Regional Agricultural BMP Planning Database Final Report

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Abbreviations

Abbreviation	Meaning
BMP	Best management practice
DIN	Dissolved inorganic nitrogen
FIB	Fecal indicator bacteria
LDC	Load duration curve
PO4	Orthophosphate
QA/QC	Quality assurance/control
QAPP	Quality assurance project plan
SELECT	Spatially Explicit Load Estimate Calculation Tool
SWAT	Soil and Water Assessment Tool
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
TWRI	Texas Water Resources Institute

Project Summary

Limited resources are available for watershed planners and stakeholders to assess the location and scale of agricultural best management practices (BMPs) required to obtain pollutant load reductions needed to achieve state water quality standards. Scenario planning with mechanistic models such as the Soil and Water Assessment Tool (SWAT) can be used to estimate resulting instream water quality based on placement and amount of BMPs in a watershed. The accuracy and effectiveness of these modelling approaches are contingent on the modelling technician and can be prone to over- or underestimation of load reductions depending on the effectiveness of the model parameter calibration process. To balance cost, complexity, and uncertainty, the Bacteria Total Maximum Daily Load (TMDL) Taskforce suggested the use of simpler tools as a first step where appropriate to assess needed load reduction (Jones et al. 2007). As a result, many watershed protection plans (WPPs) and TMDL I-Plans use a combination of Load Duration Curves (LDC) and the Spatially Explicit Load Estimate Calculation Tool (SELECT) to estimate needed loading reductions and prioritize BMP and management measure placement. This approach is appealing because it is easily communicated with stakeholders and efficiently moves the planning process forward towards implementation.

The use of LDCs and SELECT are reliable and replicable ways of estimating needed load reductions and spatially allocating loads and practices. However, the planning of the number of agricultural BMPs required to achieve load reductions can be biased based on the studies selected or information available to the planner and stakeholder group. Furthermore, the estimated percentage load reductions from agricultural BMPs are typically re-estimated with each new WPP. A centralized and updated database of potential pollutant reductions resulting from agricultural BMPs would provide an unbiased source of reference and streamline work effort for future WPPs and TMDL I-Plans.

The primary goal of this project was to develop a reference database that catalogues different BMPs implemented in Texas and their performance in improving water quality. To accomplish this, TWRI identified BMPs implemented in United States by carrying out a comprehensive assessment of peer-reviewed scientific literature and results of field experimental investigations on the impacts of management measures in reducing nutrient, sediment, and pathogen loads. Published studies for potential inclusion were found by searching leading academic databases such as Google Scholar and Web of Science. To evaluate the relative effectiveness of different practices, the quality assured pooled data was meta-analyzed to develop representative statistics of typical reductions attributed to BMPs. Results of the statistical analysis were inventoried in an easy-to-use database.

Key findings from our project include:

- We only identified 34 studies (from 2000- through 2022) evaluating BMP performance on fecal indicator bacteria (FIB) in the scientific literature, 19 of which had usable data for meta-analysis.
- We only found 56 studies (from 2000 through 2022) evaluating BMP performance on nutrient related parameters, 41 of which had usable data for meta-analysis.
- Most studies were short-term, 3 years or less and the median was slightly over 2 years.
- Studies were highly geographically clustered; many studies are concentrated in the mid-Atlantic region. This could be problematic for extrapolating BMP performance (Figure 1).
- We found that on average, BMPs reduced concentrations of FIB, total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS) although with high variation in performance measures (Figure 2).
- Influent concentrations can be used to predict BMP performance for some, but not all pollutant parameters.

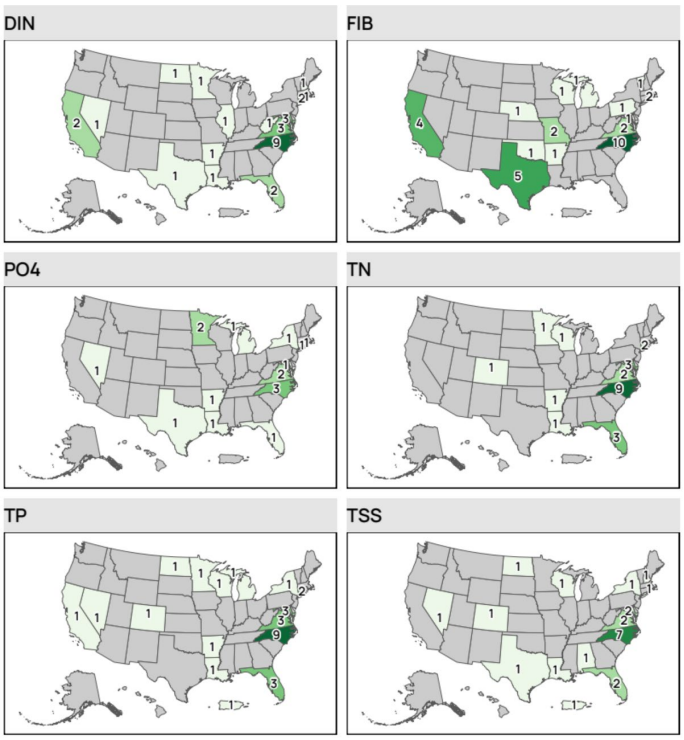

Figure 1. Geographic distribution of studies included in the BMP database.

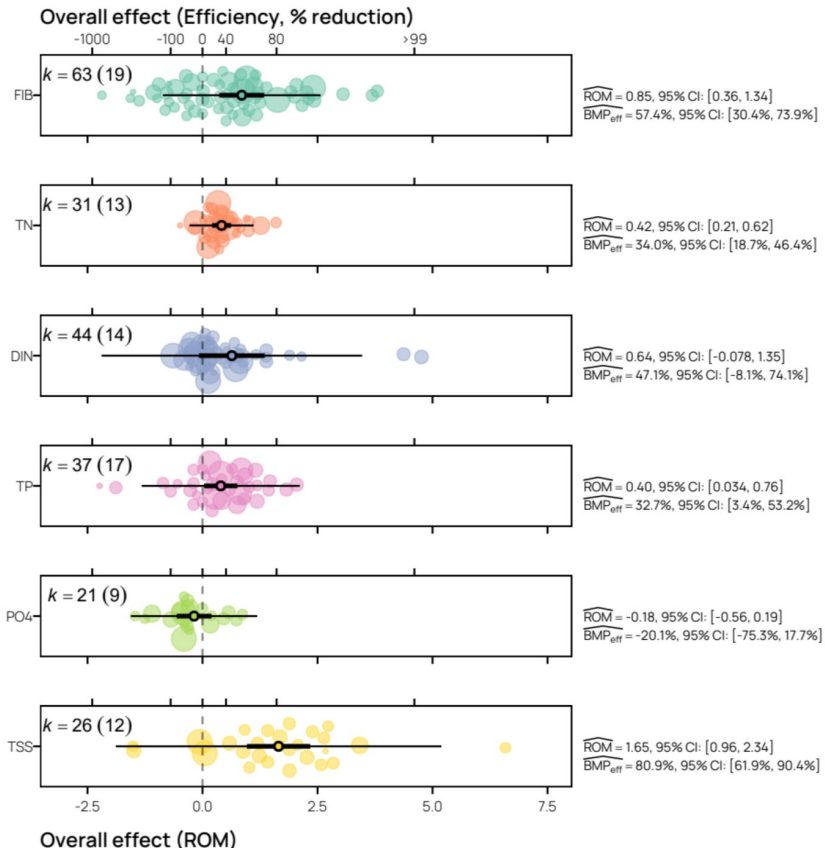

Figure 2. Weighted mean BMP performance across studies (point sizes are scaled by study sample size).

Tasks and Accomplishments

Task 1: Project Administration

Texas Water Resources Institute (TWRI) prepared electronic quarterly progress reports documenting all activities performed each quarter. Reports were submitted by the first of March, June, September, and December each year.

Coordination meetings were also held quarterly to discuss project activities, project schedule, communication needs, deliverables, and other requirements. TWRI prepared and submitted meeting notes and action items following each meeting.

TWRI performed accounting functions for project funds and submitted reimbursement forms quarterly. Project expenditures will be completed by February 28, 2024. As of mid-February 96% of project funds have been spent or encumbered.

Task 2: Quality Assurance

TWRI developed data quality objectives and quality assurance/control (QA/QC) activities to ensure data on known and acceptable quality were generated through the project. A quality assurance project plan (QAPP) was developed for Task #3 in the project, consistent with the most recent versions of *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* and the *TSSWCB Environmental Data Quality Management Plan*. The QAPP was approved on July 5, 2022. A subsequent annual revision was approved on June 5, 2023.

Task 3: Database Development and Publication

TWRI collated and developed a database of peer-reviewed studies that included BMP effectiveness information. Due to the lack of agricultural specific studies we collected information from studies that included all different types of pollutant sources to maximize the information available for drawing study conclusions. The database is available both through the project website and a permanent data repository:

Kikoyo, D., Jain, S., Wright, J., & Schramm, M. (2024). TWRI NPS-BMP-DB (v1.05) [dataset]. Zenodo. https://doi.org/10.5281/ZENODO.8302472.

TWRI developed a meta-analysis from the data to develop equations that can be used for estimated BMP efficiency values or percent reductions from implementing different types of BMPs. The meta-analysis and equations are provided in the following technical report:

Kikoyo, D., Wright, J., Jain, S., & Schramm, M. (2023). *Synthesis of Water Quality BMP Studies* (TR-552). Texas Water Resources Institute. https://twri.tamu.edu/media/6503/tr-552.pdf.

Task 4: Application, Education, and Outreach

TWRI developed a project website to host project information and share published information: https://ag-bmp.twri.tamu.edu/ (Figure 3, Figure 4). Currently pages include links to the project database, presentations, and reports. Any peer-reviewed publications accepted from this project will be provided through the website as well.

On October 10, 2023 Duncan Kikoyo presented the project and database to the Watershed Coordinators Roundtable (Figure 5).

TWRI prepared a draft manuscript for submission to Frontiers in Water. Upon acceptance, the paper will be shared on the project website.

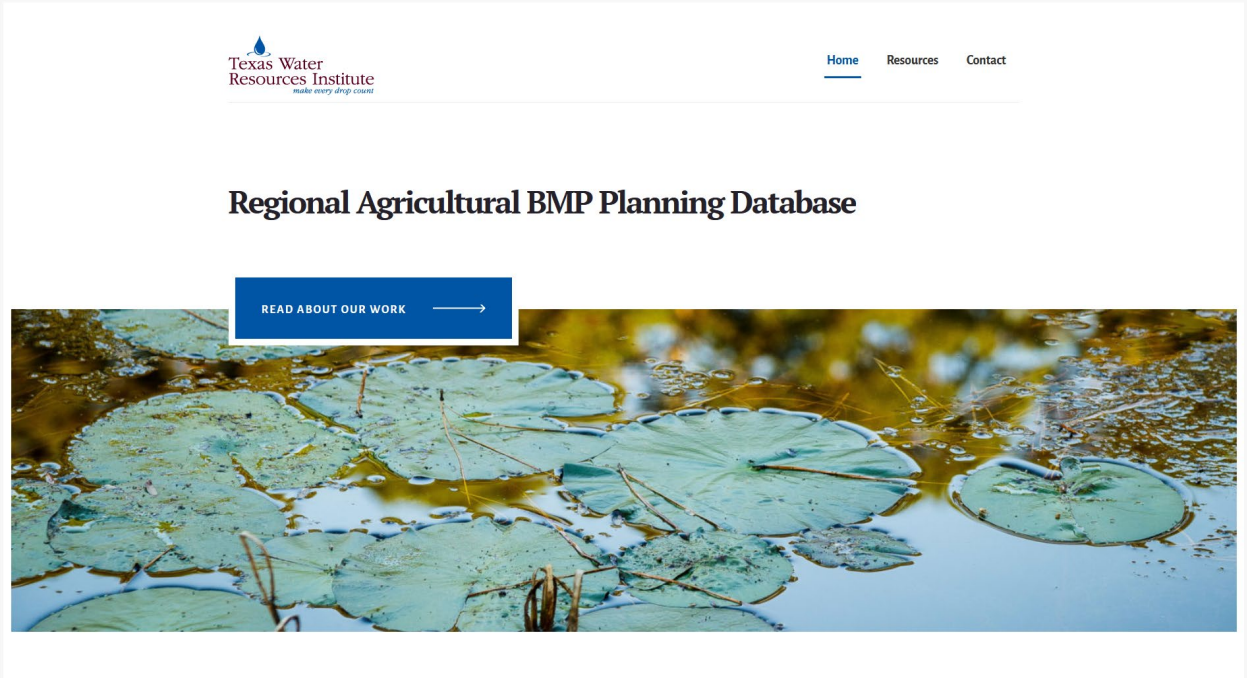

Figure 3. Website homepage.

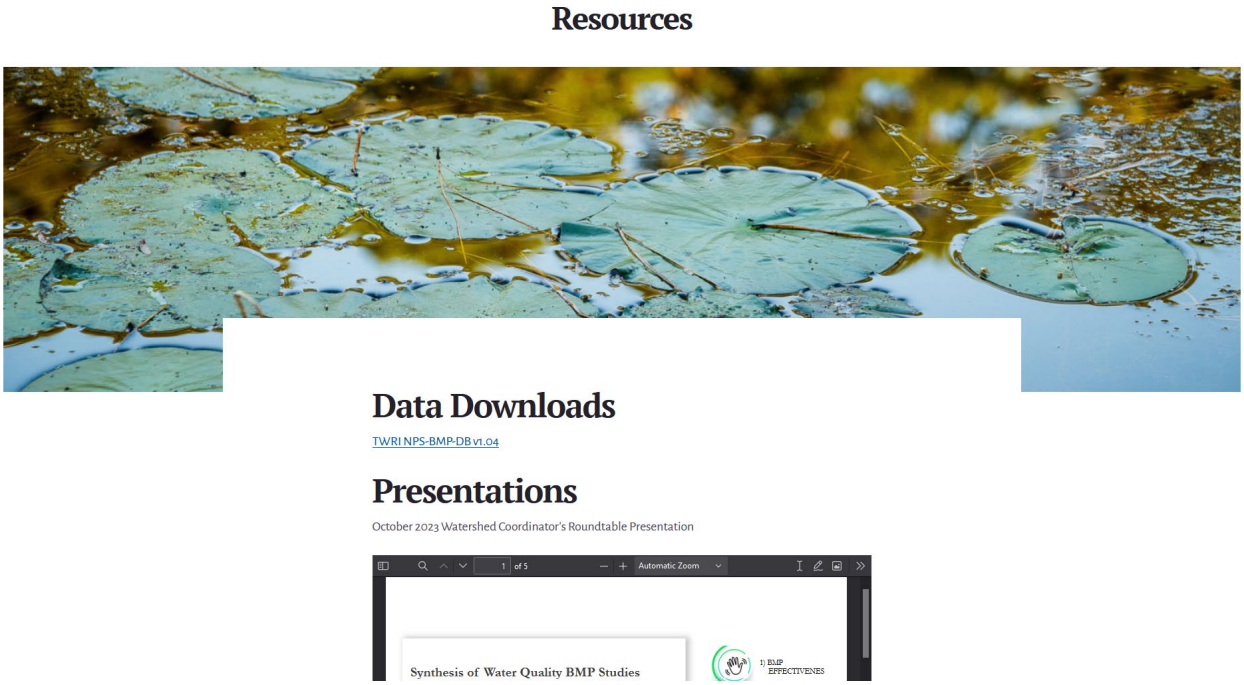

Figure 4. Website resource page.

October 10, 2023 | 9:30 a.m. – 3:00 p.m.
Houston Galveston Area Council, 3555 Timmons Ln. Ste 100., Houston TX

9:00 a.m. **Event Sign In**

9:30 a.m. **Welcome, Introductions and Round Table Overview** - Lucas Gregory

9:45 a.m. **HGAC – Urban Watershed Planning Program**
- Plan development and implementation strategies to address water quality
    - Steven Johnston and Rachel Windham

10:30 a.m. **Networking Break**

10:45 a.m. **Implementing Complex Watershed Plans Panel**
- Houston-Galveston Area Council – Todd Running
- Galveston Bay Foundation – Natasha Zarnstorff
- Galveston Bay Estuary Program – Christian Rines
- Galveston Bay Coalition of Watersheds – Celina Lowry
- Houston Advance Research Center – Stephanie Glenn

11:45 a.m. **Networking Lunch Break**

12:45 p.m. **Challenges Addressing Pollutant Loads with TMDLs & WPPs**
- *TMDLs and E. coli Trends in Freshwater Streams* - Michael Schramm
- Guided round table discussion (provided questions to discuss)

1:45 p.m. **Networking Break**

2:00 p.m. **New Data Tools and Resources for Planning**
- HGAC OSSF Mapping – Todd Running
- HGAC Vulnerability Index Screening Tool – Sayena Marandi
- TWRI Ag BMP Database – Duncan Kikoyo

2:40 p.m. **Brief Agency Updates**
- EPA, TCEQ, TSSWCB

2:50 p.m. **Wrap-Up & Program Evaluation** - Lucas Gregory
- Next Roundtable – April 2024 – DFW Area

The Texas Watershed Planning Program is managed by the Texas Water Resources Institute and is funded through a Clean Water Act Section 319(h) nonpoint source grant provided by the Texas State Soil and Water Conservation Board and U.S. Environmental Protection Agency.

Figure 5. Agenda for Fall 2023 Watershed Coordinator Roundtable.

Conclusions

TWRI completed all tasks and deliverables on time during the project period. Major goals for the project included providing and distributing an up-to-date reference database of BMP studies and conducting a meta-analysis of studies that provides watershed planners with useful data for BMP effectiveness. The team was able to successfully achieve both goals.

The meta-analysis provides ranges of expected average BMP effectiveness as well as estimates of BMP effectiveness as a function of influent concentration. The database development process was informative and highlighted missing gaps in the academic literature. In particular, BMP studies have been geographically clustered, and many studies fail to report critical information needed for successful meta-analysis. We also found shortcomings in traditional parametric statistical approaches used in prior BMP assessments and provide justification for the use of alternative effect size metrics such as log-ratios.

We found that there is still substantial uncertainty in predicting BMP performance and evaluating what variables impact BMP performance. We hope that this project serves as a starting point for future work aimed at filling those knowledge gaps and providing additional pragmatic information for planners.

Bibliography

Jones, C. A., Wagner, K., Giovanni, G. D., Hauck, L., Mott, J., Rifai, H., Srinivasan, R., & Ward, G. (2009). *Bacteria Total Maximum Daily Load Task Force Final Report* (Technical Report TR-341; p. 171). Texas Water Resources Institute. https://hdl.handle.net/1969.1/86092.