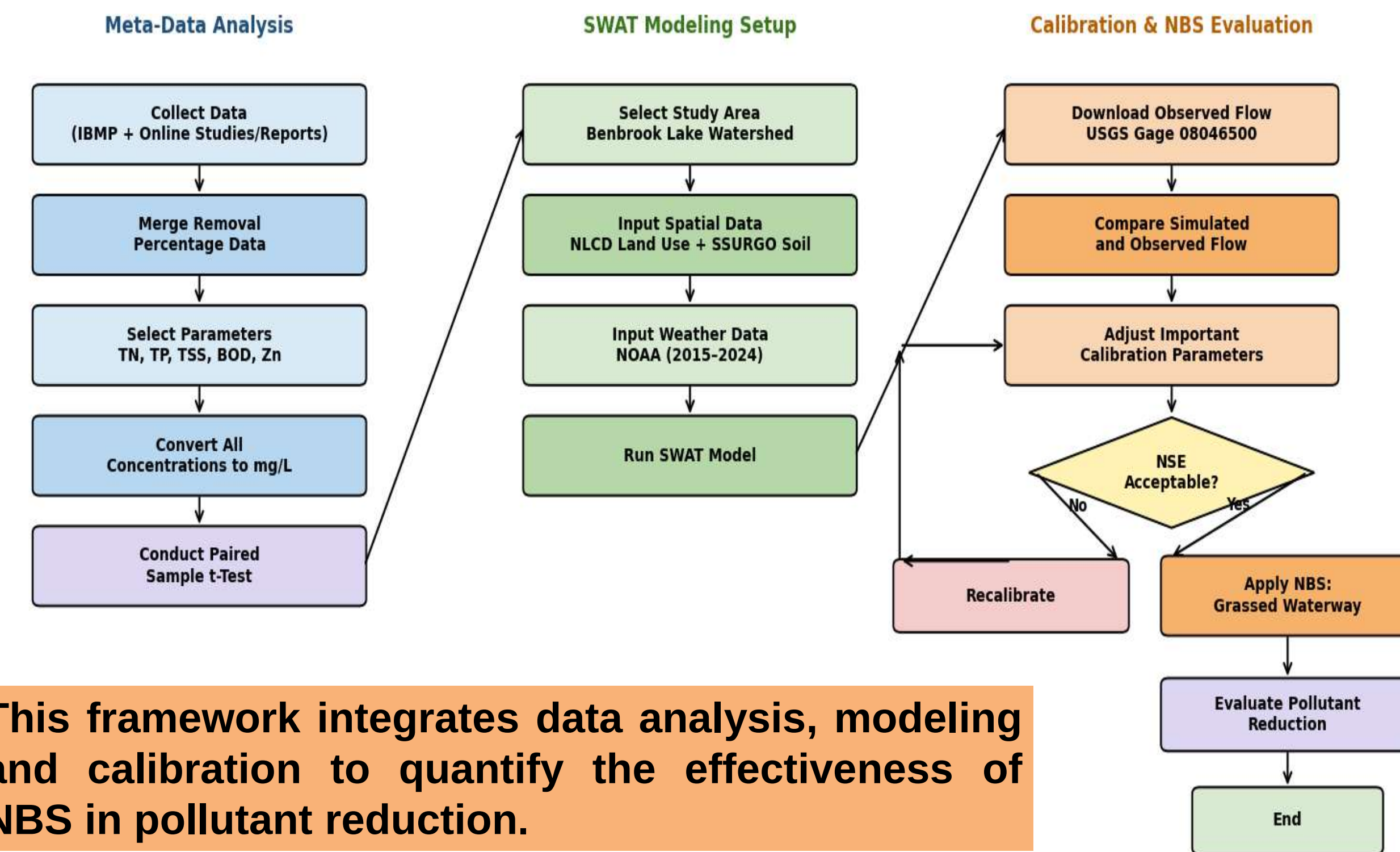


Figure 1. Study Area Location (Benbrook Watershed) in the DFW Area

Methods and Data Analysis



This framework integrates data analysis, modeling and calibration to quantify the effectiveness of NBS in pollutant reduction.

Figure 2. Methodology of Work

Results and Discussion

1. Almost all the NBS showed significant pollutant removal with a p-value less than 0.05.
2. Wetlands, bioretention, media filters are some of the most effective NBS in the removal of nutrients, TSS and heavy metals from wastewater.
3. There are a few NBS like green roof increased the pollutant removal in various cases.
4. The SWAT+ model could simulate the watershed hydrology successfully from 2015 to 2024.
5. The best calibration NSE was 0.74 for the streamflow.
6. NBS (Grassed waterway is selected for this study) demonstrated the pollutant reduction in a desired channel in the SWAT+ model.
7. $\text{NH}_3\text{-N}$ is selected as the pollutant in the SWAT+ model. After incorporating grassed waterway as the NBS in the model, the percentage reduction was approximately 66%.

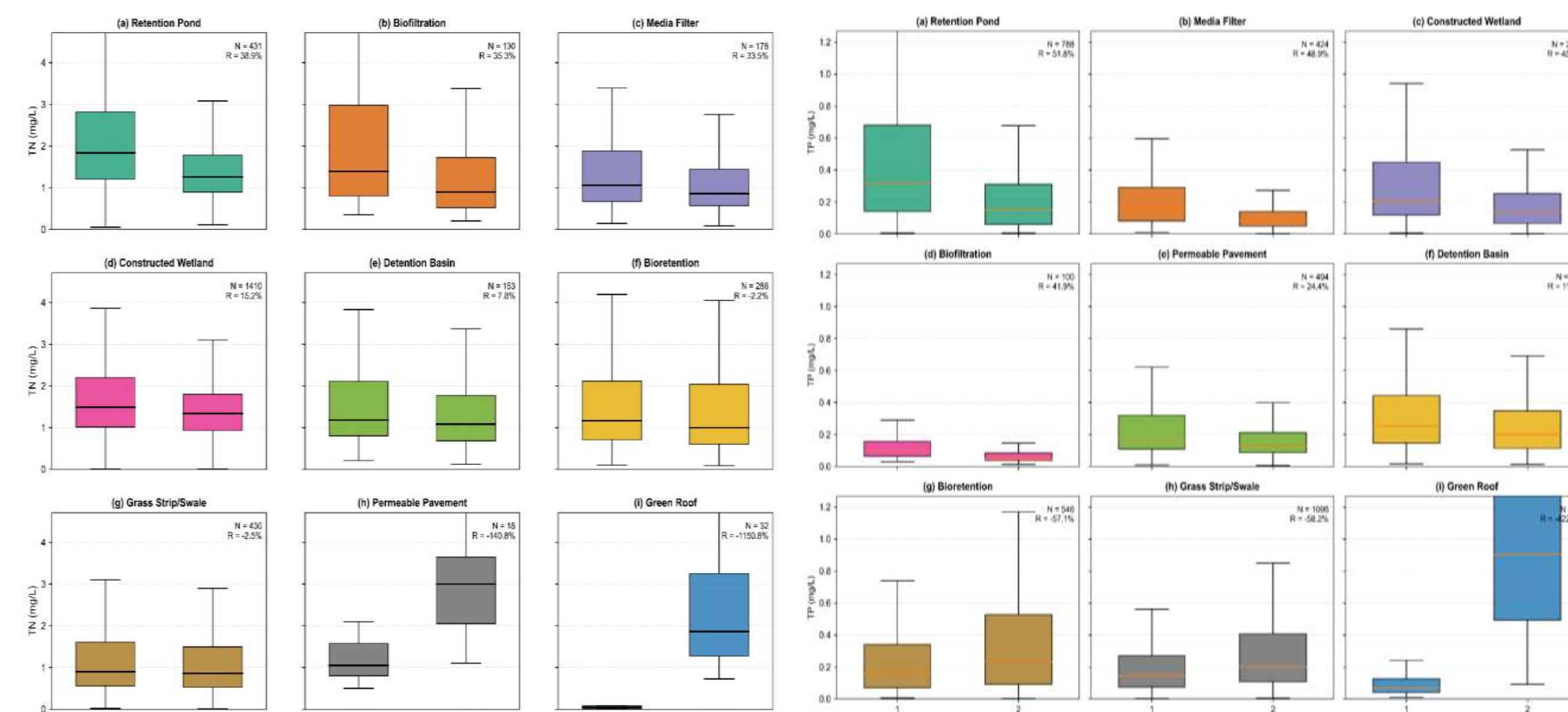


Figure 3. TN and TP Removal across Different NBS

Results and Discussion

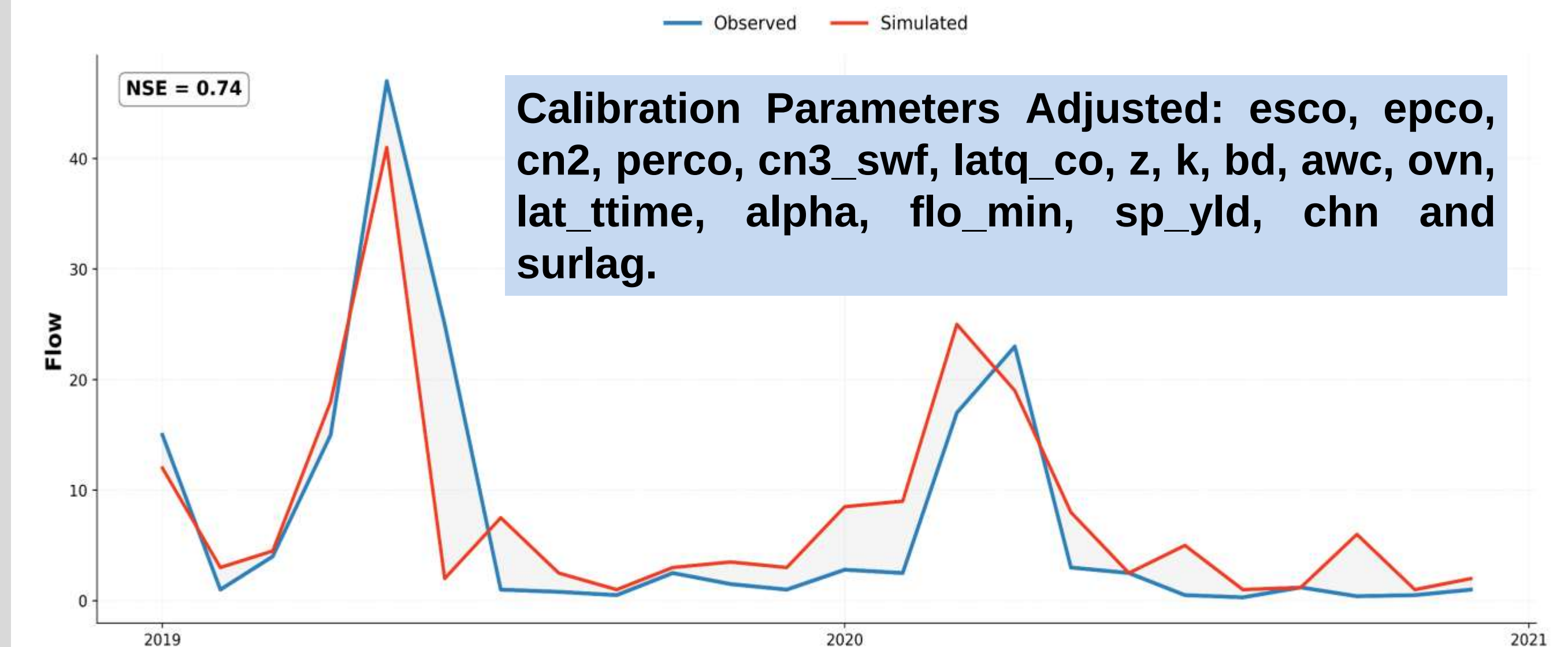


Figure 4. Streamflow Calibration (Observed vs Simulated)

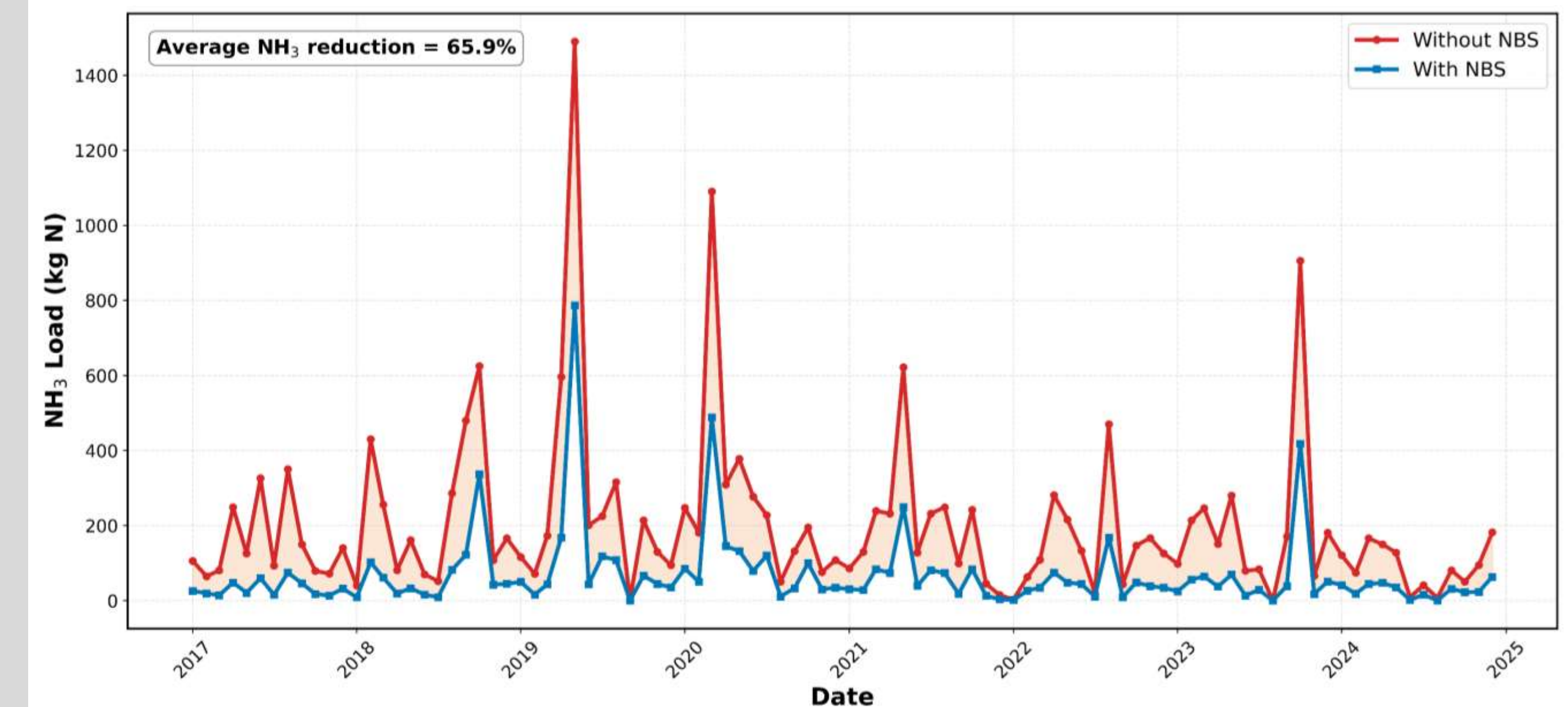


Figure 5. Amount of Monthly $\text{NH}_3\text{-N}$ With and Without NBS (2017-2024)

Yearly Reduction:
2017 (78%), 2018 (68%), 2019 (59%), 2020 (60%),
2021 (66%), 2022 (69%), 2023 (66%), 2024 (68%)

Conclusions

- NBS are very effective for the removal of different pollutant from wastewater.
- The environmental conditions and operations have great effects on NBS performance.
- The integration of SWAT+ model improves the broader understanding of their effectiveness.

References

1. Almenar, J. B., Elliot, T., Rugani, B., Philippe, B., Gutierrez, T. N., Sonnemann, G., & Geneletti, D. (2021). Nexus between nature-based solutions, ecosystem services, and urban challenges. *Land Use Policy*, 100, 104898.
2. Awan, M. T. (2021). *Innovating with urban nature for health and equity*. McGill University.
3. Baietti, A., Kingdom, W., & van Ginneken, M. (2006). *Characteristics of well-performing public water utilities*. Water Supply and Sanitation Board.
4. Bell, C. D., Spahr, K., Grubert, E., Stokes-Draut, J., Gallo, E., McCray, J. E., & Hogue, T. S. (2019). Decision making on the gray-green stormwater infrastructure continuum. *Journal of Sustainable Water in the Built Environment*, 5(1), 04018016.
5. Biswal, B. K., Bolan, N., Zhu, Y.-G., & Balasubramanian, R. (2022). Nature-based systems (NbS) for mitigation of stormwater and air pollution in urban areas: A review. *Resources, Conservation and Recycling*, 186, 106578.

Acknowledgement

This work was supported by the Water Research Foundation (WRF, 5248). The authors also thank the Texas Commission on Environmental Quality (TCEQ) and the United States Geological Survey (USGS) for providing data support. We further acknowledge Dr. Jessica A. Eisma and Jessica Seersma for their contributions to this research.