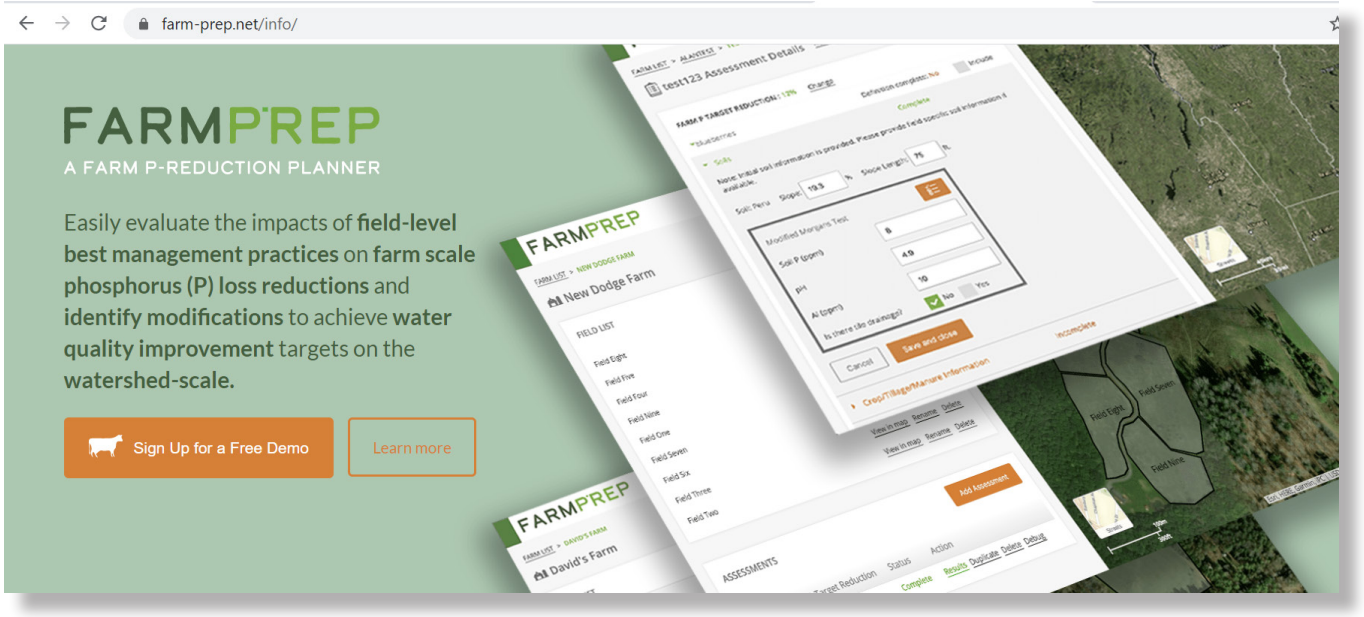
Lake Champlain Basin Program

TECHNICAL REPORT NO. 97

Implementation of a Farm Phosphorus ManagementOptimization Web-based Tool inthe Vermont Portion of the Lake Champlain Basin



June 2020

Final Report

Prepared by:
Michael Winchell / Vice President, Senior Environmental Modeler
Stone Environmental, Inc.

For:
The Lake Champlain Basin Program and
New England Interstate Water Pollution Control Commission

This report was funded and prepared under the authority of the Lake Champlain Special Designation Act of 1990, P.L. 101-596 and subsequent reauthorization in 2002 as the Daniel Patrick Moynihan Lake Champlain Basin Program Act, H. R. 1070, through the US EPA. Publication of this report does not signify that the contents necessarily reflect the views of the states of New York and Vermont, the Lake Champlain Basin Program, or the US EPA.

The Lake Champlain Basin Program has funded more than 90 technical reports and research studies since 1991. For complete list of LCBP Reports please visit:
http://www.lcbp.org/media-center/publications-library/publication-database/

NEIWPCC Job Code: 995-002-001

Final Report: Implementation of a Farm Phosphorus Management Optimization Web-based Tool in the Vermont Portion of the Lake Champlain Basin

PROJECT NO.

18-013

PREPARED FOR:

Matthew Vaughan/ *NEIWPCC Environmental Analyst, LCBP Technical Coordinator*
Lake Champlain Basin Program
54 West Shore Road
Grand Isle / VT / 05458
mvaughan@lcbp.org
802.372.0216

SUBMITTED BY:

Michael Winchell / *Vice President, Senior Environmental Modeler*
Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier / VT / 05602
mwinchell@stone-env.com
802.229.1882

Acknowledgements

This project was funded by an agreement awarded by the Environmental Protection Agency (EPA) to the New England Interstate Water Pollution Control Commission (NEIWPCC) in partnership with the Lake Champlain Basin Program (LCBP). NEIWPCC manages LCBP's personnel, contract, grant, and budget tasks and provides input on the program's activities through a partnership with the LCBP Steering Committee.

Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under agreement LC00A00394 to NEIWPCC, it has not undergone the Agency's publications review process and therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred. The viewpoints expressed here do not necessarily represent those of NEIWPCC, the LCBP Steering Committee, or EPA, nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use.

Title and Approval Page

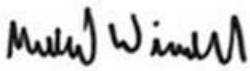
Document Title
Final Report: Implementation of a Farm Phosphorus Management Optimization Web-based Tool in the Vermont Portion of the Lake Champlain Basin, 4/29/2020

Document Prepared by
Stone Environmental, Inc., 535 Stone Cutters Way, Montpelier, Vermont 05602

Document Preparer Approvals

Michael Winchell, Vice President & Senior Environmental Modeler, Stone Environmental, Inc.

By my signature, I hereby certify that I have reviewed this document.



Signature 7/2/2020

Date

Barbara Patterson, Senior Database Developer, Stone Environmental, Inc.

By my signature, I hereby certify that I have reviewed this document.

Signature 7/2/2020

Date

Executive Summary

The Farm-P Reduction Planner tool (Farm-PREP) is designed to help farm management planners to quantify the reductions in farm-scale P losses achieved through modifications to field-level practices. Farm-PREP includes an optimization tool that will identify potential combinations of practices across multiple farm fields that will enable a targeted reduction in P loss. The tool has now been expanded for use throughout the entire state of Vermont, both within and outside of the Lake Champlain Basin. The tool has been further tested and significant enhancements have been made through a stakeholder feedback process. Farm-PREP Training workshops held throughout Vermont exposed a broad group of agricultural professionals to Farm-PREP, both providing education and serving as a platform for further user feedback.

During the Farm-PREP expansion process, the range of crop rotations that can be simulated in Farm-PREP was significantly increased, from 23 in Version 1 to 104 in Version 2. In addition, both tillage practice and cover crop practice options for annual crops were increased. The addition of a second growing season zone in Farm-PREP effectively doubled the number of possible agronomic operation schedule options available through the tool. This differentiation of growing zones added further agronomic realism to the APEX model inputs and simulation results.

A series of stakeholder engagement meetings were conducted with agricultural and natural resource professionals from Vermont Agency of Agriculture Food and Markets, University of Vermont Extension, University of Vermont Rubenstein School of Environmental and Natural Resources, Natural Resource Conservation Districts, and crop consultants. During these meetings, Farm-PREP tutorials were provided, and stakeholders were then asked to conduct Farm-PREP testing on their own. The stakeholder testing was followed by survey responses that provided feedback on 45 questions related to Farm-PREP usability, functionality, and results reporting. We received and evaluated complete survey responses from six individuals. We synthesized the results from these responses to identify common recommendations for Farm-PREP improvements and to prioritize those that would provide the greatest benefits within the scope of this project. These highest priority improvements were then implemented into Farm-PREP, including an improved help system, automatic field boundary upload, expanded user entry of soils and tile drain information, custom manure characteristics entry, BMP prioritization, reporting improvements, and exporting of results.

As part of the objective of increasing Farm-PREP stakeholder acceptance, we generated over 8,000 Farm-PREP simulations that tested a range of field conditions, crop rotations, tillage practices, and cover cropping options. These simulations demonstrated a wide range in simulated P loss for conditions and practices found within Vermont. The variability of P losses followed the expected patterns based on soil and slope condition and crop rotations. The reductions in P losses occurring with a widely applied conservation practice (cover cropping), also followed expected patterns, where higher percent reductions occur with earlier planting and lower percent reductions occur with more highly runoff prone soils. Similarly, the implementation of a 25 ft grassed buffer resulted in P loss reductions for all crop rotations as expected, where reductions were highest for continuous corn rotations. This analysis provided confidence that results from Farm-PREP were not producing any unexpected outlier results and that overall, the predictions followed a range of expected trends.

The three Farm-PREP workshops, conducted in Rutland, Colchester, and St. Johnsbury during December of 2019, provided the opportunity for over 50 agricultural and natural resources professionals to take Farm-PREP for a test drive. Participants in the workshop received lectures concerning the science behind Farm-PREP and the APEX model, as well as the use of the tool itself. Participants engaged in hands-on training that walked them through a series of Farm-PREP simulations on an example farm. Many participants had the opportunity to run simulations for their own farm fields and agronomic practices of interest. Workshop participants also provided further recommendations and feedback that can serve as the basis for potential future enhancements to Farm-PREP.

This project effort has resulted in important improvements to the Farm-PREP tool, a substantial increase in stakeholder acceptance and confidence, and a significantly broader group of agricultural professionals throughout Vermont that are familiar with and experienced in applying Farm-PREP to evaluate the beneficial impacts of applying conservation practices to reduce farm-scale P losses. We hope these accomplishments will lead to broader use of the tool across the LCB to help in the quantification and tracking of how conservation practice implementation across the basin is reducing P loss from farms and improving the water quality of Lake Champlain.

Contents

List of Figures

List of Tables

1. Project Introduction

Lake Champlain continues to suffer from the effects of excessive P loading from sources in the Lake Champlain Basin (LCB). Nonpoint source P derived from agricultural land is a substantial component of the Lake's annual P load (Troy et al. 2007; Stone Environmental, 2011; US EPA, 2016). Vermont farmers have shown strong interest in implementing best management practices (BMPs), such as conservation tillage, manure and nutrient management, and cover crops in recent decades to address losses of P, sediment, and other pollutants to surface waters. The ability to quantify the beneficial impacts of these practices on reducing additional loss of P from farm fields to surface water is imperative to meeting the long-term water quality improvement goals for Lake Champlain.

Stone Environmental and the University of Vermont (UVM) recently completed a pilot project in the St Albans Bay watershed to test a modeling approach for optimizing the implementation of best management practices (BMPs) on farms to achieve water quality goals. The resulting modeling approach and tool, called the Farm-P Reduction Planner (Farm-PREP), implements the Agricultural Policy / Environmental Extender Model (APEX, Gassman et al., 2009; Steglich et al., 2016; BREC, 2020) to quantitatively evaluate an array of possible agricultural practices across the farm and identify those that will achieve a load-based P water quality target (based on 2016 total maximum daily loads (US EPA, 2016)), allowing the farmer to pick options that fit within their preferred farm operating methods. This project engaged a technical crop consultant and pilot farm to guide the design of the system. The Farm-PREP tool quantitatively identifies the types and locations of field-level agricultural practices that meet pre-defined P load reduction targets, all specific to a specific farm's land and operations. Phase 2 of Farm-PREP development, the subject of this report, builds upon the Phase 1 pilot study to expand Farm-PREP to cover the entire Vermont portion of the LCB. This has laid the groundwork required to successfully implement Farm-PREP as part of a systematic approach to guiding farm practices and achieving water quality improvement goals.

The Farm-PREP Phase 2 project was designed to ensure successful implementation of the tool across the state of Vermont through increasing stakeholder confidence and acceptance, creating a knowledgeable user community, and making a commitment to continued technical support of the application through 2022. The project focused on four primary objectives. The first objective was to expand the geographic extent of Farm-PREP databases and model inputs to encompass the entire Vermont portion of the LCB, including reviewing and updating basin-wide agronomic practice data to cover the entire state of Vermont. Included in this first objective was updating of Farm-PREP agronomic practices to provide a wider selection on input options for all users. The second objective was to achieve increased tool acceptance through testing of the tool with stakeholders across the broader basin. Our project team engaged with stakeholders from different regions of the LCB for testing and evaluation of the tool. Testing included evaluation of Farm-PREP usability and examination of results from both the technical and practical standpoint. Feedback from the testing phase was compiled, synthesized and ultimately lead to updates to the user interface that improved the tool's usability and functionality. The third objective was to develop an educated group of stakeholders interested in applying the tool to their farms or farms of interest to their organization. This stakeholder group, which included crop consultants, university extension agents, and regulators, gathered in different regions of the basin for 1-day training courses on the use of the tool and interpretation of results. The fourth objective was to facilitate

widespread adoption and use of the tool by providing continued application hosting and technical support. Widespread use of this tool across the basin provides great potential for well-informed P management at the farm scale leading to meaningful water quality improvements at the basin scale. The tasks associated with achieving each objective are described in the sections that follow. The outcome of this project is a basin-wide tool that provides consistent and credible quantification of reductions in farm-scale P loss based on identification of field and farm level practices that meet desired water quality targets, ultimately leading to a more strategic approach to improving the water quality of Lake Champlain.

2. Tasks Completed

The tasks completed in this project closely followed the approved project workplan. These tasks are described in this section.

2.1. Task 1: Expansion of Farm-PREP Tool Across the Vermont Portion of the Lake Champlain Basin

Version 1 of the Farm-PREP tool developed by Stone was specifically designed for use in Vermont and received more focused development and testing for use in the St. Albans Bay watershed. The core spatial datasets required by the tool, including topography, soils, and weather time series, had already been compiled for the entire state of Vermont. However, the agronomic operation schedules and parameters developed for Farm-PREP during Phase 1 of the project were not wholly applicable to the complete range of farming conditions across the state. Thus, the focus of this task was on developing a database of typical agronomic practices by geographic region within the LCB.

The APEX model agronomic operation schedules provide core inputs to the APEX model regarding each farm field's operations including crop rotations, planting, fertilizer and manure application, harvesting, tillage, and cover cropping. The original operation schedule database in Farm-PREP was developed in collaboration with Vermont NRCS (past work with VT-STAR) and UVM Extension, and tested based on farm practices in the St. Albans Bay watershed region. In this task we built upon this database by refining the agronomic operation schedule options and potential best management practices (BMPs) by growing season region within the basin. For example, planting and harvest dates for corn varied across the basin, as did the number and timing of hay cuttings achieved during a season. There were also additional common tillage practices and characteristics of best management practices added, such as timing for cover crop planting. These geographically explicit agronomic operation schedules were developed in collaboration with local agricultural experts.

The QAPP from Phase 1 of the project ("Development of an Approach and Tool of Optimize Farm-Scale Phosphorus Management and Achieve Watershed-Scale Loading Targets," Approved 2017-09-22) was renewed and served as the required QAPP for this project.

2.2. Task 2: Stakeholder Farm-PREP Testing and Results Evaluation

This task focused on building confidence in and acceptance of Farm-PREP through engaging stakeholders in testing and evaluation of the tool on farms across the broader LCB. The ultimate value and success of this tool in helping guide choices in farm practices to help achieve water quality goals hinges upon both usability from the stakeholder's perspective, and accuracy in the model predictions. Our ultimate goal is to provide many planners and farmers with a tool that can optimize alternative agronomic management and BMP strategies on a targeted farm-field basis and provides assurance that they have met their obligation in meeting the TMDL water quality targets.

2.2.1. Task 2.1: Engage Stakeholders in Testing and Evaluation of Farm-PREP

Previous work completed on Farm-PREP benefited from engagement of local crop consultants on guiding its development for application within the St. Alban's Bay watershed. To broaden the base of stakeholder input and feedback for this project, we sought to identify additional groups and individuals to evaluate and provide feedback on the value and usability of the tool. We identified five different groups of stakeholders to involve in training, testing, and feedback of Farm-PREP. These groups included Vermont Agency of Agriculture Food and Markets, University of Vermont Extension, University of Vermont Rubenstein School of Environmental and Natural Resources, Natural Resource Conservation Districts, and crop consultants. These groups were specifically identified to include participants who were from portions of the LCB that had limited prior involvement in the tool's development and testing.

We conducted two sessions with each group and expanded upon the second session to involve and train more participants from each of the stakeholder groups. During the first training and feedback session we provided basic training on the tool and guidance for providing feedback in a comprehensive online survey. The specific feedback we sought from these engaged stakeholders was on the usability of the tool and on the value of the information provided by its output. Once this testing and evaluation phase was complete, we generated a prioritized list of improvements to be made in Farm-PREP. High priority improvements were made in the tool and others were identified as outside of the current project scope and will be considered for later implementation.

Following the application improvements and updates, we conducted a second round of workshops with larger groups of users including NRCS Conservation Planners and specialists, District Land Treatment Planners and specialists, private Nutrient Management Planners, Agency Agronomists and specialists, and other agronomists and water quality specialists . We held three half day workshops where we trained users on the updated functionality to Farm-PREP and provided exercises and hands-on time to use the application (see additional information Task 3). These workshops produced additional stakeholder feedback which can be used to further enhance Farm-PREP in the future.

2.2.2. Task 2.2: Implement Farm-PREP Tool Updates Based on User Feedback

This task focused on the implementation of the highest priority Farm-PREP updates based upon stakeholder feedback. The feedback on the tool was both positive and substantial. Many stakeholders provided similar recommendations as to how the tool could be improved. The highest priority improvements were determined based on the frequency mentioned, the level of benefit versus the level of effort within the current project funding, and our own understanding of how the suggested update would impact overall model results and tool functionality. Updates to Farm-PREP improved both the usability in terms of ease of adding information into the system, flexibility with specifying inputs to the model, functionality, and improvements in viewing reported results.

2.2.3. Task 2.3: Comprehensive Evaluation of Farm-PREP Simulation Results

An earlier version of the Farm-PREP tool (VT-STAR) has been tested and compared against five edge-of-field monitoring sites in Vermont (Stone Environmental, 2015). More extensive calibration and validation of the APEX model (the foundation for the Farm-PREP tool) was conducted as part of a separate research effort funded by the LCBP, titled "Refinement of Critically Needed Assessment Tools for Tile Drainage P Loading in the Lake Champlain Basin", which focused on simulation of tile and surface P losses from drained and un-drained fields. In addition, during the Phase 1 project effort of the Farm-PREP tool development, APEX model simulation results were selectively examined over a range of agronomic practices and field conditions. As the intended usage of the Farm-PREP tool is across the Vermont side of the LCB, additional and more comprehensive testing of the tool and evaluation of outputs were conducted in this assessment.

The evaluation of Farm-PREP simulation results included testing thousands of combinations of agronomic management practices over a range of field conditions. The results of these simulations were analyzed to determine: 1) do any combinations result in failure of the APEX model execution, 2.) are the results within expected ranges for their cropping system and field conditions, and 3.) are there conditions that result in "outliers" in model results that may require special constraints of the model parameterization. The goal of this sub-task was to ensure that Farm-PREP simulations produce realistic predictions of P load and P load reductions across Vermont portion of the LCB.

2.3. Task 3: Creation of a Knowledgeable User Community through Outreach and Training

One measure of success of this tool is the development of a knowledgeable user community. This task included organizing and delivering an outreach and training program on the use of the tool to a broader group of stakeholders. These groups included crop consultants, farmer organizations, university extension agents, and regulators, gathered in 3 different regions of the basin for a 1-day training on the use of the tool and interpretation of results. Our goal was to create a core sustainable user community across the basin that is proficient in assisting farmers to identify the best field level management practices that enable a farm to achieve TMDL-based water quality targets.

2.3.1. Task 3.1: Identify Stakeholders and Prepare Training Materials

We worked with staff from LCBP, Vermont Agency of Agriculture, Farms and Markets, the Vermont Department of Environmental Conservation, UVM Extension, Vermont NRCS, and Conservation Districts to identify additional users to help make Farm-PREP a widely used and accepted key tool in identifying best management practices for farms in the basin. Stone located suitable venues for conducting the all-day training in three locations in the basin distributed geographically. Invitations were sent to the identified stakeholders with a request that they further extend the invitation to other interested practitioners.

Stone developed Farm-PREP workshop training materials that include sample application scenarios. The workshop materials were tested prior to the formal training sessions. The training materials will also be available for download from the Farm-PREP web site.

2.3.2. Task 3.2: Conduct Training Session

At each training session, Stone provided a printed training guide and sample applications, drinks & snacks for breaks, and a bag lunch. An evaluation form was also provided for input from participants to assist with future training sessions.

2.4. Task 4: Application Hosting and Technical Support

The Farm-PREP tool will be made available to users throughout the LCB through hosting of the application, maintenance of the model and databases, and technical support provided to users. For the benefits of this tool to be fully realized, widespread adoption and use of the tool will be necessary. The primary objectives of this expansion of Farm-PREP were focused on building out the tool's geographic relevance, improving upon the existing tool and increasing technical acceptance, and engaging and educating stakeholders through training workshops. We also need to support and maintain the tool in the years following to ensure continued expansion of its use.

As part of this project, Stone is providing hosting and maintenance of the application for a period of 2 years, where year 1 overlapped with the development process of the project (2019 – 2020). Technical support for

server access and server resource management or use is provided as part of the hosting arrangement, as is ongoing system maintenance such as backups, software security updates/patches, and metrics tracking. The application continues to meet security standards to ensure confidentiality of data entered by users. No data will be shared across farms. Stone will not use or share data entered into Farm-PREP without explicit consent of the user who provided the data. Additional hosting support for the years 2021 – 2022 will be provided under a separate agreement between Stone and the LCBP.

2.5. Task 5: Approved Quarterly Reports and Internal Project Meetings

Quarterly progress reports were submitted within 10 days of each calendar quarter and were submitted in April 2019, July 2019, October 2019, and January 2020. These quarterly reports provided updates on the progress of each task and described any problems encountered. In addition, internal project team meetings were conducted throughout the project to provide team updates and serve as a forum for decision-making.

2.6. Task 6: Approved Final Report

The final deliverables for this project include this final report that contains: a description of the compilation and analysis of data to expand the tool throughout the LCB, a description of the methodology and outcomes of the user testing and model evaluation results, and a compilation of the stakeholder training materials. In addition, the Farm-PREP tool will be hosted and maintained for users throughout the LCB through the end of 2020, with further hosting support lasting through 2022.

3. Task 1: Methods and Results—Expansion of Farm-PREP Tool Across the Vermont Portion of the Lake Champlain Basin

3.1. New Operation Schedules

One of the primary objectives of Task 1 was to expand the operation schedules available in Farm-PREP. Version 1 of Farm-PREP focused on the most common crop rotation, tillage practices, and cover cropping practices across the northern Champlain Valley region. The goal for Version 2 of Farm-PREP was to broaden the relevance of the tool to cover all the Vermont portions of the LCB, which also include areas of Vermont outside of the Basin. The identification of additional agronomic practices to be incorporated into Fam-PREP was led by Kip Potter, former Vermont NRCS Resource Conservationist and water quality specialist.

The addition of new operation schedules for Farm-PREP was focused on adding crop rotations, with some additional options for tillage practices and cover cropping. These new crop rotations, tillage options, and cover crop options are described below.

3.1.1. Crop Rotation Updates

The number of crop rotation options in Farm-PREP was increased from 23 in Version 1 to 104 in Version 2 (81 new rotations). These are summarized in Table 1 below. A significant number of new corn/hay rotations represented the majority of the new crop rotations added, offering Farm-PREP users the ability to more closely represent their farm's practices for each field. In addition, continuous mixed vegetables and small grains rotations were added. Finally, new corn/soy and mixed vegetables/cover crop rotations were also added.

Table 1. Summary of Crop Rotations Available and Added to Farm-PREP

Crop 1	Years	Crop 2	Years	New Rotation
Corn grain	Continuous	N/A	N/A	No
Corn silage	Continuous	N/A	N/A	No
Grass hay	Continuous	N/A	N/A	No
Legume hay	Continuous	N/A	N/A	No
Mixed vegetables	Continuous	N/A	N/A	Yes
Small grains	Continuous	N/A	N/A	Yes
Corn grain	1	Alfalfa mix	4	No
Corn grain	1	Alfalfa mix	7	Yes
Corn grain	1	Alfalfa mix	9	Yes
Corn grain	1	Grass hay	4	No
Corn grain	1	Grass hay	7	Yes

Crop 1	Years	Crop 2	Years	New Rotation
Corn grain	1	Legume hay	4	No
Corn grain	1	Legume hay	7	Yes
Corn grain	1	Legume hay	9	Yes
Corn grain	1	Soybeans	1	No
Corn grain	1	Soybeans	2	Yes
Corn grain	2	Alfalfa mix	5	Yes
Corn grain	2	Alfalfa mix	6	Yes
Corn grain	2	Grass hay	6	Yes
Corn grain	2	Legume hay	5	Yes
Corn grain	2	Legume hay	6	Yes
Corn grain	2	Soybeans	2	Yes
Corn grain	3	Alfalfa mix	5	Yes
Corn grain	3	Alfalfa mix	7	Yes
Corn grain	3	Grass hay	7	Yes
Corn grain	3	Legume hay	5	Yes
Corn grain	3	Legume hay	7	Yes
Corn grain	4	Alfalfa mix	5	Yes
Corn grain	4	Alfalfa mix	6	Yes
Corn grain	4	Grass hay	4	No
Corn grain	4	Grass hay	6	Yes
Corn grain	4	Legume hay	4	No
Corn grain	4	Legume hay	5	Yes
Corn grain	4	Legume hay	6	Yes
Corn grain	5	Alfalfa mix	5	Yes
Corn grain	5	Legume hay	5	Yes
Corn grain	6	Alfalfa mix	4	Yes
Corn grain	6	Alfalfa mix	6	Yes
Corn grain	6	Grass hay	6	Yes
Corn grain	6	Legume hay	4	Yes
Corn grain	6	Legume hay	6	Yes
Corn grain	7	Alfalfa mix	3	Yes
Corn grain	7	Alfalfa mix	7	Yes
Corn grain	7	Grass hay	7	Yes
Corn grain	7	Legume hay	3	Yes
Corn grain	7	Legume hay	7	Yes
Corn silage	1	Alfalfa mix	4	No
Corn silage	1	Alfalfa mix	7	Yes
Corn silage	1	Alfalfa mix	9	Yes
Corn silage	1	Grass hay	4	No

Crop 1	Years	Crop 2	Years	New Rotation
Corn silage	1	Grass hay	7	Yes
Corn silage	1	Grass hay	9	Yes
Corn silage	1	Legume hay	4	No
Corn silage	1	Legume hay	7	Yes
Corn silage	1	Legume hay	9	Yes
Corn silage	1	Soybeans	1	No
Corn silage	1	Soybeans	2	Yes
Corn silage	2	Alfalfa mix	4	No
Corn silage	2	Alfalfa mix	5	Yes
Corn silage	2	Alfalfa mix	6	Yes
Corn silage	2	Grass hay	4	No
Corn silage	2	Grass hay	5	Yes
Corn silage	2	Grass hay	6	Yes
Corn silage	2	Legume hay	4	No
Corn silage	2	Legume hay	5	Yes
Corn silage	2	Legume hay	6	Yes
Corn silage	2	Soybeans	2	Yes
Corn silage	3	Alfalfa mix	4	No
Corn silage	3	Alfalfa mix	5	Yes
Corn silage	3	Alfalfa mix	7	Yes
Corn silage	3	Grass hay	4	No
Corn silage	3	Grass hay	5	Yes
Corn silage	3	Grass hay	7	Yes
Corn silage	3	Legume hay	4	No
Corn silage	3	Legume hay	5	Yes
Corn silage	3	Legume hay	7	Yes
Corn silage	4	Alfalfa mix	4	No
Corn silage	4	Alfalfa mix	5	Yes
Corn silage	4	Alfalfa mix	6	Yes
Corn silage	4	Grass hay	4	No
Corn silage	4	Grass hay	5	Yes
Corn silage	4	Grass hay	6	Yes
Corn silage	4	Legume hay	4	No
Corn silage	4	Legume hay	5	Yes
Corn silage	4	Legume hay	6	Yes
Corn silage	5	Alfalfa mix	5	Yes
Corn silage	5	Grass hay	5	Yes
Corn silage	5	Legume hay	5	Yes
Corn silage	6	Alfalfa mix	4	Yes

Crop 1	Years	Crop 2	Years	New Rotation
Corn silage	6	Alfalfa mix	6	Yes
Corn silage	6	Grass hay	4	Yes
Corn silage	6	Grass hay	6	Yes
Corn silage	6	Legume hay	4	Yes
Corn silage	6	Legume hay	6	Yes
Corn silage	7	Alfalfa mix	3	Yes
Corn silage	7	Alfalfa mix	7	Yes
Corn silage	7	Grass hay	3	Yes
Corn silage	7	Grass hay	7	Yes
Corn silage	7	Legume hay	3	Yes
Corn silage	7	Legume hay	7	Yes
Mixed vegetables	1	Cover Crop	1	Yes
Mixed vegetables	2	Cover Crop	1	Yes
Mixed vegetables	3	Cover Crop	1	Yes
Mixed vegetables	4	Cover Crop	1	Yes

3.1.2. Tillage Updates

Several new spring and fall tillage options were added to each crop, increasing the total number of tillage options for cultivated crops from 18 to 25. The tillage options by crop that are available in Farm-PREP Version 2 are summarized in Table 2 below.

Table 2. Summary of Tillage Options Available and Added to Farm-PREP.

Crop	Spring Tillage	Fall Tillage	New Tillage
Corn grain	Conventional and Reduced	None	Yes
Corn grain	Conventional and Reduced	Reduced	No
Corn grain	No-till	Conventional	Yes
Corn grain	No-till	None	No
Corn grain	No-till	Reduced	No
Corn grain	Reduced	Conventional	No
Corn grain	Reduced	None	No
Corn grain	Reduced	Reduced	No
Corn silage	Conventional and Reduced	None	Yes
Corn silage	Conventional and Reduced	Reduced	No
Corn silage	No-till	Conventional	Yes
Corn silage	No-till	None	No
Corn silage	No-till	Reduced	No
Corn silage	Reduced	Conventional	No
Corn silage	Reduced	None	No
Corn silage	Reduced	Reduced	No

Crop	Spring Tillage	Fall Tillage	New Tillage
Mixed vegetables	Conventional and Reduced	None	Yes
Mixed vegetables	Conventional and Reduced	Reduced	Yes
Mixed vegetables	No-till	Conventional	Yes
Mixed vegetables	No-till	None	Yes
Mixed vegetables	No-till	Reduced	Yes
Mixed vegetables	Reduced	Conventional	Yes
Mixed vegetables	Reduced	None	Yes
Mixed vegetables	Reduced	Reduced	Yes
Small grains	None	Conventional and Reduced	Yes
Small grains	None	No-till	Yes
Small grains	None	Reduced	Yes
Soybeans	Conventional and Reduced	None	Yes
Soybeans	Conventional and Reduced	Reduced	No
Soybeans	No-till	Conventional	Yes
Soybeans	No-till	None	No
Soybeans	No-till	Reduced	No
Soybeans	Reduced	Conventional	No
Soybeans	Reduced	None	No
Soybeans	Reduced	Reduced	No

3.1.3. Cover Crop Updates

The primary update to the cover crop options in Farm-PREP was adding a cover crop planting date on October 1st, representing a middle timing compared to the September 15th and October 15th options available in Farm-PREP Version 1. These cover crop planting date options by crop are summarized in Table 3.

Table 3. Summary of Cover Crop Options Available and Added to Farm-PREP

Crop	Cover Crop	Plant Date	New Crop
Corn grain	Inter-seeded cover crop	by 7/15	No
Corn grain	Winter hardy cover crop	Early - by 9/15	No
Corn grain	Winter hardy cover crop	Late - by 10/15	No
Corn grain	Winter hardy cover crop	Mid - by 10/1	Yes
Corn grain	Winter kill cover crop	Early - by 9/15	No
Corn grain	Winter kill cover crop	Late - by 10/15	No
Corn grain	Winter kill cover crop	Mid - by 10/1	Yes
Corn silage	Inter-seeded cover crop	by 7/15	No
Corn silage	Winter hardy cover crop	Early - by 9/15	No
Corn silage	Winter hardy cover crop	Late - by 10/15	No
Corn silage	Winter hardy cover crop	Mid - by 10/1	Yes
Corn silage	Winter kill cover crop	Early - by 9/15	No
Corn silage	Winter kill cover crop	Late - by 10/15	No

Crop	Cover Crop	Plant Date	New Crop
Corn silage	Winter kill cover crop	Mid - by 10/1	Yes
Mixed vegetables	Inter-seeded cover crop	by 7/15	Yes
Mixed vegetables	Winter hardy cover crop	Early - by 9/15	Yes
Mixed vegetables	Winter hardy cover crop	Late - by 10/15	Yes
Mixed vegetables	Winter hardy cover crop	Mid - by 10/1	Yes
Mixed vegetables	Winter kill cover crop	Early - by 9/15	Yes
Mixed vegetables	Winter kill cover crop	Late - by 10/15	Yes
Mixed vegetables	Winter kill cover crop	Mid - by 10/1	Yes
Soybeans	Inter-seeded cover crop	by 7/15	No
Soybeans	Winter hardy cover crop	Early - by 9/15	No
Soybeans	Winter hardy cover crop	Late - by 10/15	No
Soybeans	Winter hardy cover crop	Mid - by 10/1	Yes
Soybeans	Winter kill cover crop	Early - by 9/15	No
Soybeans	Winter kill cover crop	Late - by 10/15	No
Soybeans	Winter kill cover crop	Mid - by 10/1	Yes

3.1.4. New Operation Schedules Summary

The updates to Farm-PREP crop rotations, tillage options, and cover crop options significantly increased the possible operation schedules that a user can choose from, which in turn allows for more realistic simulation a farm's field level practices. The total number of unique agronomic operation schedules available in Farm-PREP is now over 2,094,000. This is before adding additional structural practices such as buffers and grass waterways.

3.2. Growing Season Zones

Expanding Farm-PREP to throughout the LCB and other regions of Vermont required that the variability in the growing season be recognized. The operation schedules in Version 1 of Farm-PREP were based upon typical planting and harvest dates for farming in the ST. Albans Bay watershed. Other parts of Vermont, higher in elevation and further to the Northeast, experience a shorter growing season. For incorporation into Farm-PREP, these different growing season zones needed to be represented as a spatial data layer so that a determination of an appropriate growing season for a farm could be determined automatically by Farm-PREP through a geospatial analysis. We determined that two distinct growing season zones, representing a "long" and "short" growing season, would be sufficient to cover the range in conditions found across the entire LCB.

3.2.1. Delineation of Growing Season Zones

Several spatial datasets were evaluated when creating the growing season zones, including the NRCS Major Land Source Regions (MLRAs), elevation, and the USDA Plant Hardiness Zones (PHZs). The MLRAs are distinguished based on physiography, geology, climate, water, soils, biological resources, and land use. Many of these attributes that define MLRAs have impacts on growing season, which is why MLRAs were first considered. Elevation is a driving factor in Vermont's climate, impacting average annual temperature, snowfall accumulation and spring melt timing, and frost-free periods. The USDA PHZs are based upon expected minimum winter temperature, which is related to overall temperature regime and growing season length.

The three datasets described above were used to generate candidate maps of growing season zones for Vermont as following:

- MLRA-Based Map:
    - Short Growing Season: Northeastern Mountains, New England and Eastern New York Uplands (Northern Part)
    - Long Growing Season: St. Lawrence-Champlain Plain, New England and Eastern New York Uplands (Northern Part)
- Elevation-Based Map:
    - Short Growing Season: >= 1,000 ft elevation
    - Long Growing Season: < 1,000 ft elevation
- Plant Hardiness Zone-Based Map:
    - Short Growing Season: Zones 3b, 4a, and 4b
    - Long Growing Season: Zone 5a and 5b

The growing season zones maps based on the individual data sources are shown in Figure 1-A, -B, and -C. Each of them did a reasonable job of representing our conceptual division of growing zones, yet each had some drawbacks. The MLRA-based delineation did not represent enough of the Connecticut River Valley or some of the other valleys of the LCP tributaries such as the Winooski or the Lamoille valleys. The elevation-based delineation did not recognize the Northeastern part of the state as a contiguous region in the shorter growing season. The USDA PHZ-based map did not include the northern Champlain Valley in the longer growing season zone and seemed to over represent the longer season zone in the southern mountains. To address the modest shortcomings in the growing zones based on individual datasets, we developed a "hybrid" approach to delineate these growing zones by combining the elevation-based delineation with the PHZ-based delineation. The criteria used were as follows.

- Elevation/ Plant Hardiness Zone-Based Map:
    - Short Growing Season: PHZs 4b, 5a, and 5b, greater than 1000 ft elevation, plus PHZs 3a and 3b
    - Long Growing Season: PHZs 4b, 5a, and 5b, less than 1000 ft elevation

The resulting hybrid delineation of growing season zones is shown in Figure 1-D. This map best fit our conceptual model of boundaries for long and short growing seasons throughout the state. The Champlain Valley from north to south is well-defined, the Connecticut River and other major valleys are included in the longer growing season, and the southern and central Green Mountains and Northeast Kingdom are all included in the shorter growing season. This growing season delineation was incorporated into Farm-PREP to assign growing season-specific operation schedules to each farm.

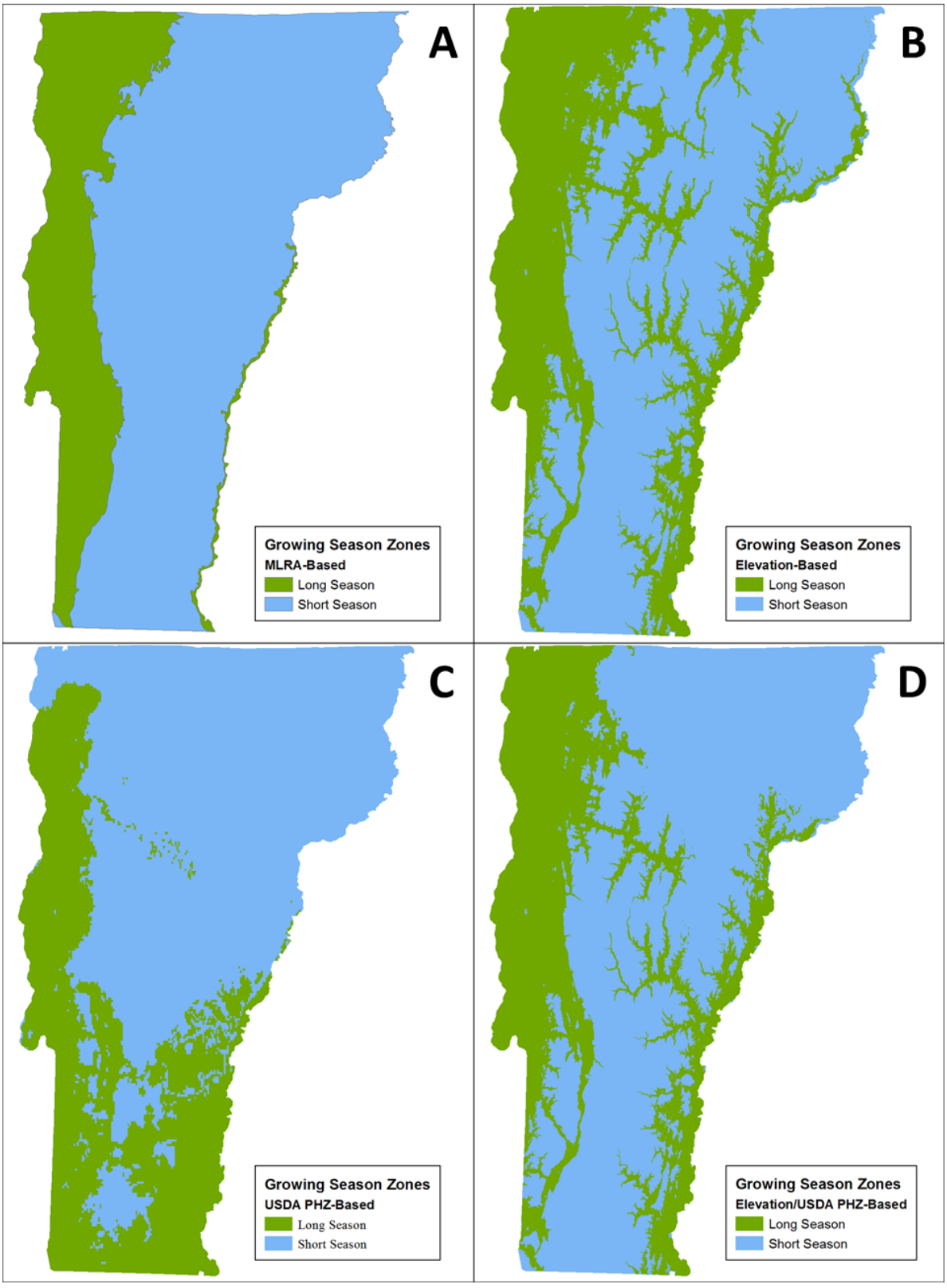


Figure 1. Growing Season Zones Considered

3.2.2. Modification of Operation Schedules

Operation schedules developed for Farm-PREP Version 1 were representative of the long growing season. For these operation schedules, typical planting dates for corn grain and corn sileage were May 15th and typical harvest dates were October 10th. For the short growing season, the typical planting date was shifted by two weeks to May 29th and the typical harvest date was shifted by two weeks to September 26th. The planting and harvest dates for each annual crop simulated in Farm-PREP for both growing season zones is provided in Table 4. For hay crops, cutting dates were adjusted for the short growing season from the original cutting dates developed for the long growing season. In addition, a 6-cut per year hay crop in the short growing season zone is not applicable. These hay cutting dates are summarized in Table 5.

Table 4. Planting and Harvest Dates for Annual Crops in Farm-PREP

	Planting Date		Harvest Date	
Crop	**Short Season**	**Long Season**	**Short Season**	**Long Season**
Corn grain	29-May	15-May	26-Sep	10-Oct
Corn silage	29-May	15-May	26-Sep	10-Oct
Mixed vegetables	29-May	15-May	14-Jul	30-Jun
Small grains, spring plant	3-Jun	20-May	15-Sep	15-Sep
Soybeans	29-May	15-May	21-Sep	5-Oct

Table 5. Hay Cutting Dates in Farm-PREP

		Hay Cutting Date	
Crop	**Cuts/Year**	**Short Season**	**Long Season**
Hay	2	16-Jun	16-Jun
Hay	2	1-Sep	1-Sep
Hay	3	1-Jun	7-Jun
Hay	3	15-Jul	15-Jul
Hay	3	1-Sep	1-Sep
Hay	4	1-Jun	1-Jun
Hay	4	15-Jul	15-Jul
Hay	4	1-Sep	1-Sep
Hay	4	15-Oct	1-Oct
Hay	5	15-May	1-Jun
Hay	5	15-Jun	1-Jul
Hay	5	15-Jul	1-Aug
Hay	5	1-Sep	1-Sep
Hay	5	1-Oct	1-Oct
Hay	6	15-May	N/A
Hay	6	15-Jun	N/A
Hay	6	15-Jul	N/A
Hay	6	15-Aug	N/A
Hay	6	15-Sep	N/A
Hay	6	15-Oct	N/A

4. Task 2: Methods and Results: Stakeholder Farm-PREP Testing and Simulations Evaluation

4.1. Engage Stakeholders in Testing and Evaluation of Farm-PREP

This task involved identification of stakeholder groups, an initial demonstration and training session with each group, development of a comprehensive on-line survey, testing and survey completion by the stakeholders, and prioritization of stakeholder feedback.

4.1.1. Stakeholder Identification and Farm-PREP Basic Training

We identified five stakeholder groups to participate in Farm-PREP training and evaluation. These stakeholder groups included: Vermont Agency of Agriculture Food and Markets, University of Vermont Extension, University of Vermont Rubenstein School of Environmental and Natural Resources, Natural Resource Conservation Districts, and crop consultants. These groups included users with limited previous exposure to Farm-PREP and also users from the southern and eastern part of the state.

We conducted three Farm-PREP demonstrations and basic training sessions with these five group:

- August 9, 2019 with the UVM Extension and UVM Research
- August 20, 2019 with the Vermont Agency of Agriculture
- September 2019 with the Natural Resource Conservation District and Technical Service Providers

Each of the three training sessions provided participants with a basic background on Farm-PREP, an overview and update on current Farm-PREP development activities, a comprehensive demonstration of Farm-PREP to allow users to conduct further testing and evaluation on their own, and information on the stakeholder feedback survey and expectations for completion. Users were encouraged to reach out to Stone with any questions regarding the user of Farm-PREP during their testing and evaluation of the tool.

4.1.2. Farm-PREP Stakeholder Survey

A comprehensive on-line survey consisting of 45 questions was developed and provided to all users who participated in one of the three Farm-PREP Basic Training sessions. The survey collected user feedback on the ease and intuitiveness of all areas of the user interface including entry of farm information, field data entry, assessment creation, soil information, crop, tillage, manure data entry, and select of best management practices. The survey also asked several open-ended questions regarding suggestions, improvements, and additions to each component of Farm-PREP, including functionality enhancements. The full survey is provided in Appendix A.

4.1.3. Farm-PREP Survey Feedback

The online survey was completed by at least one member of each stakeholder group. The respondents included:

- Judson Peck (Vermont Agency of Agriculture)
- Lindsey Ruh (UVM Agricultural Extension)
- Kate Porterfield (UVM Rubenstein School of Environmental and Natural Resources)
- Matthew Kittredge (Technical Service Provider—Farm Compliance Services)
- Jennifer Alexander (Conservation District Planner)
- Stefano Pinna (Technical Service Provider)

Full survey responses are provided in Appendix B. Overall, most users rated the application as highly easy and intuitive to use. Table 6–12 present individual ratings and the average rating among users on a 1 to 5 scale where 5 is very easy. Most areas of the application averaged 4 or higher (somewhat easy and intuitive to very easy and intuitive). In general, for areas that users ranked lower they indicated that they needed more information and guidance. All sections of the survey were followed by open ended questions, the highlights of which are summarized below. Feedback and input received that were identified as being out of the current scope are also summarized.

4.1.3.1. Farm and Field Creation

Users generally found it easy to import fields and create new fields with the drawing tool (Table 6). Feedback to provide more information from the results of the spatial processing was identified as a high priority.

Table 6. Survey Responses to Farm and Field Creation Questions

Question	Average Rating	Individual Ratings					
How easy and intuitive is it to add a farm?	4.7	5	5	5	4	4	5
How easy and intuitive is field drawing	4.8	5	5	5	4	5	5
How easy and intuitive is uploading Shapefile of farm fields	4.3	4		5		3	5

4.1.3.2. Assessment Creation

Creation of assessments and setting of P targets also received high ratings from all users. Users again indicated interest in additional help information, more information on baseline assessment assumptions, and what goes into determining practices included in the P target. Improvements in the overall tool help system will address these requests.

Table 7. Survey Responses to Questions on Assessment Creation

Question	Average Rating	Individual Ratings					
How easy and intuitive is creating an Assessment	4.0	3	3	3	5	5	5
How clear is the purpose and meaning of the assessment "Status" Indicator	4.7	5	3	5	5	5	5
How clear is the purpose and meaning of the assessment "Action" Links	4.7	5	3	5	5	5	5
How clear is the purpose and meaning of the assessment P Target	4.7	5	3	5	5	5	5

4.1.3.3. Soil and Field Level Inputs

Users responded positively to questions rating the soils and assessment field level information (Table 8) with the primary request again being for additional help information.

Feedback related to the field soil information included display of the soil hydrologic group, a link to the soil fact sheet for the soil identified as most predominant on the field, and being able to specify whether the tile drainage is patterned or random.

The lower ratings received regarding available crop rotations were also reflected in the open-ended questions. Users requested additional rotation years for existing rotations, especially for corn/hay. Spring and fall tillage options need clarification on the "No-Till" versus "None" tillage options. Other feedback included the need for a non-winter hardy cover crop and the ability to add custom manure inputs.

Table 8. Survey Responses to Questions on Soil and Crop Input Questions

Question	Average Rating	Individual Ratings					
How clear is the source of the soils information provided and that user modifications are optional?	4.0	5	5	4	2	3	5
How clear and intuitive is accessing and entering field level information?	4.2	5	4	5	3	3	5
Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?	3.0	4	4	4	1	1	4
Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?	3.8	5	4	4	1	4	5
Is representing manure applications in terms of P2O5 rate sufficient?	3.8	4	2	4	5	3	5
Are there enough cover cropping options provided?	3.5	2	4	4	4	2	5
How valuable is the "apply settings to other fields" functionality?	4.7	5	5	5	4	4	5

4.1.3.4. Best Management Practice Inputs

Users rated the best management practice inputs for buffers and grass waterways and BMP exclusions positively but not as highly as other areas of Farm-PREP (Table 9).(Users requested the ability to measure the buffer with a distance tool in order to more accurately determine the buffer width.

Table 9. Survey Responses to Questions on Best Management Practice Input

Question	Average Rating	Individual Ratings					
How easy and intuitive is entering information on buffers and grass waterways?	4.0	5	4	5	4	1	5
How clear is the purpose and functionality of the Field BMP Exclusions?	4.0	5	4	4	4	4	3
How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?	3.8	4	4	5	4	3	3

One question related to buffers was how Farm-PREP accounts for a field's proximity to surface water and whether Farm-PREP assumes there is runoff to surface water without a buffer. Currently, Farm-PREP will evaluate the benefits of a buffer regardless of the proximity of a field to surface water. Farm-PREP assumes that the buffer is a grass filter strip that can reduce induce infiltration and sediment deposition to lower P loses

to surface water. The need to take proximity to surface water into account in Farm-PREP is a significant change to both the tool and the APEX model and will be considered in future updates to the tool.

4.1.3.5. Running an Assessment

While responses were also favorable for this section of the Farm-PREP tool, users rated the clarity of running an assessment for current practices less clear than running an assessment to achieve P target reductions (Table 10). This feedback will be addressed with updates to how users select a current practices assessment and specify a P target for an optimization assessment.

Table 10. Survey Responses to Questions on Running an Assessment

Question	Average Rating	Individual Ratings					
Running an assessment for current practices only (no optimization)	3.7	5	3	2	4	3	5
Running an assessment for achieving a target P reduction (with optimization)	4.8	5	5	5	4	5	5
Indication that an assessment is complete	4.2	5	3	2	5	5	5

4.1.3.6. Interpretation of Farm-PREP Results

Overall users rated the results reporting and optimization functionality positively (Table 11) but also had substantial feedback in the open-ended questions regarding additional outputs and improvements to the optimization process. This feedback is provided below.

Table 11. Survey Responses to Questions on Results

Question	Average Rating	Individual Ratings					
How clear are the differences between "Baseline" and "Current" ?	3.2	4	2	3	4	2	4
How easy and intuitive is accessing field-level results?	4.2	4	4	4	4	4	5
Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?	4.0	4	4	5	2	4	5
How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?	4.0	4	3	5	4	3	5
If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?	3.2	4	4	4		2	2
Would more information on the mechanics of how the optimization is conducted be helpful?	3.7	3	5	4	3	5	2
Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?	3.7	5	4	4	4	2	3

Users were asked what additional APEX outputs would be desirable. While implementing these additional outputs in not in the current scope, these ideas included:

- Soil loss
- Nitrogen loss
- Soil organic matter
- Total pounds per field

Suggested improvements to reporting optimization results for improved decision-making included:

- Changes to the naming of the optimizations in the results report
- Highlighting of differences in the results to more easily identify where changes from current conditions are more apparent for each field

Users were asked what areas they were most interested in having more control over in the optimization. Four of the six evaluators indicated that they were interested in being able to prioritize BMPs in the optimization while one indicated wanting to select which solutions were returned. Given the strong interest in BMP prioritization we chose to make that optimization improvement a high priority.

4.1.3.7. General Farm-PREP Feedback

Users were asked several questions regarding their general Farm-PREP impressions with most of the input gathered from open ended questions. Users felt that Farm-PREP operated well and was not "buggy". In general, they also felt the amount of time to enter information was reasonable (Table 12).

Table 12. Survey Responses to General Questions on Farm-Prep

Question	Average Rating	Individual Ratings					
Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or "buggy" behavior?*	4.4	5	3	2	4	3	5
How would you rate the level of effort/time required to provide all information on a farm?	3.7	3	3	4	4	3	5
Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?	3.5	4	4	5	2	1	5

**This scale was reversed so the numbers have been adjusted to be consistent with the other scale ratings.*

When asked for suggestions on how to make Farm-PREP more efficient, the stakeholder group again emphasized the need for help and tips throughout the application. Other ideas included being able to edit fields and transfer data from the VT Partners or GoCrop applications. These latter suggestions are out of the current scope but will be considered in a future version of Farm-PREP.

4.1.3.8. Additional Feedback Received

Some input received from users was identified as being out of the current scope. These items are addressed below:

- One user requested that the operation schedules be matched up with RUSLE2 so there is better compatibility. This could be considered for a future version of Farm-PREP
- Hemp is becoming a more common crop and several users asked if it is an option. There is not currently enough information available for modeling hemp. This will be considered in a future version.
- Option for side-dress manure applications
- Adding an option for PSNT "Pre-sidedress Nitrate test" to tell how much available nitrogen is in the soil when long season crops are about to take off. While we recognize the value of this, since the current focus is on phosphorus, nitrogen optimization will be considered in a future version of Farm-PREP.

4.2. Implement Farm-PREP Tool Updates Based on User Feedback

The following section summarizes the improvements and updates that have been made to both the Farm-PREP user interface and database based on stakeholder feedback.

4.2.1. Help System Updates

In all areas of the Farm-PREP user interface, stakeholders indicated they wanted additional information. We have added help throughout the entire user interface with context related "Hints". The hint pop-ups provide users with explanations and background information as well as "how-to" (Figure 2). Hints are now available when adding an assessment, selecting an assessment option, soils information, tillage and rotation info, and best management practice prioritization.

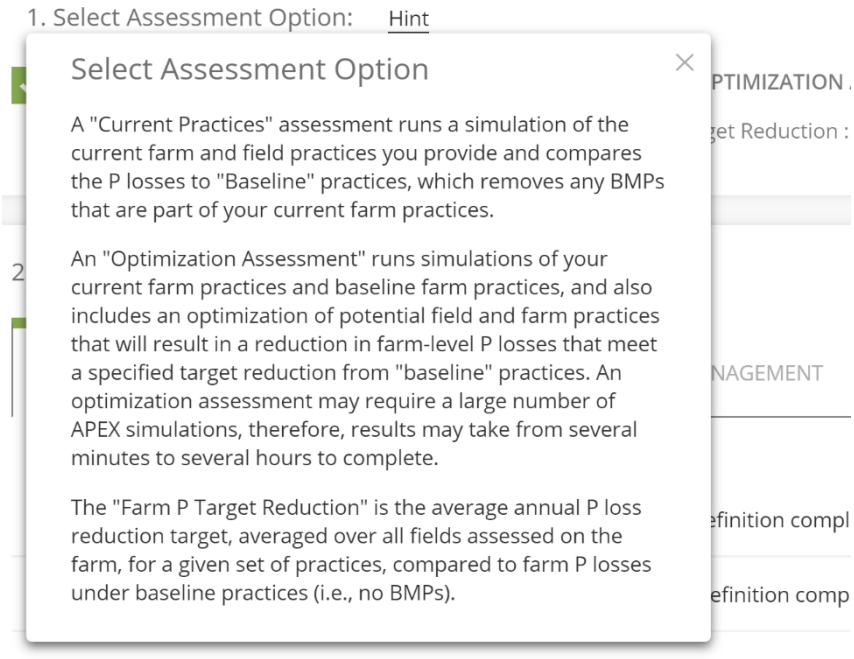


Figure 2. Hint Pop-Up for Select Assessment

Additional information was also provided directly in the user input forms to provide more guidance for entering crop, tillage, and manure information and best management practice prioritization.

Addition of new operation schedules for additional crops and a shorter growing season are described in Task 1 of this report.

4.2.2. Field Based Tool Updates

Increasing the efficiency of entering of information into Farm-PREP is an ongoing priority. Prior to the stakeholder feedback, farm field shapefile import was identified as necessary functionality. This import tool has been added to Farm-PREP and users can now import a shapefile of their farm fields. When the farm fields are imported, the field boundaries are intersected with spatial data layers and returns the predominant soils, the average slope and elevation, and the nearest weather station. With the updated growing season operation schedules and expansion of the application state-wide, the growing zone based on field location is also determined as the fields are imported.

Users requested to see more of the spatial processing results in the field information. The initial field list now includes soil name, hydrologic group, and slope. This also includes a link to the soil fact sheet for predominant field soils (Figure 3).

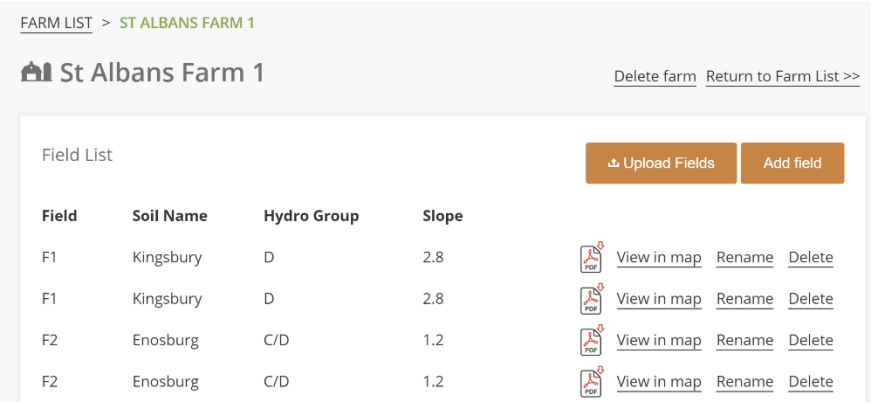


Figure 3. The Field List Displays Spatial Processing Results

4.2.3. Assessment Info Updates

Several changes were made in how the user creates a current practices and optimization assessment in order to clarify the difference between these options. When users first create an assessment, they are only asked for the Assessment Name and are not immediately prompted for a P Reduction Target. On the Assessment inputs page, they are then provided with context sensitive help and the option to choose between running a current practices assessment or an optimization assessment. If they choose an optimization assessment, the P Target Reduction will default to 30% and the user has the option to change that value (Figure 4).

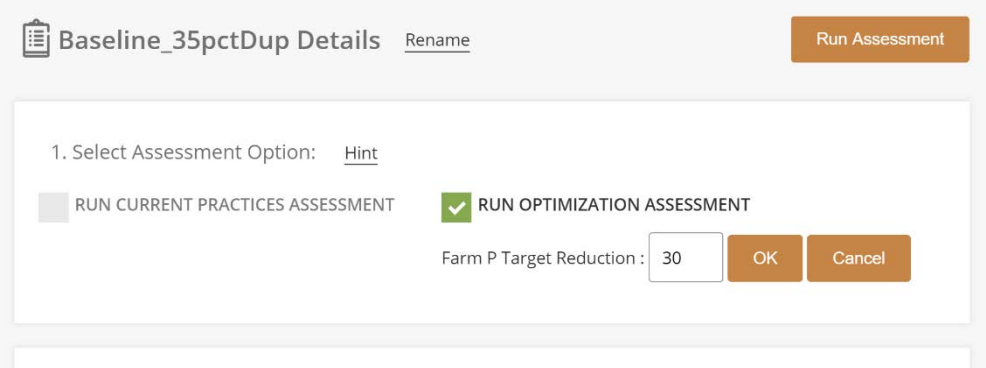


Figure 4. Assessment and P Target Reduction Options

4.2.4. Soils Inputs

Based on user feedback, the soil hydrologic group is now displayed on the soil form. Additional inputs have been added to allow users to modify the surface layer organic matter (%) and specify tile drainage options to indicate random or patterned.

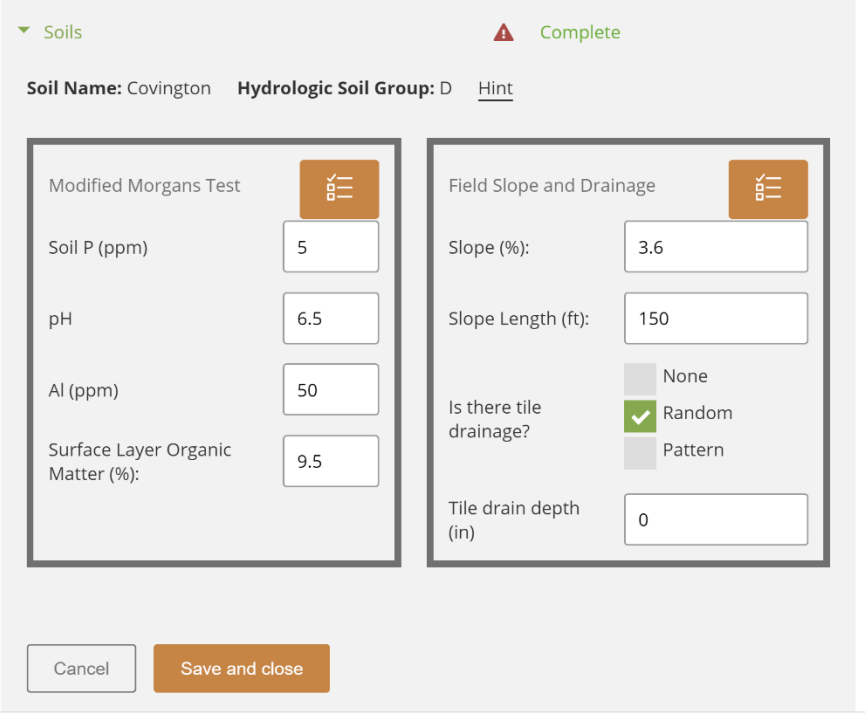


Figure 5. Additions to Soil Input Form

4.2.5. Crop, Tillage, and Manure Inputs

The Farm-PREP database of crop rotations and operation schedules has been expanded based on user feedback. These additions are summarized in Section 3.1. The addition of appropriate rotations and operation schedules based on growing season zone has also been implemented and is summarized in Section 3.2.

Users can review a full list of rotations from the "Hint" pop-up on the crop, tillage, and manure form. This context sensitive help also explains how the selection of tillage and manure options functions. Other features added to simplify data entry include a button to clear the Tillage/Manure inputs or clear the entire form.

Other improvements in this section include the addition of manure injection and a winter kill cover crop option with four planting date options: inter-seeded 7/15, early 9/15, mid-10/1, late -10/15.

Significant updates were made to the interface and database to allow users to specify manure characteristics. Users now have the option to enter custom manure characteristics which then allow them to enter their manure application rates in gallons per acre (Figure 6).

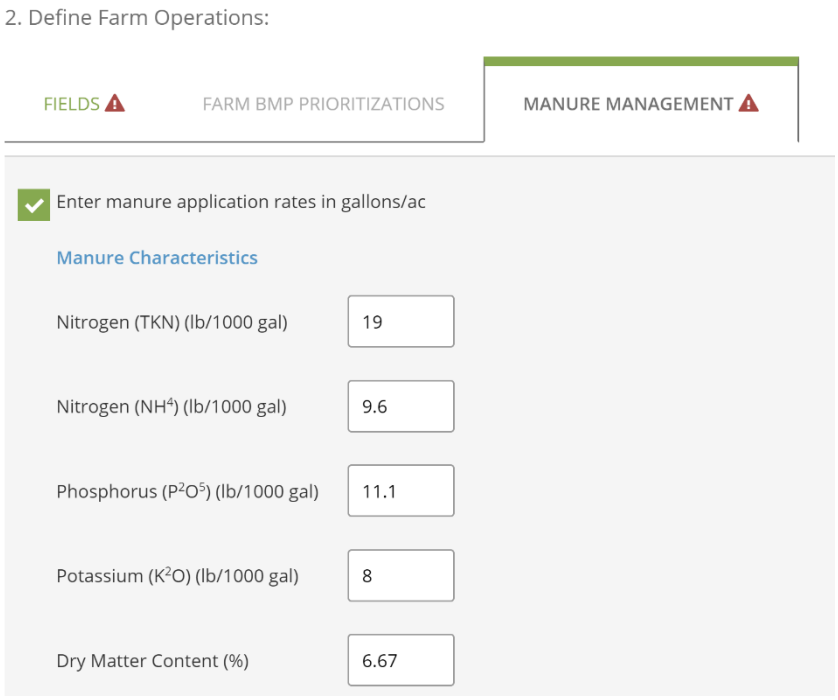


Figure 6. Manure Characteristics Input Form

4.2.6. BMP Prioritization for Optimization Assessments

Significant updates and improvements were made to how users select BMPs for inclusion in optimization assessments. Farm-PREP was initially configured to prioritize BMPs for optimization based on pre-determined priority rankings, and individual BMPs could not be excluded from consideration. This configuration resulted in situations where BMPs that may not be feasible for users were suggested in the results. Similarly, this approach inadvertently often did not include the BMPs that users were most likely to want to implement. The optimization assessments now prompt users to choose their prioritization for each BMP (Figure 7). BMPs can still be excluded and will not be considered in the practice optimization. BMPs identified as priority 1 will first be evaluated in order to determine if those practices will meet target reductions. There are three priority levels and each set of priorities is run until the target is met. This modification to the approach results in solutions that are much more likely to fit with how a user is willing to operate their farm.

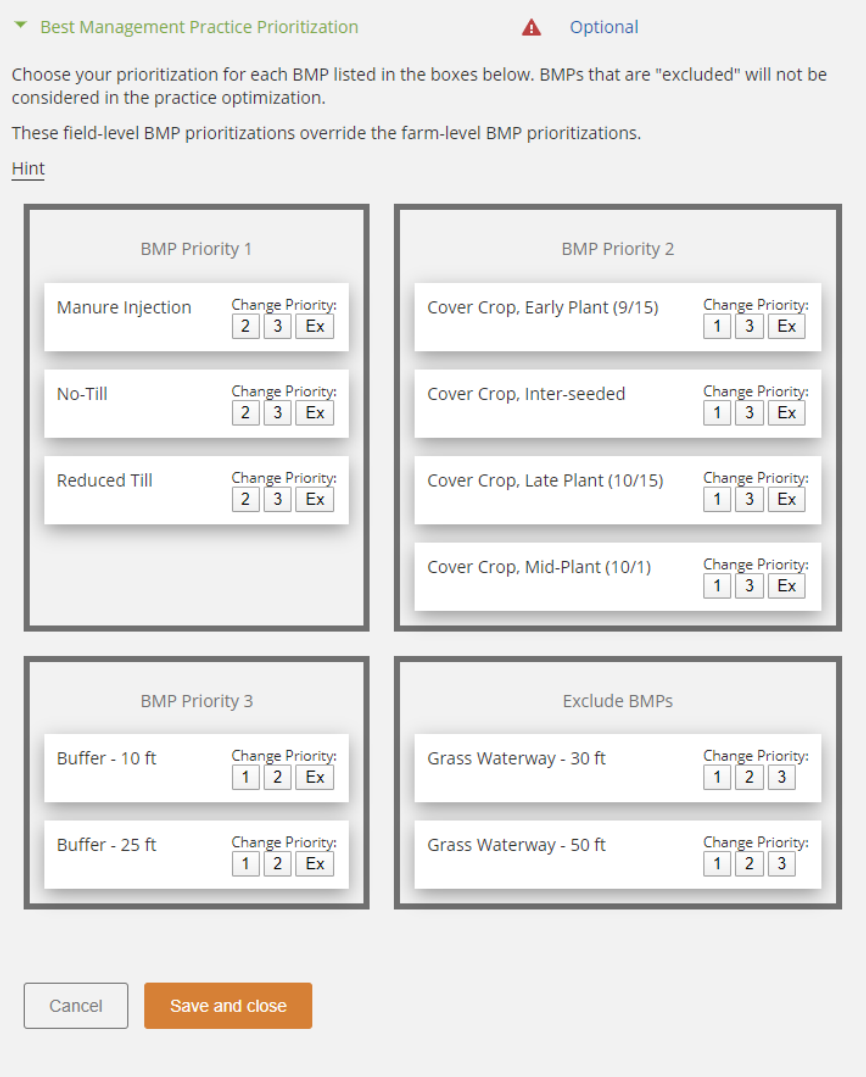


Figure 7. BMP Prioritization Specification Form

4.2.7. Reporting Improvements

Several improvements and enhancements were made to the results reporting based on feedback received. The updates are listed below.

- Report results can now be exported to a CSV file
- The report now highlights fields where practices changed in an optimization
- Users are now notified that they will receive an email with a link to the results
- The naming of optimization results has been simplified to avoid confusion. They are now numbered 1-10 starting with the result that get the user closest to the specified P target.

4.3. Comprehensive Evaluation of Farm-PREP Simulation Results

The objective of this task was to test combinations of agronomic management practices over a range of field conditions (soils, slopes). This testing should identify combinations of operations that result in the failure of the APEX model, ensure that results are within expected ranges for the associated cropping system and field conditions, and identify any conditions that result in extreme outliers that may require special constraints of the model parameterization. The goal of this sub-task was to ensure that Farm-PREP simulations will produce realistic predictions of P load and P load reductions, throughout the Vermont portion of the LCB.

4.3.1. Simulations Tested

Eight APEX models were initially set up using Farm-PREP to represent fields with different soil and land characteristics. These eight fields served as the base file decks for creating additional models to evaluate Farm-PREP operations and management options. Four soil types were simulated, representing the four hydrologic soil types (A, B, C, and D soils). For A soils, a single APEX model was developed for a field with a slope of 2%. For C soils, a single APEX model was developed for a field with a slope of 6%. For B and D soils, three APEX models were developed for fields with slopes of 2%, 4%, and 6% (referred to as fields 1, 2, and 3, respectively). Characteristics that were varied in the field set-ups are shown in Table 13. All fields were 10 hectares and other physical characteristics were the same. Initial soil test P was set to 5 ppm (Modified Morgan's).

Table 13. Field Characteristics in APEX Models Used for Evaluation of Farm-PREP Simulations

Field Name	Field ID	Hydrologic Group	Soil Name	Slope (%)
SoilA_1	1	A	Agawam	2
SoilB_1	1	B	Hadley	2
SoilB_2	2	B	Hadley	4
SoilB_3	3	B	Hadley	6
SoilC_1	1	C	Stockbridge	6
SoilD_1	1	D	Vergennes	2
SoilD_2	2	D	Vergennes	4
SoilD_3	3	D	Vergennes	6

Farm-PREP operations schedules were sampled to include realistic combinations of crop rotation, spring and fall tillage operations, cover crop type, and cover crop planting date. Operation schedules available in Farm-PREP are described in Section 3.1. Combining these operations options resulted in 1,026 unique operations schedules. Each of the eight field models were then set up to run each of the 1,026 operations schedules described above, resulting in a total of 8,208 simulations. In addition, two different weather stations were used to drive all 8,208 simulations (16,416 total simulations). The two weather stations were Bristol, VT 5 NNW (USC00430922) and Eden 2 S (USC00432698). Results presented below thereby capture variability caused by field conditions and farm operations (e.g. soil, slope, crop, and land use management practices) as well as by differences in temperature and precipitation. While results from both weather stations were used to examine trends across fields and crop rotations, only the Bristol, VT weather station (representative of the Champlain Valley) was used in the cover crop and buffer evaluations in order to simplify the comparisons across the different field conditions. Evaluation of results focused on total P in runoff: annual average total P for 20-year simulations (1996 – 2015) was calculated from all APEX runs and used as the basis for analysis presented in Section 4.3.2.

4.3.2. Results Summary

4.3.2.1. Analysis of Trends in Farm-PREP Simulations

To isolate the impact of various factors on model-predicted total P, simulations were grouped by specified inputs and boxplots used to visualize the distribution in annual average total P loss results. For this evaluation, simulations were grouped by field (unique combination of slope and soil, Table 13), by crop/rotation, and by cover crop planting date. Boxplots shown below provide the following information: the lower and upper edges of the box indicates the 25th and 75th percentiles, respectively; the blue horizontal line indicates the median, the red dashed line indicates the mean, and the whiskers show the minimum and maximum values within each grouping.

Results were first examined by looking for trends across the eight fields. Figure 8 shows boxplots of results for all simulations (both weather stations), grouped by field. Annual average total P was generally higher for soils with higher runoff potential and with higher slopes (in the case of B and D soils), as was expected. Variability generally increased in the same manner, where D soils with 6% slope had the highest maximum total P loss value and largest difference between quartiles. Similar trends were also seen in annual average runoff and erosion results. Annual average soluble P comprised a smaller portion of total P in runoff in comparison to sediment P.

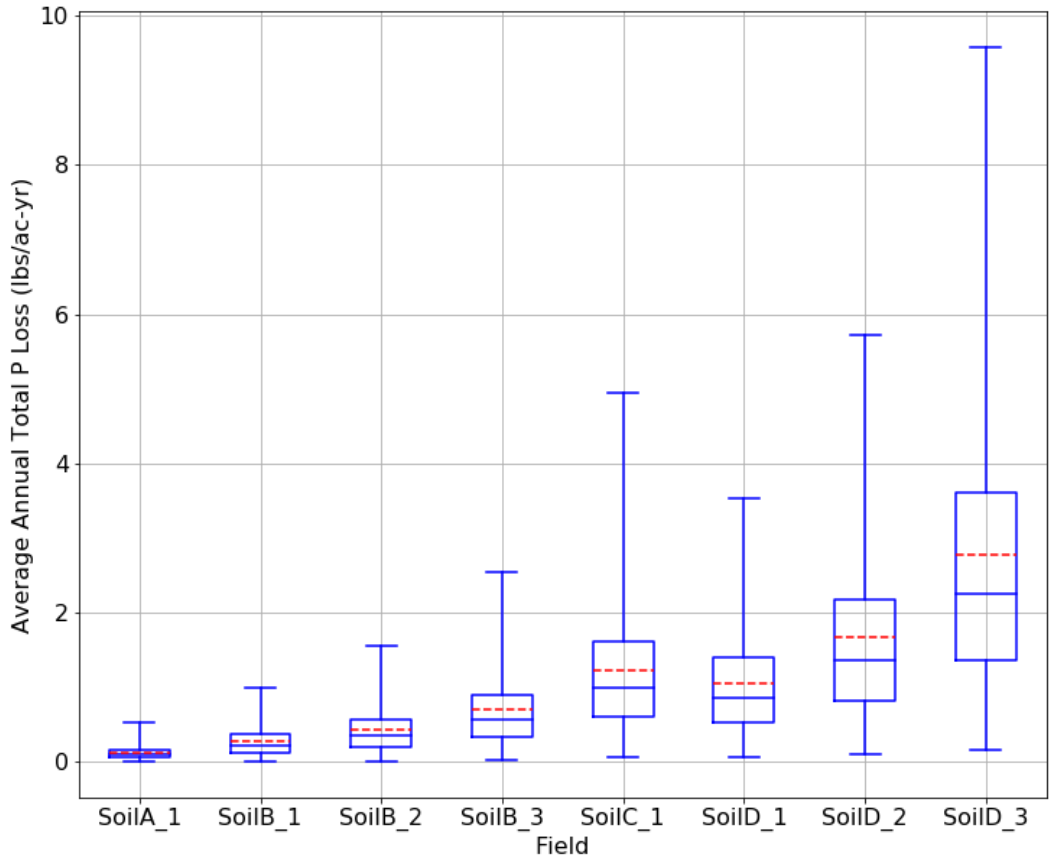


Figure 8. Simulation Results for Total P (lbs/ac-yr), Grouped by Field

Simulations were then grouped by crop rotation and similar boxplots created (Figure 9). Annual average total P was lowest and generally exhibited smaller variability in rotations that included legume hay (from lowest to highest median total P: continuous legume hay, corn 2 yr – legume hay 5 yr, corn 5 yr – legume hay 5 yr). Grass hay rotations also showed relatively low total P and smaller variability. Simulations of continuous small grains showed the highest median and mean values, as well as largest variability in results. Continous corn rotations (both silage and grain) also showed similarly high median and mean values and larger variabiltiy. Total P in runoff was again dominated by sediment P, and the trends described above were similar for erosion results. Again results demonstrated expected trends; corn rotations generated higher erosion and higher sediment P, leading to higher total P in runoff.

To evaluate trends attributed to changes in cover crop planting dates, simulations driven by the Bristol, VT weather station were first grouped by crop rotation and then further grouped by cover crop planting dates. Here all hay types were also combined, such that results for corn 2 yr - hay 5 yr includes alfalfa, legume, and grass hay rotations. Figure 10 through Figure 13 show simulation results for annual average total P loss for continuous corn silage, continuous corn grain, corn 2 yr – hay 5 yr, and corn 5 yr – hay 5 yr rotations, respectively. In all these cases, inter-seeded cover cropping generally produced the lowest total P loss results, followed by early, mid, late, and no cover cropping. These results indicated the expected impacts of cover cropping, where lower erosion and total P occurred with earlier cover crop planting dates.

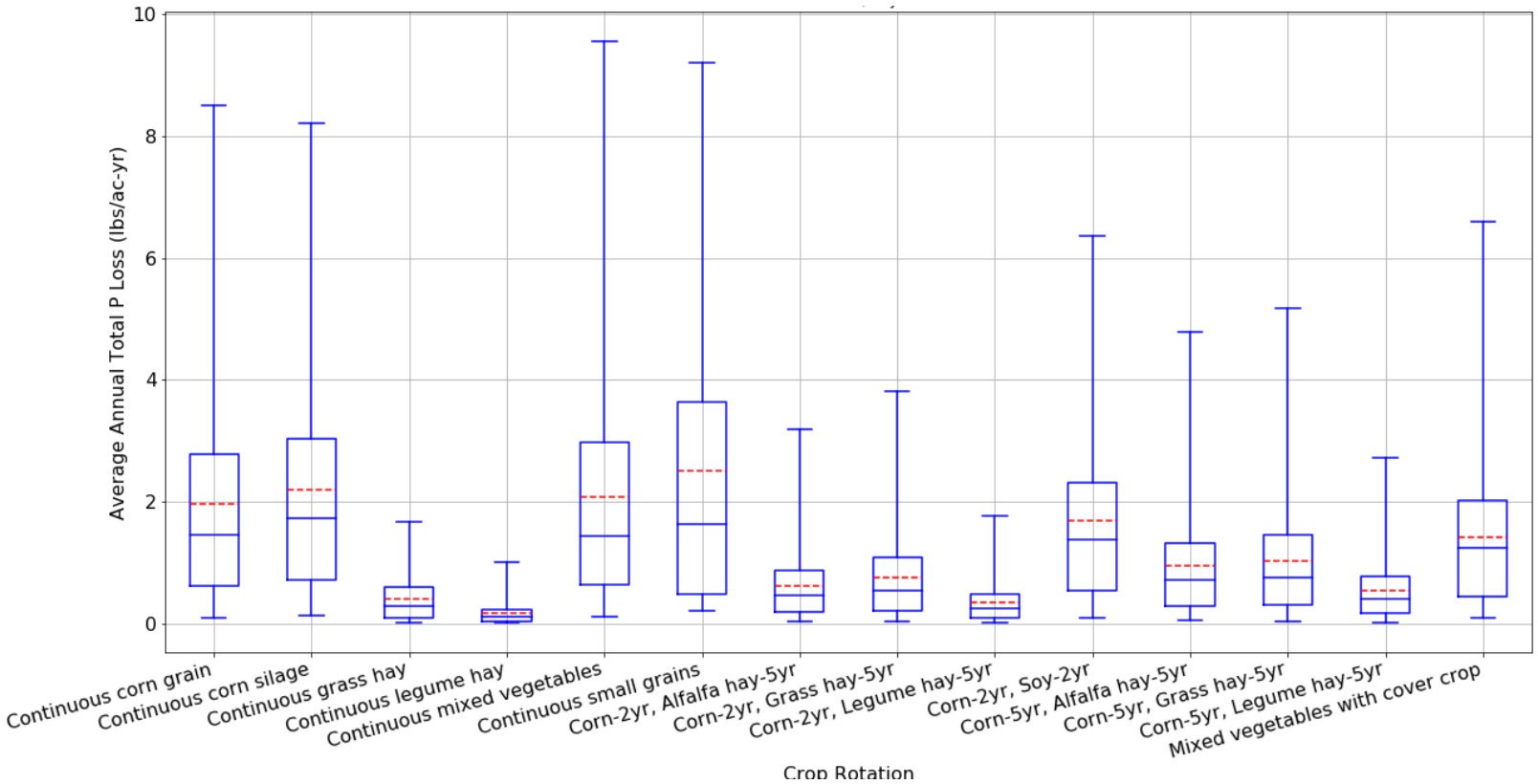


Figure 9. Simulation Results for Total P (lbs/ac-yr), Grouped by Crop Rotation

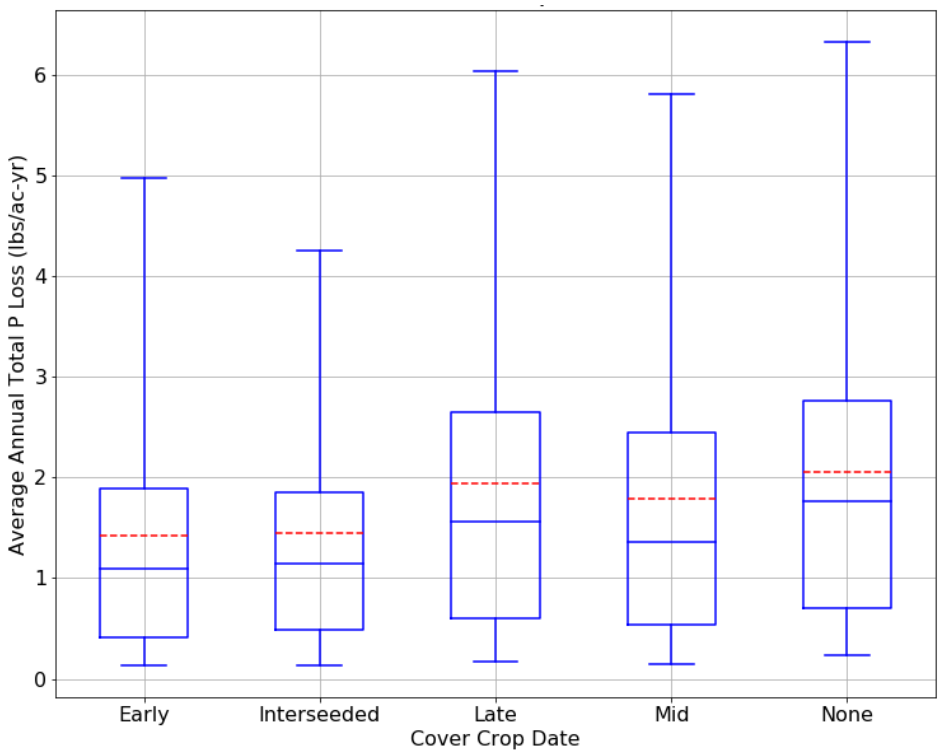


Figure 10. Continuous Corn Silage Simulation Results for Total P (lbs/ac-yr), Grouped by Cover Crop Date

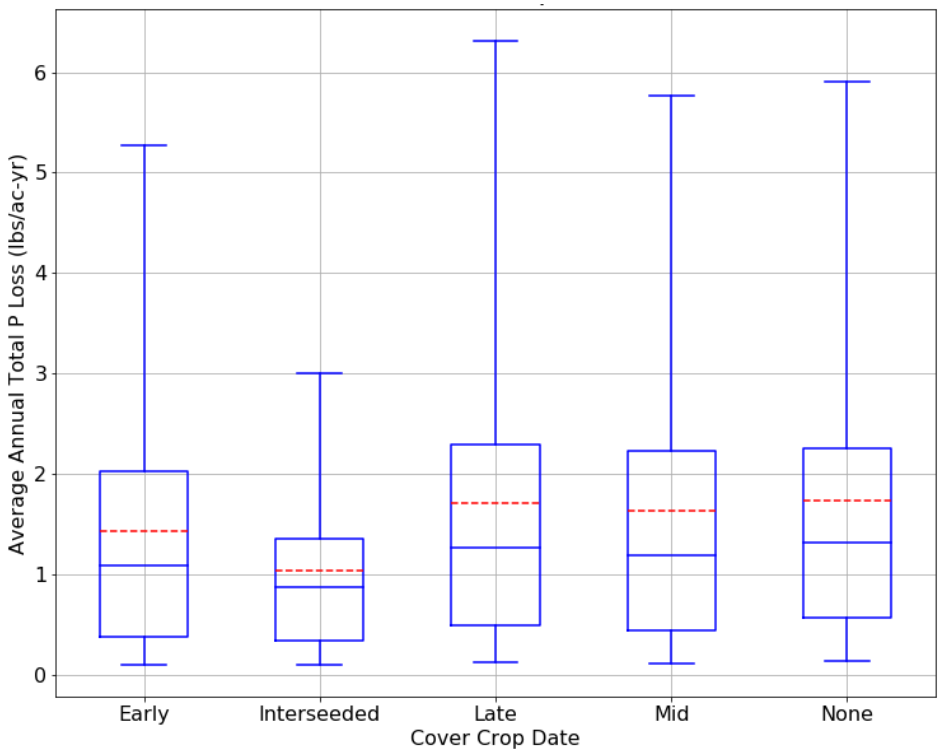


Figure 11. Continuous Corn Grain Simulation Results for Total P (lbs/ac-yr), Grouped by Cover Crop Date

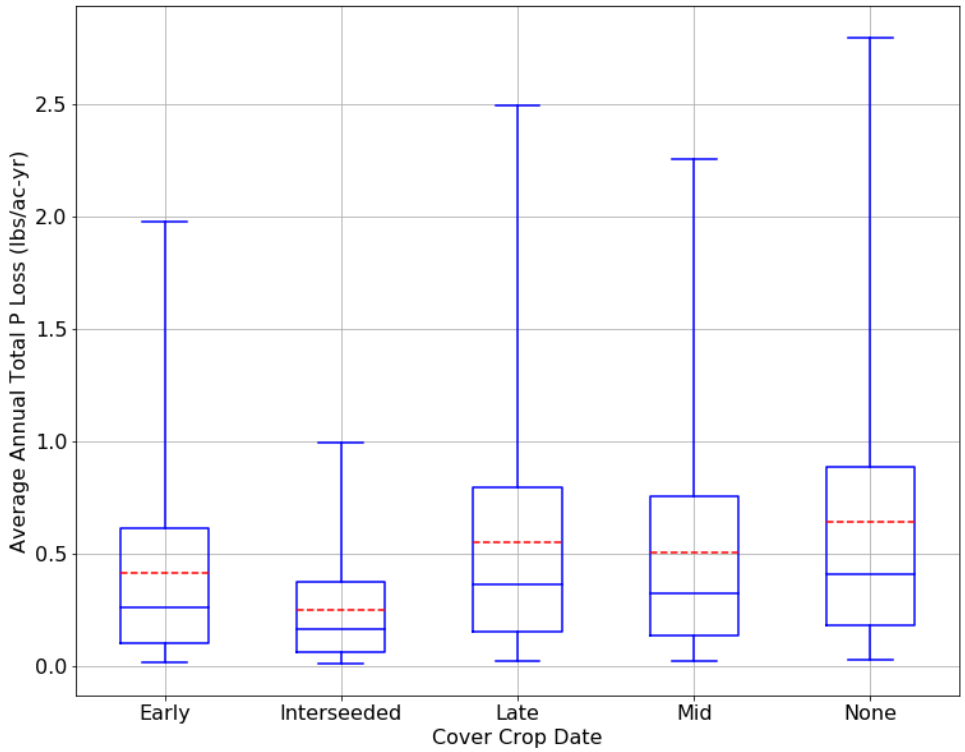


Figure 12. Corn 2 yr - Hay 5 yr Simulation Results for Total P (lbs/ac-yr), Grouped by Cover Crop Date

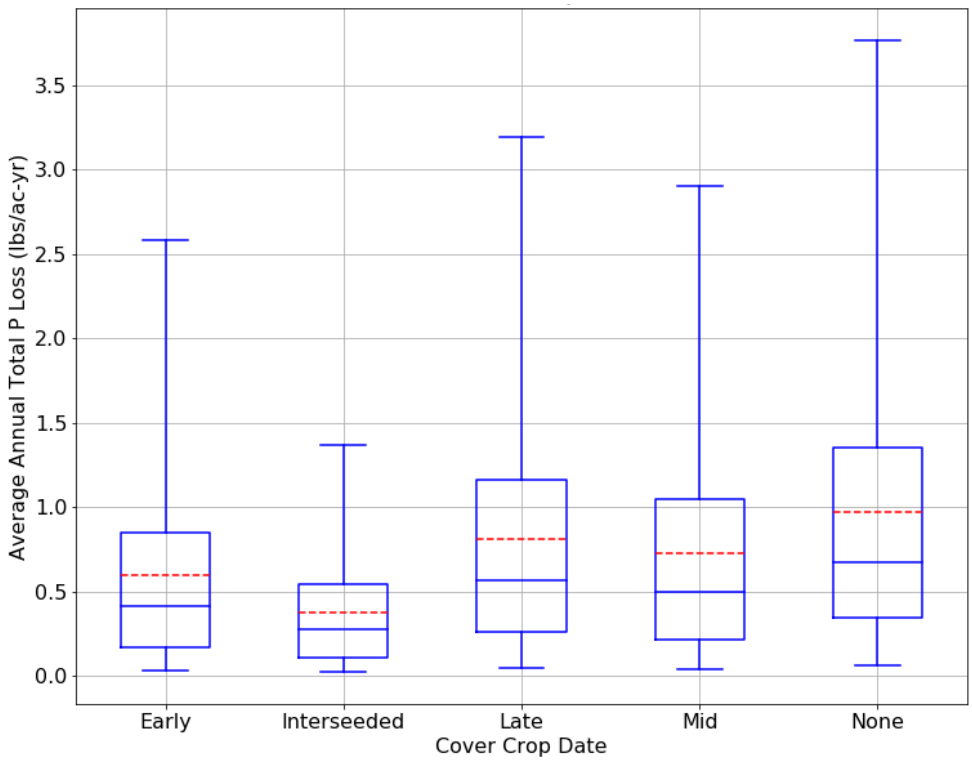


Figure 13. Corn 5 yr - Hay 5 yr Simulation Results for Total P (lbs/ac-yr), Grouped by Cover Crop Date

Results largely followed our conceptual understanding of the impacts of field conditions, rotations, and cover cropping, although no data is currently available to verify these expectations. Overall hydro group D soils on 6% slopes for corn and small grains rotations without cover crops results in the highest total P loads.

4.3.2.2. Cover Crop Effects on Total P Loss Reductions

The impacts of cover cropping and the associated planting date were further examined by calculating the percent reduction between simulations with no cover crops and the corresponding simulations where cover crops were included (based on simulations using the Bristol, VT weather station). Table 14 shows the percent reductions in annual average total P due to cover cropping for three rotations: continuous corn, corn 2 yr – hay 5 yr, and corn 5 yr – hay 5 yr. For this analysis, all hay types (alfalfa, legume, and grass) were combined and results include all eight different spring/fall tillage combinations. Average annual total P loss across simulations with no cover crop were compared to average annual total P in simulations where cover crops were planted (either inter-seeded, early planting, mid planting, or late planting). These results show that reductions are highest for inter-seeded cover crops and decrease as cover crop planting dates gets later. Reductions were higher as a result of cover cropping on corn-hay rotations in comparison to reductions seen for continuous corn silage (this trend cannot yet be explained).

Table 14. Cover Crop Reductions by Planting Date

Rotation	Field Name	% Reduction in Total P (from no cover crop to cover crop planted at specified times)			
		Inter-seeded	Early	Mid	Late
Continuous corn silage	SoilA_1	51	46	37	32
	SoilB_1	42	43	26	14
	SoilB_2	41	43	24	13
	SoilB_3	41	42	23	12
	SoilC_1	30	31	10	3
	SoilD_1	26	27	10	4
	SoilD_2	26	27	9	3
	SoilD_3	25	26	9	3
Corn 2 yr - Hay 5 yr	SoilA_1	72	52	36	32
	SoilB_1	68	48	31	21
	SoilB_2	69	48	30	20
	SoilB_3	70	48	29	19
	SoilC_1	61	35	19	12
	SoilD_1	57	32	18	12
	SoilD_2	58	32	19	12
	SoilD_3	59	32	19	12
Corn 5 yr - Hay 5 yr	SoilA_1	71	54	41	39
	SoilB_1	67	49	35	23
	SoilB_2	68	48	33	22
	SoilB_3	68	48	33	21
	SoilC_1	60	38	23	13
	SoilD_1	58	35	23	14
	SoilD_2	59	35	23	14
	SoilD_3	59	35	23	14

4.3.2.3. Analysis of Buffer Effectiveness

The impacts of buffers were also further investigated by calculating the percent reduction between simulations presented in Section 4.3.2.1 and corresponding simulations where a 25 ft buffer was implemented. For this analysis, buffers were simulated on all runs using the Bristol, VT weather station. Average annual total P loss across simulations where buffers were implemented were compared to the corresponding simulations (same field, soil, operations, and weather station) where no buffer was simulated (Section 4.3.2.1). Table 15 shows the percent reductions in annual average total P due to implementing buffers for four rotations: continuous corn silage, continuous corn grain, corn 2 yr – hay 5 yr, and corn 5 yr – hay 5 yr. All hay types (alfalfa, legume, and grass) were combined and results include all different spring/fall tillage combinations as well as all cover crop types and planting dates. Reductions in total P are highest for continuous corn simulations.

Table 15. Average Annual Total P Load Reductions By Simulating Buffers in Farm-PREP.

Rotation	**% Reduction in Total P** (between no buffer and implementing a 25 ft buffer)		
	Min (%)	**Mean (%)**	**Max (%)**
Continuous corn silage	14	24	31
Continuous corn grain	14	22	30
Corn 2 yr - Hay 5 yr	0	15	27
Corn 5 yr - Hay 5 yr	0	18	28

5. Task 3: Creation of a Knowledgeable User Community through Outreach and Training

Following updates to the Farm-PREP tool based on feedback received from Stakeholders, Stone organized three training sessions with a broader group of users.

5.1. Organize Training Workshops

Stone organized three separate training workshops in different areas of the state in order to reach out to an extended user community. The three workshops were scheduled in the following locations:

- UVM Extension Conference Room, Rutland, Vermont (December 9, 2019)
- USDA Conference Room, Colchester, Vermont (December 12, 2019)
- UVM Extension Conference Room, St. Johnsbury, Vermont (December 13, 2019)

Two e-mail invitations were sent via a targeted mailing describing the workshop, Farm-PREP, and schedule for the training sessions (Appendix C). The invitation included a link to register for the workshop online. Thirty-seven individuals from across Vermont registered for the workshop representing a broad spectrum of organizations including USDA NRCS, Vermont Agency of Agriculture, Vermont Association of Conservation Districts, county Conservation Districts, the Lake Champlain Basin Program, US EPA, and the Miner Institute. These participants also came from a diversity of professions including Soil Conservationists, Conservation Planners, Agricultural Water Quality Specialists, Agronomists, Engineers, District Conservationists, Outreach Agronomists, Nutrient Management Planners, and District Managers.

5.2. Conduct Training Sessions and Provide Workshop Materials

Each of the three training sessions were held from 8:30 am – 1 pm. The workshops were designed to give users a background to Farm-PREP and the APEX model, conduct demonstrations of new functionality, and then provide them with the opportunity for do hands on exercises. The full workshop presentation materials are provided in Appendix D.

In order to provide users with the appropriate background, the first hour of the workshop focused on all components of Farm-PREP including the APEX model, data compilation of spatial datasets and agronomic practices, the modeling approach to achieve P loss reduction targets, recent model calibration and validation, and recent updates as covered in Section 4 of this report (Task 2). Users were then presented with a full demonstration of Farm-PREP including all newly implemented functionality.

The final 2-hours of the workshop provided users with an opportunity to work on developing their own Farm-PREP assessments. For each of the three workshops, a comprehensive workbook was developed to guide users through creating their own farm, fields, and assessments. The workbooks and exercises were

customized for each region. The workbook created for the Rutland workshop is provided in Appendix E Participants in the workshops actively engaged in the Farm-PREP excises and had many engaging questions and suggestions.

6. Quality Assurance Tasks Completed

The following represents a summary of the quality control tasks completed during this study.

6.1. Expansion of the Database that Supports the Farm-PREP Modeling System

The quality assurance tasks concerning the expansion of the database to support Farm-PREP modeling system were focused in three primary areas:

1. Identification of additional operation schedules and growing zones for modeling in Farm-PREP;
2. Translating these operation schedules into database tables ensuring that all schedules were complete and accurate; and
3. Generating simulations from Farm-PREP to test a broad sampling of operation schedules to identify potential model errors, simulation outliers, and evaluate model results. These tasks were performed as follows.

In the case of item 1, generation of new operation schedules and growing zones, this task was conducted by a Stone Senior Scientist and independently reviewed by a second Senior Scientist. The review consisted of checking for consistency in agronomic operation timing and consistency with the structure of existing Farm-PREP simulations. The development of the growing zones delineation involved multiple Senior Scientists, reviewing the results of the analysis to come to a professional consensus on the methodology and results.

The translating of new operation schedules into the Farm-PREP database (item 2) required a comparison of operation schedule definitions in spreadsheet format with operation schedule information in a relational database data structure. Database quality control queries were written to check that the records storing information in Farm-PREP matched the original definition of operation schedules as intended.

Generating thousands of Farm-PREP simulations based on the database representation of each operation schedule served several purposes. First, the exercise tested whether the operation schedules resulted in any APEX model crashes or errors. Second, evaluation of simulation results served as a "reality check" to ensure that the results being predicted by the model are congruent with our scientific understanding of how environmental and agronomic conditions affect P loss from agricultural fields. Finally, the analysis provided the opportunity to identify potential "outliers" in the model predictions that might need to be addressed.

6.2. Development of APEX-based Farm Optimization Model

The focus of this quality assurance task was concerning the functioning of the Farm-PREP tool to provide a suite of optimal agricultural management options that are realistic and useful for agricultural planners in meeting P loading reduction targets. The farm level optimization process in Farm-PREP identifies combinations of field practices across a farm that results in a reduction in total P loss that is as close to the specified target reduction as possible. This requires the execution of potentially thousands of APEX simulations and subsequent evaluation of the output based on the many combinations of fields and field

practices. Internal checks of the aggregating of field-level results to farm-scale results were made to ensure that the analysis was identifying solutions that correctly met the target P loss reduction, within a tolerance of 5%. The results determined by the application "back-end" optimization module were also checked for consistency with the post-processed results reported through the "front-end" user interface of the Farm-PREP application. These results were verified to be consistent.

The results of the optimization of field practices received review during stakeholder testing as well. It was noted that either some practices were recommended in solutions that may be undesirable to a particular farm, or that the same combinations of practices consistently were selected, when in fact other practices may have been more preferred. This observation led to the implementation of the BMP Prioritization functionality, where Farm-PREP users can identify practices to exclude from the optimization, as well as practices that should be considered first before considering additional practices. The functionality improvement resulted higher relevance of the Farm-PREP results and overall, higher quality of the application.

6.3. Integration of Modeling Framework into Web Application

This quality assurance task was a significant focus of Task 2, Stakeholder Farm-PREP Testing and Simulations Evaluation. The stakeholder feedback process, which met with three groups representing six organizations, gave a broad sampling of potential Farm-PREP users an opportunity to take part in the testing and development of the tool. As a result of six survey questionnaires returned from these stakeholder meetings, we were able to identify issues with the tool's functionality, usability, and performance that needed improvement, including from a quality standpoint. The highest priority improvements identified from this stakeholder feedback process were implemented into Farm-PREP Version 2.

7. Deliverables Completed

The following section provides a discussion of the deliverables completed as part of this project.

7.1. Quality Assurance Project Plan

A secondary data quality assurance project plan (QAPP) was completed on April 1, 2019.

7.2. Quarterly Reports

Quarterly reports were prepared and submitted to the Lake Champlain Basin Program and NEIWPCC on 4/10/2019, 7/10/2019, 10/10/2019, and 1/10/2020.

7.3. Farm-PREP Workshops Training Workshops

Farm-PREP workshops were held at three different locations across Vermont in early December in 2019. The three dates and locations included:

1. UVM Extension Conference Room, Rutland, Vermont (December 9, 2019)
2. USDA Conference Room, Colchester, Vermont (December 12, 2019)
3. UVM Extension Conference Room, St. Johnsbury, Vermont (December 13, 2019)

7.4. Final Report and Deliverables

The final report and deliverables included a written final report (this document) and the Farm-PREP web-based application. The written report includes a description of the compilation and analysis of data to expand the tool throughout the LCB, a description of the methodology and outcomes of the user testing and model evaluation results, and a compilation of the stakeholder training materials.

An important final deliverable is Version 2.0 of the Farm-PREP tool itself. The tool provides the ability to efficiently run APEX model simulations of a farm, including the identification of alternative management scenarios that meet P-loss reduction targets, designed to meet water quality objectives. The tool now has multiple enhancements over Version 1.0 of Farm-PREP and can be run throughout Vermont. The final deliverables were completed on June 1, 2020. Screenshots of the Farm-PREP Version 2.0 application are shown in Figure 14—Figure 18.

The Farm-PREP web site can be accessed at: https://farmprep.net/#!/login

The application requires that a login and password be provided for secure access to an individual's farm assessments. To receive a login and password for the Farm-PREP Version 2.0, you must contact the application administrator at: Nick@stone-env.com

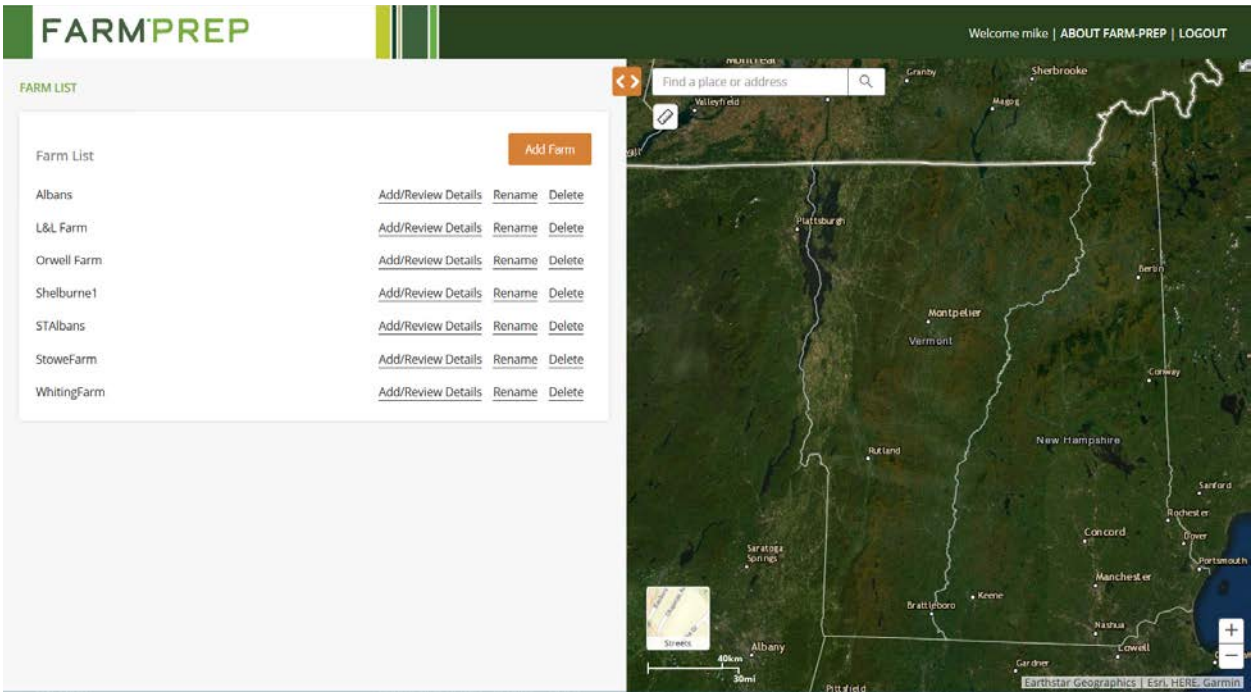


Figure 14. Farm-PREP Farm Creation Page

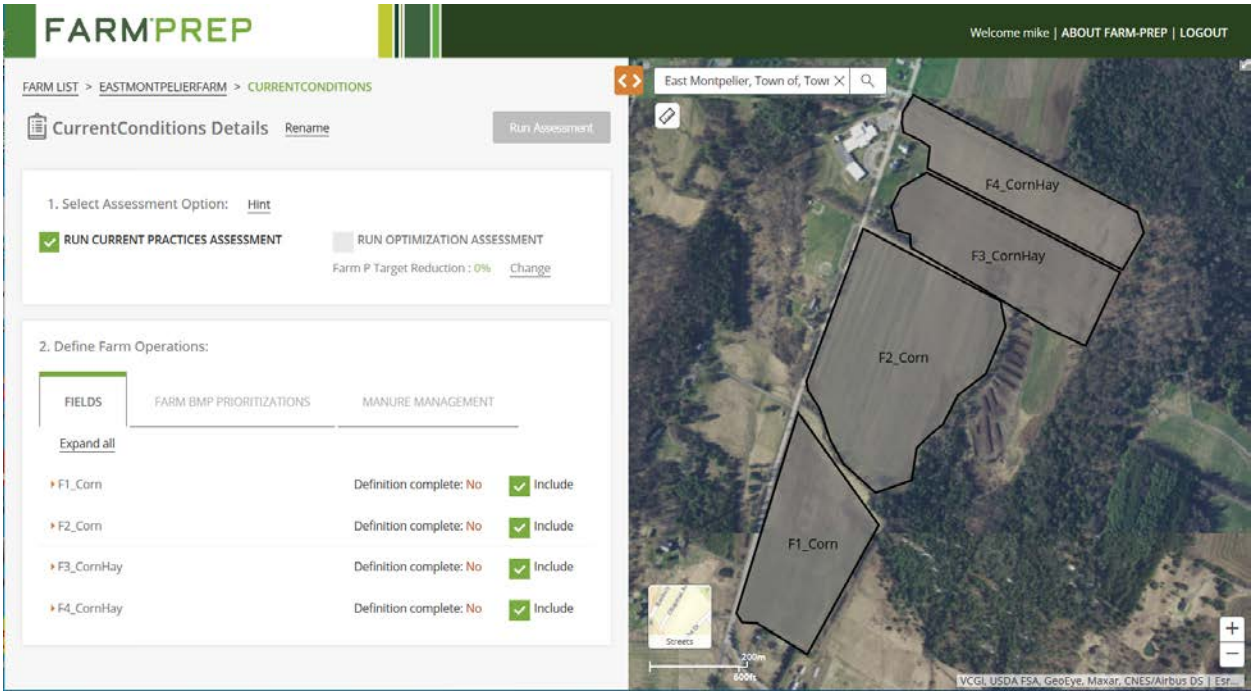


Figure 15. Farm-PREP Assessment and Fields Page

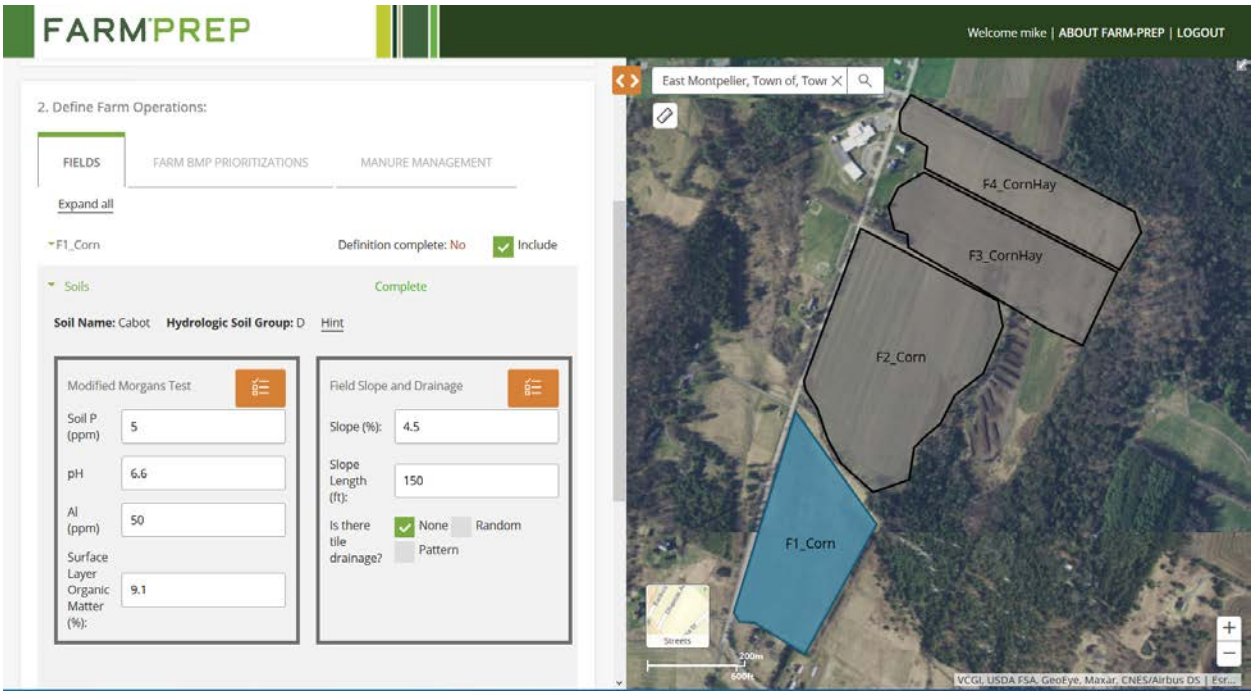


Figure 16. Farm-PREP Soils Data Entry Page

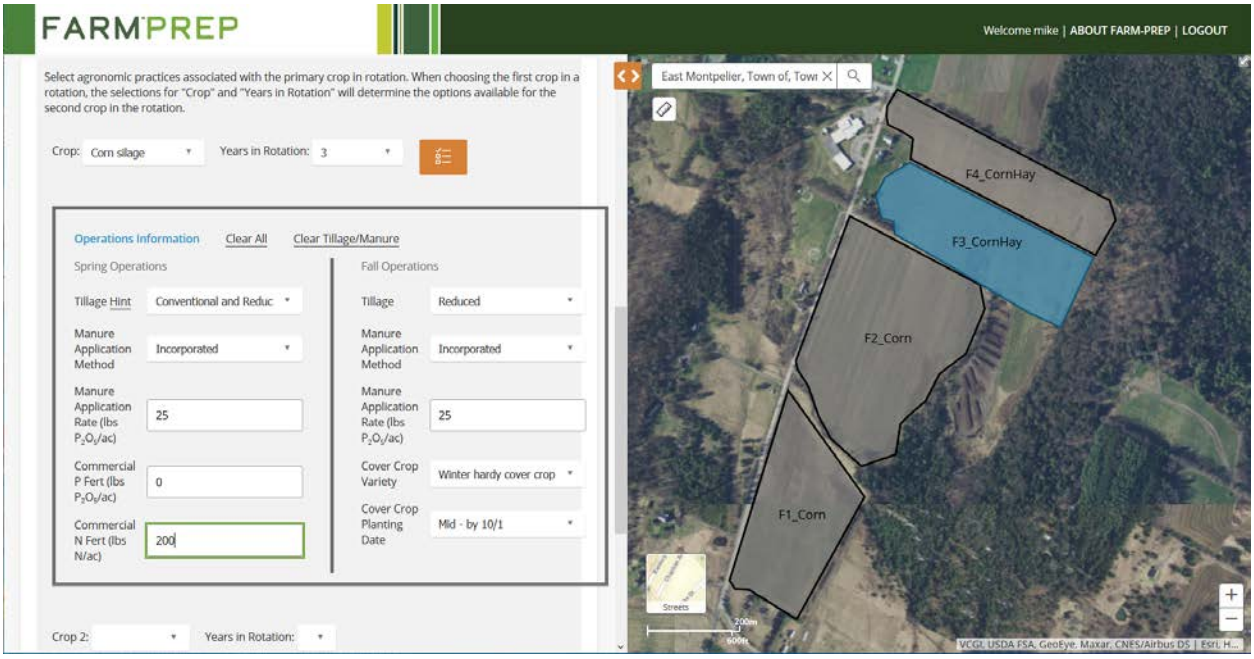


Figure 17. Farm-PREP Crop/Tillage/Manure Information Page

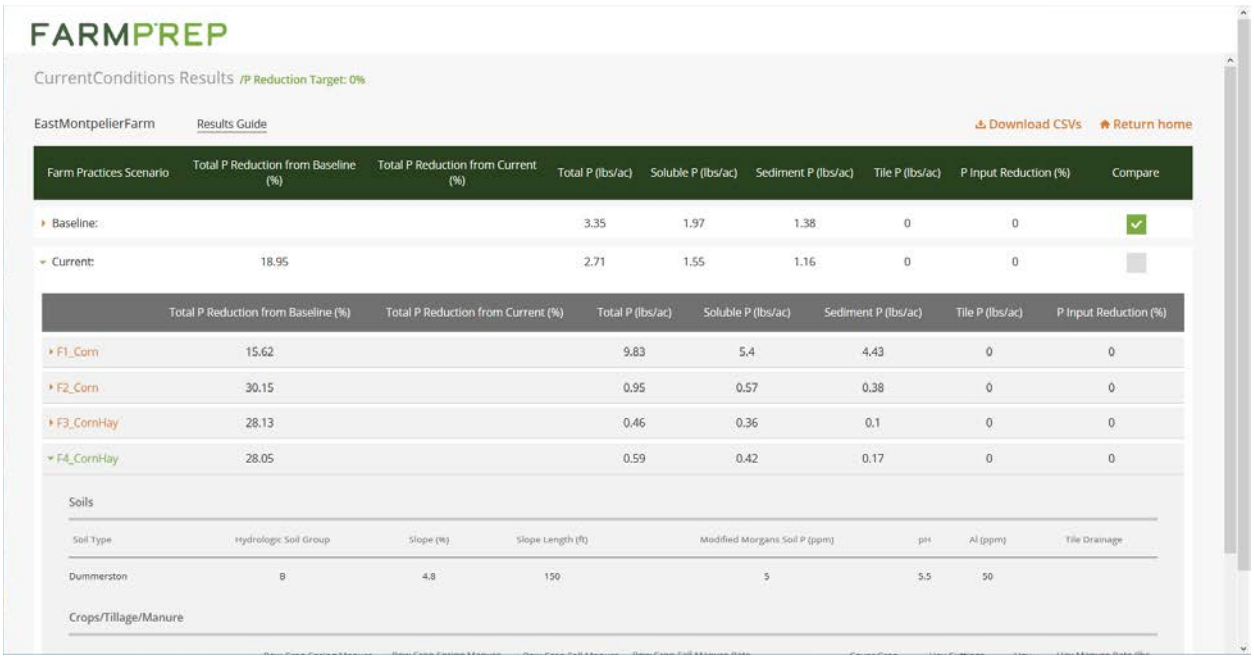


Figure 18. Farm-PREP Current versus Baseline Conditions Reporting

8. Conclusions

The Farm-P Reduction Planner tool (Farm-PREP) is designed to help farm management planners to quantify the reductions in farm-scale P losses achieved through modifications to field-level practices. Farm-PREP includes an optimization tool that will identify potential combinations of practices across multiple farm fields that will enable a targeted reduction in P loss. The tool has now been expanded for use throughout the entire state of Vermont, both within and outside of the Lake Champlain Basin. The tool has been further tested and significant enhancements have been made through a stakeholder feedback process. Farm-PREP Training workshops held throughout Vermont exposed a broad group of agricultural professionals to Farm-PREP, both providing education and serving as a platform for further user feedback.

During the Farm-PREP expansion process, the range of crop rotations that can be simulated in Farm-PREP was significantly increased, from 23 in Version 1 to 104 in Version 2. In addition, both tillage practice and cover crop practice options for annual crops were increased. The addition of a second growing season zone in Farm-PREP effectively doubled the number of possible agronomic operation schedule options available through the tool. This differentiation of growing zones added further agronomic realism to the APEX model inputs and simulation results.

A series of stakeholder engagement meetings were conducted with agricultural and natural resource professionals from Vermont Agency of Agriculture Food and Markets, University of Vermont Extension, University of Vermont Rubenstein School of Environmental and Natural Resources, Natural Resource Conservation Districts, and crop consultants. During these meetings, Farm-PREP tutorials were provided and stakeholders were then asked to conduct Farm-PREP testing on their own. The stakeholder testing was followed by survey responses that provided feedback on 45 questions related to Farm-PREP usability, functionality, and results reporting. We received and evaluated complete survey responses from six individuals. We synthesized the results from these responses to identify common recommendations for Farm-PREP improvements and to prioritize those that would provide the greatest benefits within the scope of this project. These highest priority improvements were then implemented into Farm-PREP, including an improved help system, automatic field boundary upload, expanded user entry of soils and tile drain information, custom manure characteristics entry, BMP prioritization, reporting improvements, and exporting of results.

As part of the objective of increasing Farm-PREP stakeholder acceptance, we generated over 16,000 Farm-PREP simulations that tested a range of field and weather conditions, crop rotations, tillage practices, and cover cropping options. These simulations demonstrated a wide range in simulated P loss for conditions and practices found within Vermont. The variability of P losses followed the expected patterns based on soil and slope condition and crop rotations. The reductions in P losses occurring with a widely applied conservation practice (cover cropping), also followed expected patterns, where higher percent reductions occur with earlier planting and lower percent reductions occur with more highly runoff prone soils. Similarly, the implementation of a 25 ft grassed buffer resulted in P loss reductions for all crop rotations as expected, where reductions were highest for continuous corn rotations. This analysis provided confidence that results from

Farm-PREP were not producing any unexpected outlier results and that overall, the predictions followed a range of expected trends.

The three Farm-PREP workshops, conducted in Rutland, Colchester, and St. Johnsbury during December of 2019, provided the opportunity for over 50 agricultural and natural resources professionals to take Farm-PREP for a test drive. Participants in the workshop received lectures concerning the science behind Farm-PREP and the APEX model, as well as the use of the tool itself. Participants engaged in hands-on training that walked them through a series of Farm-PREP simulations on an example farm. Many participants had the opportunity to run simulations for their own farm fields and agronomic practices of interest. Workshop participants also provided further recommendations and feedback that can serve as the basis for potential future enhancements to Farm-PREP.

This project effort has resulted in important improvements to the Farm-PREP tool, a substantial increase in stakeholder acceptance and confidence, and a significantly broader group of agricultural professionals throughout Vermont that are familiar with and experienced in applying Farm-PREP to evaluate the beneficial impacts of applying conservation practices to reduce farm-scale P losses. We hope these accomplishments will lead to broader use of the tool across the LCB to help in the quantification and tracking of how conservation practice implementation across the basin is reducing P loss from farms and improving the water quality of Lake Champlain.

9. References

BREC (Blackland Research and Extension Center). 2020. Agricultural hydrologic and water quality models supported and developed by BREC and USDA. Available at: https://epicapex.tamu.edu/apex/.

Gassman, P. W., J.R. Williams, X. Wang, A. Saleh, E. Osei, L. Hauck, R.C. Izaurralde, and J. Flowers. 2009. The Agricultural Policy/Environmental Extender (Apex) Model: An Emerging Tool for Landscape and Watershed Environmental Analyses. CARD Technical Reports 41.

Steglich, E.M., J. Jeong, and J.R. Williams. 2016. Agricultural Policy/Environmental eXtender Model: User's manual version 1501. Natural Resources Conservation Service, Blackland Research and Extension Center. Temple, TX. 241 pp.

Stone Environmental. 2011. Identification of Critical Source Areas of Phosphorus within the Vermont Sector of the Misssquoi Bay Basin. Prepared for the Lake Champlain Basin Program by Stone Environmental, Inc., Montpelier, VT. Available at: http://www.lcbp.org/techreportPDF/63B_Missisquoi_CSA.pdf.

Troy, A., D. Wang, D. Capen, J. O'Neil-Dunne, and S. MacFaden. 2007. Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading. Lake Champlain Basin Program Technical Report # 54, Grand Isle, VT.

US EPA Region 1 (United States Environmental Protection Agency). 2016. Phosphorus TMDLs for Vermont Segments of Lake Champlain; June 17, 2016. Boston, MA.

10. Appendices

Appendix A. Farm-PREP Stakeholder Survey

Respondent

Respondent 7

00:34
Time to complete

Your Information

1. *

Sample Survey

2. Please provide your email

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

4. Please provide any comments regarding adding a farm.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	○
Uploading Shapefile of farm fields	○	○	○	○	○

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [ ] Ability to view the spatial information right away (rather than only with assessment results)
- [ ] Field soils or slope information by clicking on the map
- [ ] Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	○	○
The "Status" Indicator	○	○	○
The "Action" Links	○	○	○
P Target	○	○	○

8. Would more information on the background of establishing a P Target be helpful?

9. Please provide any additional comments you have on the Assessment information

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	○	○	○	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	○	○	○	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

14. Which additional crops or rotations would you add?

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

16. What additional spring and fall tillage options would you add?

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	○	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	○	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	○	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	○	○	○	○	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	○	○	○
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	○	○
Indication that an assessment is complete	○	○	○	○	○

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline” and “Current” ?

	1	2	3	4	5	
Very unclear	◯	◯	◯	◯	◯	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	◯	◯	◯	◯	◯	Very easy

29. List any additional APEX outputs that would be desirable

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	◯	◯	◯	◯	◯	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	◯	◯	◯	◯	◯	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	○	○	○	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	○	○	○	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- ☐ Prioritization of BMPs
- ☐ Closeness of results to target P reduction
- ☐ How many solutions are returned
- ☐ Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	○	Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	○	○	○	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

42. What is greatest value that Farm-PREP can bring to Vermont’s efforts to improve farm practices to reduce off-farm P losses?

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

45. Please provide any additional comments and/or suggestion on Farm-PREP:

THANK YOU FOR YOUR VALUABLE INPUT!

Appendix B. Farm-PREP Stakeholder Survey Responses

Respondent

Respondent 5

95:43

Time to complete

Your Information

1. *

Jennifer Alexander

2. Please provide your email

Jennifer@pmnrcd.org or acap.Jennifer@gmail.com

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

4. Please provide any comments regarding adding a farm.

Seemed fairly easy. I did not try to upload fields and only added one field to evaluate rather than multiple fields

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	◉
Uploading Shapefile of farm fields	○	○	◉	○	○

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [x] Ability to view the spatial information right away (rather than only with assessment results)
- [x] Field soils or slope information by clicking on the map
- [ ] Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	○	◉
The "Status" Indicator	○	○	◉
The "Action" Links	○	○	◉
P Target	○	○	◉

8. Would more information on the background of establishing a P Target be helpful?

Yes. It would also be helpful to know what the baseline assumptions are.

9. Please provide any additional comments you have on the Assessment information

Some of the recommendations that the program came up with are unrealistic (early cover crop in corn grain fields, fall plowing along a river that floods most springs)

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

You should be prompted to add soil info (soil test P, slope and length etc) It would be nice if a pdf of the dominate soil type were available as well.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	●	○	○	○	○	Strongly agree

14. Which additional crops or rotations would you add?

Up to 7 years in silage and up to 7 years in hay.

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	●	○	Strongly agree

16. What additional spring and fall tillage options would you add?

yes. You will probably need a guidance document on what is constituted for reduced and conventional tillage.

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	●	○	○	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	●	○	○	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	◉	○	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Need to ask what type of manure is used. liquid, semi-solid or solid. The runoff potential drops as the manure has more organic matter. Organic matter is vital for good soil health. A 60 cow dairy is not likely to have a liquid system as it is cost prohibitive.

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	◉	○	○	○	○	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

Is the farm using an enhanced nitrogen source like a urease inhibitor or a nitrification inhibitor

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	◉	○	○	○	○	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	◉	○	○
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	○	◉
Indication that an assessment is complete	○	○	○	○	◉

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline“ and “Current” ?

	1	2	3	4	5	
Very unclear	○	◉	○	○	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

29. List any additional APEX outputs that would be desirable

It would be nice if the report could give a little canned comments for each BMP. I really see people that do not work with farms on a regular basis trying to use this tool and being somewhat clueless as to what each BMP really is and the associated cost of implementing the BMP

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	○	○	◉	○	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

See 29

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	○	○	◉	○	○	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	◉	○	○	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	○	○	◉	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

Have an optimization that allows harvesting of the buffer as a hay crop. No farm wants to have productive land be "fallowed" by a buffer. This would be more beneficial than a non-productive buffer (from a farmer stand point)

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- [x] Prioritization of BMPs
- [ ] Closeness of results to target P reduction
- [ ] How many solutions are returned
- [ ] Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

	1	2	3	4	5	
Not at all valuable	○	◉	○	○	○	Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	○	○	◉	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

Program would freeze, although that could of been our internet connection. Need to remember that not all areas of VT have good internet connections.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	◉	○	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

Add an advanced user section where the user can add variables such as flooding frequency, likelyhood of flooding. (example I have a farm that the inspector doesn't want him using a stacking site because the ANR Atlas has the fields as

"occasionally flooded" when the fields has never flooded.) Again Canned comments that could be edited for each BMP. Add a harvest-able buffer option.

42. What is greatest value that Farm-PREP can bring to Vermont's efforts to improve farm practices to reduce off-farm P losses?

It has the potential to encourage those farms that are resistant to changing practices.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

I can see State Regulators using Farm PREP as a tool to mandate practices. TSP's would use it on those farms that are reluctant to implement field based BMP's, Farmers and TSP's would use it to show how well their farms are doing. Conservation District would probably (or at least I would) as documentation of P reduction for certain practices in grant applications to get funding.

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

1) Add a harvest-able buffer 2) Need to somehow take into account that not all fields are bounded by water and those fields impact on WQ 3) Need to add manure type and perhaps calculate book values based on tons/gallons spread for manure P2O5.

45. Please provide any additional comments and/or suggestion on Farm-PREP:

I think that the program makes too many assumptions for losses and the benefit gained. Climate Change is making modeling difficult. There needs to be an instructions page and in-depth discussion on what buffers should be added (The up-slope buffer does not have value) Program makes assumptions on losses based on fields being near a waterway which we have many fields that are not near a waterway. What happens when it is shown that farmers are meeting all the

reductions that the EPA is requiring but lake levels of phosphorous doesn't change or is increasing?

THANK YOU FOR YOUR VALUABLE INPUT!

Respondent

Respondent 1

120:07
Time to complete

Your Information

1. *

Judson Peck

2. Please provide your email

judson.peck@vermont.gov

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

4. Please provide any comments regarding adding a farm.

Might want note on the fact that shapefiles need to be zipped.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	◉
Uploading Shapefile of farm fields	○	○	○	◉	○

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [x] Ability to view the spatial information right away (rather than only with assessment results)
- [x] Field soils or slope information by clicking on the map
- [x] As long as it does nc

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	◉	○
The "Status" Indicator	○	○	◉
The "Action" Links	○	○	◉
P Target	○	○	◉

8. Would more information on the background of establishing a P Target be helpful?

Trained previously by Stone, so hard to answer, but probably yes.

9. Please provide any additional comments you have on the Assessment information

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

Perhaps soil hydrologic group

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	●	○	Strongly agree

14. Which additional crops or rotations would you add?

Adding rotation years 5, 6 is common practice and still not continuous.

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	●	Strongly agree

16. What additional spring and fall tillage options would you add?

None

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	○	●	○	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	●	○	○	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	◉	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Cover Crops should have a non-winter hardy option and maybe an option for mixes, i.e. hardy and non-hardy, as this practice is becoming more common.

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

Tile drain, if not already. Also, is the assumption that surface water is adjacent? i.e. do need to add buffer for every field in order for Farm-PREP not to assume runoff to surface water?

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	○	○	◉	○	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	○	○	◉
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	○	◉
Indication that an assessment is complete	○	○	○	○	◉

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline“ and “Current” ?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

29. List any additional APEX outputs that would be desirable

Soil loss and nitrogen loss and soil organic matter

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	○	○	◉	○	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

None

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	○	○	○	◉	○	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	○	○	◉	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	◉	○	○	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

The comparison feature is great. Names of the 10 optimizations is confusing. If cannot come up with clear way to label, just numbering 1-10 might be best.

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- [x] Prioritization of BMPs
- [ ] Closeness of results to target P reduction
- [ ] How many solutions are returned
- [ ] Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	◉	Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	◉	○	○	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	◉	○	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

Transferring field and practice data from the Partner Database or GoCrop would save time entering data.

42. What is greatest value that Farm-PREP can bring to Vermont’s efforts to improve farm practices to reduce off-farm P losses?

Actual P reductions at the farm-scale and concrete methods on how to achieve targets through optimizations.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

Farms, state regulators and all those provide technical service to farms.

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

1. Statewide capability 2. Transfer field and practice capability 3. Other outputs, i.e. soil loss, N loss

45. Please provide any additional comments and/or suggestion on Farm-PREP:

Great effort, can't wait to actually use it!

THANK YOU FOR YOUR VALUABLE INPUT!

Respondent

Respondent 3

49:44

Time to complete

Your Information

1. *

Kate Porterfield

2. Please provide your email

kporterf@uvm.edu

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

4. Please provide any comments regarding adding a farm.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	◉
Uploading Shapefile of farm fields	○	○	○	○	◉

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [x] Ability to view the spatial information right away (rather than only with assessment results)
- [x] Field soils or slope information by clicking on the map
- [ ] Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	◉	○
The "Status" Indicator	○	○	◉
The "Action" Links	○	○	◉
P Target	○	○	◉

8. Would more information on the background of establishing a P Target be helpful?

I'm not sure how much information managers will have on P reduction targets coming into this, but maybe it would be helpful to have a option to click on a link that will take you to a page where there is a brief example of a state that has implemented P reduction targets and what that target might be. Even a link to an external source might be nice.

9. Please provide any additional comments you have on the Assessment information

I went through and made a list of possible inputs and I noticed that some selections made other entry fields default to a certain selection. I know this was done on purpose to make it more straight forward, but would it be possible to have a simple explanation show up when this happens?

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

It doesn't explicitly say where the soil series data is being pulled from. I probably would have guessed that it was from SSURGO though even if I hadn't been told that.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

14. Which additional crops or rotations would you add?

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

16. What additional spring and fall tillage options would you add?

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	◉	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	○	○	○	◉	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	◉	○	○	○
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	○	◉
Indication that an assessment is complete	○	◉	○	○	○

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline” and “Current” ?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

29. List any additional APEX outputs that would be desirable

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	○	○	○	◉	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	○	○	○	○	◉	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	○	○	◉	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	○	◉	○	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- [x] Prioritization of BMPs
- [ ] Closeness of results to target P reduction
- [ ] How many solutions are returned
- [ ] Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

	1	2	3	4	5	
Not at all valuable	○	○	○	◉	○	Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	○	○	○	◉	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

I can't tell if this is a bug or not, but I've been trying to run a quick baseline assessment (0% P reduction) on 1 field and nothing is happening. I've left it alone for a couple minutes after pressing "Run Optimization" and a blue halo appears around the button but nothing happens and when I go back to the Farm page the status is "Ready". It would be nice if after you pressed the "Run Optimization" button some kind of progress bar appeared to show that the optimization is running.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

A help bar would be nice with "Common Questions" and trouble shooting solutions

42. What is greatest value that Farm-PREP can bring to Vermont's efforts to improve farm practices to reduce off-farm P losses?

Farm-PREP seems like it could be a good tool to help farmers decide which best management practices to prioritize adopting on which fields to achieve a target P reduction.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

Farm-PREP seems to be geared towards farmers. I think it could be a useful tool for research, although it's hard to say without having actually used it for research yet. I think we'll know a lot more on that front in a few months.

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

Cost/benefit analysis function: optimize BMP suggestions for P reduction and least cost (I know we talked about this being controversial during our meeting) More manure management technologies

45. Please provide any additional comments and/or suggestion on Farm-PREP:

THANK YOU FOR YOUR VALUABLE INPUT!

Respondent

Respondent 2

36:41
Time to complete

Your Information

1. *

Lindsey Ruhl

2. Please provide your email

lruhl@uvm.edu

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

4. Please provide any comments regarding adding a farm.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	◉
Uploading Shapefile of farm fields	○	○	○	○	○

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [ ] Ability to view the spatial information right away (rather than only with assessment results)
- [x] Field soils or slope information by clicking on the map
- [ ] Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	◉	○
The "Status" Indicator	○	◉	○
The "Action" Links	○	◉	○
P Target	○	◉	○

8. Would more information on the background of establishing a P Target be helpful?

It would be nice to have a short write-up of what goes into determining practices included in the P target. This might be on a separate page along with a list of definitions for what constitutes reduced till vs. conventional and any other helpful hints.

9. Please provide any additional comments you have on the Assessment information

It's not terribly intuitive to click the include button before optimization will run. It appears that the BMP exclusion I chose did not visibly save. It's good that the app let's you know it's running, but it does give an estimate of how long it will take. That might be nice. It would also be helpful to have a calculator for folks to use for fertilizer and manure applications based on the rate and analysis. It also is not very intuitive where sidedress would go. It's not a spring or fall application. For tile drainage, is this all types of tile drainage, or just pattern tile drainage. Some folks may have 1-2 lines in a field to drain wet spots. Would it be possible for folks to enter fields without maps? They could just enter the soil series from a drop down menu based on the county they are in. It's great that estimates of P, Al, and pH are there and great that they can be over ridden. It should be clear that an e-mail will be sent with a link to review results and if the web page can be closed in the meantime or not. The assessment compare function is handy, but it looks like it included some practices that I already selected in 'current'. It seems like there could almost be three comparisons per field, one with no BMPs, one with BMPs currently in effect, and another that would show additional practices that would further reduce P loss potential.

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	○	●	○	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

It should be clear if tile drainage is pattern or not.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

14. Which additional crops or rotations would you add?

I think there should be more year options for silage/hay rotations.

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

16. What additional spring and fall tillage options would you add?

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	◉	○	○	○	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	○	○	◉	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	◉	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Please add a calculator so folks can put in rate and analysis to generate lbs of nutrient/acre. Also, needs to have an option for PSNT. This would be convenient so folks don't have to add up what they put down for starter and sidedress separately.

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

It would be great to have a note that says you can measure distance with the stick. A one time pop-up would solve this. With BMP Exclusions, maybe some subtext saying "click on BMPs you would not consider implementing so they are not included as options..."

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	○	○	◉	○	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	◉	○	○
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	◉	○
Indication that an assessment is complete	○	○	◉	○	○

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline” and “Current” ?

	1	2	3	4	5	
Very unclear	○	◉	○	○	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

29. List any additional APEX outputs that would be desirable

Total lbs/field or per farm would be great.

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	○	○	◉	○	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	○	○	◉	○	○	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	○	○	◉	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	○	○	◉	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

It would be helpful to bold any of the differences between the comparisons to highlight the differences and what practices could be implemented.

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- [x] Prioritization of BMPs
- [ ] Closeness of results to target P reduction
- [ ] How many solutions are returned
- [ ] Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

	1	2	3	4	5	
Not at all valuable	○	○	○	◉	○	Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	○	○	◉	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

There were a few times that options did not show up until I clicked something else. I'm wasn't prepared for this so I can't tell you the steps I took that got me there, but I can be more aware in the future. Also, please note that I did not upload a shapefile. so I do not have feedback about this at this time. Although, this is a great feature!

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	◉	○	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

Noted in my previous responses- a calculator, some help hints...

42. What is greatest value that Farm-PREP can bring to Vermont's efforts to improve farm practices to reduce off-farm P losses?

It's helpful and motivating for folks to see what the potential impact could be. With that in mind, I also know folks recognize that the feedback they get is only as good as the model and right now, folks are pretty leery of trusting models.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

I think TSPs and others could be the link between processing the farm information and aggregating the data to share with state regulators on which steps are most beneficial to reducing potential p loss.

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

1, calculator 2. help hints 3. It would be fantastic to be able to export the data to a spreadsheet for further data analysis.

45. Please provide any additional comments and/or suggestion on Farm-PREP:

Overall, I was surprised at how easy this was to navigate an input information into. I look forward to using the next iteration.

THANK YOU FOR YOUR VALUABLE INPUT!

Respondent

Respondent 4

44:45
Time to complete

Your Information

1. *

Matthew Kittredge

2. Please provide your email

matt.kittredge@farmcomplianceservices.com

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

4. Please provide any comments regarding adding a farm.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	◉	○
Uploading Shapefile of farm fields	○	○	○	○	○

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- ☐ Ability to view the spatial information right away (rather than only with assessment results)
- ☐ Field soils or slope information by clicking on the map
- ☐ Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	○	◉
The "Status" Indicator	○	○	◉
The "Action" Links	○	○	◉
P Target	○	○	◉

8. Would more information on the background of establishing a P Target be helpful?

No

9. Please provide any additional comments you have on the Assessment information

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	◉	○	○	○	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

No. As a technical service provider, I would want to be able to easily access data on the soils fact sheet (i.e. drainage characteristics) to be able to provide management alternatives that would work for that particular field.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	●	○	○	○	○	Strongly agree

14. Which additional crops or rotations would you add?

> This depends on the weight of the rotation/soil loss in the model. If you want to be able to match this up with a NMP, it would require offering all of the RUSLE2 rotational templates.

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	●	○	○	○	○	Strongly agree

16. What additional spring and fall tillage options would you add?

> Again, this depends on the weight of the tillage in the model. RUSLE2 management templates would need to be provided to match a NMP.

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	●	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	○	○	●	○	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	◉	○	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

At a minimum, I would allow for tillage but no manure incorporation. I did not see a way to provide for this.

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	◉	○	○	○	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	○	◉	○
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	◉	○
Indication that an assessment is complete	○	○	○	○	◉

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline“ and “Current” ?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

29. List any additional APEX outputs that would be desirable

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	◉	○	○	○	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

	1	2	3	4	5	
Not at all sufficient	○	○	○	◉	○	Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	○	○	○	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	○	◉	○	○	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- ☐ Prioritization of BMPs
- ☐ Closeness of results to target P reduction
- ☐ How many solutions are returned
- ☑ Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

1	2	3	4	5

Not at all valuable ○ ○ ○ ◉ ○ Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	○	◉	○	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

I think it returned an optimization that was blank (i.e. no detail after the colon) but I could have been looking at it wrong.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	○	◉	○	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

Is there a way to edit field boundaries after a field is drawn? If so, I couldn't easily find it - if not, I would suggest adding it. [I'm putting this comment under 'more efficient' because it isn't efficient to have to re-draw a field] Also, when adding a field, if you click "Add Field" at the top (accidentally) vs. "Add" at the bottom/below the name in the box, Farm-PREP will delete the field - I suggest that an accidental click on "Add Field" not delete the field.

42. What is greatest value that Farm-PREP can bring to Vermont's efforts to improve farm practices to reduce off-farm P losses?

I think the tool has tremendous potential to identify fields that are prone to P losses - however, I think that there needs to be better identification of fields that pose a water quality risk. For example, if a field experiences P losses, at the edge of field, but not into surface waters, there should be some functionality in this tool to bring it to the users attention. I believe integrating a surface waters layer and then adding a 'risk to waters' (even if only 'high, medium, low' - this would require more modeling) would help target not only fields with the greatest P losses but those that pose the greatest risk to water.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

Anyone providing technical assistance - I don't see that this should be a regulatory tool - so, everyone with the exception of regulators. If the target is regulators, I believe you would need to revamp this tool to align with state and federal permitting requirements. Essentially, that would be end up being a web-based Phosphorus Index - unless the regulations were to change.

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

(1) Add the ability to edit field boundaries; (2) have the tool auto-generated surface water layer/auto-map where buffers should be (based on state regulations); and (3) provide guidance for prioritizing those fields that would have the biggest potential for water quality impacts, not just field losses.

45. Please provide any additional comments and/or suggestion on Farm-PREP:

Overall, this is a very powerful application that has a lot of potential; however, there needs to be more connection between field losses and impacts to water. This is probably well beyond the remit of the current project; nonetheless, it would be worth considering.

THANK YOU FOR YOUR VALUABLE INPUT!

Respondent

Respondent 6

1217:40
Time to complete

Your Information

1. *

Stefano Pinna

2. Please provide your email

pinna.sfa@gmail.com

Interface Usability: Farm Information

3. How easy and intuitive is it to add a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

4. Please provide any comments regarding adding a farm.

Interface Usability: Fields Section

5. Please indicate how easy and intuitive the following field functionality is:

	Very Difficult	Somewhat Difficult	Neutral	Somewhat Easy	Very Easy
Field drawing	○	○	○	○	◉
Uploading Shapefile of farm fields	○	○	○	○	◉

6. When you add a field, spatial processing is conducted on soils, slope, elevation, and weather stations. Please check any of the following that you would be interested in seeing.

- [x] Ability to view the spatial information right away (rather than only with assessment results)
- [ ] Field soils or slope information by clicking on the map
- [ ] Other

Interface Usability: Assessments Section

7. Please indicate how clear the purpose and meaning of the following assessment information is:

	Unclear	Neutral	Very Clear
Creating an Assessment	○	○	◉
The "Status" Indicator	○	○	◉
The "Action" Links	○	○	◉
P Target	○	○	◉

8. Would more information on the background of establishing a P Target be helpful?

No

9. Please provide any additional comments you have on the Assessment information

When I opened the fields tab I felt a little lost at first because of the too many colors (orange, green, red, blue). Other than that it is really clear.

Interface Usability: Field Soils

10. How clear and intuitive is accessing and entering field level information?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

11. How clear is the source of the soils information provided and that user modifications are optional?

	1	2	3	4	5	
Very unclear	○	○	○	○	◉	Very clear

12. Is enough information regarding the field's soil provided? If no, please explain.

Interface Usability: Crops / Tillage / Manure

13. Do the available crop rotation options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	●	○	Strongly agree

14. Which additional crops or rotations would you add?

I would probably add hemp because this crop will be grown on more and more acres in the next few years and potentially will have an impact on P losses.

15. Do the spring and fall tillage options sufficiently represent the majority of Vermont agriculture?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	●	Strongly agree

16. What additional spring and fall tillage options would you add?

Not sure but it could make sense to add no till as a fall option for those who plant a cover crop in this way (?)

17. Is representing manure applications in terms of P2O5 rate sufficient?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	●	Strongly agree

18. Are there enough cover cropping options provided?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	●	Strongly agree

19. How valuable is the “apply settings to other fields” functionality?

	1	2	3	4	5	
Not at all valuable	○	○	○	○	◉	Very valuable

20. Please provide any other suggestions on improvements to the Crops / Tillage / Manure data entry:

Interface Usability: Best Management Practices

21. How easy and intuitive is entering information on buffers and grass waterways?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

22. Are there addition within field or structural BMPs that would be important for Farm-PREP to evaluate?

No

23. How clear is the purpose and functionality of the Field BMP Exclusions?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

Additional Farm-Level Inputs

24. How clear is the difference between Farm BMP Exclusions and field-level BMP exclusions?

	1	2	3	4	5	
Very unclear	○	○	◉	○	○	Very clear

25. Manure Technologies on a farm is a new functionality for Farm-PREP that is under development. Would you envision wanting to evaluate the impacts of this technology on your farms?

	1	2	3	4	5	
Not at all interested	○	○	○	○	◉	Very interested

Running Farm-PREP Assessments

26. Please indicate how clear and intuitive the following aspects of running an assessment are:

	Very unclear	Somewhat unclear	Neutral	Somewhat clear	Very clear
Running an assessment for current practices only (no optimization)	○	○	○	○	◉
Running an assessment for achieving a target P reduction (with optimization)	○	○	○	○	◉
Indication that an assessment is complete	○	○	○	○	◉

Interpreting Farm-PREP Results: Current Practices Assessment

27. How clear are the differences between “Baseline” and “Current” ?

	1	2	3	4	5	
Very unclear	○	○	○	◉	○	Very clear

28. How easy and intuitive is accessing field-level results?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

29. List any additional APEX outputs that would be desirable

30. Is the amount of field-level information provided in results report (soils, crops, BMPs) sufficient?

	1	2	3	4	5	
Not at all sufficient	○	○	○	○	◉	Very sufficient

31. List any additional field information or APEX inputs that would be desirable to report.

Would it be possible to know what practice the reduction in P is attributable to?

Interpreting Farm-PREP Results: Optimization Assessments

32. How sufficient is the information provided in the 10 optimization solutions in guiding the selection of field practices that achieve desired P reduction goals?

1 2 3 4 5

Not at all sufficient ○ ○ ○ ○ ● Very sufficient

33. If the optimization is run with appropriate BMP exclusions for your farm, how sensible and worthy of consideration are the farm/field practice solutions returned by Farm-PREP?

	1	2	3	4	5	
Not at all sensible	○	●	○	○	○	Very sensible

34. Would more information on the mechanics of how the optimization is conducted be helpful?

	1	2	3	4	5	
Not at all helpful	○	●	○	○	○	Very helpful

35. Describe how the reporting of optimization results could be improved to increase their value in decision-making?

By a farmer perspective, knowing how much weight each practice has on the total reduction of P might help to decide what strategy to adopt in the future.

36. The optimization would be more useful if the user had more control over any of the following? (choose one or more)

- ☐ Prioritization of BMPs
- ☐ Closeness of results to target P reduction
- ☐ How many solutions are returned
- ☐ Which solutions are returned

37. Overall, how valuable do you think the optimization functionality of Farm-PREP is and is there value in further development?

1 2 3 4 5

Not at all valuable ○ ○ ◉ ○ ○ Very valuable

Additional General Farm-PREP Questions

38. Did you find the interface behaved as expected, or did you experience any unusual, unexpected, or “buggy” behavior?

	1	2	3	4	5	
No bugs encountered	◉	○	○	○	○	Very buggy

39. If Farm-PREP was “buggy” please describe specifically where you experienced the issues.

40. How would you rate the level of effort/time required to provide all information on a farm?

	1	2	3	4	5	
Very difficult	○	○	○	○	◉	Very easy

41. Can you provide some ideas on how to make the use of Farm-PREP more efficient?

Add some short sentence in the BMP exclusion section just to make clear what it is.

42. What is greatest value that Farm-PREP can bring to Vermont’s efforts to improve farm practices to reduce off-farm P losses?

This software is very user friendly, it's easy to understand and it is pretty intuitive. In terms of what can help to accomplish I'm not sure. It depends by who and for what purpose is used. If it is used to guide technical service providers on which

practice suite best for a specific field, I see limited advantages. I think my self and most of my coworkers are enough qualified to know what BMPs are suitable for a certain field to reduce soil losses. For someone that is less familiar with the ag side of our job (like some conservation district), this tool might be helpful. From my point of view, this tool could be very helpful if it could be applied to the field conditions, taking into consideration more specific parameters like rain, organic matter mineralization rates, organication rates and the effect of different soil disturbance. I would find more useful to have a retrospective tool that tells me how much P I lost in those conditions so that I could engage a conversation with a farmer based on real data and look at what factors conduced to losses. An aspect that I think is valuable about this software is the quantification of the impact from manure technologies because it could show clearly the advantages of adopting such techniques.

43. What stakeholder group (e.g., farmers, technical service providers, conservation districts, state regulators, university extension and researchers) would most benefit from the use of Farm-PREP, and how?

Probably TA and extensionists

44. What new functionality/capability should be added to Farm-PREP that would provide the greatest increase in its value/usefulness (name no more than 3, in order to highest to lowest value)?

The possibility to apply this model to field conditions.

45. Please provide any additional comments and/or suggestion on Farm-PREP:

It is really easy to use and well

THANK YOU FOR YOUR VALUABLE INPUT!

Appendix C. Farm-PREP Workshop Registration Materials

Farm-PREP Workshop: Optimizing BMPs to Reduce Phosphorus Loss from Vermont Agricultural Lands

Greetings!

You are invited to attend a workshop featuring the recently updated Farm-P Reduction Planner tool (Farm-PREP). Three, half-day workshops, scheduled for mid-December, will be led by Stone Environmental and are sponsored by the Lake Champlain Basin Program. The free workshops will include a presentation on the Farm-PREP tool, as well as an interactive demonstration of how the Farm-PREP can be applied to estimate phosphorus losses from farm fields under current management practices, different BMP scenarios, and to optimize a system of BMPs to meet a phosphorus reduction goal.

Detailed information about the workshops, including how to RSVP, is provided below. You can also download our workshop flyer and view the agenda by clicking **here>>**

We hope to see you at one of the workshops!

Best Regards,

Mike Winchell, Barb Patterson, and Kip Potter
Stone Environmental

THREE WORKSHOPS ARE SCHEDULED

Monday, December 9th (8:30-1:00 pm)
UVM Extension Conference Room, 271 North Main Street, Rutland, Vermont 05701

Thursday, December 12th (8:30-1:00 pm)
USDA Conference Room, 356 Mountain View Drive, Colchester, Vermont 05446

Friday, December 13th (8:30-1:00 pm)
UVM Extension Conference Room, 374 Emerson Falls Road, St. Johnsbury, Vermont 05819

Download Agenda for the Workshop>>

RESERVE YOUR SPOT! RSVP BY NOVEMBER 29TH

The workshop is free to interested participants, but space is limited! To reserve your place at one of the workshops, please complete the **workshop registration form here>>** by November 29th, 2019.

If you have any questions or are interested in addtional information about this workshop, please email Kip Potter (**kpotter@stone-env.com**) or call (802) 229-4541.

STONE ENVIRONMENTAL 100% EMPLOYEE OWNED

Lake Champlain Basin Program

About the Farm-P Reduction Planner (Farm-PREP)

Under a Lake Champlain Basin Program grant, Stone Environmental has further developed the Farm-P Reduction Planner tool (Farm-PREP) for use across Vermont. Conservation planners and other agricultural professionals can easily use Farm-PREP to estimate phosphorus losses from farm fields under current management practices, different BMP scenarios, and to optimize a system of BMPs to meet a phosphorus reduction goal. Farm-PREP allows for quick and easy entry of farm agronomic management information used to run the USDA's APEX model, the backbone of the Farm-PREP tool. In addition, the Farm-PREP input options and APEX model parameters have been specifically customized for use in Vermont. Targeted users include: NRCS Conservation Planners and specialists, District Land Treatment Planners and specialists, private Nutrient Management Planners, Agency Agronomists and specialists, and other agronomists and water quality specialists. For more information visit **https://farm-prep.net/info/**

Appendix D. Farm-PREP Workshop Presentation Materials

STONE ENVIRONMENTAL
100% EMPLOYEE OWNED

Optimizing BMPs to Reduce Phosphorus Loss from Vermont Agricultural Lands: A Farm-P Reduction Planning (Farm-PREP) Tool Workshop

UVM Extension, Rutland, VT

12/9/2019

Presented by Stone Environmental

Workshop Agenda

8:30-9:00: Bagels, Donuts, Coffee, and Introductions

9:00-10:00: Farm-PREP Presentations and Demos

10:00-11:00: Applying Farm-PREP to an Example Farm

11:00-11:15: Coffee Break

11:15-12:30: Applying Farm-PREP to an Example Farm, Continued

12:30-1:00: Wrap-Up, Q&A, Discussion

Introductions

Who are you and where do you work?

What is your interest in Farm-PREP?

What would you like to learn at this workshop?

What do you like best about Vermont?

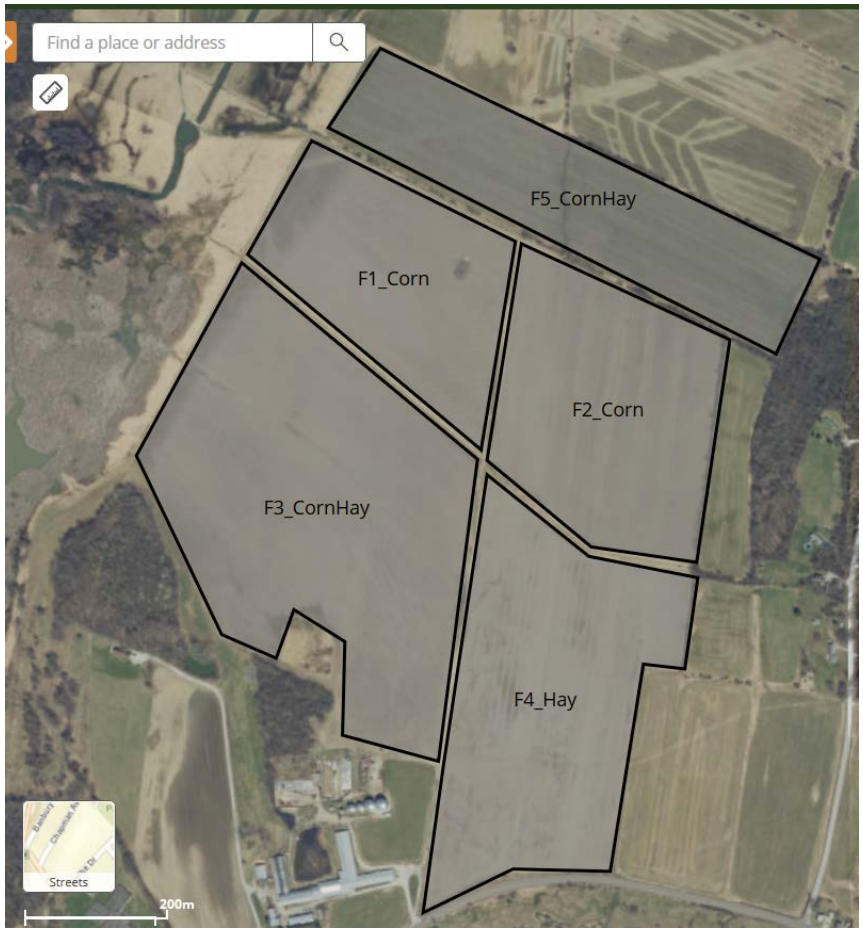
Farm-PREP Overview

Farm-PREP is a web-based interface to NRCS's Agricultural Policy/Environmental eXtender Model (APEX), designed to:

- Objectively quantify farm-specific reductions in P losses resulting BMPs
- Help farmers/planners identify field-by-field agronomic practices that allow them to achieve a targeted reduction in P losses

Farm-PREP predicts P losses from farms and farm fields by:

- Users providing inputs through a web interface
- Farm-PREP running the APEX model to make predictions
  - Simplifies APEX setup
  - Only requires key input data



APEX Model Background

Developed by USDA and Texas A&M University

- Farm/ranch small watershed scale model
- Used in national Conservation Effects Assessment Project (CEAP)

Simulates:

- Water, sediment, nutrient, and pesticide transport from fields
- Crop growth, biomass, yields, carbon cycling

Agronomic management:

- Irrigation, drainage, furrow dikes
- Buffer strips, grass waterways, cover cropping
- Fertilizer and pesticide applications
- Manure management
- Crop rotations
- Conservation tillage

Farm-PREP Data Compilation

Spatial datasets from government agencies:

- Climate (USDA/ARS): Over 50 years of daily weather from 165 stations in VT
- Topography (USGS): 10-meter resolution Digital Elevation Model (DEM)
- Soils (USDA/NRCS): 10-meter resolution soil survey (SSURGO)

Agronomic practices specific to Vermont:

- Initially aimed at conventional dairy operations, have expanded to include
  - Small grains and mixed vegetable farming
- Crop rotations, tillage practices, fertilizer/manure applications, BMPs
- Developed with technical advising from:
  - UVM Extension
  - Collaborating technical crop consultants
  - Lake Champlain Basin Program Technical Advisory Committee
  - Texas A&M University

Farm-PREP Modeling Approach to Achieve P Loss Reduction Targets

Quantify water quality benefit of current farm practices:

- Run APEX simulations of current farm practices and “baseline” conditions (without BMPs)
- Report field and farm level P losses and improvement from baseline

Identify combinations of practices that meet P loss reduction target:

- Set reduction target at the farm scale
- Specify which practices to prioritize (field or farm level)
- Automatically run MANY additional APEX simulations evaluating field-by-field farm practice scenarios

Provide the farmer/crop consultant with multiple farm practice options that achieve the desired P reduction target:

- Farmer/crop consultant can pick options best suited to their operation
- Run additional “what if” scenarios as desired

Farm-PREP Web-Based Tool for Conducting P-Reduction Assessments

Running the tool is intuitive and efficient

Tool input options should be simplified, yet still capture the key agronomic practice information that determines P loss

Output information provided clearly informs users of alternatives to current practices that allow P reduction targets to be met

The back-end application design is scalable to allow both:

- Expansion of crop rotations and practices
- Additional computational capacity

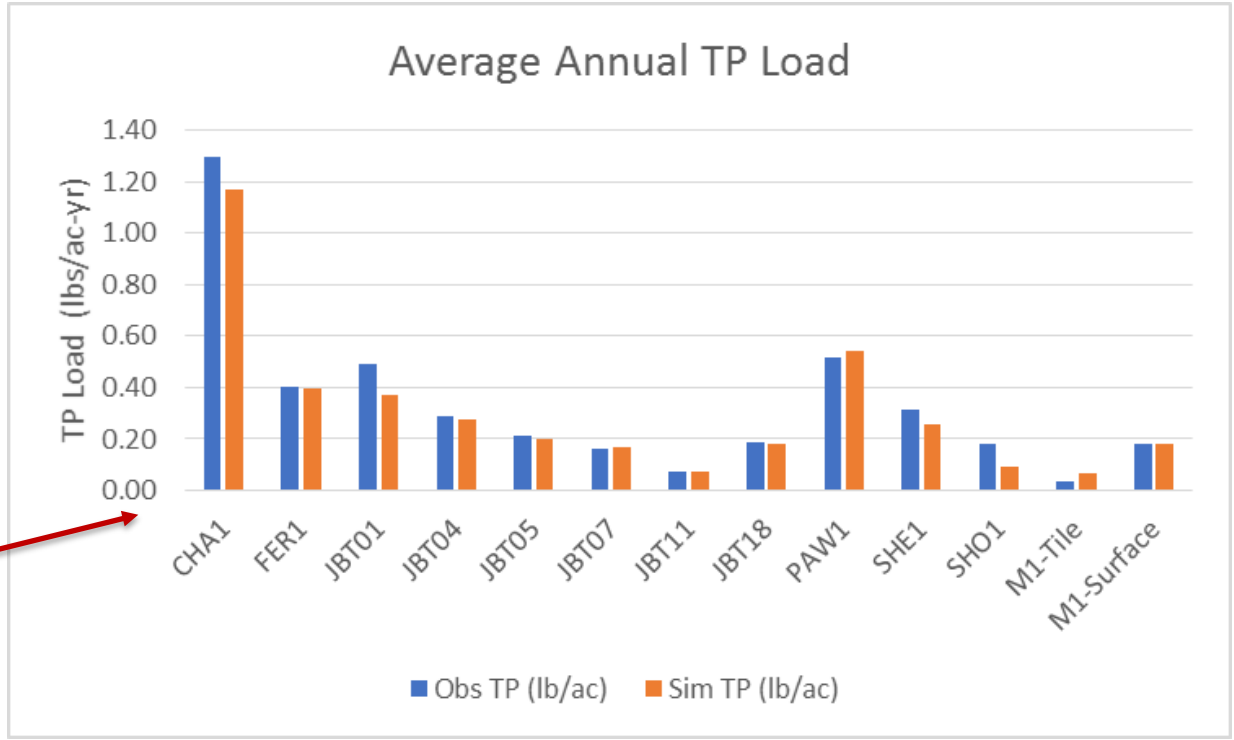
Farm-PREP Recent Developments: Model Calibration and Validation

APEX model calibration/validation for edge of field and tile P loss:

- 5 edge-of-field and 6 tile monitoring sites (all VT)
- 1 edge-of-field + tile monitoring site (NY)

Effort was deigned to improve the predictive ability of Farm-PREP, and minimize bias across sites

- Different crops, soils, and slope conditions
- Based on a single "global" calibration



Simulations based on "best" soil parameters within SSURGO range

Farm-PREP Recent Developments: Additional Crops and Tillage

Expanded number of combinations of corn and hay crop years:

- Corn crop from 1 to 7 years
- Hay crop from 3 to 7 years

Added new crops:

- Spring planted small grains
- Mixed vegetables

New spring and fall tillage combinations:

- Conventional and Reduced in spring, None in fall
- No-till in spring, Conventional in fall

Farm-PREP Recent Developments: Upload Field Boundaries from Shapefile

Farm-PREP originally only allowed fields to be drawn via the application. Could be cumbersome for large farms.

Now, field boundaries can be uploaded from a zipped Shapefile (in the proper projection), as long as there is a unique “FieldID” for each field.

Farm-PREP Recent Developments: Automatic Adjustment of Agronomic Operation Date by Zone

Divided the state into two growing zones and adjusted APEX plant/harvest/tillage operations accordingly (generally by two weeks).

Long season

- Plant Hardiness Zones 4b, 5a, and 5b less than 1000 ft elevation

Short season

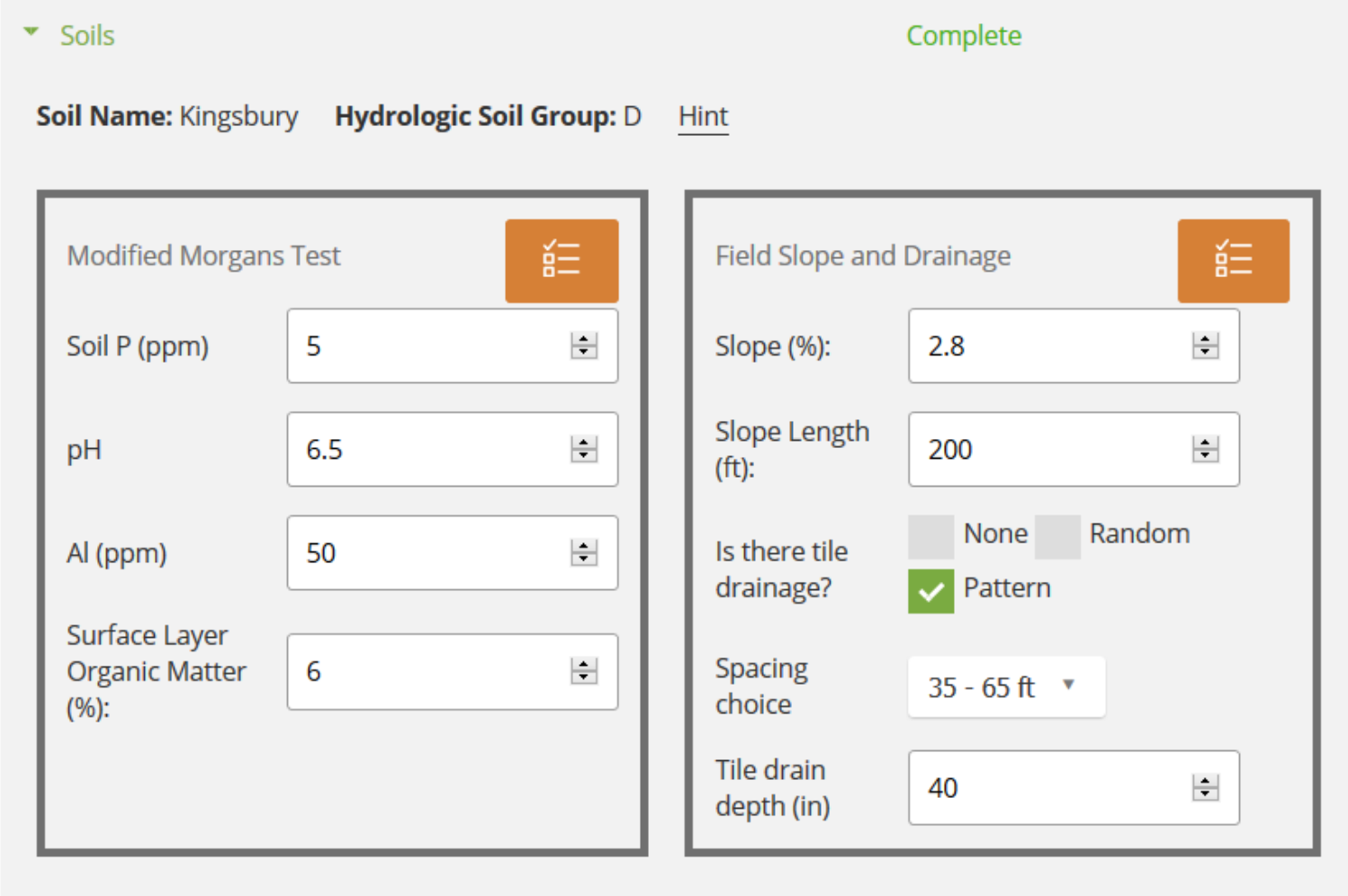
- Plant Hardiness Zones 4b, 5a, and 5b greater than 1000 ft elevation
- Plant Hardiness Zones 3a, 3b

Farm-PREP Recent Developments: Additional Tile Drainage and Soils Input Options

New tile drainage options now impact amount of tile flow and P loss:

- Drain Type:
  - Network
  - Random
- Drain Spacing:
  - < 35 ft
  - 35 – 65 ft
  - > 65 ft

Surface layer organic matter from SSURGO can now be overwritten by the user.



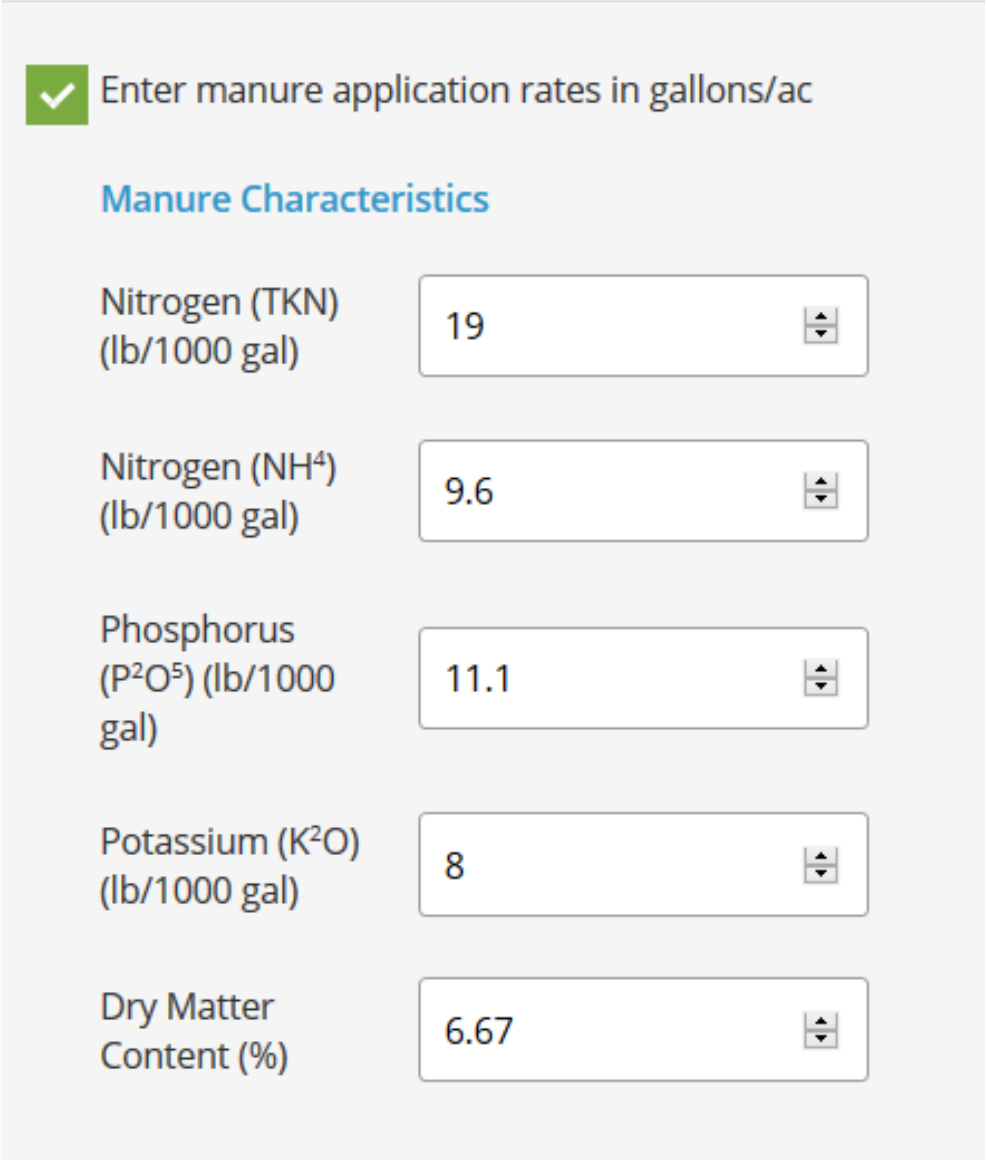
Farm-PREP Recent Developments: Custom Manure Pit Data Entry

Original Farm-PREP assumed standard liquid dairy manure properties (N, P, dry matter contents) from UVM Extension handbook.

- User provides application rates in P2O5 equivalent

New option allows entry of manure pit analysis to customize a farm's manure characteristics.

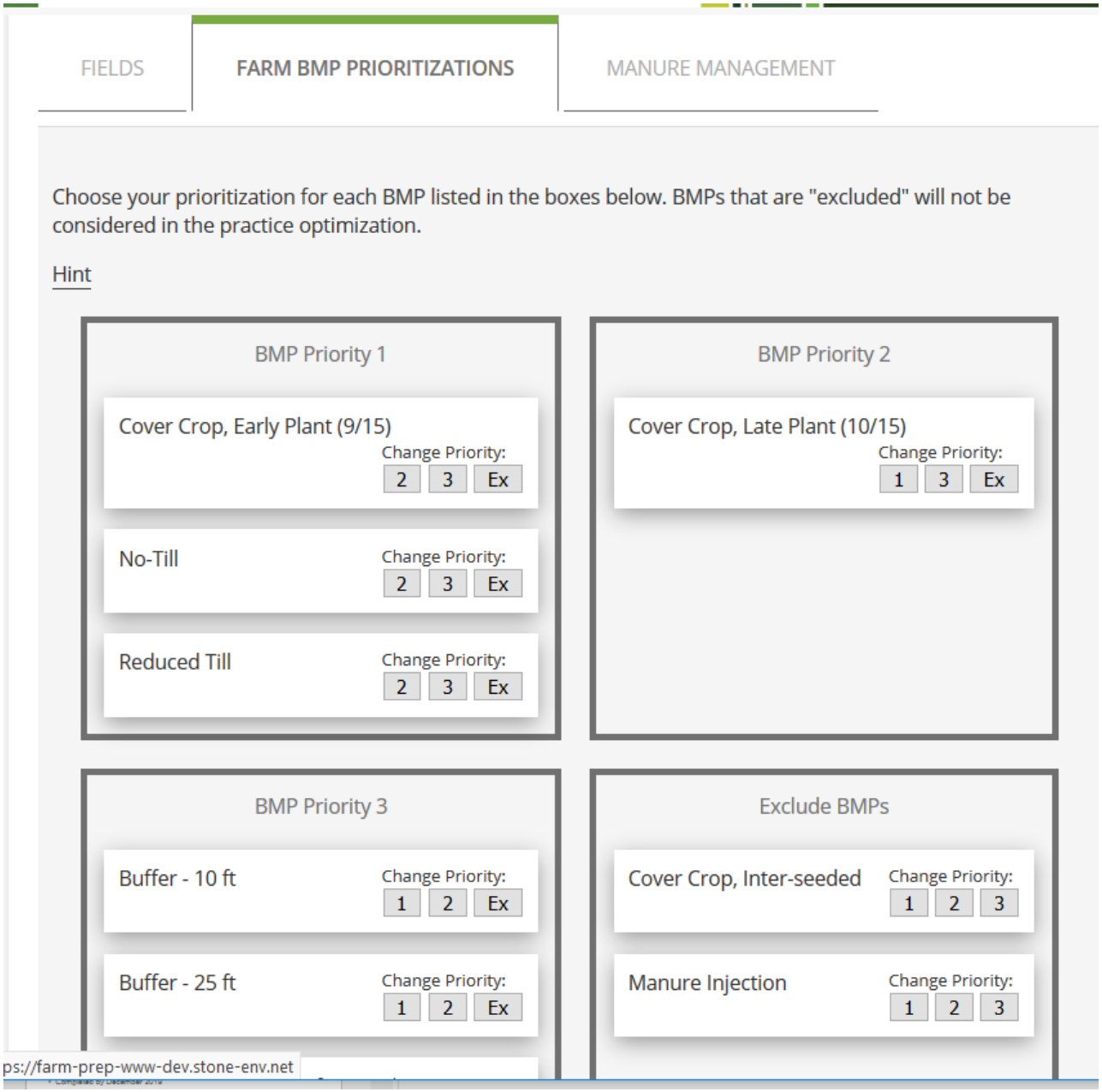
- Applications rates entered as gallons/ac



Farm-PREP Recent Developments: BMP Prioritizations and Exclusions

During practice optimization, Farm-PREP originally considered BMPs in a pre-defined order.

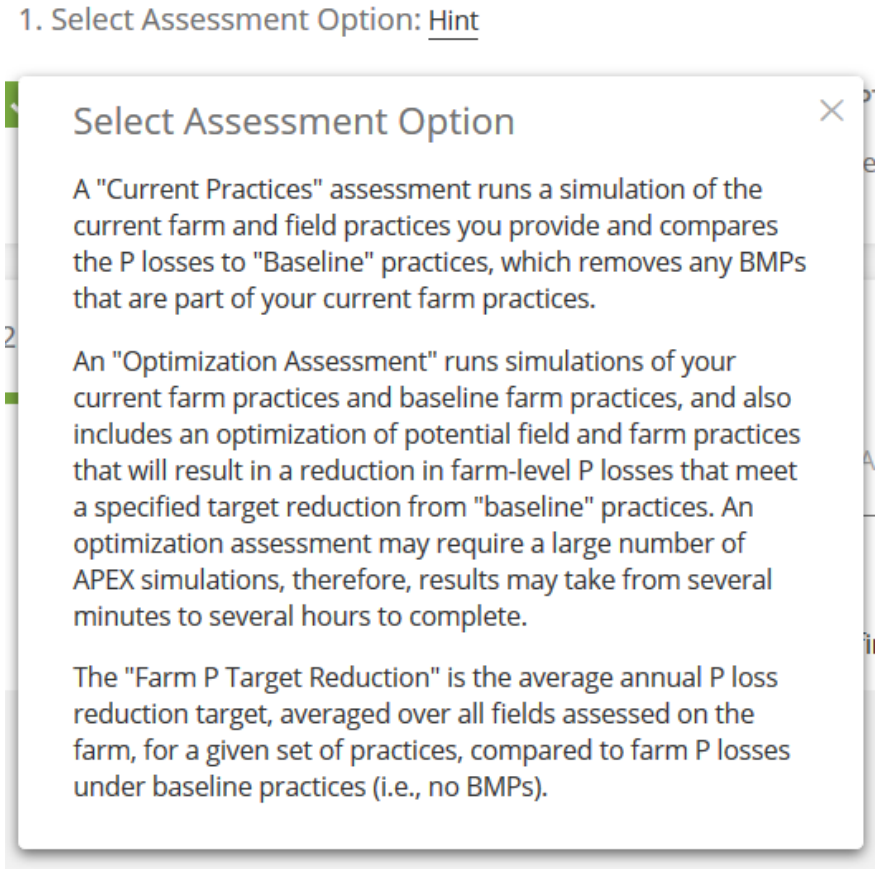
Now, the user has full control over the order in BMPs are considered and can specify which BMPs are excluded from the analysis.

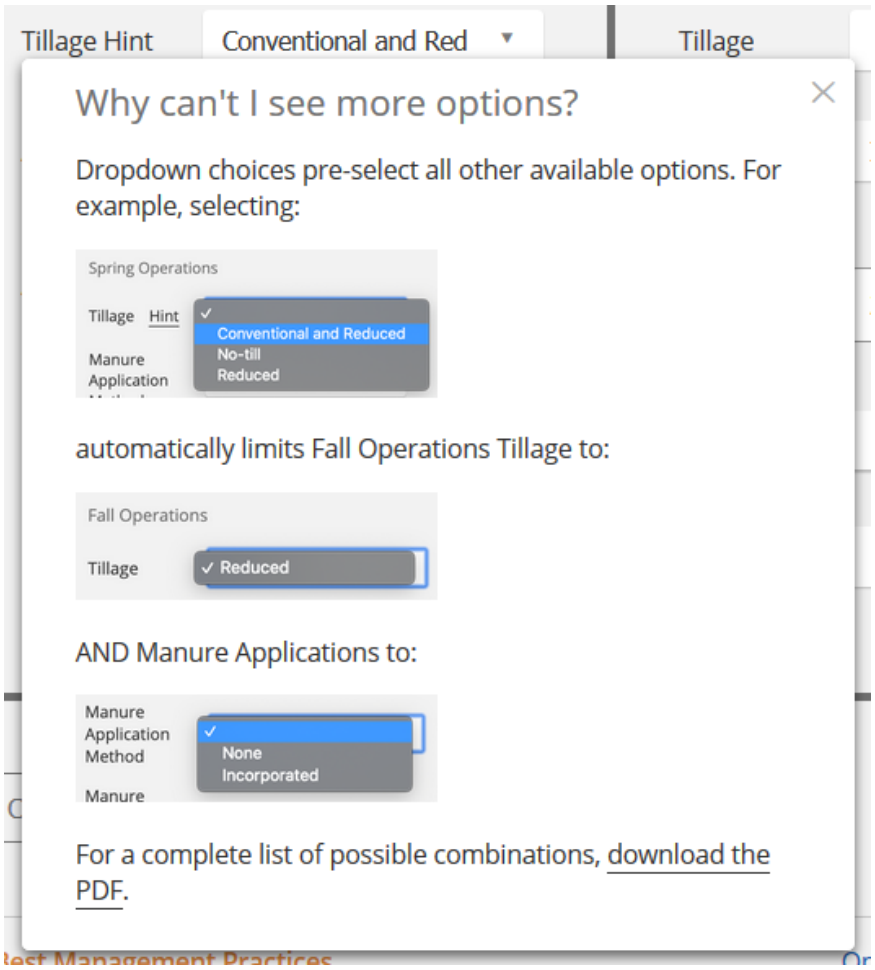


Farm-PREP Recent Developments: Improved User Help

Multiple user help tips have been added throughout the application.

- Guide the workflow
- Provide additional details on processing and assumptions

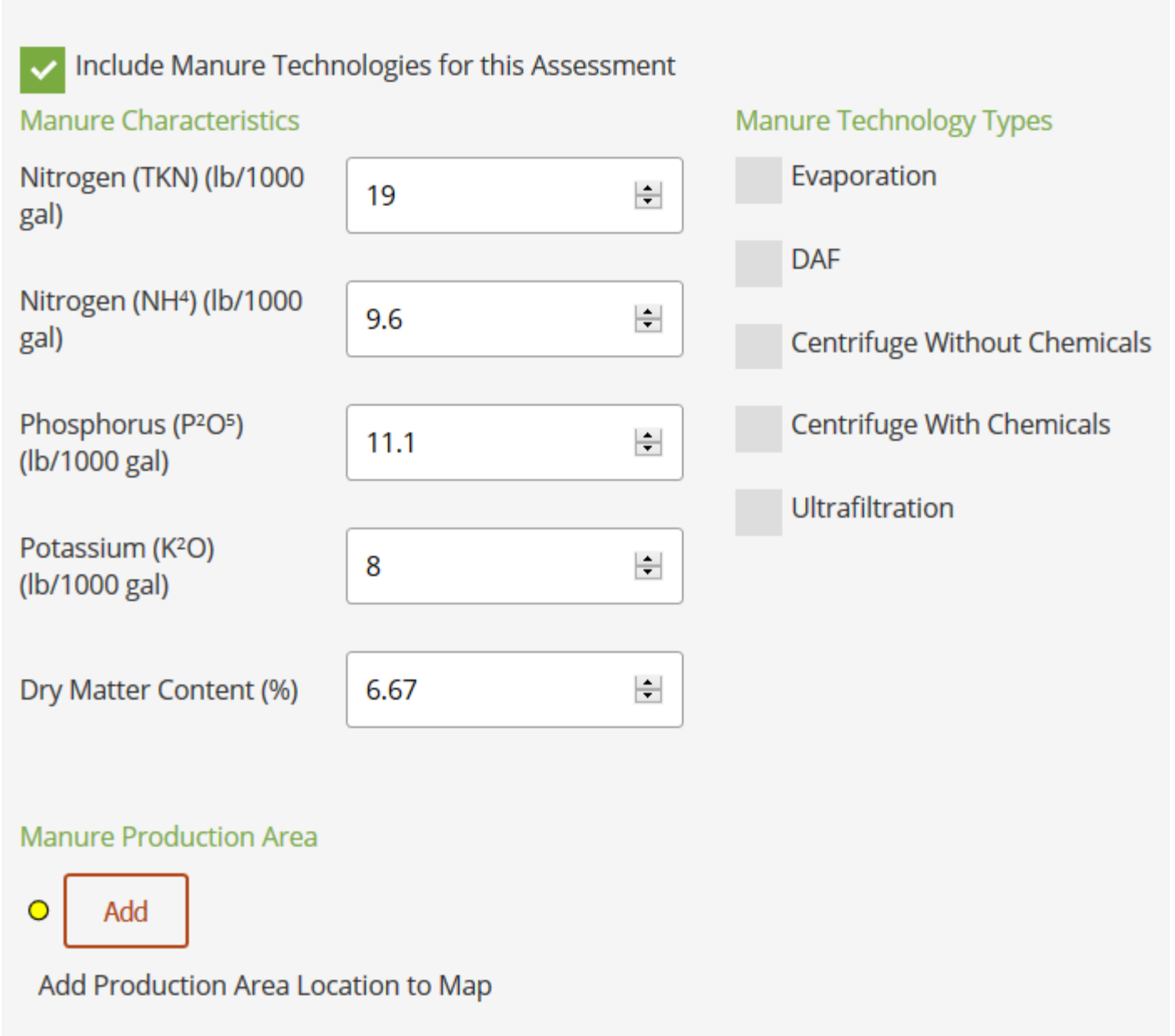




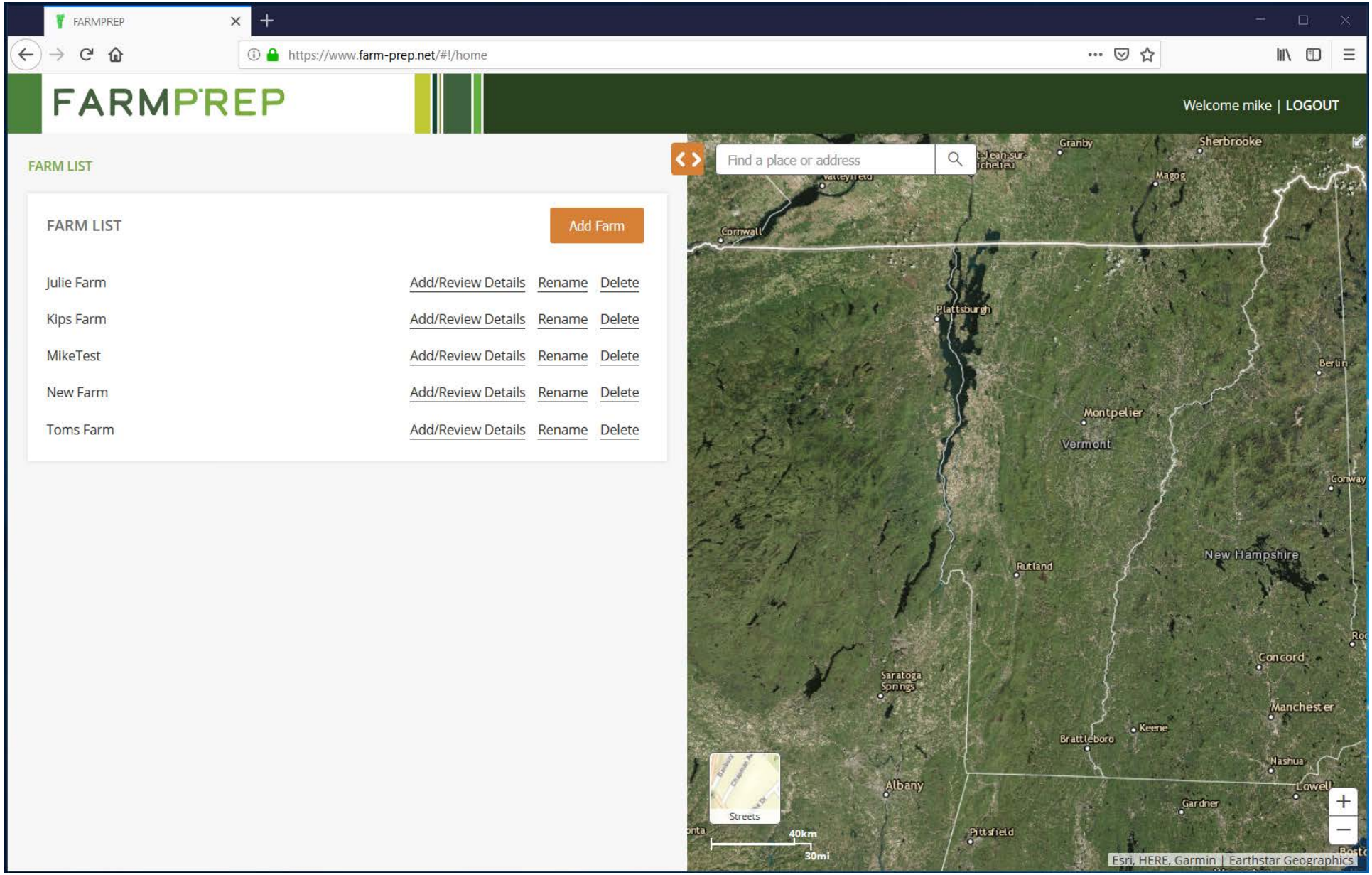
Farm-PREP Updates … Coming Soon!

Download assessment data and results from Farm-PREP to csv file.

Manure technologies implementation and nutrient application optimization.



Farm-PREP Tool Demo



Farm-PREP Workshop: Exercises

You will have around 2 hours to work on developing your own Farm-PREP assessments.

You can use the time to either:

- Follow the example farm dataset, scenarios, and workflow provided
- Enter your own farm data and follow the suggested workflow

STONE ENVIRONMENTAL
100% EMPLOYEE OWNED

Thank you.

For more information
Contact / bpatterson@stone-env.com
or mwinchell@stone-env.com

Appendix E. Workbook for the Farm-PREP Workshop

Farm-PREP Exercise with Example Farm Data
UVM Extension, Rutland, VT
12/9/19

Overview:

Example data for a small farm with 5 fields has been provided. The farm includes 2 fields that are in continuous corn, 2 field that are in corn-grass hay rotations, and 1 field that is in continuous hay. The current practices on the farm include conventional tillage practices, and some limited cover cropping. The goals of this exercise will be to:

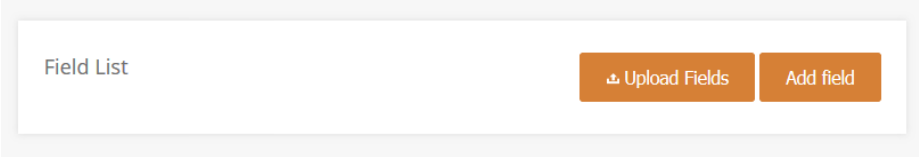
1.) Setup and run Farm-PREP for the current practices on the farm.
2.) Compare the P losses from the farm and individual fields to "baseline" practices (with no BMPs).
3.) Modify the current farming practices on several fields and compare the expected P losses to the originally planned practices for the farm.
4.) Run a farm practice optimization to meet a targeted reduction on P losses that prioritizes BMPs on the farm according to the farmer's preferences.

Step 1: Create New Farm and Current Conditions Assessment

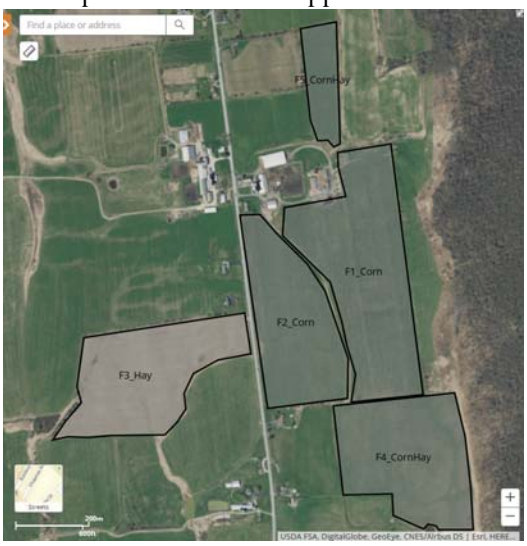
In this step, you will create a current conditions assessment for a farm located in Whiting in southern Addison County.

1. Create a new farm by clicking on the Add Farm button and name the farm "WhitingFarm". 

2. Upload a shapefile (found on your thumb drive) that contains the boundaries for five fields on your farm by clicking the "Upload Fields" button. The "zipped" shapefile is called "WhitingFarm.zip" and located in the folder called "RutlandExampleData". Click the "Upload" button after you have browsed to your "WhitingFarm.zip" dataset.



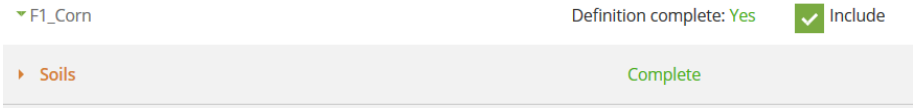
Your uploaded fields will appear within the Farm-PREP map window as shown below.



3. Create a new assessment called "Current Practices" by clicking on the "Add Assessment" button and set the P target reduction to 0%. The 0% P reduction target is used when running a Farm-PREP assessment for only current and baseline conditions, without the optimization option. This approach is helpful for understanding your farm and when evaluating changes in P loss reduction based on specific practices changes one at a time.

   You will now see the list of fields in your assessment.

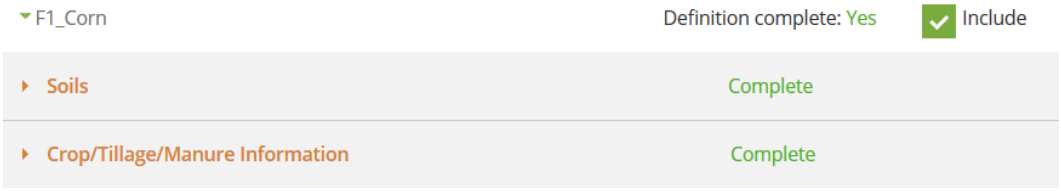
4. Enter the Modified Morgan's soil test P data for each field. This data is entered in the "Soils" section for each field. The soil test information for this farm is summarized in the table below.



Field	Soil P (ppm)	pH	Al (ppm)
F1_Corn	4.5	6	60
F2_Corn	6	5.8	55
F3_Hay	5	6.2	45
F4_CornHay	5.5	6.1	50
F5_CornHay	4.8	5.9	53

5. Enter the crop rotation, tillage, manure/fertilizer application, and cover cropping information about each of your five fields. This data is entered in the "Crop/Tillage/Manure" section for each field. The

rotation, manure and fertilizer information for this farm is summarized in the tables below.



Field	Rotation	Corn Spring Tillage	Corn Fall Tillage	Hay Cuts	Cover Crop
F1_Corn	Continuous Corn	Conventional and Reduced	Reduced	N/A	Winter Hardy, Late Plant
F2_Corn	Continuous Corn	Conventional and Reduced	Reduced	N/A	None
F3_Hay	Continuous Grass Hay	N/A	N/A	4	None
F4_CornHay	2 years Corn, 4 years Legume Hay	Conventional and Reduced	Reduced	4	None
F5_CornHay	2 years Corn, 4 years Legume Hay	Conventional and Reduced	Reduced	4	None

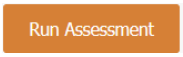
Field	Corn Spring Manure	Corn Fall Manure	Hay Manure
F1_Corn	Incorporated, 25 lbs P2O5/ac	Incorporated, 25 lbs P2O5/ac	N/A
F2_Corn	Incorporated, 25 lbs P2O5/ac	Incorporated, 25 lbs P2O5/ac	N/A
F3_Hay	N/A	N/A	Surface, 50 lbs P2O5/ac-yr
F4_CornHay	Incorporated, 25 lbs P2O5/ac	Incorporated, 25 lbs P2O5/ac	Surface, 50 lbs P2O5/ac-yr
F5_CornHay	Incorporated, 25 lbs P2O5/ac	Incorporated, 25 lbs P2O5/ac	Surface, 50 lbs P2O5/ac-yr

Field	Corn Commercial P (lbs/ac-yr)	Corn Commercial N (lbs/ac-yr)	Hay Commercial P(lbs/ac-yr)	Hay Commercial N (lbs/ac-yr)
F1_Corn	0	200	N/A	N/A
F2_Corn	0	200	N/A	N/A
F3_Hay	0	N/A	0	50
F4_CornHay	0	200	0	0
F5_CornHay	0	200	0	0

Step 2: Run the Current Conditions Assessment and Evaluate Results

In this step, you'll run the Farm-PREP simulation analysis for the farm's current conditions and compare P loss predictions between the current and baseline conditions and evaluate the P losses across the different crop rotations and fields.

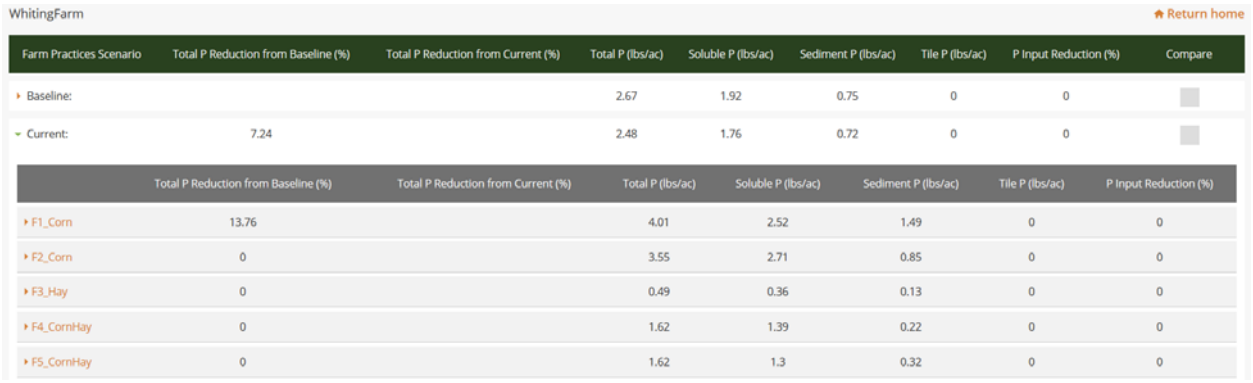
1. You have now entered all of the information into Farm-PREP that is required to run a current conditions assessment. To run the assessment, click the "Run Assessment".



The assessment will take a few minutes to run. The status of the simulation is provided in the assessments list. The status will say "Complete" when it has finished.

Assessment	P Target Reduction	Status	Action
Current Practices	0%	Complete	Results Duplicate Delete Review

2. Once completed, view the results of the assessment by clicking on the "Results" link. The initial results view is at the farm level. You can view the field level results by clicking on the orange triangle next to the name of the Baseline of Current scenarios.



WhitingFarm — Return home

Farm Practices Scenario	Total P Reduction from Baseline (%)	Total P Reduction from Current (%)	Total P (lbs/ac)	Soluble P (lbs/ac)	Sediment P (lbs/ac)	Tile P (lbs/ac)	P Input Reduction (%)	Compare
Baseline:			2.67	1.92	0.75	0	0	
Current:	7.24		2.48	1.76	0.72	0	0	

	Total P Reduction from Baseline (%)	Total P Reduction from Current (%)	Total P (lbs/ac)	Soluble P (lbs/ac)	Sediment P (lbs/ac)	Tile P (lbs/ac)	P Input Reduction (%)
F1_Corn	13.76		4.01	2.52	1.49	0	0
F2_Corn	0		3.55	2.71	0.85	0	0
F3_Hay	0		0.49	0.36	0.13	0	0
F4_CornHay	0		1.62	1.39	0.22	0	0
F5_CornHay	0		1.62	1.3	0.32	0	0

3. Having viewed the results from the current assessment, answer the following questions:
   a. Do the relative differences in the total P losses across the 3 different crop rotations (corn, corn/hay, hay) make sense? If not, why not?

   b. What is causing the current conditions P losses to be different than the baseline P losses on field "F1_Corn"? Is the change between current and baseline P losses for field "F1_Corn" as you would expect? If not, why?

   c. The P losses from field F1_Corn are higher than the P losses from field F2_Corn? Can you explain why that is the case?

   d. The P losses from field F4_CornHay and F5_CornHay are nearly identical, despite the fact that the slope for Field F5_CornHay is more than double the slope of field F4_CornHay. Can you explain why this is the case?

Step 3: Modify the Current Farm Practices and Evaluate the Impacts on P Losses

In this step, you will modify several aspects of the current farm practices and get a better understanding for the impacts of these changes on predicted P losses by field.

1. Create a new assessment called "Current Practices 2" by duplicating the initial "Current Practices" assessment that you created.
2. Make the following modifications to each field:
    a. F1_Corn: Change the cover crop from a late plant cover crop to an early plant cover crop.
    b. F2_Corn: Change the tillage in the spring to "No Till" in the spring and "None" in the fall. This change will also require that the manure application method be changed from "Incorporated" to "Surface"
    c. F3_Hay: Change the manure application method to "Injected"
    d. F4_CornHay: Change the years of corn from 2 years to 4 years (keeping the legume hay at 4 years)
    e. F5_CornHay: Add a 10 ft wide buffer along the eastern edge of the field. Use the measure tool to determine the length of the buffer (should be about 1100 feet).
3. Run the assessment and answer the following questions:
    a. How did the P losses change for field F1_Corn? Is this what you expected?

    b. What was more effective at reducing P losses, an early plant cover crop (field F1_Corn), of going for conventional tillage to no-till (field F2_Corn)? Is this what you would expect?

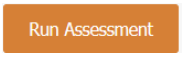
    c. Was manure injection on hay (field F3_Hay) effective at reducing P losses? How did it compare to reductions in P losses from cover cropping and no-till on the corn fields?

    d. On field F4_CornHay, how did shifting from 2 years of corn in the rotation to 4 years of corn in the rotation impact the P losses? Was this expected?

    e. On a percent basis, was the buffer on field F5_CornHay more effective at reducing the amount of sediment P or soluble P?

Step 4: Run an Optimization of Field Practices to Achieve a 35% Reduction in Annual P Loss

In this step, we will run an optimization of field level practices to identify combinations of practices that will results in a 35% reduction of farm P losses relative to baseline conditions. In this assessment, we are going to allow all practices to be considered in the assessment (no BMP exclusions).

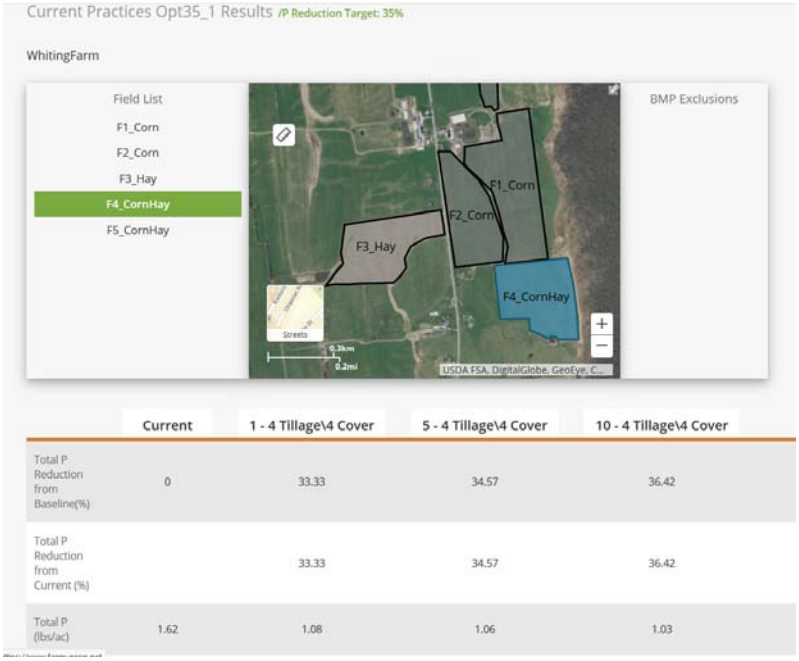
1. Duplicate the "Current Practices" assessment and name the new assessment, "Current Practices Opt35_1".
2. Change the "Farm P Target Reduction" to 35%.
3. Run the assessment by clicking the "Run Assessment button. 

This assessment will take several minutes to run (possibly as much as 10 to 15 minutes).
4. Once the optimization has completed, review the results for the assessment by clicking on the Results link.

You will likely find that the Total P reduction from multiple scenarios returned by Farm-PREP are nearly identical. This is because Farm-PREP finds combinations of practices that get as close as possible to the specified target (in our case, 35%), and there are only so many combinations of practices that get very close to the target. Try choosing 3 scenarios, in addition to "Current", to compare by checking the "Compare" checkbox and then clicking on the "Compare" button.

Farm Practices Scenario	Total P Reduction from Baseline (%)	Total P Reduction from Current (%)	Total P (lbs/ac)	Soluble P (lbs/ac)	Sediment P (lbs/ac)	Tile P (lbs/ac)	P Input Reduction (%)	Compare
Baseline:			2.7	1.94	0.75	0	0	☐
Current:	7.18		2.5	1.79	0.72	0	0	☐
1 - 4 Tillage\4 Cover:	35.23	30.22	1.75	1.17	0.57	0	0	☑
2 - 4 Tillage\4 Cover:	35.23	30.22	1.75	1.18	0.57	0	0	☐
3 - 3 Tillage\4 Cover:	35.32	30.31	1.74	1.19	0.55	0	0	☐
4 - 4 Tillage\4 Cover:	35.32	30.31	1.74	1.17	0.57	0	0	☐
5 - 4 Tillage\4 Cover:	35.4	30.4	1.74	1.17	0.57	0	0	☑
6 - 4 Tillage\4 Cover:	35.4	30.4	1.74	1.17	0.57	0	0	☐
7 - 4 Tillage\4 Cover:	35.4	30.4	1.74	1.17	0.57	0	0	☐
8 - 4 Tillage\4 Cover:	35.4	30.4	1.74	1.17	0.57	0	0	☐
9 - 4 Tillage\4 Cover:	35.48	30.49	1.74	1.17	0.57	0	0	☐
10 - 4 Tillage\4 Cover:	35.65	30.67	1.73	1.17	0.57	0	0	☑

You can then examine 1 field at a time and determine what the new practices are and what is different across the scenarios returned from the optimization.



	Current	1 - 4 Tillage\4 Cover	5 - 4 Tillage\4 Cover	10 - 4 Tillage\4 Cover
Total P Reduction from Baseline(%)	0	33.33	34.57	36.42
Total P Reduction from Current (%)		33.33	34.57	36.42
Total P (lbs/ac)	1.62	1.08	1.06	1.03

5. Answer the following questions regarding the optimization results:
    a. For the 3 scenarios reviewed, on how many fields was there a change in tillage practices?

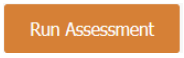
    b. For the 3 scenarios reviewed, how often was cover cropping a recommended practice, and what was the most common type of cover cropping (late plant, early plant, or inter-seeded)?

    c. Were buffers or grass waterways recommended practices for any of the solutions generated by Farm-PREP?

Step 5: Run an Updated Optimization of Field Practices to Achieve a 35% Reduction in Annual P Loss, where Some of the Potential BMPs are Excluded from Consideration

In this step, we will modify the optimization to exclude some practices that our farm would not want to implement, as well as specify some BMPs to exclude at the field level.

1. Duplicate the "Current Practices Opt35_1" assessment and name the new assessment, "Current Practices Opt35_2".
2. In the "BMP Exclusions" section, exclude the following practices from consideration:
    a. Grass Waterway (30 ft and 50 ft)
    b. Cover Crop (Inter-seeded and Early Plant)
    c. No-Till

3. For field F4-CornHay, a 25 ft buffer is not practical give the field design. Go to the F4_CornHay, Best Management Practice Exclusions inputs, and add the "Buffer 25 ft" to the list of excluded BMPs.
4. Run the assessment by clicking the "Run Assessment" button. 

This assessment will take several minutes to run (possibly as much as 10 to 15 minutes).
5. Once the optimization has completed, review the results for the assessment by clicking on the Results link.

6. Compare the "Current" scenario with 3 optimized scenarios and answer the following questions:
    a. On how many corn fields did both a change in tillage practices and a change in cover cropping occur relative to the current practices?

    b. How often were buffers also needed to help meet the 35% target reduction in P loss?

    c. How often were grass waterways needed to help meet the 35% target reduction in P loss?

Step 6 (BONUS Question!): Run an Updated Optimization of Field Practices to Achieve a 65% Reduction in Annual P Loss

This analysis will evaluate whether a more substantial target reduction in P loss can be achieved, without BMPs being excluded from consideration.

1. Duplicate the "Current Practices Opt35_1" assessment and name the new assessment, "Current Practices Opt65_1".
2. Change the P reduction target from 35% to 65% and run the assessment.
3. Was Farm-PREP able to find any solutions that meet the 65% reduction target? If so, what practices were typically required to meet that reduction target?