User Guide

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Edge of Field Conservation Planning Tool

CATENA ANALYTICS

One Water Solutions Institute

Colorado State University

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EXECUTIVE MESSAGE

Catena Analytics offers powerful platforms for building accessible and scalable analytical tools and simulation models that can be accessed via desktop or mobile devices. Our team has spent that last decade developing the Environmental Resource Assessment and Management System (eRAMS), an open source technology that provides cloud-based geospatially-enabled software solutions as online services and a platform for collaboration, development, and deployment of online tools. Our services are used to assist with strategic and tactical decision making for sustainable management of land, water and energy resources. Thank you for choosing Catena Analytics and the eRAMS platform to meet your data, modeling, analysis and geospatial needs.

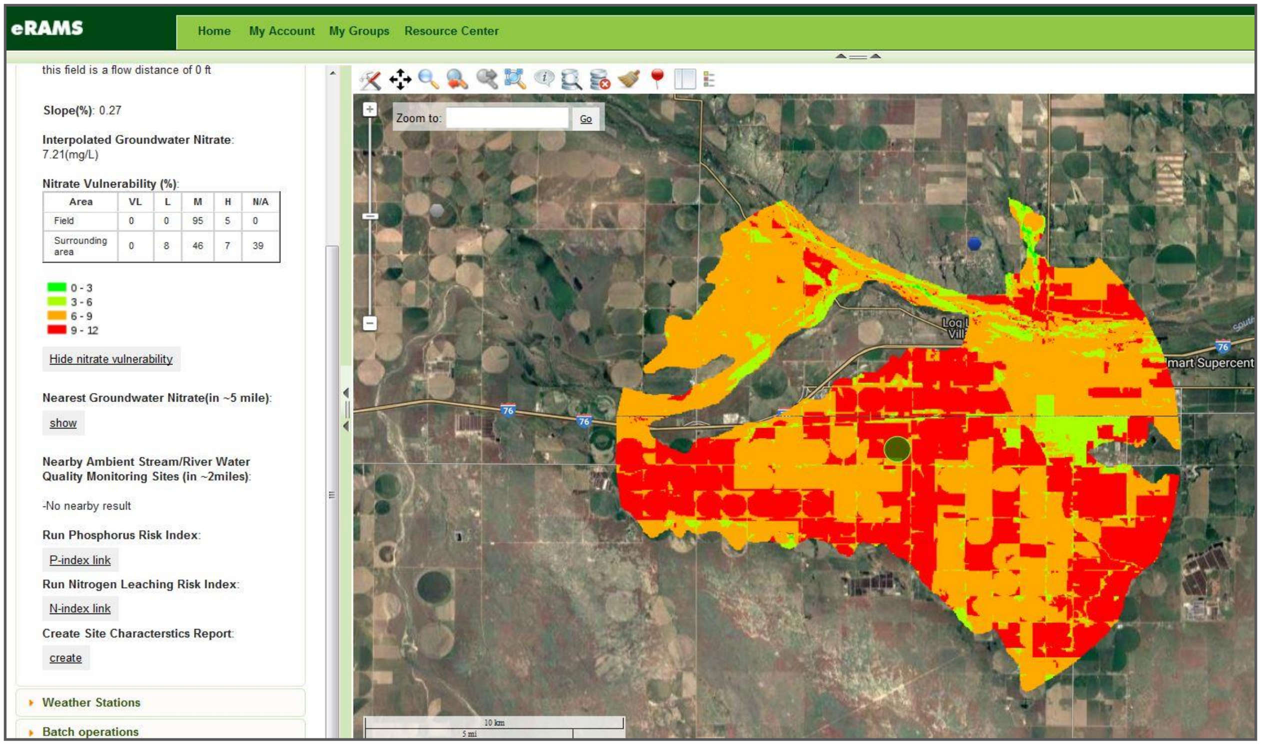
Who Should Use This Guide

This guide is a tutorial to get you started using eRAMS Edge of Field Conservation Planning tool. The guide provides instructions for commonly performed tasks and uses of the tool. This tool is intended for use by urban planners and water managers, academic groups, regulatory officials, consultants as well as state, local and federal agencies planning for the future of water resources.

Need Help?

After reviewing the guide if you need additional assistance we are here to help! This guide is designed to provide instruction on commonly performed operations and answers to many frequently asked questions. If you find any aspect of the tool challenging or missing information from this guide, please engage an eRAMS expert to guide you through any hurdles. Contact us at: eramsinfo@gmail.com

INTRODUCTION



PURPOSE

The Edge of Field Conservation Planning tool allows users to assess impacts and benefits from the application of agricultural best management practices.

DESCRIPTION

The Edge of Field Conservation Planning tool (EOFCP) allows producers, their advisers, scientists, and engineers to compare potential and modeled water quality and crop yield impacts from the implementation of agricultural nutrient, irrigation and tillage conservation best management practices (BMPs).

EOFCP also provides additional information on BMP implementation and calculates nutrient recommendations with user inputs. Users can also use the N-Index and P-index risk modules to evaluate fields for N and P losses. Once a field is mapped, EOFCP provides information on site characteristics that can show how nutrient management practices may impact water resources.

The EOFCP utilizes various technologies including open source Geographic Information Systems (GIS), Terrain Analysis Using Digital Elevation Models (TauDEM; Tarboton, 2013) and Soil and Water Assessment Tool (SWAT; Arnold et al. 2012) to provide information to help plan conservation practices for a field and to assess the effectiveness of various agricultural conservation practices.

SOFTWARE AVAILABILITY

Domain

www.erams.com

Documentation URL

https://erams.com/catena/tools/agricultural-resources/edge-of-field/

AUTHORIZED USE PERMISSION

The information contained in the Edge of Field Conservation Planning tool (the "Service") is for general information purposes only. Colorado State University's One Water Solutions Institute ("CSU-OWSI") assumes no responsibility for errors or omissions in the contents of the Service. In the Service, you agree to hold neither the creators of the software platform nor CSU-OWSI liable for any action resulting from use or misuse of the Service. In no event shall CSU-OWSI be liable for any special, direct, indirect, consequential, or incidental damages or any damages whatsoever, whether in an action of contract, negligence or other sort, arising out of or in connection with the use of the Service or the contents of the Service. CSU-OWSI reserves the right to make additions, deletions, or modification to the contents of the Service at any time without prior notice.

SYSTEM REQUIREMENTS

A modern web-browser is required to connect and run CFA. Browser options include: Google Chrome v.69, Mozilla Firefox v.62, Safari v.11.1, and Microsoft Edge v.17.

DATA

Soil data is retrieved from the USDA – Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO).

Users can also choose climate data sources from:

- Parameter Elevation Regression on Independent Slopes Model (PRISM)
- Global Historical Climatology Network – Daily (GHCND)
- Colorado Agricultural Meteorological Network

EOFCP integrates the Phosphorus Index, Nitrogen Index, Soil and Water Assessment Tool (SWAT) model, Water Irrigation Scheduler for Efficiency (WISE), Land Use and Agricultural Management Practice Service (LAMPS), and other technologies into a single geospatial application for comprehensive analysis.

USING THE TOOL

ACCESS THE TOOL

The Edge of Field Conservation Planning tool requires a registered user account to create, save and share a project and revisit previous analyses. Follow the instructions below to create your free account or visit our website to get started: https://erams.com/account/

Create an eRAMS Account

1. From the eRAMS Registration page, enter a username, password, your first and last name, and your email address. Click on the "Create Account"
    - eRAMS will display a popup box alerting you that an email confirmation has been sent to the provided email address
2. Open the email account provided in the registration form from either a new browser window or from your local email application.
    - Search for an email from eRAMS with the subject line "eRAMS Email Check"
3. Open this email and click on the provided link to confirm your email address.
    - ***Note****: If you do not see the confirmation email appear in your email inbox immediately, check your spam or junk email folder to ensure that the confirmation message wasn't automatically discarded. You may also need to wait a few moments to ensure the email is delivered successfully.*
4. Once you click on the provided email link, you should be redirected to eRAMS, where you'll be automatically logged in

Registered User Access

1. Login to your eRAMS account here: https://erams.com/account/
2. Select the "Projects" tab from the left panel (Figure 1)
   - ***Hint***: *You must be logged into your eRAMS account*
3. Select "Create Project" from the top toolbar
4. Enter a Project Name
   - Alternatively, select a project from the list to access previous projects
5. Select "Edge of Field Agricultura Conservation Planning" from the Project Type drop down
   - Optional: Select layers from previously saved project under the "Include Layers from Project" drop down
6. Click "OK"
7. Locate the name of the project you have created in the project list, click the link
   - The link will redirect you to the CFA interface where you can conduct analysis and save work to your account

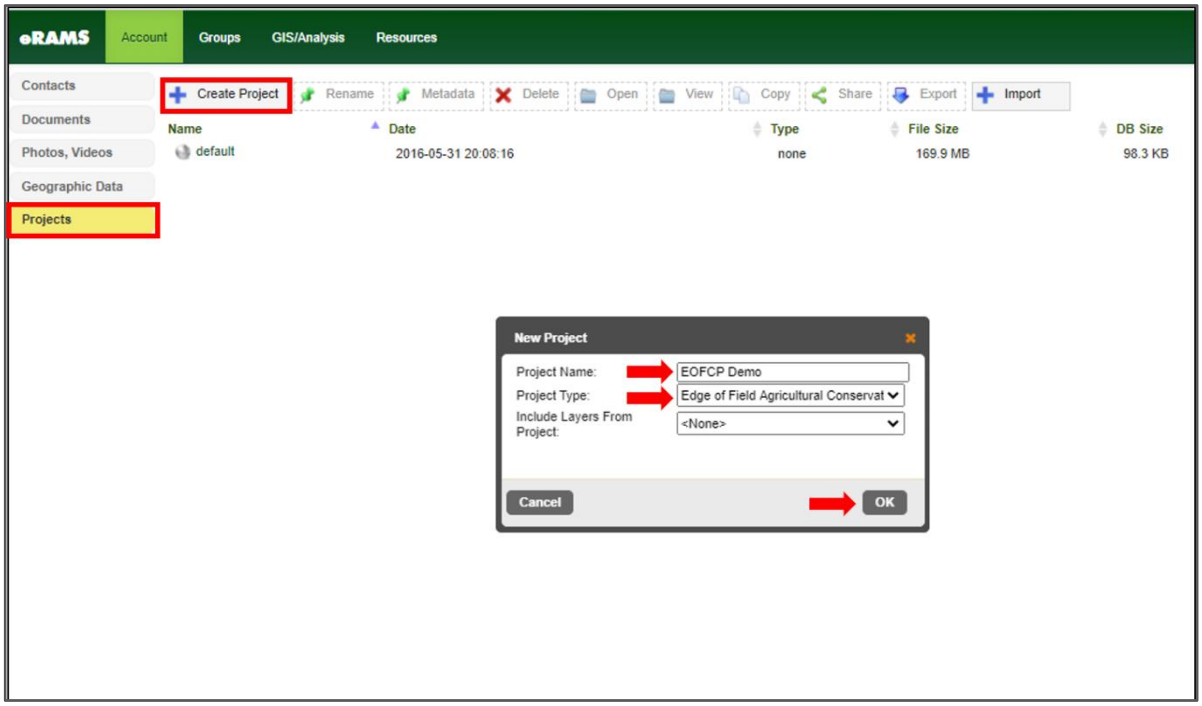


Figure 1: Registered user process for creating an EOFCP project in eRAMS

Assess Site Characteristics

Select Area of Interest

The first step for the EOFCP is for the user to map the field or site of interest within the Environmental Resource Assessment & Management System (eRAMS) platform. The application then provides users various field parameters that affect the potential movement of nutrients to surface and groundwater. These parameters include proximity to surface water, field slope, interpolated groundwater nitrate, groundwater nitrate vulnerability, nearest actual groundwater nitrate, nearby ambient stream/river water quality monitoring sites, which are provided within a site characteristics report.

Phosphorus Index

The user then has the option to assess their site with the Colorado Phosphorus Index Risk Index, Version 5 (P-Index), Sharkoff et al. (2012a), or the Nitrogen Leaching Index Risk Assessment (N-Index), Version 3, Sharkoff et al. (2012b). The P-Index is assessed based on phosphorus transport, soil test phosphorus, phosphorus application, phosphorus application method, timing and best management practices mitigation credits. N-index is assessed based on saturated hydrologic conductivity, irrigation application efficiency, nitrogen application rate risk, nitrogen application time risk factor and best management practices implementation credits.

Proximity to Surface Water

The proximity to surface water is a significant factor in potential nutrient loss impact. Proximity is calculated following flow direction. To implement this, the extent of analysis area is defined as five-mile buffered rectangle from the bounding box of field polygon. Then, Digital Elevation Model (DEM) is extracted for this area from National Hydrography Dataset (NHD)'s NHDPlusV2 (US EPA, 2015), which is a group of geospatial dataset for hydrologic framework. And each stream and waterbody raster data created from NHD is clipped for this area making consistent resolution and extent with the DEM. Next, this stream and waterbody raster is merged to a surface water raster using gdal_calc.py. The pits of DEM are removed using pitremove module of TauDEM and flow direction raster was created using d8flowdir module. Then, the distance to stream raster is calculated using d8hdisttostrm module. Now, the proximity to surface water is determined inside field boundary as minimum value of distance to stream raster using zonal_stats with minimum value parameter. Next, slope parameter is calculated using Geospatial Data Abstraction Library (GDAL) module gdaldem by inputting NHDPlus v2.0 DEM. The average slope value is calculated using zonal_stats python program.

Groundwater Nitrate

To provide the interpolated groundwater nitrate information, GDAL .vrt format file is created from multiple interpolated groundwater nitrate raster datasets for Colorado and the average value is calculated. The nitrate vulnerability layer was created using methods adapted from Ceplecha, et al. (2004), using improved soil drainage resolution from NRCS SSURGO soils and irrigated agriculture layer adapted from 2011 National Land Cover Database (NLCD) land use-land cover data. This information was combined with depth to groundwater data of U.S. Geological Survey (USGS) National Weather Information System (NWIS) groundwater monitoring wells and data from the Colorado Division of Water Resources South Platte Decision Support System (SPDSS). The nitrate vulnerability raster for field polygon is clipped using gdalwarp with the 5 mile buffered polygon created using postgis function ST_Buffer() from the field polygon. This clipped nitrate vulnerability (NV) raster is reclassified to four values: very low (0<NV<=3), low (3<NV<=6), medium (6<NV<=9), and high (9<NV<=12). The ratio of each class is calculated using zonal_stats with categorical parameters, which returns number of pixels of each class. The Nitrate Vulnerability ratio for each class is calculated for 5 miles buffered area from the field. Figure 2 shows the example of the nitrate vulnerability map.

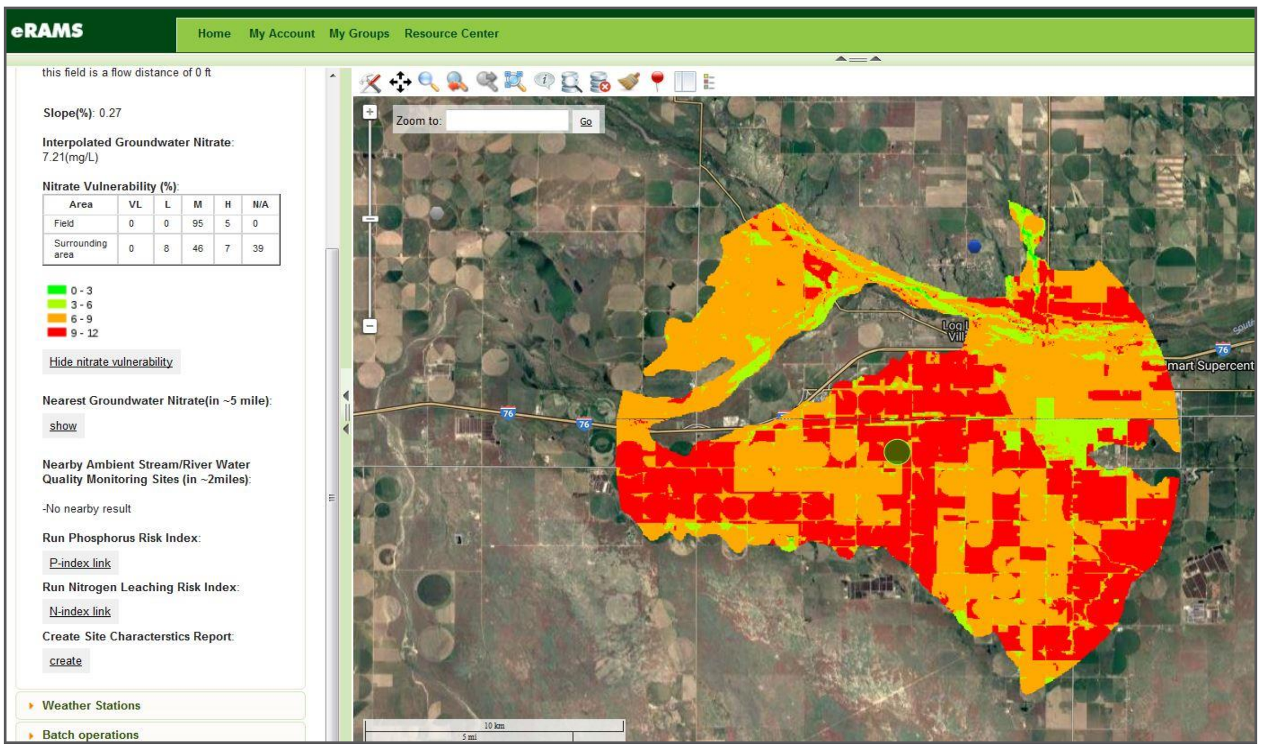


Figure 2: Nitrate vulnerability map

Groundwater

Nearby water quality data was queried from the following sources. The groundwater nitrate data was queried from the Agricultural Chemicals and Groundwater Protection Database (https://erams.com/co_groundwater/). The first step for calculating nearest groundwater nitrate is exporting field polygon using ogr2ogr. Then, nearest groundwater nitrate parameter is calculated by averaging values for monitoring sites in approximately 5 miles in east-west and north-south direction and shown as bar chart. Figure 3 shows the bar chart for groundwater nitrate concentration in 5 miles buffer rectangle for the field.

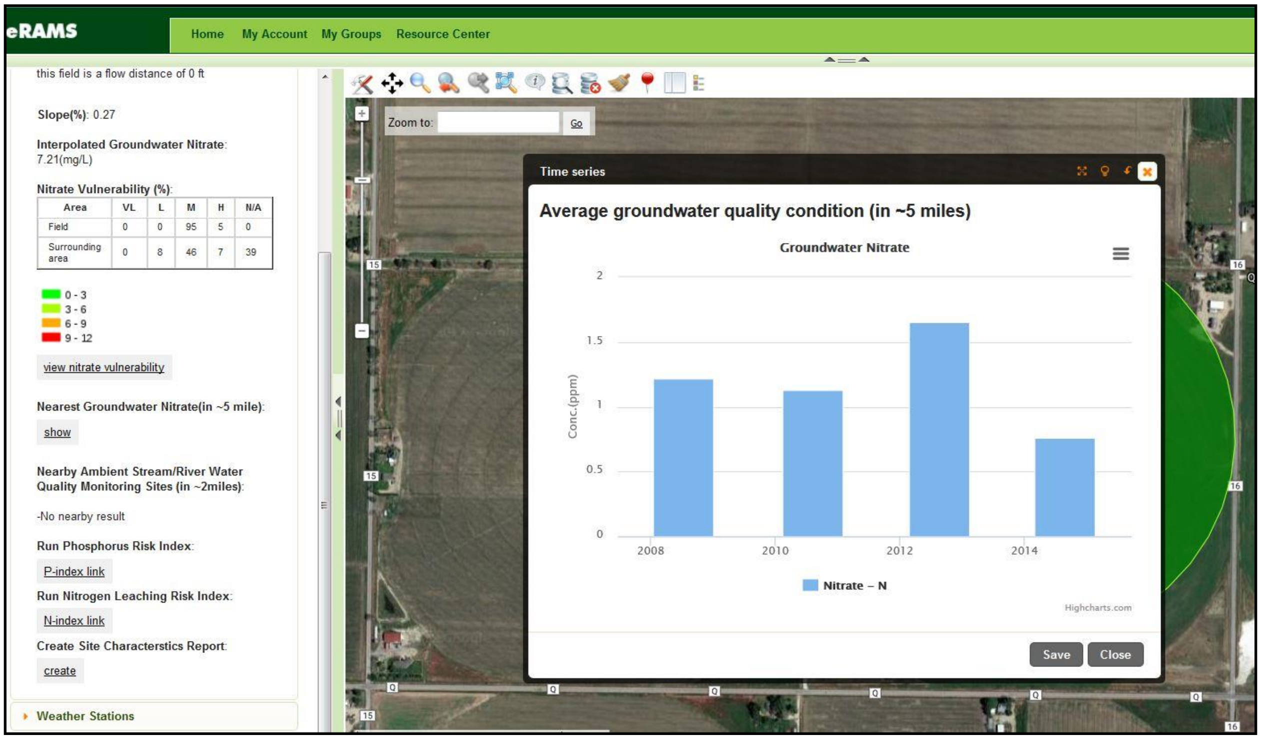


Figure 3: Example bar chart for groundwater nitrate

Ambient Stream/River Quality

For Nearby Ambient Stream/River Quality Monitoring sites parameter, water quality data from Environmental Protection Agency (EPA)'s Storage and Retrieval Data Warehouse (STORET) and USGS monitoring sites are selected for 2-mile radius from the field polygon. Those monitoring sites are shown on the map as place marks using OpenLayers Application Program Interface (API). This was implemented by defining markers as vector layer of feature object in OpenLayers. Next, Nitrate, Ammonia-nitrogen, Phosphate-phosphorus parameters are extracted for those layers using eRAMS' Watershed Rapid Assessment Program (WRAP) services. The time series for surface water quality can be shown if user clicks the place marks on the map. Figure 4 shows the example of ammonia data from STORET.

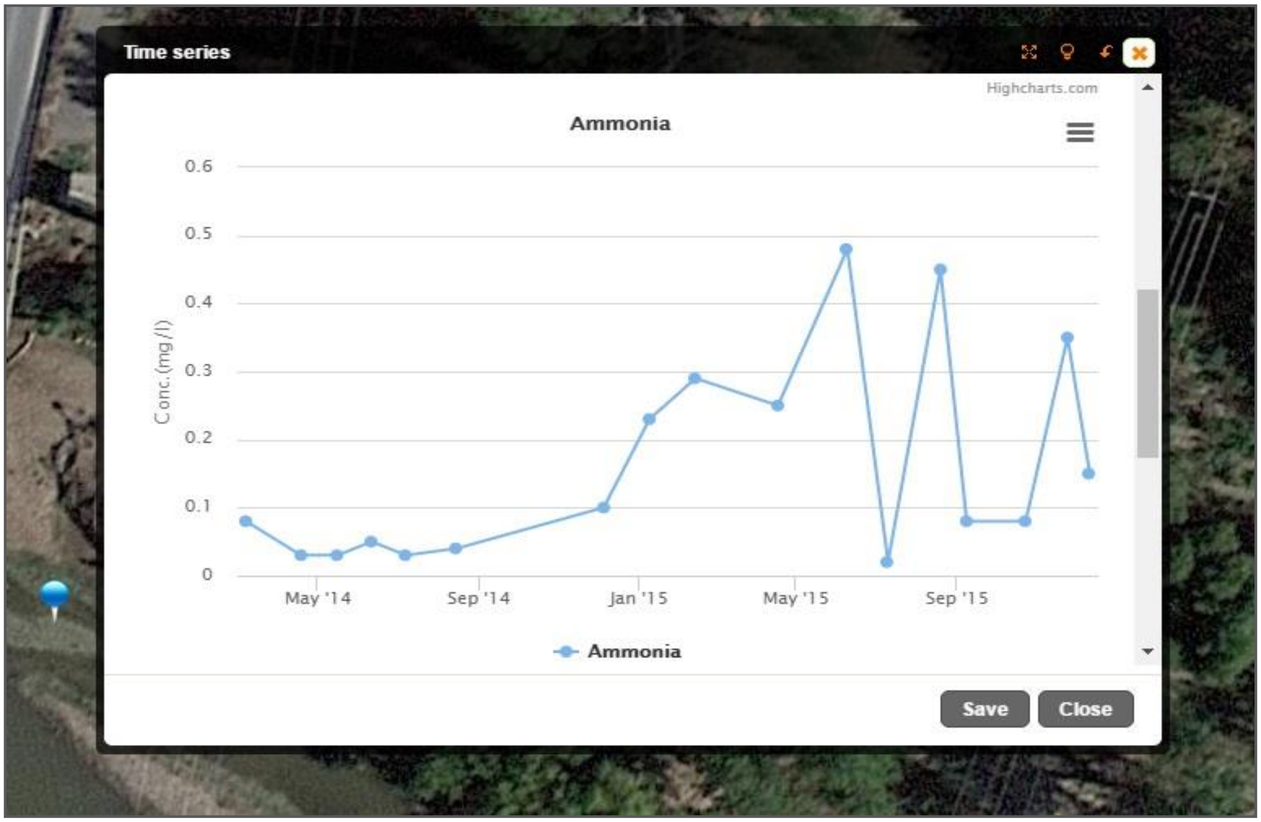


Figure 4: Ammonia concentration for STORET site

Site Characteristics Report

Finally, the field report is generated to provide users with the essential field information including location (centroid), size (acres), soil type from SSURGO, and the slope of field. For each soil type, the report provides erosion class, runoff class, saturated hydraulic conductivity and the ratio of sand, silt, clay of each soil.

Assess Agricultural Conservation Practices

The EOFCP allows users to compare the impact of BMPs on nutrient and sediment losses as well as crop yield. The core backend technology for this application is SWAT. Once users create management scenarios, it is written to various SWAT input files including HRU management (.mgt), the scheduled management operations (.ops), chemical characteristics (.chm), sub-basin general (.sub), and basin (.bsn) input files

The first main input parameters are Planting, Tillage, Nutrient, Irrigation and Harvest. For Planting, users can specify planting date and crop type. Also, date and tillage type can be specified for Tillage. For nutrient, users can specify nutrient type, amount and fraction applied to the surface of the field (incorporated or not). In addition, users can customize commercial fertilizer with percentage of N, P_2O_5 and N applied as ammonia. In addition, users can specify manure's parameters such as fraction of mineral N, mineral P_2O_5, organic N, organic P_2O_5, and mineral N applied as ammonia in addition to the optional parameters such as concentration of persistent bacteria, concentration of less persistent bacteria and bacteria partition coefficient.

For irrigation, irrigation amount and irrigation efficiency can be identified. Also, an irrigation efficiency configuration tool was provided to users so that users can decide the efficiency based on irrigation type and irrigation method. Optionally, users can choose auto irrigation. Finally, users can set the harvest date. These main input parameters are written to HRU management file (.mgt). Figure 5 shows the user interface (UI), where main input parameters can be typed in.

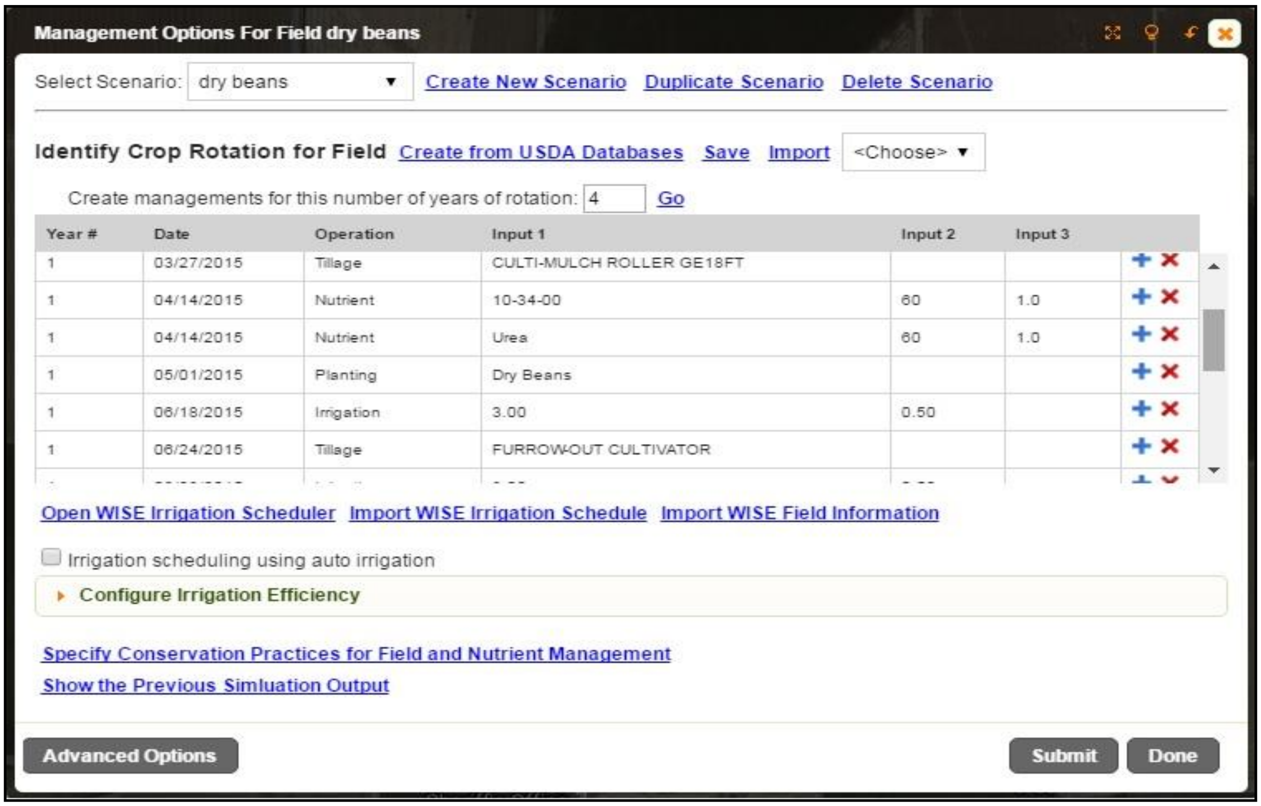


Figure 5: Example user interface for main input parameters

This tool also provides advanced conservation practices options where 1) users can estimate the recommended nutrient amount; 2) users can update main input parameters including Nutrient, Tillage, Irrigation; 3) users add more conservation practices parameters such as Filter Strip, Filed Border, and Grassed Waterway.

A nutrient recommendation calculation tool is also included in the EOFCP for every crop with a CSU Extension fertilizer factsheet. For nutrient recommendations, N and P amounts are recommended based on crop type, expected yield, organic matter, residual soil nitrate, irrigation water, nitrate nitrogen, previous legume credits, previous manure credits and soil test phosphorus. A .pdf report is supplied to the users to save and print with the inputs shown and the recommendation provided.

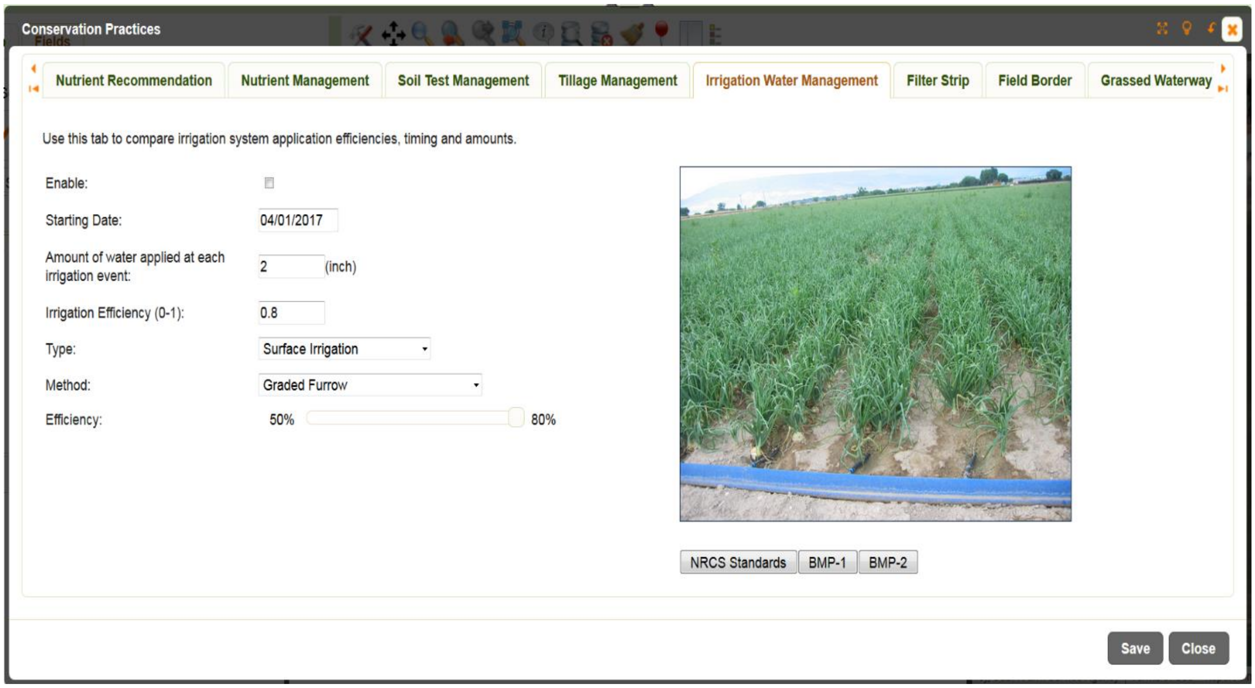


Figure 6: User interface for additional conservation practices

For the main input parameter update, the HRU management file (.mgt) is overwritten with user specified values. For additional conservation practices parameters, the parameter values will be written to the scheduled management operations (.ops) file. The parameters for filter strip are starting date, ratio of field area to filter strip area, flow concentration ratio, and channelized fraction. For field border, users can specify the width of field border. The parameters for grassed waterway are starting date, manning's roughness coefficient, sediment linear parameter, depth, width, length and average slope. Figure 6 shows the UI for additional conservation practices parameter configuration with an example of filter strip.

Also, in an advanced option in user interface, users can specify field parameters for the Initial Soil Nitrogen & Phosphorous levels, Hydrology, and Nutrient Cycling. For Initial Soil Nitrogen & Phosphorous levels, users can define Nitrate, Organic N, Labile P and Organic P according to each depth. Those parameters are written to chemical characteristics (.chm) input file. For Hydrology parameters, users can specify curve number and manning's number, slope, slope length, and length of concentrated flow. Curve number is written to the HRU management file (.mgt), channel length is written to subbasin general input file (.sub), and slope length, slope, manning's number are written to the HRU management file (.mgt).

For nutrient cycling parameters, users can specify denitrification exponential rate coefficient, concentration of nitrogen in rainfall, rate factor for humus mineralization of active organic nitrogen, nitrogen uptake distribution parameter, phosphorus uptake distribution parameter, nitrate percolation coefficient, phosphorus percolation coefficient, phosphorus soil partitioning coefficient, residue decomposition coefficient, which would be written to basin input file (.bsn). Most users will not use these advanced features, but the option exists if they choose and understand how they work.

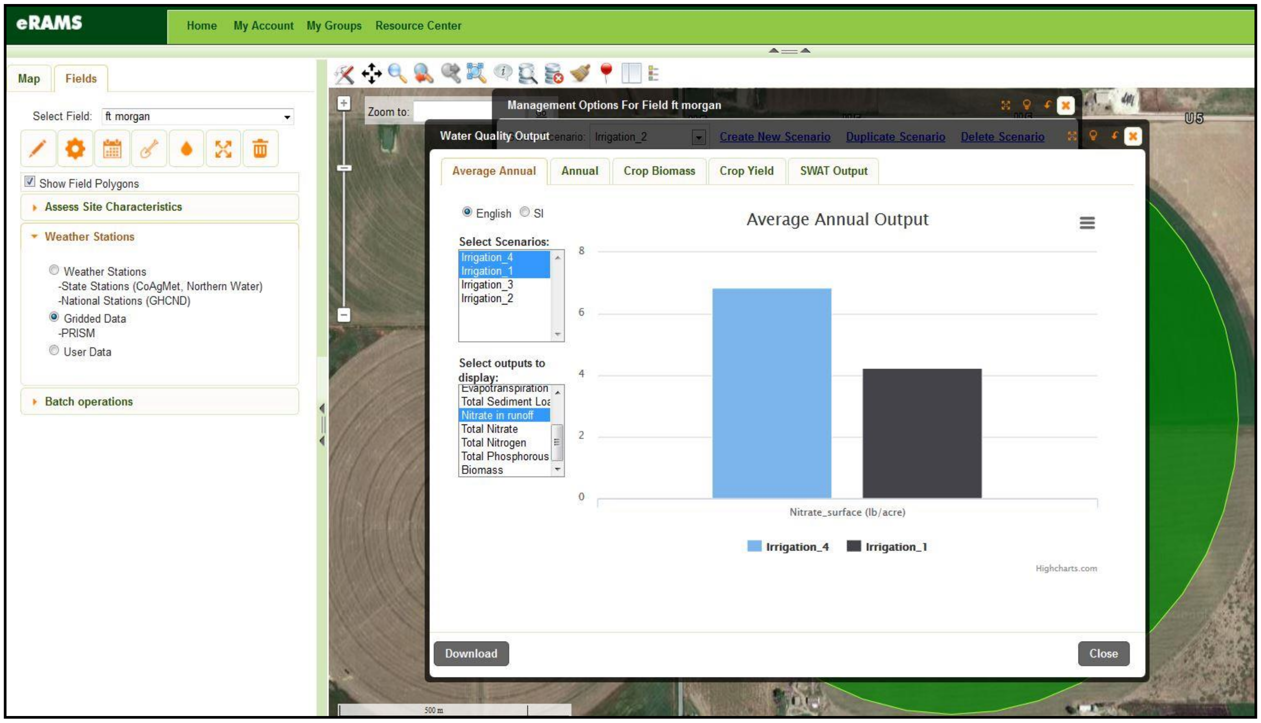


Figure 7: Example of average annual output for nitrate in runoff from comparisons of two BMP scenarios

When users run the model with defined inputs, the tool will give the average annual, annual, crop biomass, and crop yield output parameters. The average annual output includes precipitation, surface runoff, percolation, evapotranspiration, total sediment loading, nitrate in runoff, total nitrate, total nitrogen, total phosphorous, and biomass. Those parameters were averaged for simulation period. Annual outputs include biomass, total nitrate, total nitrogen and total Phosphorous, which are displayed with box plots. Crop biomass output shows daily or monthly crop outputs for simulation period. Crop Yield output shows yield amount at the end of simulation period. If the simulation period includes the time beyond climate availability, it will use climate data from 2010 and will show multiple outputs for crop biomass and yield using historic climate data for each year. Figure 7 shows the example of average annual output for nitrate in runoff with two cases.

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