User's Guide

Spreadsheet Tool for the Estimation of Pollutant Load (STEPL)

Version 4.4

Developed for U.S. Environmental Protection Agency

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Contents

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Quick Guide

Note: You may access the STEPL Web site (http://it.tetratech-ffx.com/steplweb) for the latest information and an online STEPL input data server (Appendix D). Optionally, you may obtain the initial model input from the STEPL input data server. However, it is the **user's responsibility** to check and refine the initial data for study areas.

Step 1. After the installation, run the STEPL program by selecting its menu shortcut from the Start >Programs menu bar or double-clicking the STEPL.exe file in the STEPL folder.

Step 2. Once the STEPL Excel sheet is created, named, and saved, begin to enter the necessary parameter values (displayed in red) in the STEPL input sheet.

The *STEPL input sheet* is composed of ten input tables. The first four tables require that you change the initial values. The next six tables contain default values that you may choose to change.

Step 3.

- Check the first checkbox (in row 10, column F) if you want to treat all subwatersheds as parts of a single watershed (the sediment delivery ratio will be calculated using the total watershed area).
- Check the second checkbox (in row 10, column J) if you want to include groundwater load calculation.
- Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.

Step 4

- Enter land use areas in acres in Table 1.
- Enter total number of agricultural animals by type and number of months per year that manure is applied to croplands and pastureland in Table 2.
- Enter values for septic system parameters in Table 3.
- If desired, modify USLE parameters associated with the selected county in Table 4.

Step 5. You may stop here and proceed to Step 7. If you have more detailed information on your watersheds, proceed with optional input tables.

Step 6. Specify optional parameter values for tables 5, 6, 6a, 7, 7a, 8, 9, and 10:

- Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5.
- Modify the curve number table in Table 6 and Table 6a.
- Modify the nutrient concentrations (mg/L) in surface runoff in Table 7.
- Modify the nutrient concentrations (mg/L) in shallow groundwater in Table 7a.
- Specify the detailed land use distribution in the urban area in Table 8.
- Specify cropland irrigation information in Table 9.
- Modify the nutrient concentrations (mg/L) in surface runoff for pastureland with and without manure application in Table 10.

Step 7. Navigate to the BMP sheet by clicking on the BMP tab at the bottom of the spreadsheet. From the pull-down list, select the best management practices (BMPs) for different *non-urban* land uses in each subwatershed. For *urban* land uses, click the ***Urban BMP Tool*** button on the top-right corner of the worksheet to specify urban BMPs. For gully and stream bank erosion, click the ***Gully and Streambank Erosion*** button to specify the dimensions for each gully formation and impaired streambank.

Step 8. View the estimates of loads and load reductions in the Total Load and Graphs sheets.

Updates to STEPL Version 4.4

Input Worksheet.

Weather Station Updates:

Spatial and temporal coverage of precipitation stations has been updated to increase the number of weather stations in STEPL from 493 to 4,998. Data from US EPA's BASINS system's meteorological database were used to make the updates. The BASINS 4.0 meteorological database provides a national database that is quality controlled and corrected for missing and accumulated data. Specifically, the database contains data from NOAA – NCDC's three data sources which are – Summary of the Day (SOD), Hourly Precipitation Data (HPD), and Integrated Surface Hourly (ISH). For inclusion into STEPL, the BASINS data were filtered to limit the number of weather stations to those with at least 30 years of data, to provide a long-period to calculate the average annual precipitation and average annual number of rain days at each of the stations.

Figure U1 and Figure U2 show the spatial locations of the weather stations included in STEPL model for the contiguous U.S. and for Alaska, Puerto Rico, and Hawaii respectively.

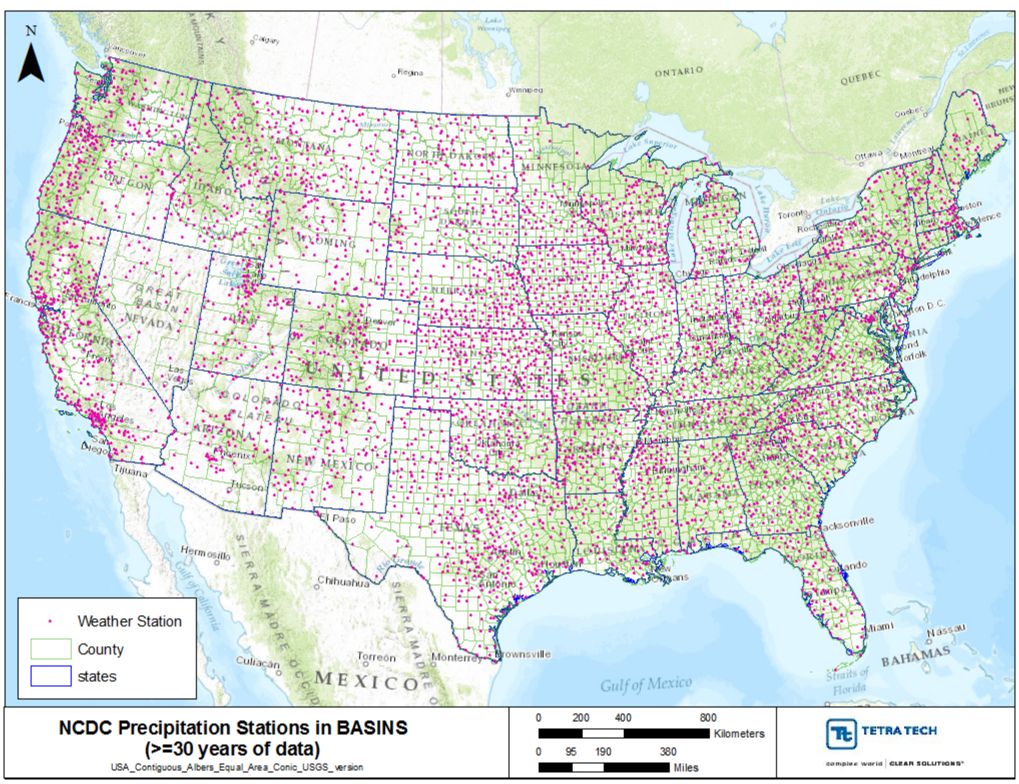


Figure U1. NCDC Precipitation Stations included in STEPL – Contiguous United States.

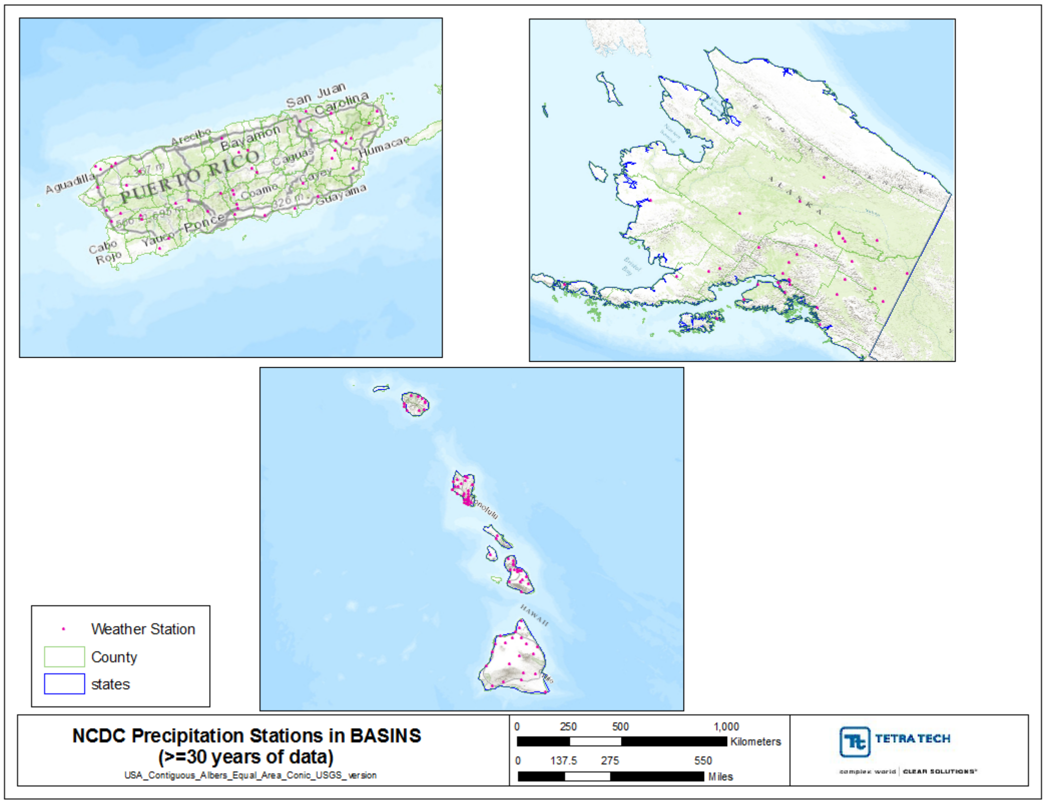


Figure U2. NCDC Precipitation Stations included in STEPL – Alaska, Puerto Rico, and Hawaii.

Manure Application on Pastureland:

In previous versions of STEPL, manure application was only available for cropland. In version 4.4, manure application can now be included on pastureland. This function is available in Table 2 in the Input worksheet. The updated Table 2 is shown in Figure U3.

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied on Cropland	# of months manure applied on Pastureland
W1	100	100	100	100	100	100	100	100	9	6
W2	0	0	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0	0
W6	0	0	0	0	0	0	0	0	0	0
W7	0	0	0	0	0	0	0	0	0	0
W8	0	0	0	0	0	0	0	0	0	0
W9	0	0	0	0	0	0	0	0	0	0
W10	0	0	0	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100		

Figure U3. Updated Table 2 in the Input worksheet where the user can include manure application on pastureland.

Average Number of Months for Manure Application:

A new worksheet ManureApplication has been added to calculate the average number of months for manure application per year with varying application frequency across the watershed. This worksheet (hidden by default) is accessed via the Manure Application button above Table 1 in the Input worksheet, adjacent to the weather station inputs, as shown in Figure U4, below.

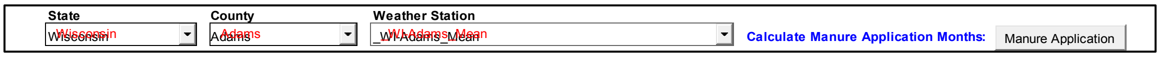


Figure U4. Manure Application button on the Input worksheet to access the ManureApplication worksheet.

The *ManureApplication* worksheet allows the user to specify treatment subareas within a watershed, each with a specific number of months where manure is applied. The worksheet will automatically calculate the area-weighted number of months when manure is applied across the watershed, as shown in Figure U5. This value is then entered into Table 2 in the Input worksheet. The results from the *ManureApplication* worksheet are manually entered by the user to allow the worksheet to be reused for multiple watersheds. The worksheet can be used for both cropland and pastureland calculations of months of manure application.

Estimate an area-weighted frequency of application based on varying manure application across a watershed

Enter total land use area 100.00 acres

Enter the subarea and its corresponding number of months of manure application below (upto 20 varying frequency of treatment allowed)

Treatment	Area (ac)	# of Months Manure Applied in a Year	
1	50.00	9	
2	20.00	7	
3	30.00	0	
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Total Land Use Area	100.00	**6**	*<--- Enter the calculated value in Table 2. located in "Input" tab, under the appropriate watershed and landuse (cropland or pastureland under columns K or L)*
Total Area check:	OK		

Figure U5. ManureApplication worksheet where the user can calculate area-weighted frequency of manure application across a watershed.

A new table, Table 10 on the *Input* worksheet, shown in Figure U6, provides EMCs for pastureland based on six groups of livestock density:

- Low Live Stock Density with manure
- Low Live Stock Density without manure
- Medium Live Stock Density with manure

- Medium Live Stock Density without manure
- High Live Stock Density with manure
- High Live Stock Density without manure

10. Pastureland Nutrient concentration in runoff (mg/l) and E. coli (MPN/100ml				
Land use	N	P	BOD	E. coli
1. L-Pasturel	**4**	**0.3**	**13**	0
1a. w/ manure	4	0.3	13	0
2. M-Pasture	**4**	**0.3**	**13**	0
2a. w/ manure	4	0.3	13	0
3. H-Pasturel	**4**	**0.3**	**13**	0
3a. w/ manure	4	0.3	13	0

Figure U6. Default values for pastureland nutrient concentrations (mg/L).

The default values in Table 10 are the average EMC taken from the previous version 4.3 of STEPL model. The EMC values for all six categories need to be updated based on the published literature and after review/approval of EPA.

Export input/output data:

An Export Data button has been added to the *Input* worksheet to allow the user to export input and output data and associated summary tables and plots into a Word document. The button, shown in Figure U7, is located at the top of the *Input* worksheet, just below the instructions.

Export input/output data: Export Data

Figure U7. The export data button on the Input worksheet to allow the user to export data, summary tables and plots into a Word document.

The *Export Data* provides the following four options to generate a summary report.

1. Output summary tables only
2. Output summary tables with graphs
3. Input and Output summary tables only
4. Input and Output summary tables with graphs

BMPs Worksheet.

New Agricultural BMPs and Updated Pollutant Efficiencies for Nutrients:

New BMPs for cropland and pastureland have been added to STEPL version 4.4. The cropland BMP list has been expanded from 6 BMPs to 17, and 17 pastureland BMPs were added, see Table U1. Previous version of STEPL did not have pastureland BMPs. In addition, the pollutant efficiency numbers for some existing cropland BMPs have been updated. The efficiencies are summarized in the *BMPList* worksheet in STEPL.

Table U1. BMPs available in STEPL version 4.4 for cropland and pastureland.

Land Use	BMP
Cropland	Bioreactor
Cropland	Buffer - Forest (100ft wide)
Cropland	Buffer - Grass (35ft wide)
Cropland	Combined BMPs-Calculated
Cropland	Conservation Tillage 1 (30-59% Residue)
Cropland	Conservation Tillage 2 (equal or more than 60% Residue)
Cropland	Contour Farming
Cropland	Controlled Drainage
Cropland	Cover Crop 1 (Group A Commodity) (High Till only for Sediment)
Cropland	Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)
Cropland	Land Retirement
Cropland	Nutrient Management 1 (Determined Rate)
Cropland	Nutrient Management 2 (Determined Rate Plus Additional Considerations)
Cropland	Streambank Stabilization and Fencing
Cropland	Terrace
Cropland	Two-Stage Ditch
Pastureland	30m Buffer with Optimal Grazing
Pastureland	Alternative Water Supply
Pastureland	Combined BMPs-Calculated
Pastureland	Critical Area Planting
Pastureland	Forest Buffer (minimum 35 feet wide)
Pastureland	Grass Buffer (minimum 35 feet wide)
Pastureland	Grazing Land Management (rotational grazing with fenced areas)
Pastureland	Heavy Use Area Protection
Pastureland	Litter Storage and Management
Pastureland	Livestock Exclusion Fencing
Pastureland	Multiple Practices
Pastureland	Pasture and Hayland Planting (also called Forage Planting)
Pastureland	Prescribed Grazing
Pastureland	Streambank Protection w/o Fencing
Pastureland	Streambank Stabilization and Fencing
Pastureland	Use Exclusion
Pastureland	Winter Feeding Facility

Flow Volume Reductions for Urban LID and Infiltration Practices:

STEPL can now estimate flow volume reductions for urban LID and infiltration BMP practices. This is represented as gallons/year by urban land use type in each watershed. These results are shown in Table 5 in the *Urban* worksheet, as seen in Figure U8 below. The *BMPList* worksheet contains pre-populated design storage depths for each of the available infiltration BMPs. The user enters the design runoff captured depth and percent imperviousness of the BMP drainage areas. The urban practices in STEPL that provide the flow volume reduction are listed in Table U2.

5. Captured Flow Volume (gallon/year)									
Landuse	Commerci	Industrial	Institutiona	Transporta	Multi-Fami	Single-Far	Urban-Cul	Vacant (de	Open Space
W1	1435371.9	0	0	0	0	49855.14	0	0	0
W2	0	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0
W6	0	0	0	0	0	0	0	0	0
W7	0	0	0	0	0	0	0	0	0
W8	0	0	0	0	0	0	0	0	0
W9	0	0	0	0	0	0	0	0	0
W10	0	0	0	0	0	0	0	0	0

Figure U8. Table 5 in Urban worksheet showing volume reductions from urban infiltration BMPs.

Table U2. Urban LID and infiltration practices in STEPL version 4.4 with flow volume reductions.

Land Use	BMP
Urban	Infiltration Basin
Urban	Infiltration Devices
Urban	Infiltration Trench
Urban	LID*/Cistern
Urban	LID*/Cistern+Rain Barrel
Urban	LID*/Rain Barrel
Urban	LID/Bioretention
Urban	LID/Dry Well
Urban	LID/Filter/Buffer Strip
Urban	LID/Infiltration Swale
Urban	LID/Infiltration Trench
Urban	LID/Vegetated Swale
Urban	LID/Wet Swale
Urban	Oil/Grit Separator
Urban	Porous Pavement
Urban	Sand Filter/Infiltration Basin

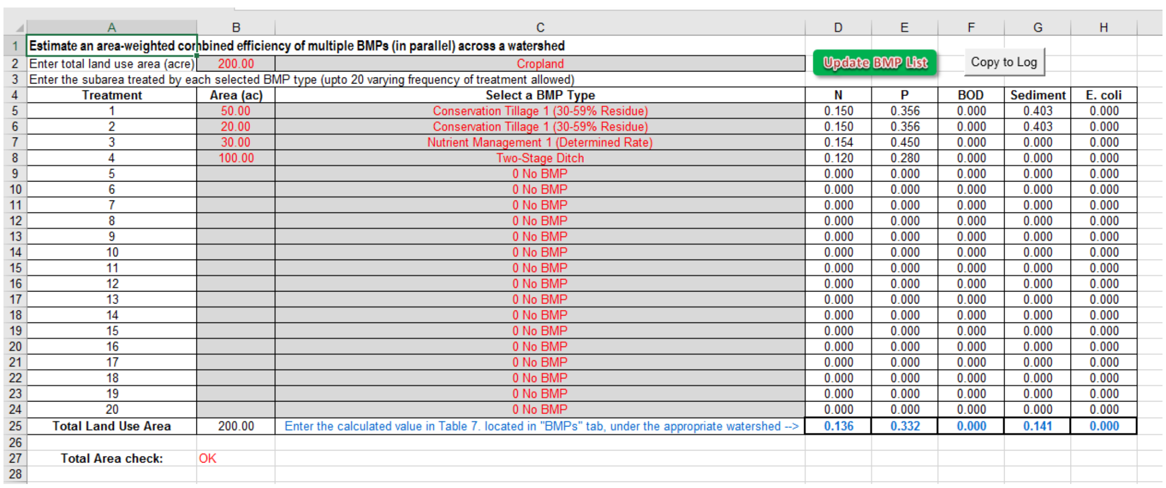
Combined BMP Efficiency Worksheet:

The combined BMP efficiency functionality has been updated. The *CombinedBMPEfficiency* worksheet (hidden by default) can be accessed from the *BMPs* worksheet by clicking on the Calculate Combined BMP Efficiency button, see Figure U9.

This tool calculates a combined BMP efficiency from multiple types of parallel management practices on the same landuse category across the watershed.

Figure U9. The Calculated Combined BMP Efficiency button on the BMPs worksheet, used to access the CombinedBMPEfficiency worksheet.

In the BMP pull-down list boxes, there are items called "Combined BMPs-Calculated". Select "Combined BMPs-Calculated" if there are multiple BMPs on the same land use type in a given subwatershed. If "Combined BMPs-Calculated" is selected, the *CombinedBMPEfficiency* worksheet (Figure U10) can be used to obtain the watershed-wide combined BMP efficiencies for calculating pollutant reductions. Note that for nested BMPs that route to each other, BMP calculator can be used to estimate the combined BMP efficiency.



	A	B	C	D	E	F	G	H
1	Estimate an area-weighted combined efficiency of multiple BMPs (in parallel) across a watershed							
2	Enter total land use area (acre)	200.00	Cropland	Update BMP List		Copy to Log		
3	Enter the subarea treated by each selected BMP type (upto 20 varying frequency of treatment allowed)							
4	Treatment	Area (ac)	Select a BMP Type	N	P	BOD	Sediment	E. coli
5	1	50.00	Conservation Tillage 1 (30-59% Residue)	0.150	0.356	0.000	0.403	0.000
6	2	20.00	Conservation Tillage 1 (30-59% Residue)	0.150	0.356	0.000	0.403	0.000
7	3	30.00	Nutrient Management 1 (Determined Rate)	0.154	0.450	0.000	0.000	0.000
8	4	100.00	Two-Stage Ditch	0.120	0.280	0.000	0.000	0.000
9	5		0 No BMP	0.000	0.000	0.000	0.000	0.000
10	6		0 No BMP	0.000	0.000	0.000	0.000	0.000
11	7		0 No BMP	0.000	0.000	0.000	0.000	0.000
12	8		0 No BMP	0.000	0.000	0.000	0.000	0.000
13	9		0 No BMP	0.000	0.000	0.000	0.000	0.000
14	10		0 No BMP	0.000	0.000	0.000	0.000	0.000
15	11		0 No BMP	0.000	0.000	0.000	0.000	0.000
16	12		0 No BMP	0.000	0.000	0.000	0.000	0.000
17	13		0 No BMP	0.000	0.000	0.000	0.000	0.000
18	14		0 No BMP	0.000	0.000	0.000	0.000	0.000
19	15		0 No BMP	0.000	0.000	0.000	0.000	0.000
20	16		0 No BMP	0.000	0.000	0.000	0.000	0.000
21	17		0 No BMP	0.000	0.000	0.000	0.000	0.000
22	18		0 No BMP	0.000	0.000	0.000	0.000	0.000
23	19		0 No BMP	0.000	0.000	0.000	0.000	0.000
24	20		0 No BMP	0.000	0.000	0.000	0.000	0.000
25	Total Land Use Area	200.00	Enter the calculated value in Table 7. located in "BMPs" tab, under the appropriate watershed -->	0.136	0.332	0.000	0.141	0.000
26								
27	Total Area check:	OK						
28								

Figure U10. The CombinedBMPEfficiency worksheet where area-weighted combined efficiency of multiple parallel BMPs can be calculated.

Combined BMP efficiencies can be calculated individually for cropland and pastureland in each watershed. The user should select the total treated area by land use and then selected BMP types and acreage of treatment for each area in the watershed. The practices are assumed to be functioning in parallel. BMP efficiencies are automatically populated based on the BMP selected. When all BMP treatment areas have been added, the resulting area-weighted values in blue color should be added to Table 7 in the *BMPs* worksheet. This process can be repeated for agricultural land use in each watershed.

The Copy to Log button allows the user to keep a record of various combinations of combined BMP efficiencies by creating a Word document in the same location where the STEPL workbook is saved. The same Word document is updated/appended every time the user clicks on the Copy To Log button. The date/time are included in the document, so the user can keep track of the various iterations.

E. coli place holder for next release:

An E. coli place holder has been added to STEPL in preparation for the next release of the tool. Currently, E. coli is not calculated by STEPL. Place holders for E. coli appear in Tables 5, 7, 7a, and 10 on the *Input* worksheet, in Tables 1-7 on the *BMPs* worksheet, in Tables 1 and 4 on the *Urban* worksheet, and Tables 1 and 2 on the *Total Load* worksheet. None of these tables are populated with loading or reduction data in STEPL version 4.4. Similarly, the E. coli graphs and figures in the *Graphs* worksheet are blank.

New STEPL Customized Versions (Microsoft Excel 2016).

Customized spreadsheet model:

In addition to the executable file that creates a STEPL model workbook, a customized spreadsheet model with 10 watersheds (STEPL10ws) was added. This model allows the user to start working in STEPL without using the executable file, and provides the user the ability to populate the model with up to 10 watersheds. Up to 100 gullies and banks also come with the customized STEPL spreadsheet.

Optimization algorithm:

A simple optimization algorithm (Run Solver) is now available in the customized spreadsheet model (STEPL10ws), which allows the user to identify the extent of treatment areas to meet a load reduction target from the user selected BMP types. The optimization is not available in the original STEPL executable version.

The optimization algorithm only solves for non-urban BMPs, and the user must enter a selection of BMPs for the optimizer to use in the solution. The optimizer is intended to maximize the load reduction and minimize the treated land use area based on the suite of BMPs provided by the user.

The user inputs required to run the optimization tool are:

- Pollutant – select a pollutant of concern that will define the load reduction target (Figure U11).
- Target – define the numeric load reduction target for the selected pollutant. The target should be for all land uses and watersheds in the spreadsheet (Figure U11).
- BMPs – suitable BMP types for each land use and watershed combination (Figure U12).
- Constraints – define the minimum and maximum percent treated area for each land use by watershed for the selected BMPs (Figure U12).

Run Solver	Target Load Reduction (lb/yr)	625.00	Select a Pollutant:	N	Total Load Reduction (lb/yr)	625.00

Figure U11. Run Solver button to run optimization scenario and the inputs for target load reduction and pollutant of concern.

Prior to running an optimization scenario, the user should set the maximum area constraint as high as possible, taking into consideration any land in the watershed that may not be available/suitable for the BMP to determine the maximum load reduction possible with the selected BMPs. The target load reduction should be lower than the total load reduction determined at the maximum area constraint settings, since a larger reduction target will not be possible with the BMPs and constraints as defined. The minimum area constraint can be set as zero or as pre-identified treatment area for the selected BMP type in any given watershed.

1. BMPs and efficiencies for different pollutants on CROPLAND, ND=No Data

Watershed	Cropland							CONSTRAINT	
	N	P	BOD	Sediment	E. coli	BMPs	% Area BMP Applied	Min Area (%)	Max Area (%)
W1	0.24	0.23	ND	0.29	ND	Buffer - Forest (100ft wide)	50.00	0	50
W2	0.03	0.08	ND	0.09	ND	Conservation Tillage 1 (30-59% Residue)	22.25	0	50
W3	0.00	0.00	ND	0.00	ND	Contour Farming	0.00	0	50
W4	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W5	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W6	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W7	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W8	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W9	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W10	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0

2. BMPs and efficiencies for different pollutants on PASTURELAND, ND=No Data

Watershed	Pastureland							CONSTRAINT	
	N	P	BOD	Sediment	E. coli	BMPs	% Area BMP Applied	Min Area (%)	Max Area (%)
W1	0.20	0.30	ND	0.62	ND	Livestock Exclusion Fencing	100.00	0	100
W2	0.00	0.00	ND	0.00	ND	Alternative Water Supply	0.00	0	100
W3	0.00	0.00	ND	0.00	ND	Critical Area Planting	0.00	0	100
W4	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W5	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W6	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W7	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W8	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W9	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0
W10	0.00	0.00	0.00	0.00	0.00	0 No BMP	0.00	0	0

Figure U12. Example land uses with BMPs selected and constraints set.

User's Guide: Spreadsheet Tool for the Estimation of Pollutant Load (STEPL)[1]

1. Introduction

This document is a concise user's guide to the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL, Version 4.4). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs), including Low Impact Development practices (LIDs) for urban areas. It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD_5); and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

2. Program Flow and Spreadsheet Tool Structure

STEPL uses a VB interface to generate the spreadsheet model in MS Excel (Figure 1). The VB interface allows users to customize the generated spreadsheet in terms of the number of watersheds to include in the analysis. Depending on users' choices, the generated spreadsheet can have the zero initial input values (e.g. zero land use areas and animal counts), or the non-zero sample input values for testing or learning purposes. Users are encouraged to collect their local land use, animal, population, and soil data to obtain good estimates of watershed loads and load reductions for their specific watersheds. The spreadsheet presents the results in both tabular and graphic formats.

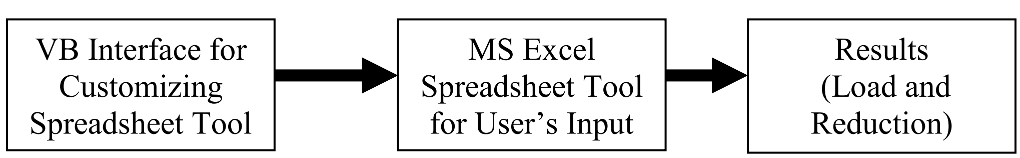


Figure 1. Program flow.

[1] STEPL is designed for the Grants Reporting and Tracking System of the U.S. Environmental Protection Agency (EPA). EPA Work Assignment Manager: Don Waye. Tetra Tech Manager: Khalid Alvi. Tetra Tech Developers: Khalid Alvi and Mustafa Faizullabhoy.

Figure 2 shows the overall spreadsheet structure of STEPL. It is composed of worksheets for input and output interaction with the user, as well as hidden worksheets to handle intermediate calculations. The input data include state name, county name, weather station, land use areas, agricultural animal numbers, manure application months, population using septic tanks, septic tank failure rate, direct wastewater discharges, irrigation amount/frequency, and BMPs for simulated watersheds. When local data are available, users may choose to modify the default values for USLE parameters, soil hydrologic group, nutrient concentrations in soil and runoff, runoff curve numbers, and detailed urban land use distribution. Pollutant loads and load reductions are automatically calculated for total nitrogen, total phosphorus, BOD_5, and sediment.

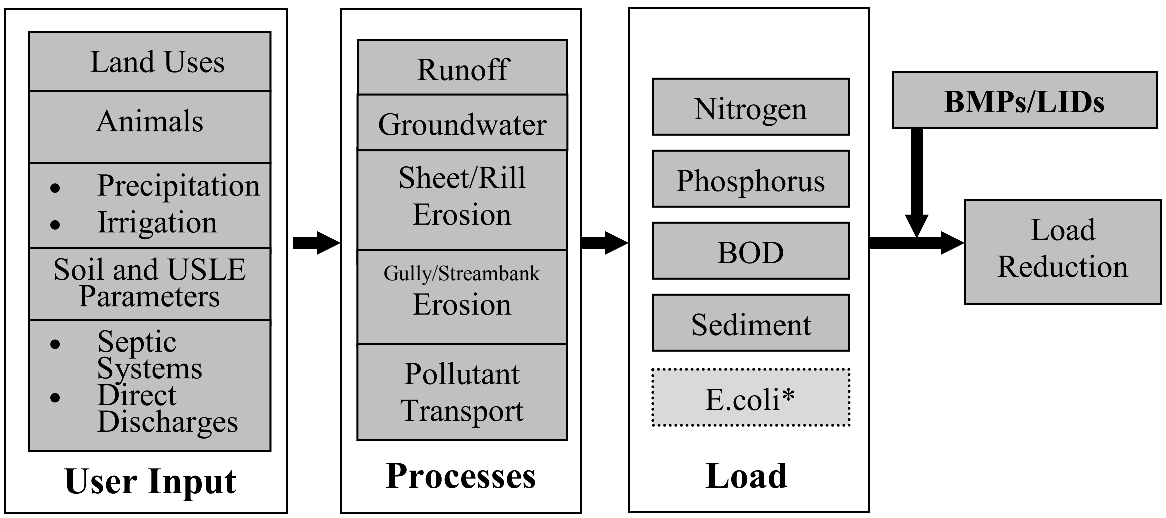


Figure 2. Spreadsheet structure (*place holder for next release).

3. Installation

3.1 System Requirements

- Windows 7 or 10.
- MS Excel 2013 or 2016.
- 40 MB hard disk space.

3.2 Installing STEPL

- STEPL can be downloaded as a zipped file (http://it.tetratech-ffx.com/steplweb). If you downloaded the STEPL*xxx*.zip (*xxx* stands for version number) file, unzip it to a temporary directory and then run the *STEPLSetup.exe* program. It is recommended that you install STEPL in the default STEPL folder on the target drive.
- Reboot your computer (not required but recommended).

3.3 System and Data Files

Installation of STEPL will copy the following system files and data files into the target drive:

STEPL.exe	Main program used to generate a customized STEPL model in MS Excel.
BMPCalculator.exe	Calculator for computing combined BMP efficiencies if multiple BMPs have been implemented in a watershed. (See Appendix A.)
BMPCalculator_Help.pdf	Help document and examples for using the BMP calculator.
NutrTplt.xlsm	Excel template that stores macros for STEPL's customized Excel menus and internal data manipulation.
allBMPstepl.csv	File that contains BMP and efficiency data that will be loaded into STEPL. You can edit the file through STEPL's STEPL > View/Edit BMP List menu. The installation also puts a backup copy of the same file named as allBMPstepl_original.csv on your hard drive.
allBMPcalculator.csv	File that contains BMP and efficiency data that are same as the allBMPstepl.csv data except the feedlot BMPs. This file is used by the BMP calculator only. The installation also puts a backup copy of the same file named as allBMPcalculator_original.csv on your hard drive.
BMPDefinition.doc	Reference file that contains BMP descriptions.
PrecRunoff.csv	File that provides a summary of precipitation, number of days with measurable precipitation, and USGS observed runoff for all the US counties except those in Alaska and Hawaii.
USLEbyLU.csv	File that provides a summary of USLE parameters based on the1992 National Resources Inventory (NRI) database. USLE parameter values are estimated by county and land use.
STEPLGuide.pdf	User's guide in Adobe Acrobat PDF format that is installed along with STEPL (this document).
STEPL.xlsm	Sample STEPL spreadsheet created using STEPL.exe and Excel 2013.
Release.txt	File that contains release notes, last-minute changes, tips, and other miscellaneous information.

3.4 Directory Structure on Your Hard Drive

If you have installed STEPL on C: drive, you will have the following directory structure:

C:\STEPL
- STEPL.exe
- STEPLGuide.pdf
- STEPL.xlsm
- BMPCalculator.exe
- BMPCalculator_help.pdf
- BMPDefinition.pdf
- Release.txt
- \SUPPORT folder
    - allBMPcalculator.csv
    - allBMPcalculator_original.csv
    - allBMPstepl.csv
    - allBMPstepl_original.csv
    - NutrTplt.xlsm
    - PrecRunoff.csv
    - USLEbyLU.csv

3.5 Creating a Customized STEPL Model

Follow these key steps to create a user-customized spreadsheet tool:

- Run the STEPL program by selecting its menu shortcut from the Start-> Programs menu bar or double-clicking the STEPL.exe file in the STEPL folder.
- Click Start in the main interface window (Figure 3).

Figure 3. Main program.

- Select the number of watersheds and number of special sediment sources (i.e., gully formations and impaired streambanks) in the study area (Figure 4).

- Select an option to create the STEPL model with zero initial input or non-zero sample input for land use areas and animal counts.

  Note: *Five types of pollutants — total nitrogen, total phosphorus, BOD_5, sediment, and E.coli (place holder); five types of land uses — cropland, pastureland, forest, feedlots, urban, and a user-defined type; and eight types of animals — beef cattle, dairy cattle, swine, sheep, horse, chicken, turkey, and duck, are simulated in STEPL.*

- Click OK to begin creating the STEPL model. A progress bar indicates the progress for the creation of the spreadsheet tool.

- A message box will ask you to save the file and set your Excel security level to enable macros once the system completes the spreadsheet tool (Figure 5).

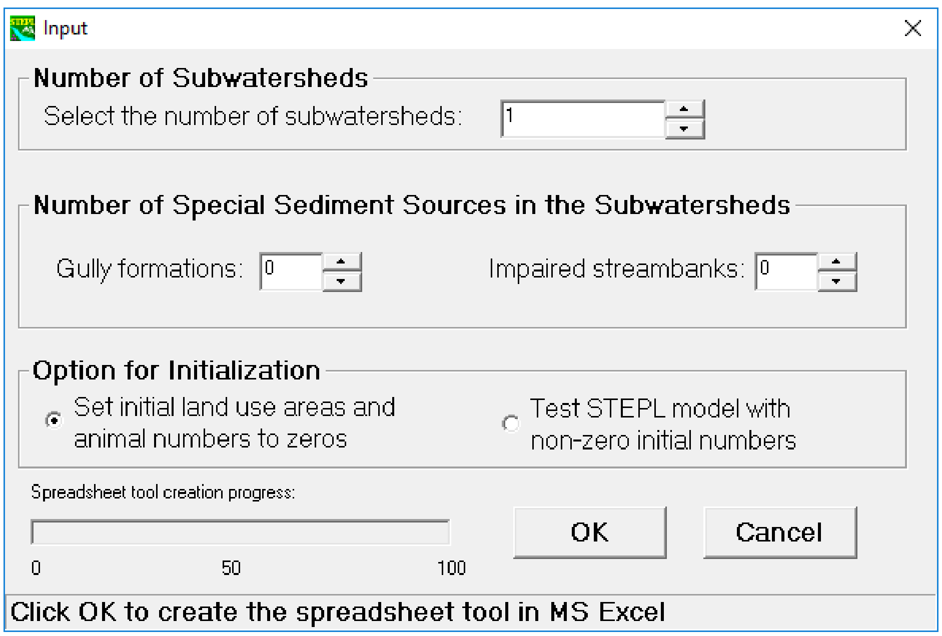


Figure 4. Interface for initial user input to customize the spreadsheet tool.

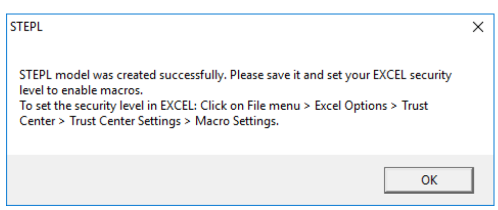


Figure 5. Message box shown after creation of the spreadsheet tool. Follow the instruction to save the newly created STEPL model and to set proper security level for EXCEL application.

4. Using the STEPL Model

STEPL is primarily composed of four worksheets—*Input*, *BMPs*, *Total Load,* and *Graphs*—all designed for user interaction. STEPL also includes several other worksheets that are hidden by default. To display all worksheets, click the STEPL > Hide/Unhide Other STEPL Sheets menu. Data entries in the worksheets are in different colors. The hidden worksheets contain detailed data and intermediate calculations.

- Red entries designate values or controls that should be specified (e.g., cropland area in acres) by the user.
- Blue entries provide useful information and assumptions to help users understand the spreadsheet tool.
- Black entries are information calculated by the spreadsheet and should not be changed.

The four worksheets and a *BMPList* worksheet primarily intended for input and output interaction with the user are described below. The intermediate (hidden) worksheets are described in Appendix B. A complete summary of all the STEPL worksheets is documented in Appendix C.

4.1 *STEPL* Menu

The spreadsheet tool provides customized MS Excel menu commands under "ADD-INS" on the menu bar to assist you in evaluating and obtaining appropriate parameter values. Under the STEPL menu are the following menu items (Figure 6):

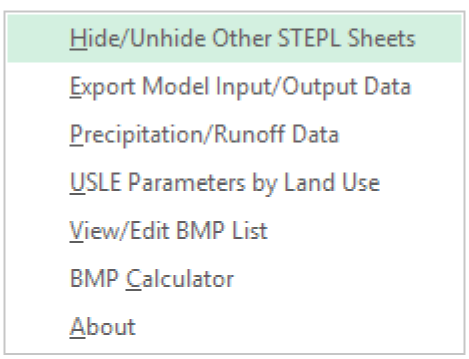


Figure 6. Customized EXCEL menu—the STEPL menu in Excel 2013.

Hide/Unhide Other STEPL Sheets – Click this menu to display or hide the STEPL intermediate worksheets.

Export Model Input/Output Data – Click this menu to create a word document with model input and output summary tables. The user has a choice to output either tables or both tables and plots.

Precipitation/Runoff Data – Click this menu to open PrecRunoff.xls, which contains summary information on precipitation, rain days, and observed runoff for each state. (See section 3.3.)

USLE Parameters by Land Use – Click this menu to open USLEbyLU.xls, which contains USLE parameter values by land use and county. (See section 3.3.)

View/Edit BMP List – Click this menu to view the *BMPList* worksheet and edit (change, add, or delete) the BMP database, which contains the BMP name and efficiency data. (See sections 3.3, 4.3, and 4.6.)

BMP Calculator – Click this menu to open the BMP calculator to calculate combined BMP efficiencies for a watershed. (See Appendix A.)

About – Click this menu to view contact and developer information for STEPL.

4.2 *Input* Worksheet

This worksheet contains your input to the model. It is composed of twelve input tables. The first four tables require you to change initial input values (Figure 7). The next eight tables (initially hidden) contain default values that you may choose to change (Figure 8). You can obtain pollutant loads and reductions by following these steps:

Step 1: Check the first checkbox (in row 10, column F) if all the subwatersheds are considered as parts of a single watershed (the sediment delivery ratio will be calculated using the total watershed area). Check the second checkbox (in row 10, column J) if groundwater load calculation is desired. Select the state and county where your watersheds of interest are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4 (Figure 7).

Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2; (c) enter values for septic system parameters, population counts that discharge wastewater directly, and reduction percentages on direct wastewater discharge in Table 3; and (d) optionally modify USLE parameters associated with the selected county in Table 4.

Step 3: You may stop here and proceed to the BMP worksheet. If you have more detailed information on your watersheds, proceed to optional input tables.

Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) [2] and soil nutrient concentrations in Table 5; (b) modify curve number table by land use and SHG in Table 6 and Table 6a; (c) modify the default nutrient concentrations (mg/L) in runoff and shallow groundwater in Table 7[3] and Table 7a; (d) specify detailed land use distribution in the urban area in Table 8; (e) enter irrigation information (acreage/amount/frequency) in Table 9; and (f) modify the default nutrient concentrations (mg/L) in runoff for pastureland in Table 10.

Step 5: Once you have entered and modified the tables in the *Input* worksheet, proceed to the BMP worksheet (section 4.3) to select appropriate BMPs for your watersheds. Pollutant loads and reductions will be calculated and shown on the *Total Load* and *Graphs* sheets. (See sections 4.4 and 4.5.)

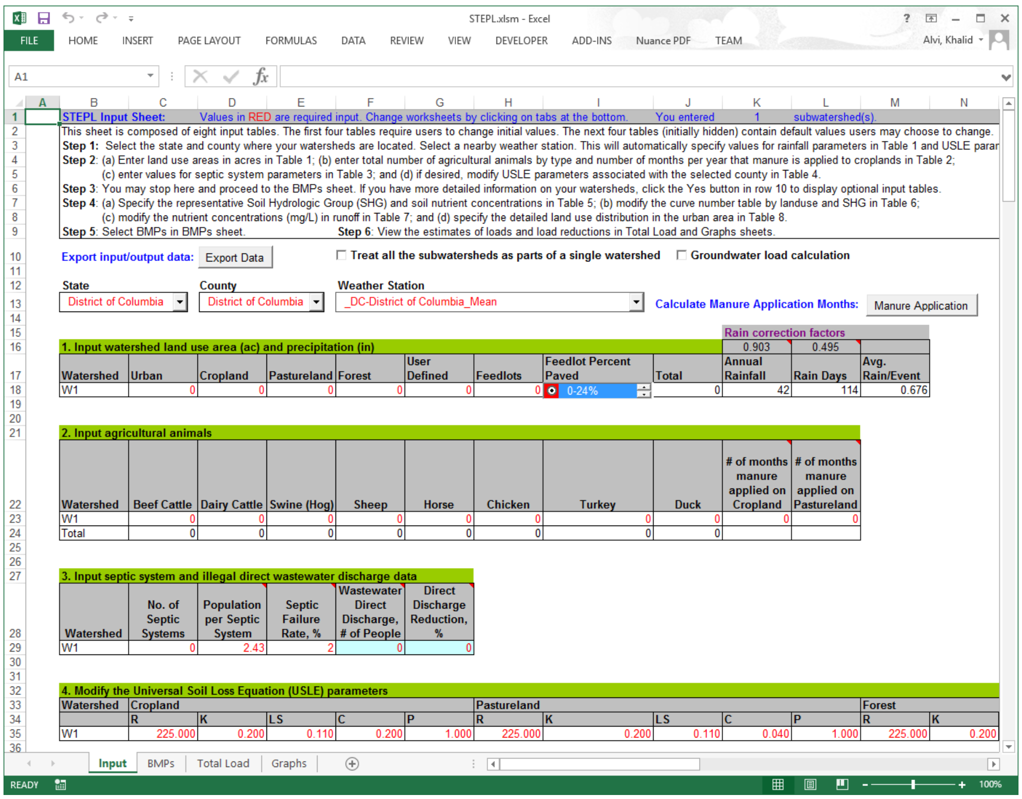


Figure 7. *Input* worksheet, which contains user's input to the model.

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[2] SHG A: Low runoff potential and high infiltration rates even when thoroughly wetted. Chiefly deep, well to excessively drained sands or gravels. High rate of water transmission (< 75 cm/hr).

SHG B: Moderate infiltration rates when thoroughly wetted. Chiefly moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. Moderate rate of water transmission (0.4 to 0.75 cm/hr).

SHG C: Low infiltration rates when thoroughly wetted. Chiefly soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. Low rate of water transmission (0.15 to 0.40 cm/hr).

SHG D: High runoff potential. Very low infiltration rates when thoroughly wetted. Chiefly clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, or shallow soils over nearly impervious material. Very low rate of water transmission (0 to 0.15 cm/hr).

[3] See footnote on next page.

All the table values are directly linked to other worksheets (including hidden worksheets) in STEPL for calculating pollutant loads. Table 1 is linked to the *Land&Rain* and *Feedlots* sheets, which calculate surface runoff. Table 2 is linked to the *Animal* and *Feedlots* sheets, which calculate pollutant loads from agricultural animals. Table 3 is linked to the *Septic* worksheet, which calculates nutrient load from human populations that use septic systems or discharge wastewater directly. Table 4 is linked to the *Sediment* worksheet, which calculates soil erosion and sediment delivery from watersheds. Table 5 is linked to the *Land&Rain* and *Sediment* sheets for determining runoff curve numbers and sediment nutrient concentrations. Table 6 and Table 6a provide reference curve numbers for the *Land&Rain* worksheet. Table 7 [4] and Table 7a provide nutrient concentrations in runoff and shallow groundwater for calculating pollutant loads in the *Total Load* worksheet. Table 8 provides detailed urban land use distribution for the *Urban* worksheet. Table 9 provides irrigation management information for the *Land&Rain* worksheet. Table 10 provides nutrient concentrations (mg/L) in runoff for pastureland.

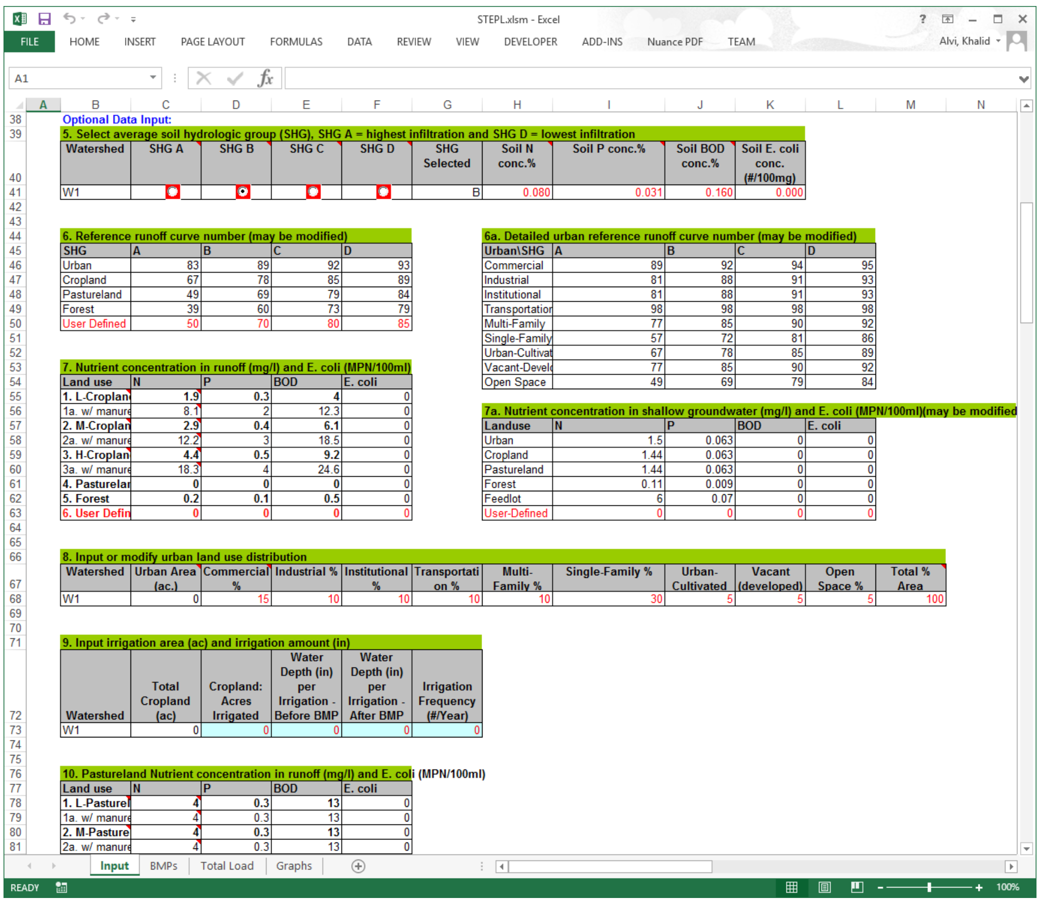


Figure 8. Tables 5, 6, 6a, 7, 7a, 8, 9, and 10 located in the Input worksheet, contain default values that users may choose to change.

---

[4] Note: Table 7 contains pollutants concentrations in runoff for croplands and other land uses. Based on the density of agricultural animals in the study area (STEPL calculates animal density automatically), croplands are divided into three categories, *i.e.* cropland in a low animal density area, cropland in a medium animal density area, and cropland in a high animal density area. There are six rows of data for croplands in Table 7. The first two rows contain the concentrations during the non-manure application months and the manure application months, respectively, for croplands in the low animal density areas. The third and fourth rows contain the data for croplands the medium animal density area. And the fifth and sixth rows contain the data for croplands in the high animal density area.

4.3 *BMPs* Worksheet

The *BMPs* worksheet contains BMP tables for cropland, pastureland, forest, user-defined land use type, and feedlot, respectively, as well as two tool buttons for specifying BMPs or LIDs for urban land uses and parameters for the gully formation and the impaired streambank (Figure 9).

For each non-urban land use, you need to click to select a BMP from a list for each watershed. If no BMP is used, select "0 No BMP" from the lists. Once you have selected a BMP for a watershed, the pollutant removal efficiencies will be displayed. The efficiencies in the BMP tables are linked to other worksheets for the calculation of pollutant load reductions.

You can add, delete, or edit BMPs in the *BMPList* worksheet, which can be shown by clicking the STEPL > View/Edit BMP List menu. (See section 4.6.)

You can also add, delete, or edit BMPs by changing the comma-delimited text file called AllBMPstepl.csv in the \Support directory. For example, if you want to add new BMP data for the cropland, you might append line "Cropland, NewBMP, 0.500, ND, 0.300, 0.800, ND" in the cropland section as illustrated below (in *italic*):

```
Landuse,BMP & Efficiency,N,P,BOD,Sediment,E.coli
Cropland,,,,,,
Cropland,0 No BMP,0,0,0,0,0
Cropland,Contour Farming,0.485,0.550,ND,0.405,ND
Cropland,Diversion,0.100,0.300,ND,0.350,ND
Cropland,Filter strip,0.700,0.750,0.394,0.650,ND
Cropland,Reduced Tillage Systems,0.550,0.450,ND,0.750,ND
Cropland,Streambank stabilization and fencing,0.750,0.750,ND,0.750,ND
Cropland,Terrace,0.200,0.700,ND,0.850,ND
Cropland,NewBMP,0.500,ND,0.300,0.800,ND
```

Use "ND" for no data and numbers for pollutant removal efficiencies for nitrogen, phosphorus, BOD, sediment, and E.coli. The removal efficiency **must be less than one**!

In the BMP pull-down list boxes, there are items called "Combined BMPs-Calculated". Select "Combined BMPs-Calculated" if you have detailed information on multiple BMPs and their interactions in the subwatersheds. If you have selected "Combined BMPs-Calculated", you need to use the BMP calculator to obtain the watershed-wide combined BMP efficiencies for calculating pollutant reductions. The combined BMP efficiencies can be calculated if you know the locations, removal efficiencies, and spatial relationships of BMPs that have been or will be implemented in your watersheds. You can find detailed instructions for using the BMP calculator in Appendix A of this manual. The BMP calculator can be accessed by clicking the "BMP calculator" menu under the STEPL menu (Figure 6). Once you have obtained combined BMP efficiencies for your watersheds, enter them in Table 7 of the worksheet (Figure 9). The combined BMP efficiencies will **not** be used in Table 5 (the feedlot BMP table) because STEPL treats feedlots as special high-loading point sources for which feedlot-specific BMPs must be individually selected.

Tip: If you *do not* have detailed information on the locations and spatial relationships of BMPs implemented in a watershed, you need only select an appropriate BMP from the pull-down list box for each non-urban land use in each subwatershed.

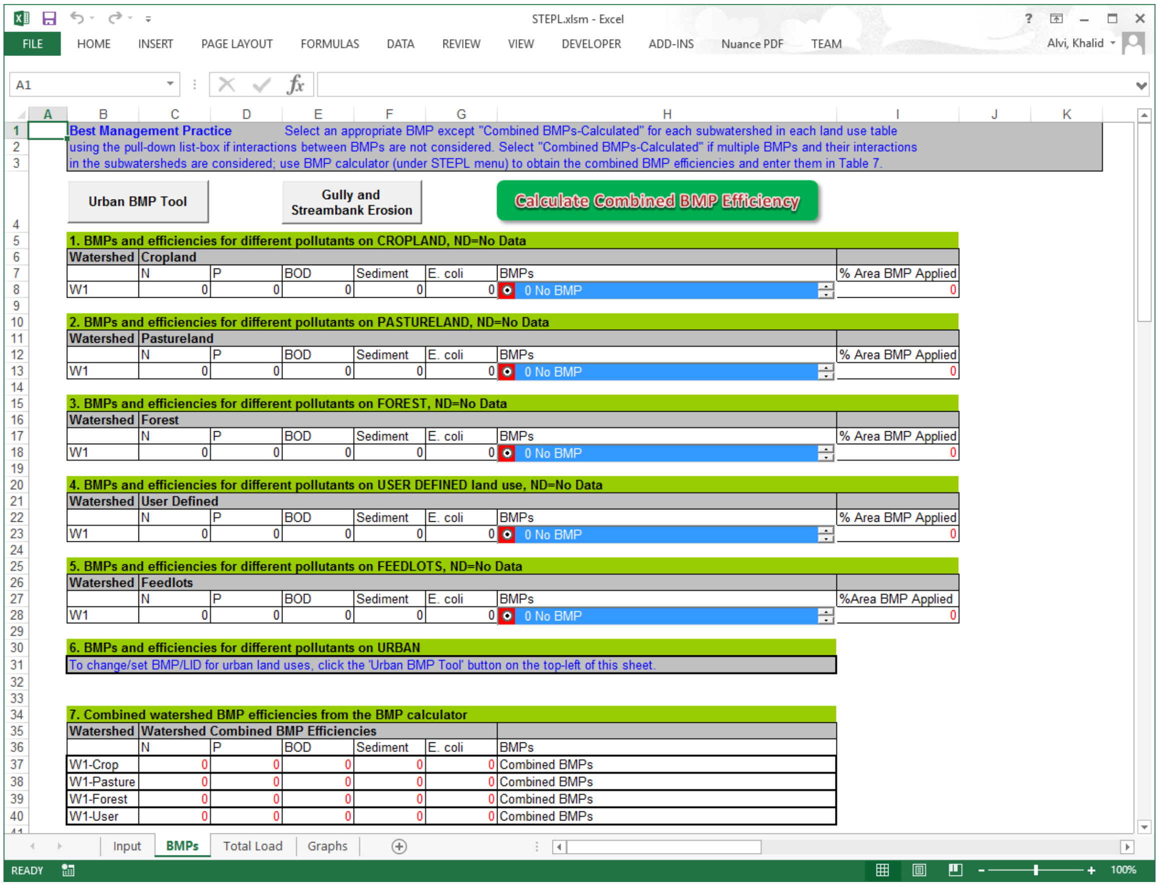


Figure 9. The BMPs worksheet, which lets you select BMPs for different land uses. Note that for this example, no BMPs are specified for user-defined land uses. You need to use the BMP calculator to calculate combined BMP efficiencies and enter them in Table 7 if you select "Combined BMPs-Calculated" from any of the BMP pull-down list boxes. For example, "Combined BMPs-Calculated" was selected for pastureland in watershed W1 in this figure. You can also specify a partial area BMP application as shown in Table 1.

4.3.1 Partial Area BMP Application

By default, after the user selects a BMP in *BMPs* worksheet for a land type in a watershed, STEPL assumes that the BMP applies to 0% of the area of the specific land type.

For a partial area BMP application, the user can specify percent of land area that a BMP is applied in the last columns ("% Area BMP Applied") of tables 1 to 5. For example, if only 50% of the cropland is applied with the reduced tillage practice, you can enter 50 in the cell of column "% Area BMP Applied" of Table1 (Figure 9). The overall BMP pollutant removal efficiencies are adjusted (reduced) accordingly; and for this example, the total nitrogen removal efficiency is changed from 0.55 to 0.275 for the entire area of cropland.

4.3.2 Urban BMP Tool

On the top-left corner of *BMPs* worksheet, there is a tool button—***Urban BMP Tool*** (Figure 9). The ***Urban BMP Tool*** is used for select LIDs or BMPs for different urban land uses. Click ***Urban BMP Tool*** will bring forward a form "Set Urban LID/BMP" on the *Urban* worksheet (Figure 10). You can select or change a LID or BMP for a particular urban land use following the following three steps:

1. Select a watershed; e.g. the watershed number 1 (Figure 10).
2. Select a type of urban land use; e.g. commercial use.
3. Select a LID or BMP by clicking the pull-down list box; e.g. dry detention pond.
4. Specify the area that the selected practice applies; e.g. 1,000 acres from a total of 16,875 acres available area are controlled by the selected practice.
5. Click ***Apply LID/BMP*** button to set the selected management practice for the selected urban land use; e.g. apply the dry detention pond for the 1,000 acres of commercial land in the watershed number 1.

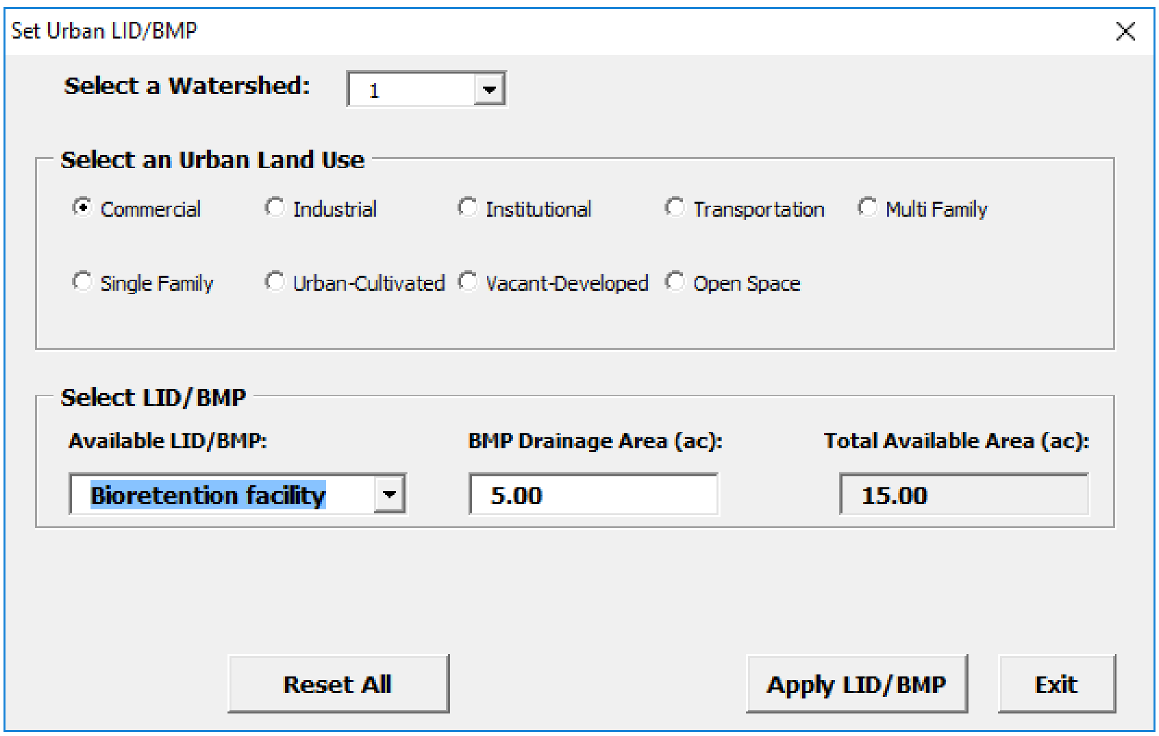


Figure 10. The form for selecting and applying LIDs/BMPs for urban land uses.

On the "Set Urban LID/BMP" form (Figure 10), in addition to ***Apply LID/BMP*** button, there are three other controls:

- ***Reset All*** button: Resets all the urban LIDs or BMPs to 'No BMP' and BMP application areas equal to the total available areas.
- ***Exit*** button: Closes the form.
- ***Simple form*** check box: Uncheck the box will expand the form showing pollutant load information for the selected urban land use and an additional button—***Next Land Use***, which is for navigating land use from the current selection to the next land use type.

In the available LID/BMP drop-down box, if you select "Combined BMPs-Calculated" or any item with an asterisk (*) following 'LID' in its name (e.g. "LID*/Cistern") and click ***Apply LID/BMP*** button, the system will display special forms (Figure 11 and Figure 12) for you to enter required parameter values before it can determine the pollutant load reduction efficiencies.

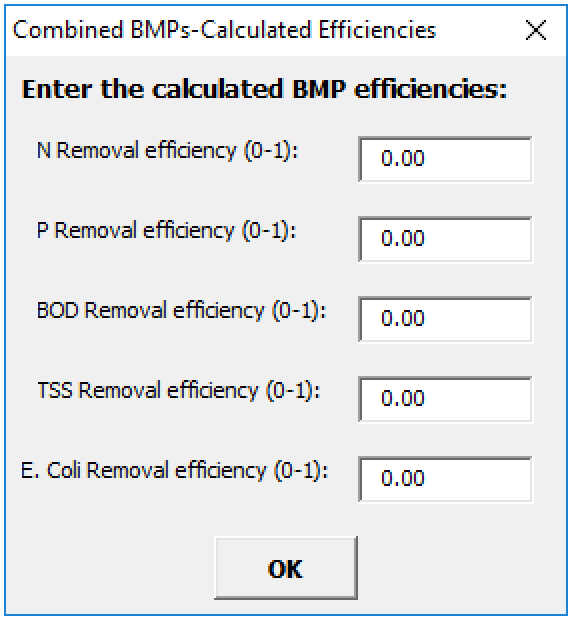


Figure 11. If the "Combined BMP-Calculated" is selected for an urban area, you must specify the BMP efficiencies calculated using the BMP calculator in the form shown above.

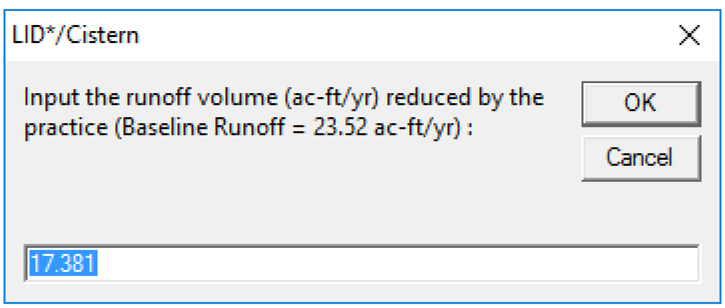


Figure 12. If the "LID*/Cistern", "LID*/Rain Barrel", or "LID*/Cistern/Rain Barrel" is selected for an urban area, you must specify the annual rainfall volume being trapped by the rainfall capture devices.

4.3.3 Gully and Streambank Erosion

The ***Gully and Streambank Erosion*** tool, next to the ***Urban BMP Tool*** as shown in Figure 9 is used for defining the dimensions for the user-specified gully formations and impaired streambanks. Click ***Gully and Streambank Erosion*** will open another worksheet *Gully&Streambank* (Figure 13). This sheet contains two input tables: the first table will show the gully formations and the second table will show the impaired streambanks. The numbers of the gully formations and impaired streambanks are defined by the user when the spreadsheet is generated (Figure 4). The required information can be defined in following steps:

1. Specify the gully dimensions and assign each gully to a watershed.
2. Specify the time (number of years) that the gully has taken to form the current size.
3. Specify the gully stabilization (BMP) efficiency (0-1) and the gully soil textural class.
4. Specify the streambank dimensions and assign each bank to a watershed.
5. Specify the lateral recession rate (ft/yr) of the eroding streambank.
6. Specify the streambank stabilization (BMP) efficiency (0-1) and the streambank soil textural class.

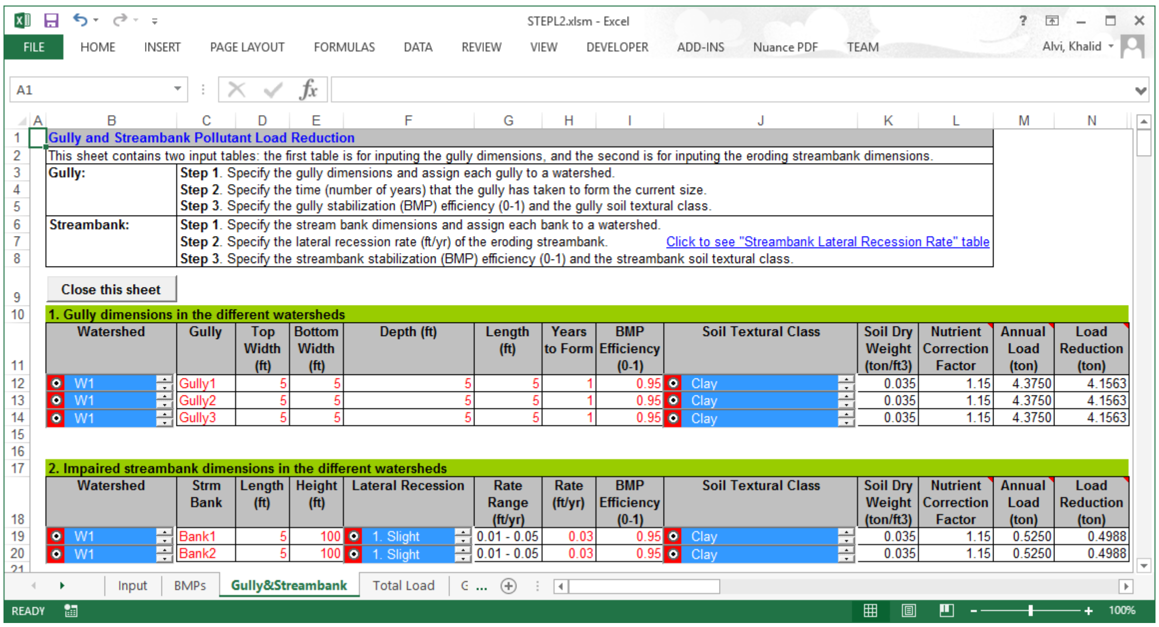
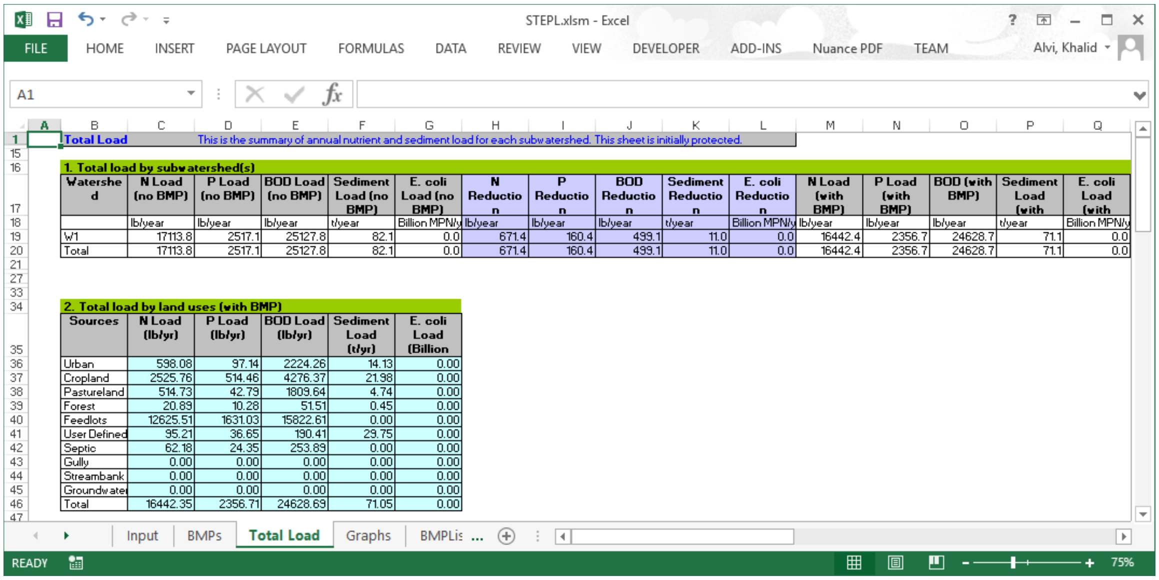


Figure 13. The Gully&Streambank worksheet, which lets you define the dimensions, BMP efficiency, and soil textural class for the gully formation and impaired streambank with in the selected watershed. Note that for this example, there are user-defined three gully formations and two impaired streambanks.

4.4 *Total Load* Worksheet

The *Total Load* worksheet shows the final results of the calculations in terms of watershed pollutant loads and load reduction (Figure 14). This worksheet has two visible tables. Table 1 shows the total nutrient and sediment loads (before and after BMPs), load reduction, and reduction percentages resulting from the BMPs that you selected on the *BMPs* worksheet. Table 2 summarizes the load from the various sources (urban, cropland, pastureland, forest, feedlots, septic, gully, streambank, and groundwater). This worksheet is *protected* for editing initially, but you may unprotect it if you want to change it. Load summaries in this worksheet are used in the *Graphs* worksheet for plotting.


Total Load — This is the summary of annual nutrient and sediment load for each subwatershed. This sheet is initially protected.

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	E. coli Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	E. coli Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with	E. coli Load (with
	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/y	lb/year	lb/year	lb/year	t/year	Billion MPN/y
W1	17113.8	2517.1	25127.8	82.1	0.0	671.4	160.4	499.1	11.0	0.0	16442.4	2356.7	24628.7	71.1	0.0
Total	17113.8	2517.1	25127.8	82.1	0.0	671.4	160.4	499.1	11.0	0.0	16442.4	2356.7	24628.7	71.1	0.0

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)	E. coli Load (Billion
Urban	598.08	97.14	2224.26	14.13	0.00
Cropland	2525.76	514.46	4276.37	21.98	0.00
Pastureland	514.73	42.79	1809.64	4.74	0.00
Forest	20.89	10.28	51.51	0.45	0.00
Feedlots	12625.51	1631.03	15822.61	0.00	0.00
User Defined	95.21	36.65	190.41	29.75	0.00
Septic	62.18	24.35	253.89	0.00	0.00
Gully	0.00	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00	0.00
Total	16442.35	2356.71	24628.69	71.05	0.00

Figure 14. *Total Load* worksheet, which summarizes nutrient and sediment loads from all the sources considered in the model.

4.5 *Graphs* Worksheet

The *Graphs* worksheet (Figure 15 and 16) shows the pollutant loads and reductions by watersheds and pollutant loads by sources in graphical format. It contains the following graphs:

- Comparison of nutrient loads among the watersheds
- Comparison of sediment loads among the watersheds
- Comparison of E.coli loads among the watersheds
- Comparison of nutrient reductions among the watersheds
- Comparison of sediment reductions among the watersheds
- Comparison of E.coli reductions among the watersheds
- Total nitrogen load (lb/yr) by sources
- Total phosphorus load (lb/yr) by sources
- Total BOD load (lb/yr) by sources
- Total sediment load (t/yr) by sources
- Total E.coli load (Billion MPN/yr) by sources

This worksheet is *protected* initially, but you may unprotect this worksheet and modify the graphs.

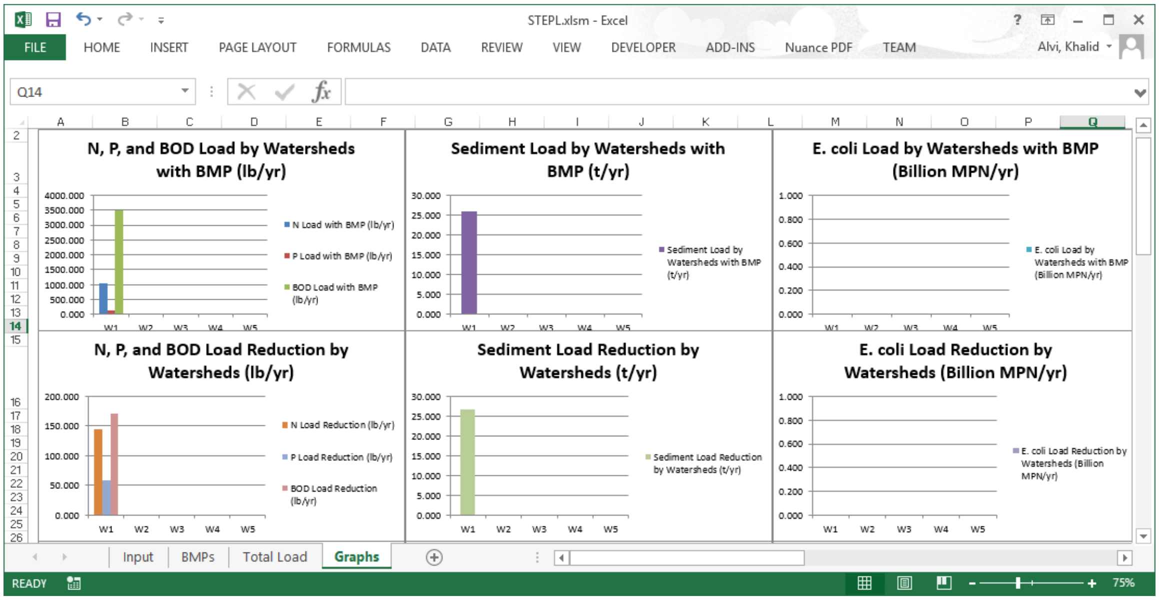


Figure 15. ***Graphs*** **worksheet, which shows the pollutant loads and load reductions by watersheds in graphic format.**

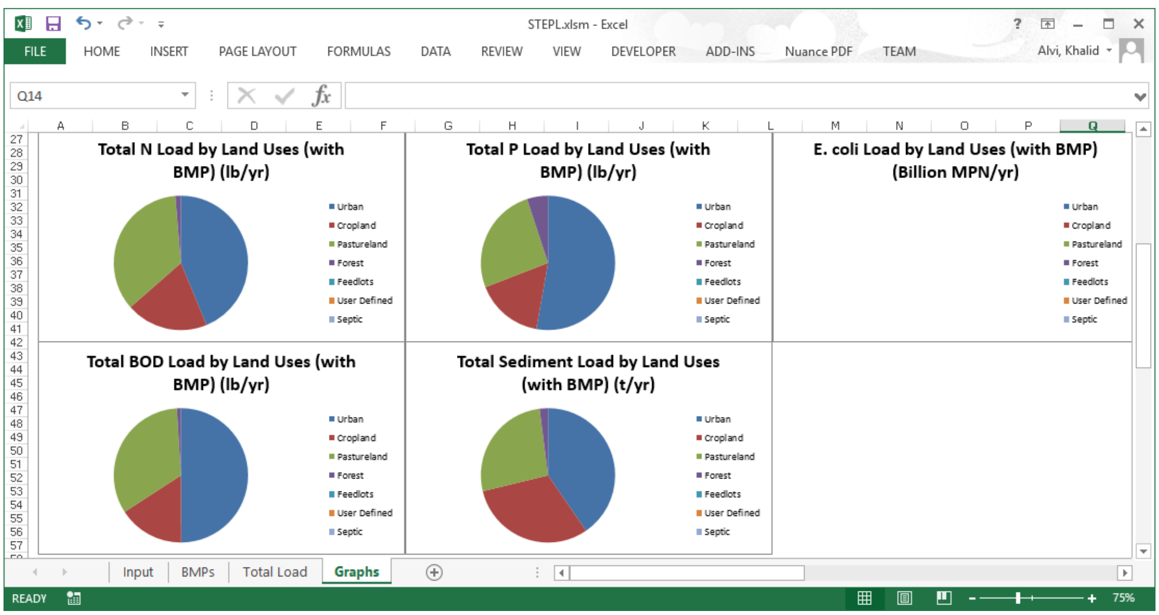


Figure 16. ***Graphs*** **worksheet, which shows the pollutant loads by sources in graphic format.**

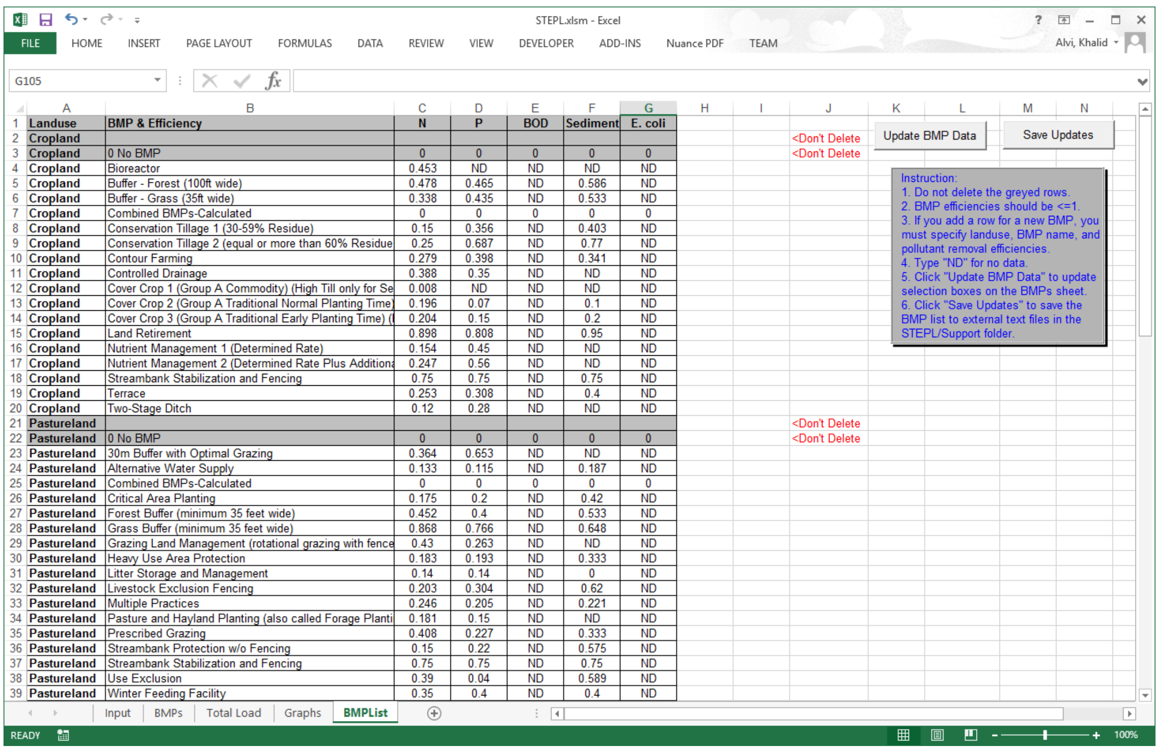
4.6 *BMPList* Worksheet

The *BMPList* worksheet (Figure 17) becomes visible when the STEPL > View/Edit BMP List menu is clicked. The worksheet contains a list of BMP names and efficiencies for different land uses and pollutant types. The *BMPList* worksheet allows you to update BMP data in the *BMPs* worksheet and the two external text files (AllBMPstepl.csv and AllBMPs.csv; see section 3.3).

You can add new BMP records for the six predefined land use categories (Cropland, Pastureland, Forest, User-defined, Feedlots, and Urban). If you insert a row for a new BMP record, you must specify the land use, BMP name, and pollutant removal efficiencies. Pollutant removal efficiencies should be always be less than or equal to 1.0, and you must type "ND" for no data.

Each BMP record in the BMP list can be changed and deleted, but **do not** change or delete the greyed (shaded) rows.

The *BMPList* worksheet has two command buttons: ***Update BMP Data*** and ***Save Updates***. The ***Update BMP Data*** button is used to update the lists in selection boxes in the *BMPs* worksheet. The ***Save Updates*** button is used to save the BMP list to external text files (AllBMPstepl.csv and AllBMPs.csv) in the STEPL/Support folder.



Landuse	BMP & Efficiency	N	P	BOD	Sediment	E. coli
Cropland						
Cropland	0 No BMP	0	0	0	0	0
Cropland	Bioreactor	0.453	ND	ND	ND	ND
Cropland	Buffer - Forest (100ft wide)	0.478	0.465	ND	0.586	ND
Cropland	Buffer - Grass (35ft wide)	0.338	0.435	ND	0.533	ND
Cropland	Combined BMPs-Calculated	0	0	0	0	0
Cropland	Conservation Tillage 1 (30-59% Residue)	0.15	0.356	ND	0.403	ND
Cropland	Conservation Tillage 2 (equal or more than 60% Residue	0.25	0.687	ND	0.77	ND
Cropland	Contour Farming	0.279	0.398	ND	0.341	ND
Cropland	Controlled Drainage	0.388	0.35	ND	ND	ND
Cropland	Cover Crop 1 (Group A Commodity) (High Till only for Se	0.008	ND	ND	ND	ND
Cropland	Cover Crop 2 (Group A Traditional Normal Planting Time)	0.196	0.07	ND	0.1	ND
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (	0.204	0.15	ND	0.2	ND
Cropland	Land Retirement	0.898	0.808	ND	0.95	ND
Cropland	Nutrient Management 1 (Determined Rate)	0.154	0.45	ND	ND	ND
Cropland	Nutrient Management 2 (Determined Rate Plus Additiona	0.247	0.56	ND	ND	ND
Cropland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	ND
Cropland	Terrace	0.253	0.308	ND	0.4	ND
Cropland	Two-Stage Ditch	0.12	0.28	ND	ND	ND
Pastureland						
Pastureland	0 No BMP	0	0	0	0	0
Pastureland	30m Buffer with Optimal Grazing	0.364	0.653	ND	ND	ND
Pastureland	Alternative Water Supply	0.133	0.115	ND	0.187	ND
Pastureland	Combined BMPs-Calculated	0	0	0	0	0
Pastureland	Critical Area Planting	0.175	0.2	ND	0.42	ND
Pastureland	Forest Buffer (minimum 35 feet wide)	0.452	0.4	ND	0.533	ND
Pastureland	Grass Buffer (minimum 35 feet wide)	0.868	0.766	ND	0.648	ND
Pastureland	Grazing Land Management (rotational grazing with fence	0.43	0.263	ND	ND	ND
Pastureland	Heavy Use Area Protection	0.183	0.193	ND	0.333	ND
Pastureland	Litter Storage and Management	0.14	0.14	ND	0	ND
Pastureland	Livestock Exclusion Fencing	0.203	0.304	ND	0.62	ND
Pastureland	Multiple Practices	0.246	0.205	ND	0.221	ND
Pastureland	Pasture and Hayland Planting (also called Forage Planti	0.181	0.15	ND	ND	ND
Pastureland	Prescribed Grazing	0.408	0.227	ND	0.333	ND
Pastureland	Streambank Protection w/o Fencing	0.15	0.22	ND	0.575	ND
Pastureland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	ND
Pastureland	Use Exclusion	0.39	0.04	ND	0.589	ND
Pastureland	Winter Feeding Facility	0.35	0.4	ND	0.4	ND

Figure 17. ***BMPList*** **worksheet. BMP records can be viewed, changed, added, or deleted. The changes can be saved to the** ***BMPs*** **worksheet or to external text files.**

5. References

(References include those cited in appendices.)

ASAE (American Society of Agricultural Engineers). 1998. *ASAE standards: Standards, engineering practice, and data*. 45th ed. American Society of Agricultural Engineers, St. Joseph, Michigan.

Evans, B.M., S. A. Sheeder, K. J. Corradini, and W. S. Brown. 2001. *AVGWLF version 3.2, users guide*. Environmental Resources Research Institute, Pennsylvania State University, University Park, Pennsylvania.

Haith, D.A., R. Mandal, and R.S. Wu. 1992. *GWLF: General watershed loading functions, user's manual, version 2.0.* Cornell University, Ithaca, New York.

MDEQ (Michigan Department of Environmental Quality). 1999. Pollutants controlled: Calculation and documentation for section 319 watersheds training manual. Michigan Department of Environmental Quality, Lansing, Michigan.

USDA-NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service). 1983. Sediment sources, yields, and delivery ratios. In *National Engineering Handbook*, Chapter 6, Section 3, Sedimentation.

In the *Reference* sheet of STEPL model, there are additional 28 references listed for the default parameter values used in the model.

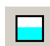
Appendix A: BMP Calculator User Guide and Formulas

If BMP locations, implementation areas, and efficiencies in a watershed are known, the combined pollutant removal efficiencies can be calculated using the BMP Calculator that is included in STEPL. The combined efficiencies can be entered in Table 7 of the *BMPs* worksheet (see section 4.3).

The following sections describe Step-by-Step procedures and examples to use the BMP Calculator as well as the mathematic formulas that BMP Calculator is based on.

A.1. Step-by-Step Instructions for Using the BMP Calculator

1. Click the "BMP calculator" menu on the STEPL menu bar or double-click the BMPcalculator.exe file in the STEPL directory to start the calculator.

2. Click the  button to add a new BMP (represented by a box with a default area and BMP efficiencies) to the program window. You may add as many boxes as you wish by clicking the button. **Initially, all the default values in the BMP boxes are set to zero**. To assign values to the parameters in the BMP boxes, see step 4.

   Arrange the BMP boxes to approximate BMP locations in your watershed. To move a BMP box, click and drag it using the left mouse button. Three configuration examples are shown in Figures A1, A2, and A3.

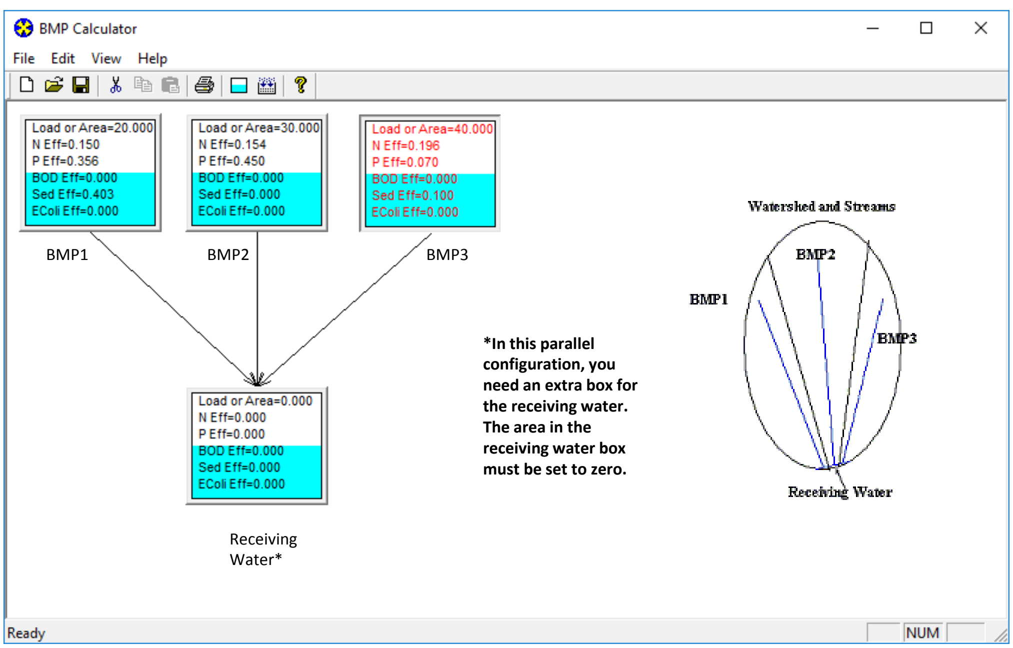


Figure A1. Comparison of parallel BMP configuration in the calculator window with BMP locations in a watershed. The diagram at the right shows three parallel BMP implementations in a watershed. In the calculator window at the left, three BMP boxes are connected to a fourth box, which represents the receiving stream. The area of the receiving stream box must be set to zero.

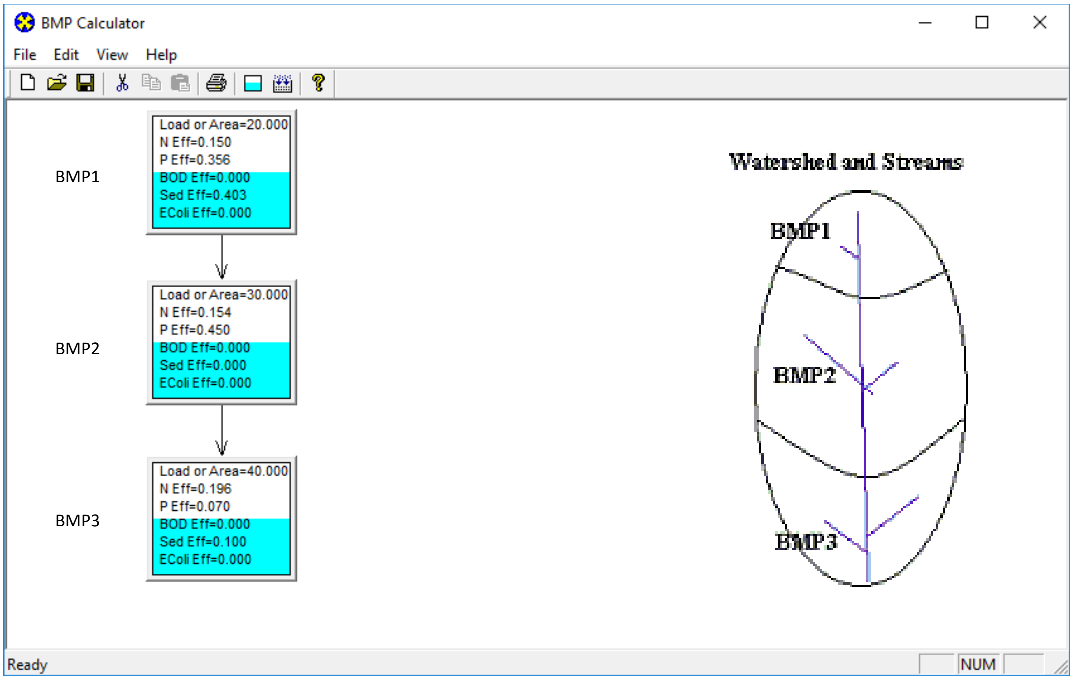


Figure A2. Comparison of serial BMP configuration in the calculator window with BMP locations in a watershed. The diagram at the right shows three serial BMP implementations in the watershed. In the calculator window at the left, three BMP boxes are connected one after another.

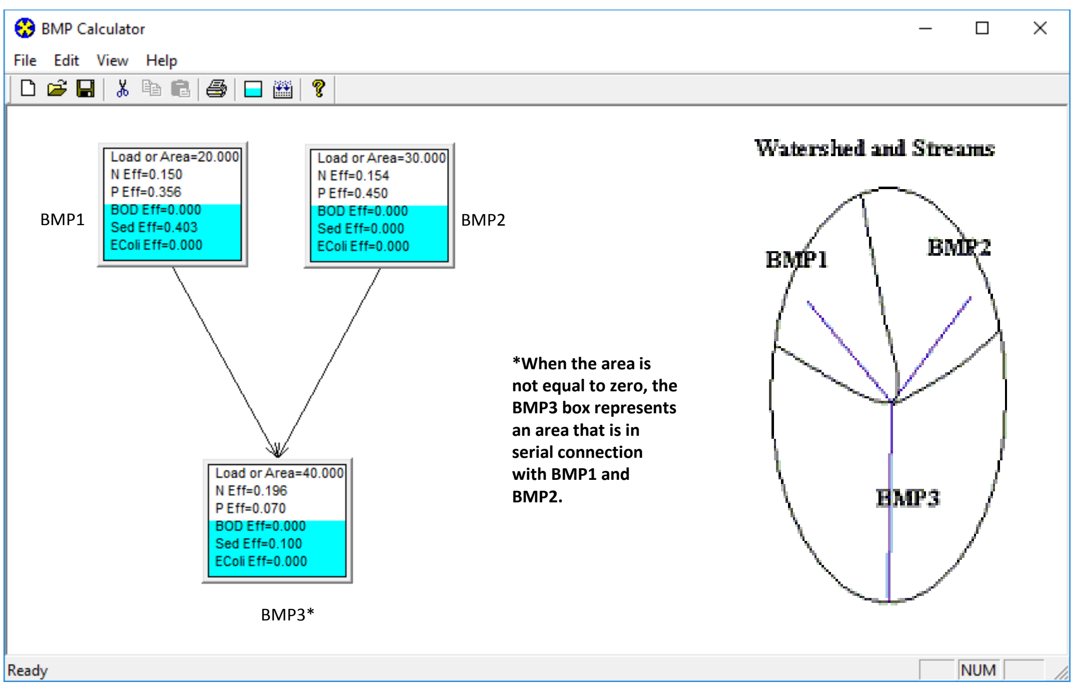


Figure A3. Comparison of mixed BMP configuration in the calculator window with BMP locations in a watershed. The diagram at the right shows two parallel BMPs in series with a third BMP in the watershed. In the calculator window at the left, two BMP boxes are connected to a third BMP box.

3. Drag your mouse from one box to another to add links (lines with arrowheads) between BMP boxes. **Caution**: **When you drag your mouse between two boxes, you must touch both boxes to make the line.** Only one link can originate from a BMP box; however, a BMP box can receive many incoming links.

   Tip: To delete a BMP box, click it and press the DEL key. (If the BMP box is selected, the text in the box is displayed in red.) To delete a link between two BMPs, click the connection to select it and press the DEL key.

4. Once you finish adding BMP boxes and links as shown in Figures A1, A2, and A3, you can double-click each box to set the parameter values. The dialog box that appears lets you select a type of BMP from a list (Figure A4). After you select a BMP from the list, pollutant removal efficiencies will appear automatically in the appropriate text boxes in the dialog box. You need to specify the BMP area or total pre-BMP load (in any units, as long as you are consistent throughout the calculation) for each BMP selected. You may also choose to modify the BMP efficiencies in the dialog box.

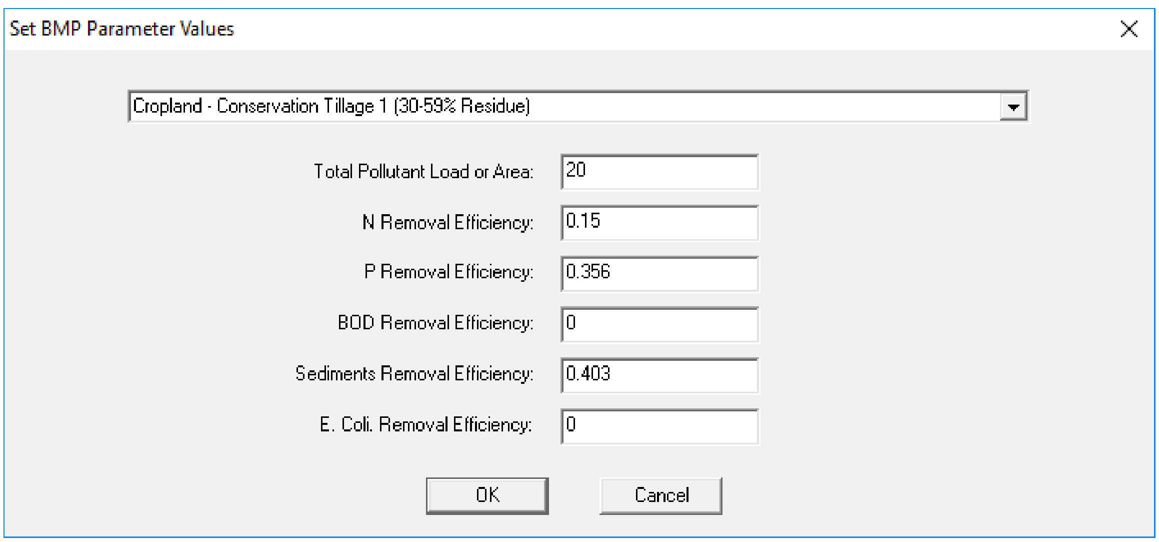


Figure A4. Editing BMP parameter values.

Note: The combined BMP efficiencies are calculated using the pollutant load (before BMP implementation) or the area of a subwatershed as the weighting factor. If the subwatersheds or subareas associated with different BMPs have the same or similar land use types, you can use the area as the weighting factor. However, if the combined BMP efficiencies are to be calculated for subwatersheds or areas that have different land use types, the pre-BMP pollutant load of each land use type should be used as the weighting factor.

5. On the tool bar, click the  button to calculate the combined BMP efficiencies (Figures A5, A6, and A7.)

Tip: You may use the "Save as" and "Open" submenus under the File menu to save and open your BMP configurations.

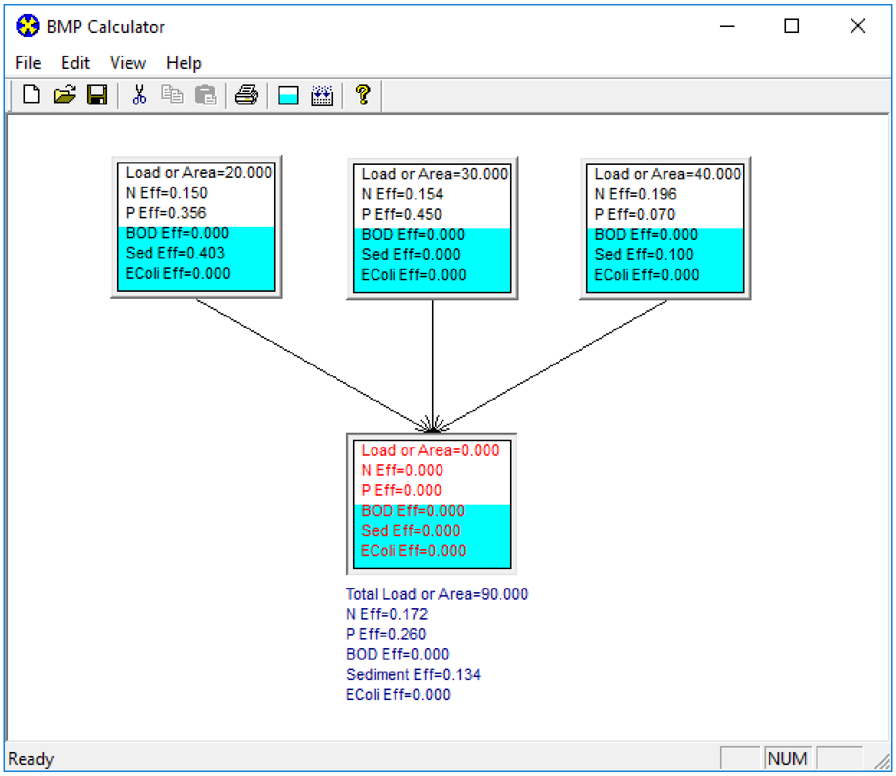


Figure A5. Calculated combined BMP efficiencies for three parallel BMP implementations in a watershed.

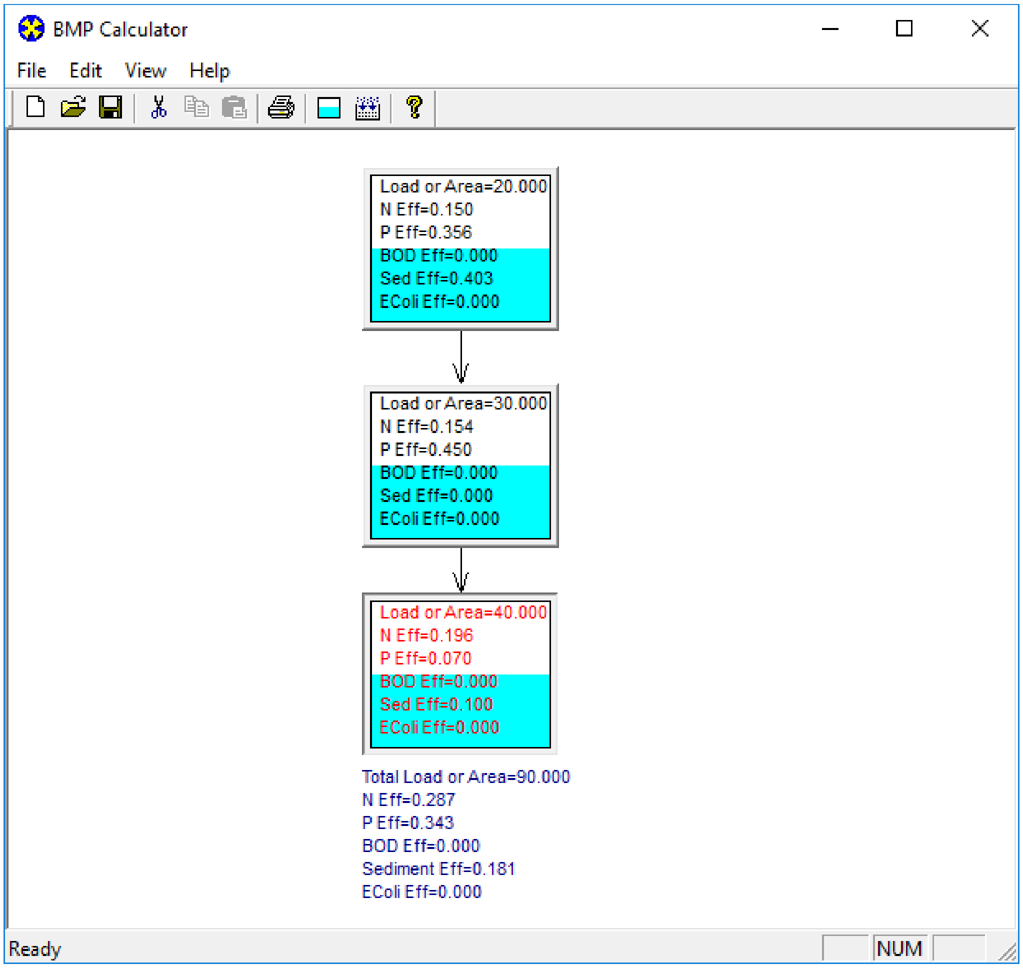


Figure A6. Calculated combined BMP efficiencies for three serial BMP implementations in a watershed.

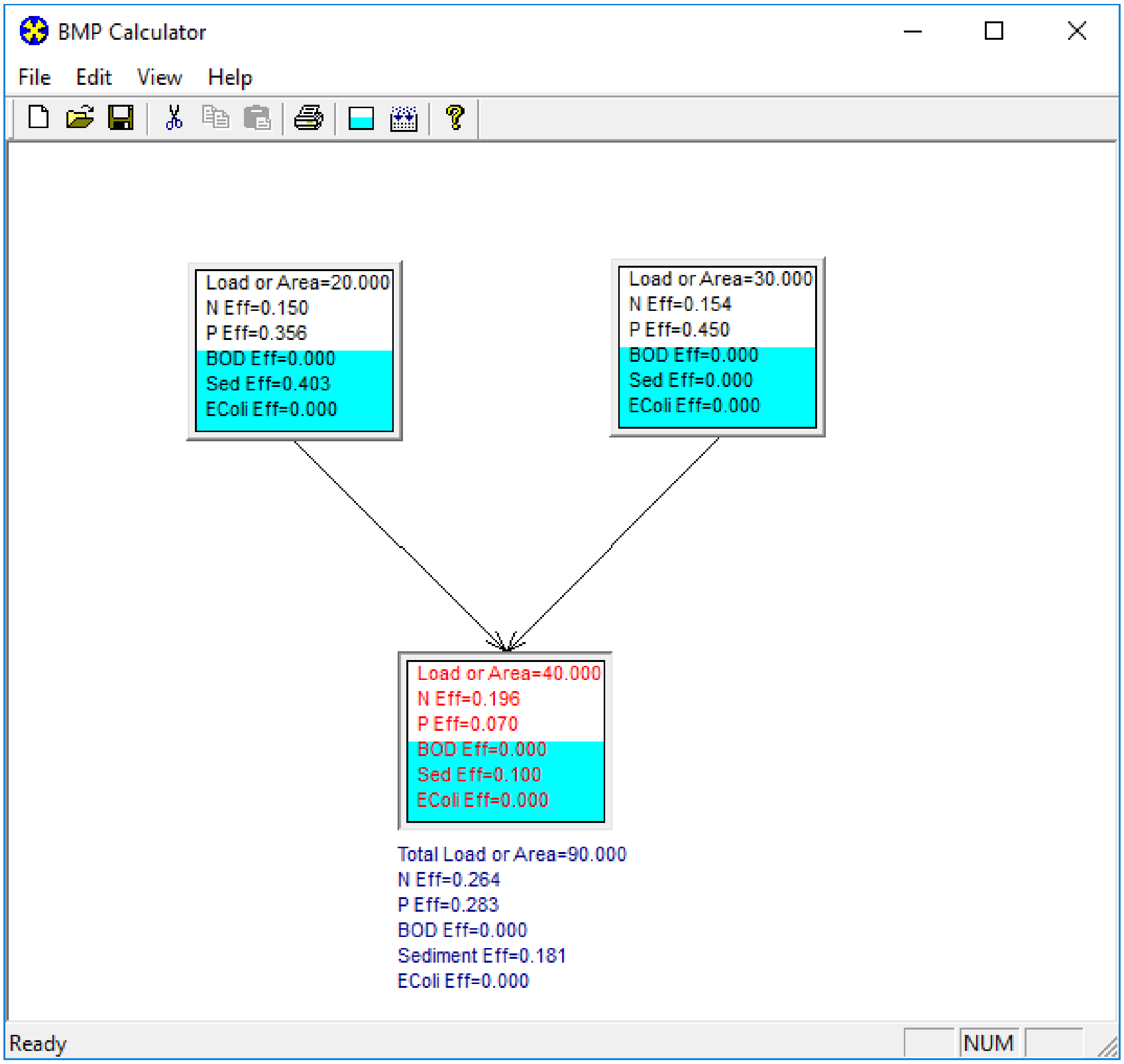


Figure A7. Calculated combined BMP efficiencies for two parallel BMPs in series with a third BMP in a watershed.

6. Enter the combined efficiencies in Table 7 of the *BMPs* worksheet (see section 4.3). You can right-click your mouse button on the result text in BMP Calculator window and you will see a small pop-up window with a copy command. Select the copy command to copy the calculated combined BMP efficiency and paste the copied value to the STEPL worksheet.

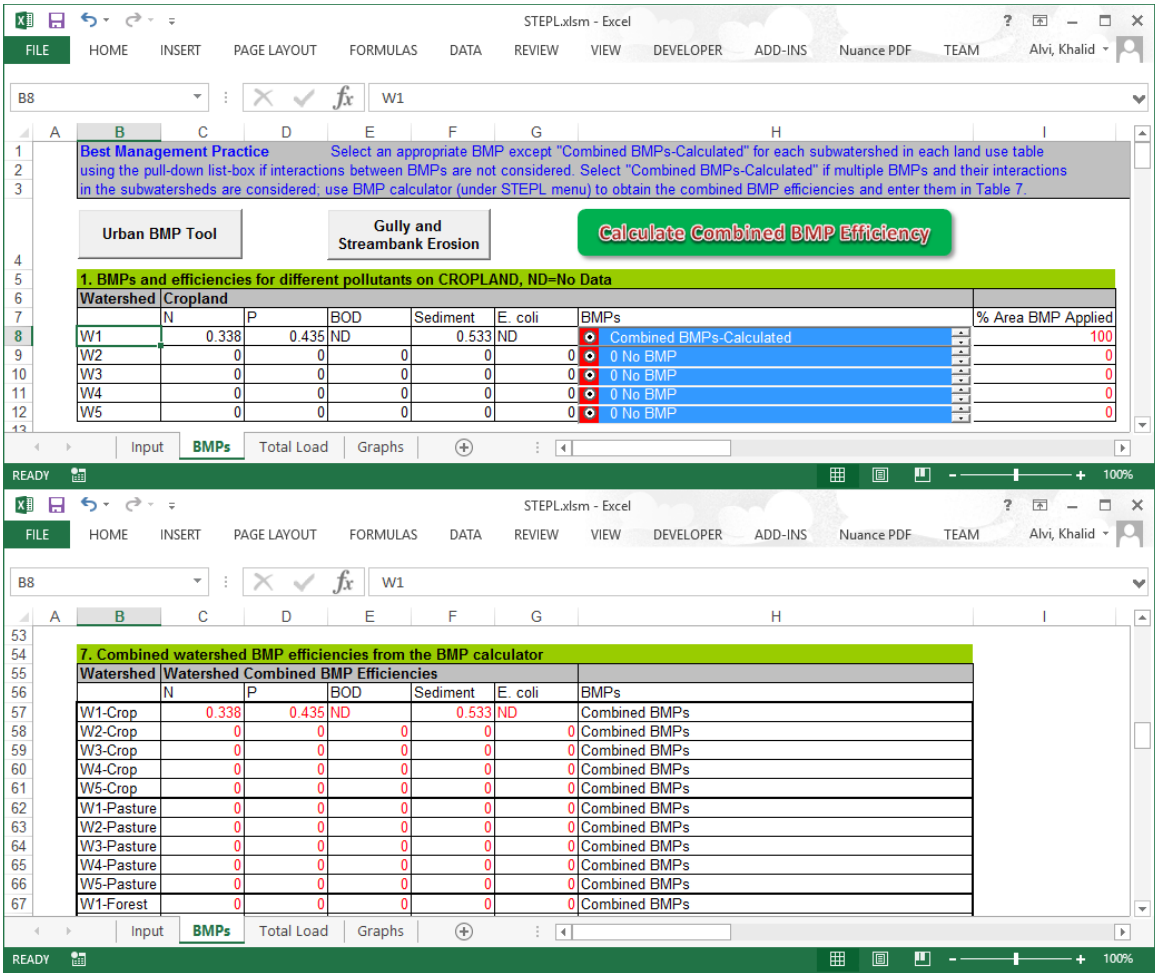


Figure A8. The *BMP* worksheet of the STEPL model, which lets you select BMPs for different land uses. If you select "Combined BMPs-Calculated" from any of the BMP pull-down list boxes, you need to use the BMP Calculator to calculate combined BMP efficiencies and then enter them in Table 7.

A.2. Advanced Examples

Consider the following information before you attempt advanced calculations.

- Combined BMP efficiencies are calculated by using area as the weighting factor when all the BMPs are located in the same land use type. Combined BMP efficiencies can also be calculated using the original or pre-BMP load as the weighting factor when the BMPs are located in different land use types with varying pollutant loading rates. Refer to the BMP calculator formulas for details. This document shows only examples using area to calculate the combined BMP efficiencies.

- The area weighting factor in the BMP Calculator refers more specifically to a source area treated by an on-site BMP or a source area treated by an off-site BMP. In many cases, an off-site BMP (e.g., filter strips to intercept pollutants from an upslope cropland) can be separated from its source and represented in the BMP Calculator as an individual box. The source area for the individual off-site BMP should be zero because the BMP itself is not the source area.

- Beyond the original design objectives of the BMP Calculator for two or three BMPs, the BMP Calculator can be used to calculate the combined efficiencies of very complicated BMP arrangements (three or more BMPs arranged in mixed configurations in a watershed), providing that you fully understand the calculator's mathematical formulas and the properties of the BMPs being implemented.

Four example cases are shown in Figures A9 through A12.

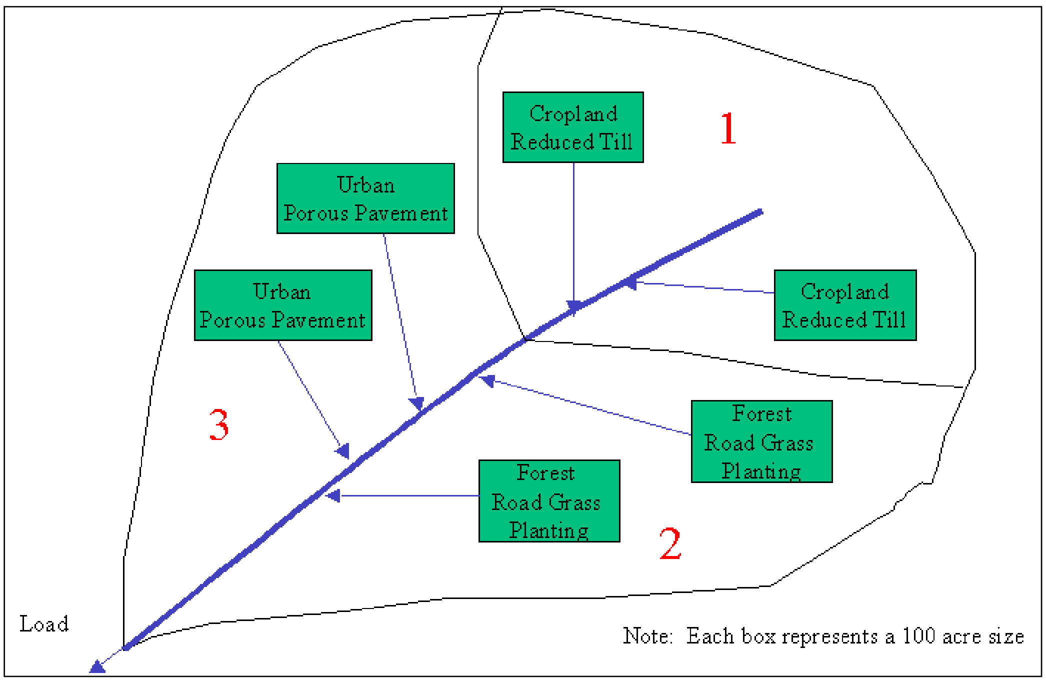


Figure A9. A case that does not need the BMP Calculator. You do not need to calculate the combined BMP efficiency because each land use type uses the same BMP practice (e.g., reduced till for all croplands) regardless of BMP locations in the subwatersheds.

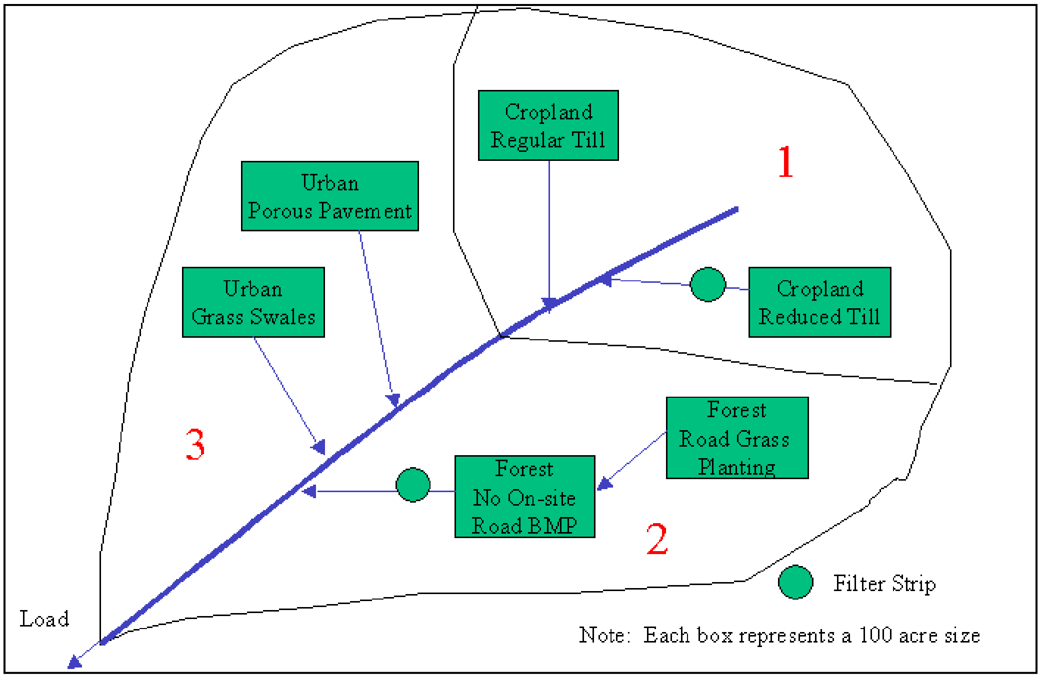


Figure A10. Case that needs the BMP Calculator. You need to calculate the combined BMP efficiency because each land use type uses more than one practice (e.g., regular till and reduced till combined with filter strips for cropland). In this example, you need to calculate a combined efficiency for each land use type or subwatershed.

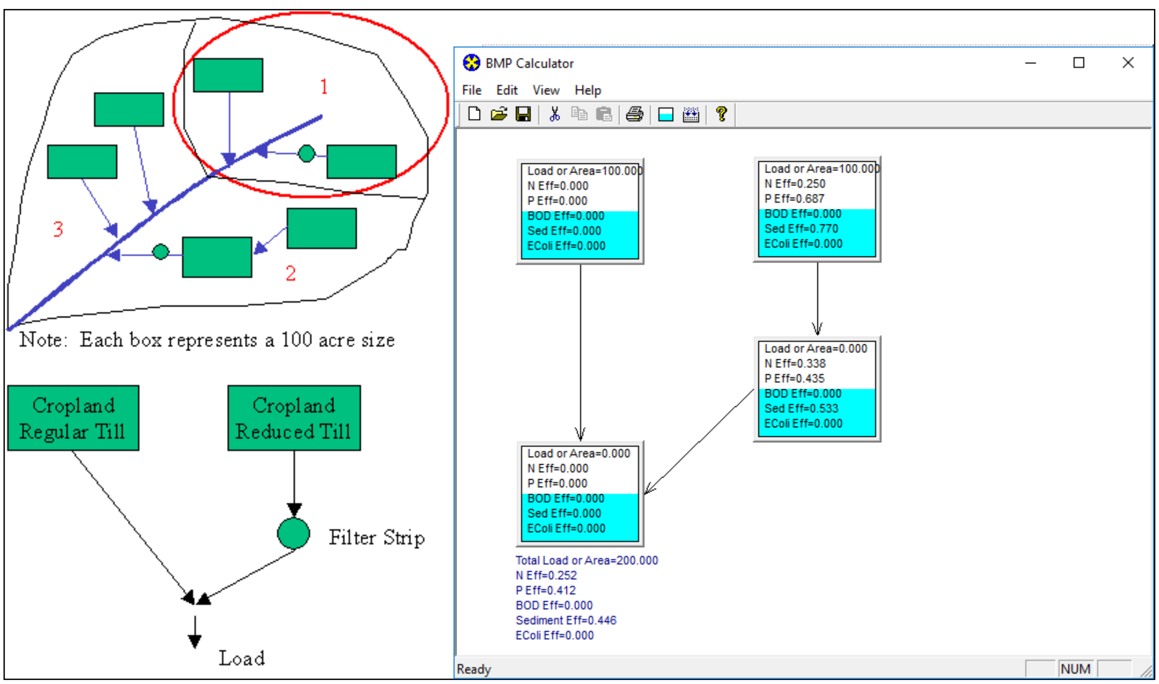


Figure A11. Calculation of combined BMP efficiency for sample cropland. For Area 1 in the watershed, one-half of the cropland uses no BMPs and the other half uses reduced tillage practice and a filter strip in a serial configuration. The two halves of the cropland are arranged in a parallel configuration. Because the filter strip is represented in the BMP Calculator as a box that is separated from the filter strip's treatment area, the source area for the filter strip itself equals zero.

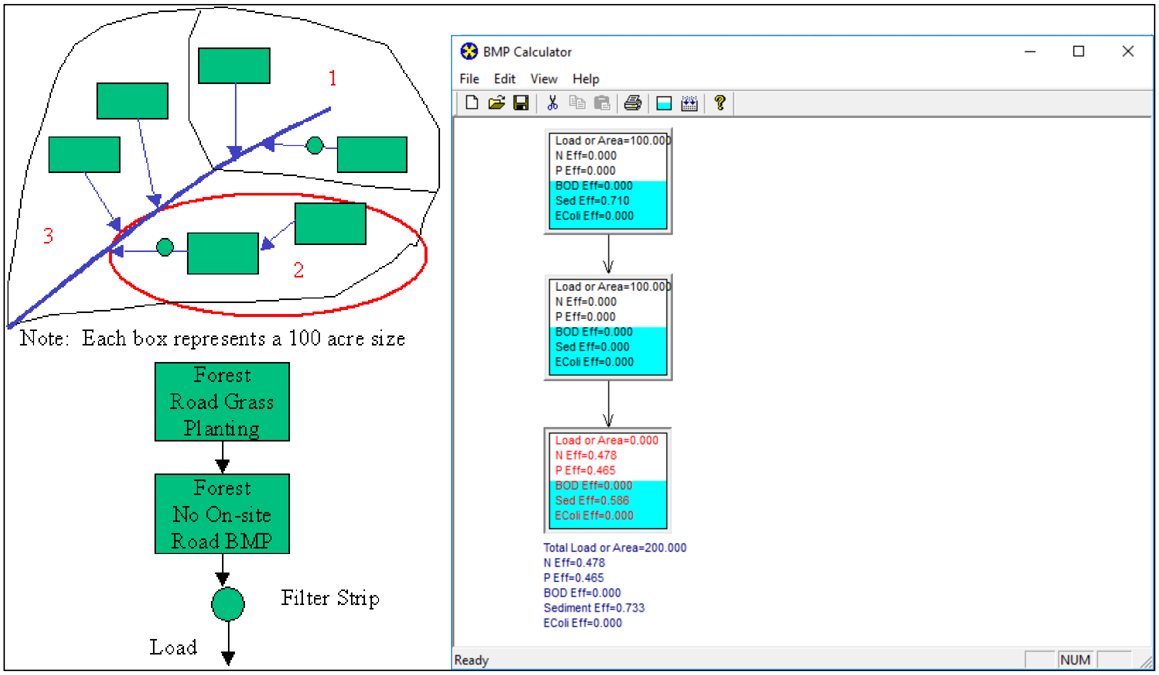


Figure A12. Calculation of combined BMP efficiency for sample forestland. For Area 2 in the watershed, one-half of the forest uses road grass planting and the other half uses no BMPs but has a filter strip between it and the receiving stream. The two halves of the forest are arranged in a serial configuration. Because the filter strip is represented in the BMP Calculator as a box that is separated from the filter strip's treatment area, the source area for the filter strip itself equals zero.

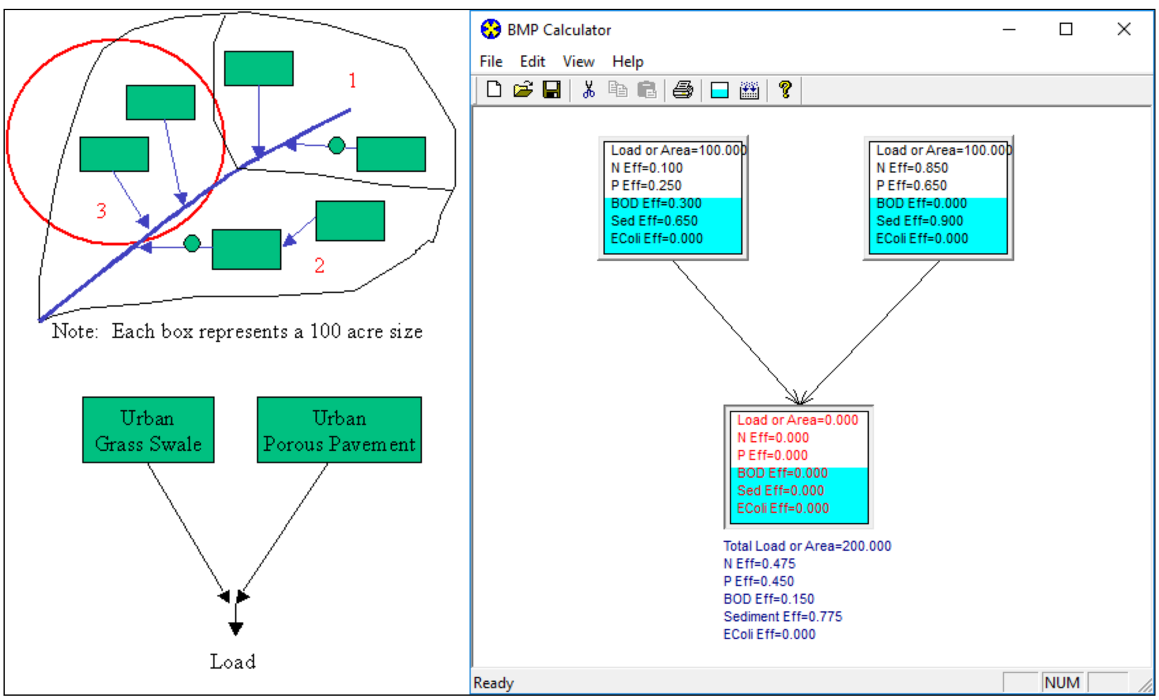


Figure A13. Calculation of combined BMP efficiency for sample urban land. For Area 3 in the watershed, one-half of the urban land is treated with grass swales and the other half is treated with porous pavement. The two halves of the urban land are arranged in a parallel configuration. The configuration is connected through a common box in the BMP Calculator, representing a receiving stream.

A.3. BMP Calculator Formulas

Define e_1, e_2, …, and e_n as BMP pollutant removal efficiencies for area A_1, area A_2, …., and area A_n, which have corresponding pollutant loads of T_1, T_2, and T_n. (1-e_1), (1-e_2), …, and (1-e_n) represent pollutant-retaining efficiencies.

For a parallel BMP configuration, the combined efficiency is equal to

$$1-\frac{T_1*(1-e_1)+T_2*(1-e_2)}{T_1+T_2} \text{ or } 1-\frac{\sum_{i=1}^{n}T_i*(1-e_i)}{\sum_{i=1}^{n}T_i}.$$

For a serial BMP configuration, the combined efficiency is equal to

$$1-\frac{T_1*(1-e_1)*(1-e_2)+T_2*(1-e_2)}{T_1+T_2} \text{ or } 1-\frac{\sum_{i=1}^{n}T_i*(1-e_i)*(1-e_{i+1})*...(1-e_n)}{\sum_{i=1}^{n}T_i}.$$

For a single area,

$T_2 = 0$ and $e_2 = 0$, and both of the above formulas are reduced to 1- (1-e_1) = e_1.

If all the subareas have similar pollutant loading rates ($t = T/A$), the T in the above two formulas can be replaced by A for approximation.

Appendix B: Description of the Intermediate STEPL Worksheets

B.1 *General Input Data* Worksheet

This worksheet is hidden from users by default. To display the worksheet, click the STEPL > Hide/Unhide Other STEPL Sheets menu.

This worksheet summarizes your initial input for the creation of the customized spreadsheet tool (Figure B1).

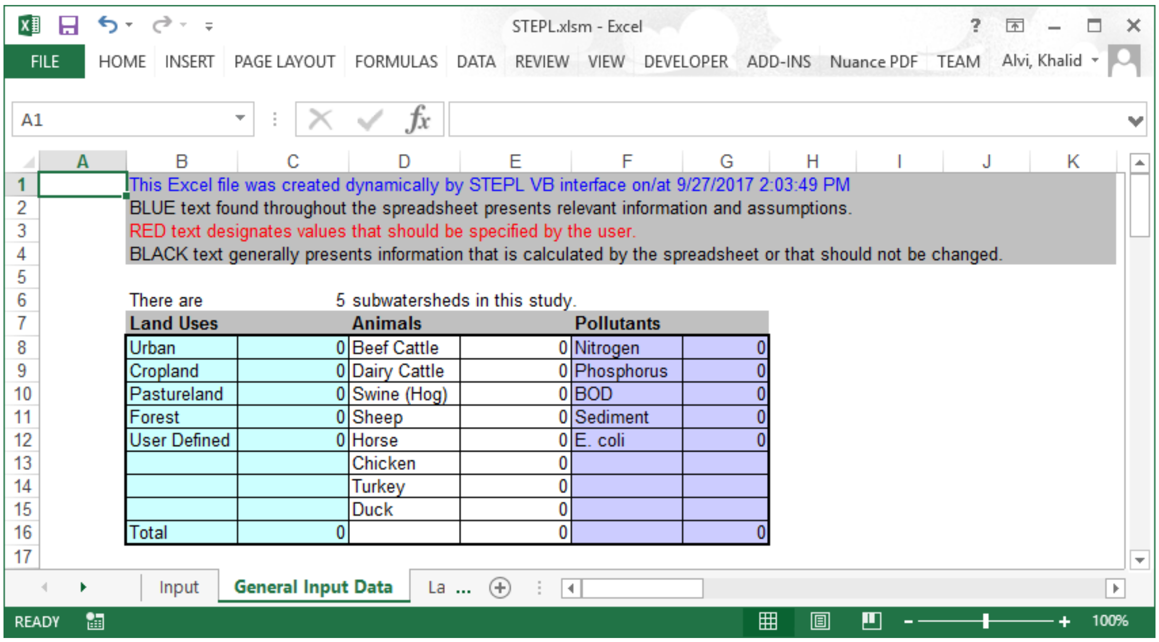
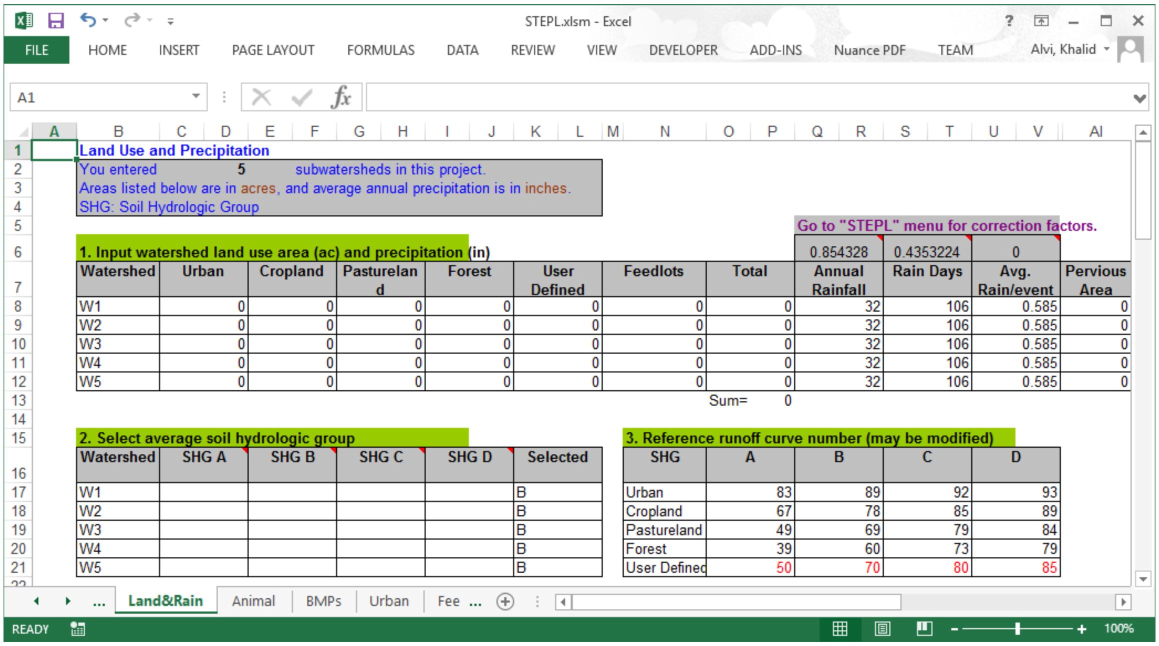


Figure B1. The *General Input Data* worksheet, which displays a summary of your initial input.

B.2 *Land&Rain* Worksheet

This worksheet is hidden from users by default. When displayed, there are seven visible tables in this worksheet (Figure B2). The values in Tables 1, 2, 3, and 5 are linked to tables in the *Input* worksheets.



Land Use and Precipitation
You entered 5 subwatersheds in this project.
Areas listed below are in acres, and average annual precipitation is in inches.
SHG: Soil Hydrologic Group

Go to "STEPL" menu for correction factors.

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Total	Annual Rainfall	Rain Days	Avg. Rain/event	Pervious Area
								0.854328	0.4353224	0	
W1	0	0	0	0	0	0	0	32	106	0.585	0
W2	0	0	0	0	0	0	0	32	106	0.585	0
W3	0	0	0	0	0	0	0	32	106	0.585	0
W4	0	0	0	0	0	0	0	32	106	0.585	0
W5	0	0	0	0	0	0	0	32	106	0.585	0
						Sum=	0				

2. Select average soil hydrologic group

Watershed	SHG A	SHG B	SHG C	SHG D	Selected
W1					B
W2					B
W3					B
W4					B
W5					B

3. Reference runoff curve number (may be modified)

SHG	A	B	C	D
Urban	83	89	92	93
Cropland	67	78	85	89
Pastureland	49	69	79	84
Forest	39	60	73	79
User Defined	50	70	80	85

Figure B2. The *Land&Rain* worksheet, which calculates average annual runoff based on precipitation, soil hydrologic group, and soil curve number.

Table 1 contains model input on land use area in acres, annual precipitation in inches, number of days with measurable precipitation, and correction factors for each watershed. There are three correction factors in row 6: (1) Rainfall correction factor, (2) number of rain day correction factor, and (3) rainfall initial abstraction factor. Rainfall initial abstraction factor determines initial rainfall retention on the land surface, ranges from 0 to 0.2. The default is set to zero. Table 2 contains the soil hydrological group (SHG) information for each watershed. Table 3 shows the default curve numbers by SHG for each land use type.

Once STEPL has the land use area, precipitation data, and soil hydrological group for each watershed, the worksheet calculates the runoff for each type of land use automatically. The results are shown in Table 4, "Annual runoff by land uses (ac-ft)."

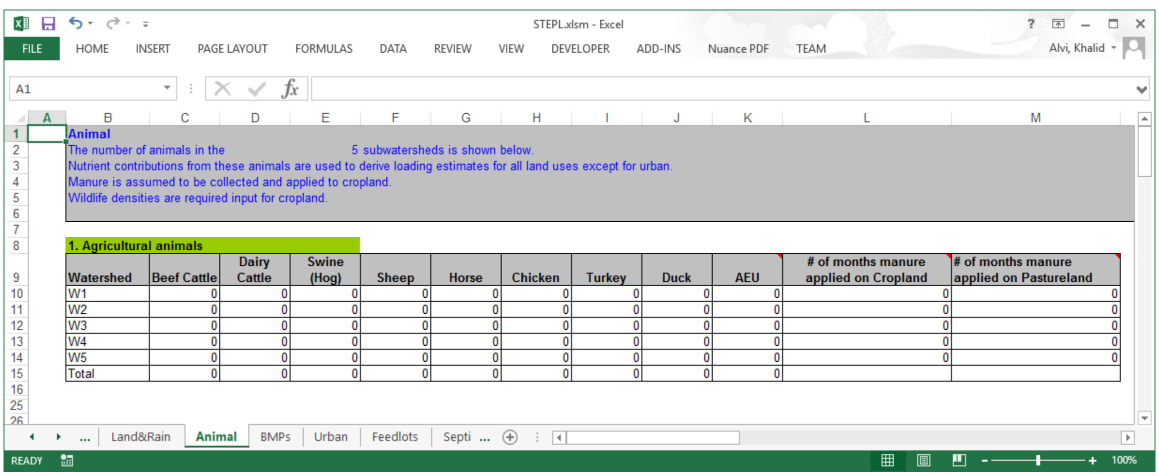
Table 5 shows default nutrient concentrations in runoff (mg/L) for pastureland, forest, and the user-defined type. The concentration values are used in the *Total Load* worksheet to calculate the nutrient load from runoff. (Nutrient concentrations from cropland are determined based on the default nutrient concentrations and animal density and manure application in the study area in *Input* and *Animal* worksheet.)

The *Land&Rain* worksheet calculates the groundwater volume by using the infiltration rates for different soil hydrologic group (Table GW1). Based on the infiltration rate, the annual infiltration volume is calculated for the different land uses (Table GW2-hidden, GW3-hidden, and GW4). The annual infiltration volume is assumed to be equivalent to the annual groundwater output in the local hydrological cycle. Groundwater output is used to calculate the pollutant loads for *Total Load* worksheet.

The *Land&Rain* worksheet also calculates the runoff and runoff reduction due to the irrigation practice (hidden Table 2.3) as well as runoff for the detailed urban land uses (hidden tables in Excel Column X to Column AH). Runoff for urban land uses is used to calculate the pollutant loads for *Urban* worksheet.

B.3 *Animal* Worksheet

This worksheet is hidden from users by default. Table 1 in the *Anima*l worksheet (Figure B3) links to the *Input* worksheet for the number of farm animals and number of months that manure is applied on cropland in each watershed. The worksheet calculates each animal equivalent unit (AEU, i.e., 1000 lb animal weight per acre) based on number of animals and standard animal weight. The nutrient concentrations in cropland runoff are adjusted with the AEU. The higher the AUE, the higher the nutrient concentrations in the cropland runoff. A step function is used to represent the relationship between the nutrient concentrations and AEU, and nutrient concentrations reach the maximum when the AEU is equal to or greater than 2.5 (Evans et al. 2001).



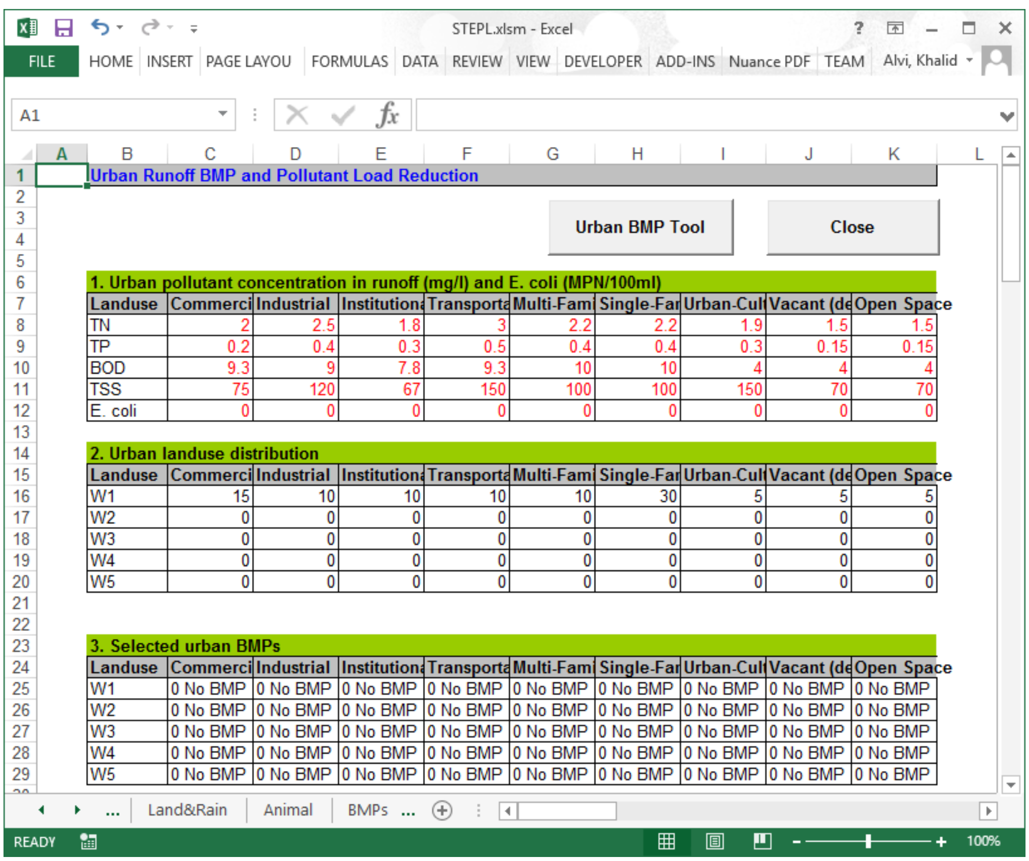
Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	AEU	# of months manure applied on Cropland	# of months manure applied on Pastureland
W1	0	0	0	0	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0		

Figure B3. The *Animal* worksheet, which contains information on agricultural animal numbers and number of months that manure is applied to cropland.

B.4 *Urban* worksheet

The *Urban* worksheet is created for calculating urban pollutant load and load reduction due to the application of management practices. This worksheet is hidden from users by default. It will be displayed if the user clicks the ***Urban BMP Tool*** button on the *BMPs* worksheet. When displayed, two tool buttons and six tables are visible in this worksheet (Figure B4). The ***Urban BMP Tool*** will allow you to set/select/change a LID/BMP for each urban land use (see detailed description in section 4.3.2). Click the ***Close*** button will hide the *Urban* worksheet. Table 1 contains pollutant concentrations (mg/L) for each urban land use category including: Commercial, Industrial, Institutional, Transportation, Multi-family, Single-family, Urban-cultivated, Vacant (developed), and Open Space. Table 2 contains urban land use distribution by area. Table 2a has the LID/BMP application area (or effective area). Table 3 displays LID or BMP selected for each urban land use. In addition, the percentages of the LID/BMP effective area (100 x effective area / total available area) are calculated in Table 3a.

Once the system has the urban area distribution data (*Input* worksheet) and the LID or BMP application areas, the estimated urban pollutant loads are displayed in Table 4 (Figure B4). The load reductions are calculated by multiplying the total loads by the efficiencies of selected LIDs/BMPs shown in Table 3.



1. Urban pollutant concentration in runoff (mg/l) and E. coli (MPN/100ml)

Landuse	Commerci	Industrial	Institution	Transporta	Multi-Fami	Single-Far	Urban-Cul	Vacant (de	Open Space
TN	2	2.5	1.8	3	2.2	2.2	1.9	1.5	1.5
TP	0.2	0.4	0.3	0.5	0.4	0.4	0.3	0.15	0.15
BOD	9.3	9	7.8	9.3	10	10	4	4	4
TSS	75	120	67	150	100	100	150	70	70
E. coli	0	0	0	0	0	0	0	0	0

2. Urban landuse distribution

Landuse	Commerci	Industrial	Institution	Transporta	Multi-Fami	Single-Far	Urban-Cul	Vacant (de	Open Space
W1	15	10	10	10	10	30	5	5	5
W2	0	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0

3. Selected urban BMPs

Landuse	Commerci	Industrial	Institution	Transporta	Multi-Fami	Single-Far	Urban-Cul	Vacant (de	Open Space
W1	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W2	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W3	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W4	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W5	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP

Figure B4. The *Urban* worksheet, which calculates pollutant loads from urbanized areas.

B.5 Gully&Streambank Worksheet

The *Gully&Streambank* worksheet is created for calculating the pollutant loads from the gully formations and impaired streambanks. This worksheet is hidden from users by default. It will be displayed if the user clicks the ***Gully and Streambank Erosion*** button on the *BMPs* worksheet. When displayed, two tables are visible in this worksheet (Figure B5). The ***Gully and Streambank Erosion*** will allow you to define the dimensions, BMP efficiency, and soil textural class for selected watershed (see description in section 4.3.3). Click the ***Close*** button will hide the *Gully&Streambank* worksheet. Table 1 and Table 2 contain gully and impaired streambank dimensions, BMP efficiency, soil textural class, annual load, and load reduction for the selected watershed. The load reduction is calculated by multiplying the total load by the BMP efficiency defined in the same table.

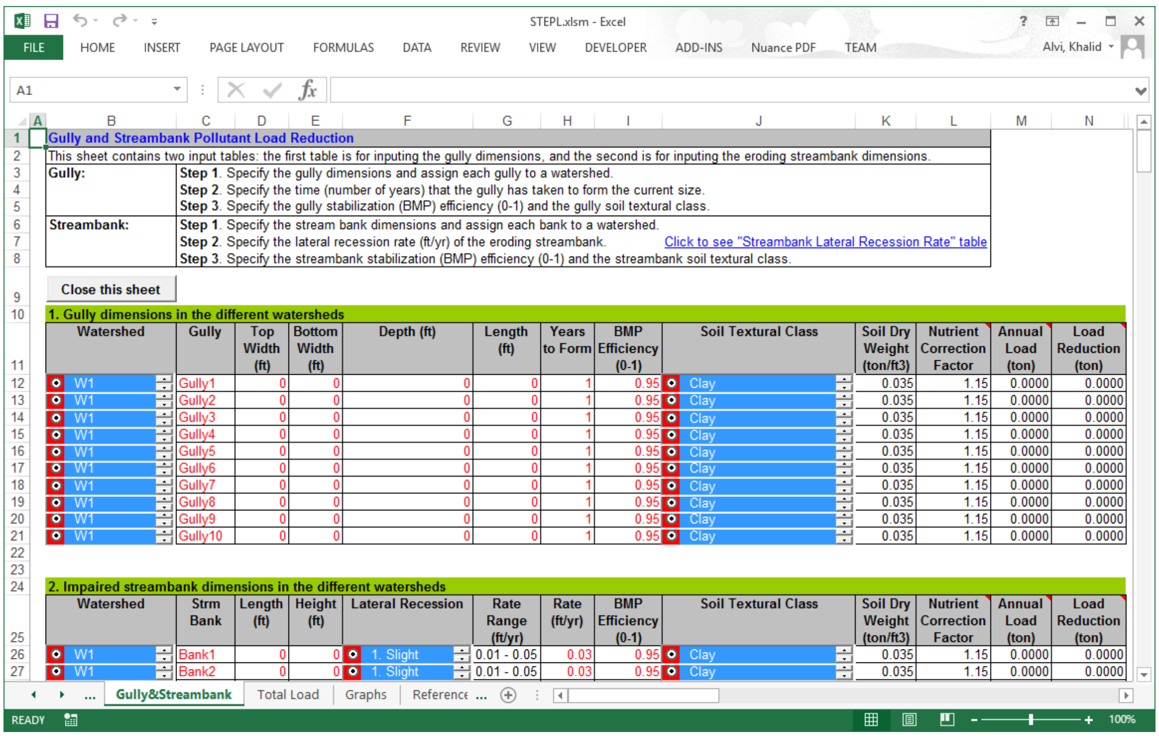
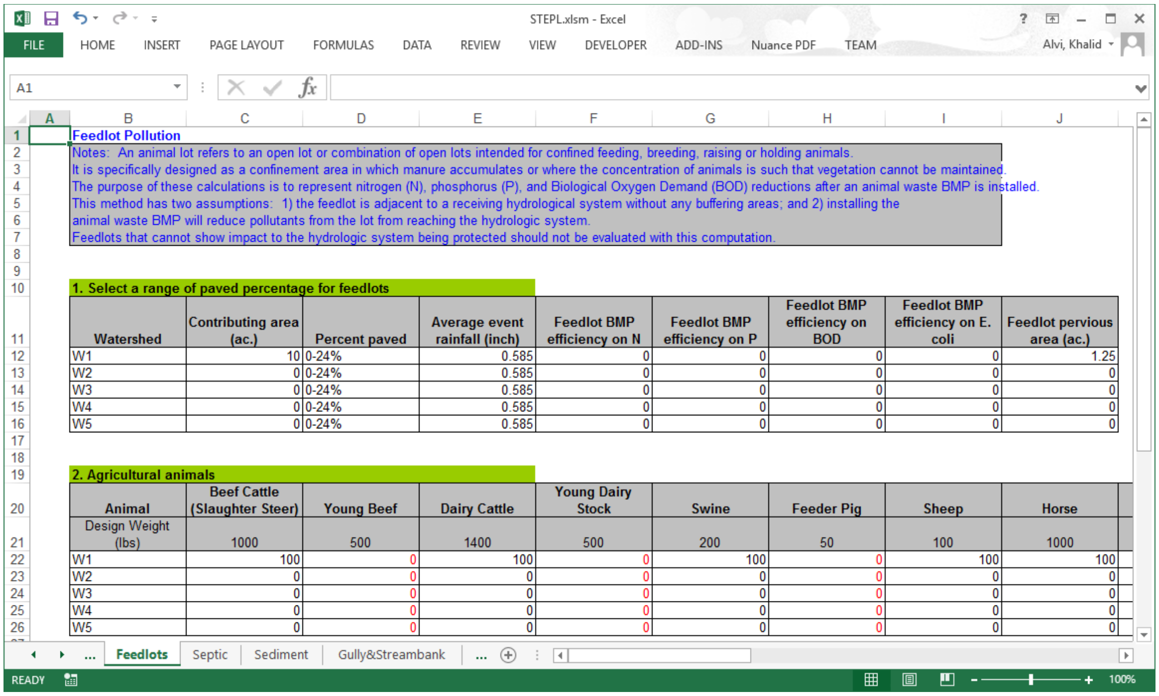


Figure B5. The Gully&Streambank worksheet, which calculates pollutant loads from the gully formations and impaired streambanks.

B.6 *Feedlots* Worksheet

The *Feedlots* worksheet is modified from a model developed by EPA Region 5 (MDEQ 1999). The worksheet is hidden from users by default. When displayed, three tables are visible in this worksheet (Figure B6). Table 1 contains information on size, percentage of imperviousness (paved area), average rainfall, and BMP efficiencies for the feedlots in each watershed. In Table 2, you may enter detailed information on young beef, young dairy stock, and feeder pigs in addition to the animal numbers in the *Animal* worksheet.

The nutrient loads from feedlots are calculated based on animal numbers, feedlot runoff, and default nutrient concentrations in the runoff. They are shown in Table 3 (Figure B6).



Feedlot Pollution

Notes: An animal lot refers to an open lot or combination of open lots intended for confined feeding, breeding, raising or holding animals.
It is specifically designed as a confinement area in which manure accumulates or where the concentration of animals is such that vegetation cannot be maintained.
The purpose of these calculations is to represent nitrogen (N), phosphorus (P), and Biological Oxygen Demand (BOD) reductions after an animal waste BMP is installed.
This method has two assumptions: 1) the feedlot is adjacent to a receiving hydrological system without any buffering areas; and 2) installing the
animal waste BMP will reduce pollutants from the lot from reaching the hydrologic system.
Feedlots that cannot show impact to the hydrologic system being protected should not be evaluated with this computation.

1. Select a range of paved percentage for feedlots

Watershed	Contributing area (ac.)	Percent paved	Average event rainfall (inch)	Feedlot BMP efficiency on N	Feedlot BMP efficiency on P	Feedlot BMP efficiency on BOD	Feedlot BMP efficiency on E. coli	Feedlot pervious area (ac.)
W1	10	0-24%	0.585	0	0	0	0	1.25
W2	0	0-24%	0.585	0	0	0	0	0
W3	0	0-24%	0.585	0	0	0	0	0
W4	0	0-24%	0.585	0	0	0	0	0
W5	0	0-24%	0.585	0	0	0	0	0

2. Agricultural animals

Animal	Beef Cattle (Slaughter Steer)	Young Beef	Dairy Cattle	Young Dairy Stock	Swine	Feeder Pig	Sheep	Horse
Design Weight (lbs)	1000	500	1400	500	200	50	100	1000
W1	100	0	100	0	100	0	100	100
W2	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0

Figure B6. The *Feedlots* worksheet, which calculates pollutant loads from animal feedlots.

B.7 *Septic* Worksheet

The *Septic* worksheet is hidden from users by default. When displayed, there are two visible tables on this worksheet (Figure B7). Table 1 contains information on the number of septic systems (tanks), the failure rates (percentage), the ratio of persons per septic system, and calculated direct wastewater discharge flow for each watershed. The default ratio of persons per septic system is based on the number of people per U.S. home in 1990. Table 2 shows the calculated septic load together with the direct discharge load in pounds per year.

(*Tip: You can reveal the section between the two tables using Excel's unhide function to change the default per capita septic flow rate and nutrient concentrations.*)

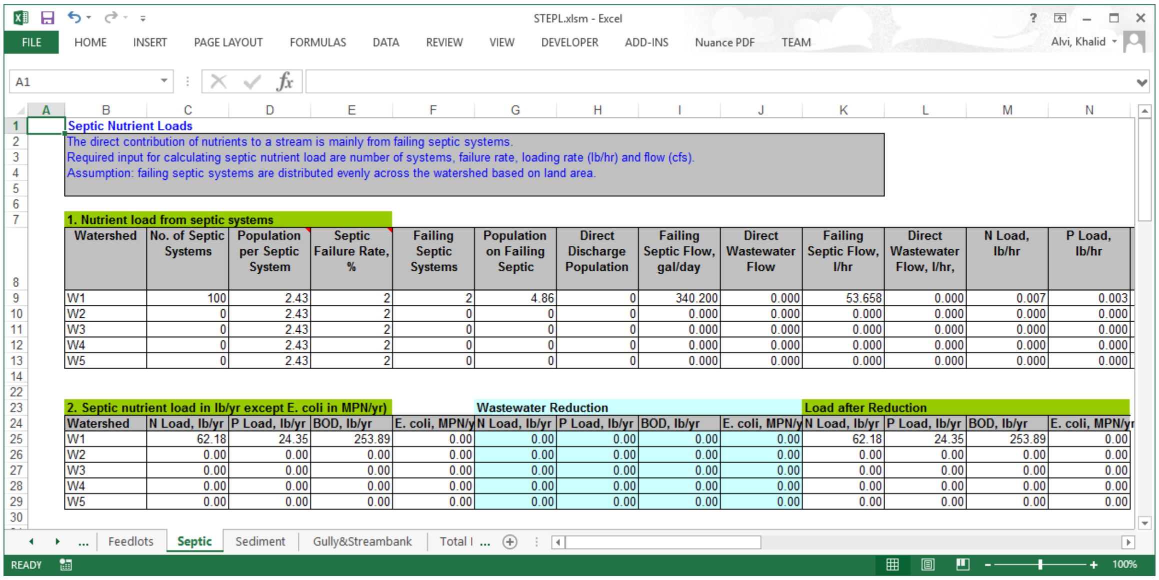


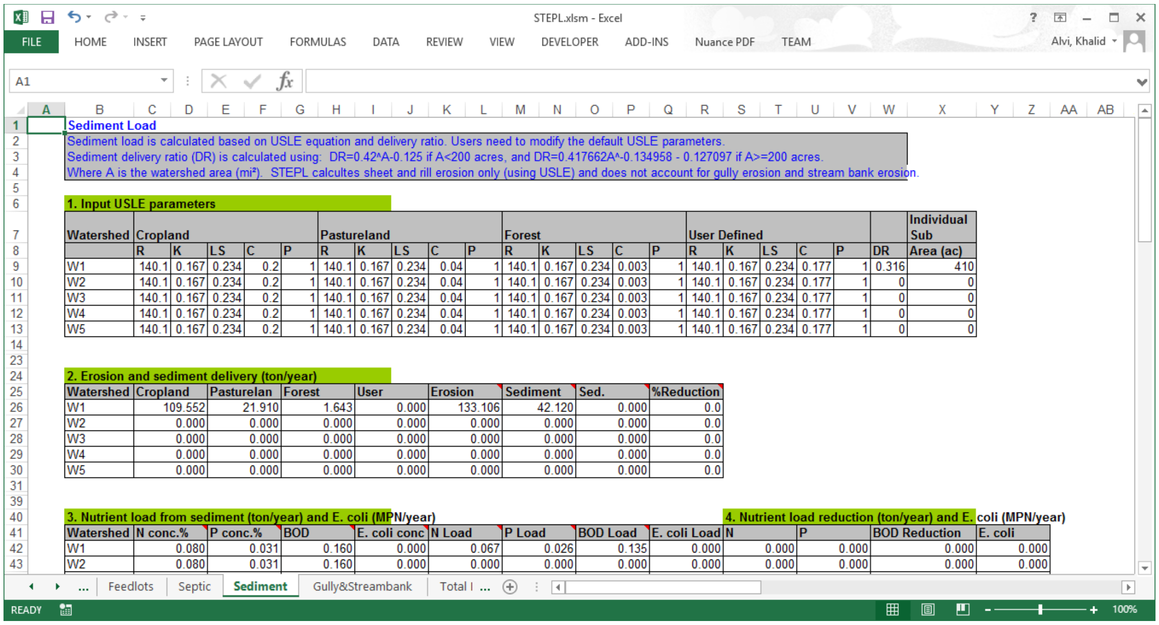
Figure B7. The *Septic* worksheet, which estimates pollutant loads from failed septic systems and direct wastewater discharge.

B.8 *Sediment* worksheet

The *Sediment* worksheet is hidden from users by default. When displayed, there are four visible tables (Figure B8) in the worksheet. Table 1 links to the *Input* worksheet for the USLE parameter values (R, the rainfall erosivity index; K, the soil erodibility factor; LS, the topographic factor; C, the cropping factor; and P, the conservation practice factor) for different types of rural land uses. STEPL does not account for gully erosion and stream bank erosion because USLE calculates sheet and rill erosion only. You can obtain soil erosion parameter values from your local Natural Resources Conservation Service office or from the National Resources Inventory (NRI) database (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/). Click STEPL's USLE Parameters by Land Use menu to open a summary NRI table for major land uses in each U.S. county. The worksheet calculates annual erosion in tons per acre for all the watersheds (Table 2). The sediment delivery ratio (SDR) is calculated based on watershed area (USDA-NRCS 1983). Based on whether the first checkbox is checked or not on the *Input* sheet (Figure 7), the SDR is calculated either using the total watershed area or using the individual subwatershed (or project) areas. *The larger the area is, the smaller the SDR.* The sediment output is calculated by multiplying soil erosion by the sediment delivery ratio.

Nutrient concentrations in the soil and a default enrichment ratio of 2 are used to estimate the nutrient load carried by sediment (Table 3).

Using the BMPs selected on the *BMPs* worksheet, the nutrient reduction carried by sediment is calculated in Table 4.



Sediment Load

Sediment load is calculated based on USLE equation and delivery ratio. Users need to modify the default USLE parameters.
Sediment delivery ratio (DR) is calculated using: DR=0.42^A-0.125 if A<200 acres, and DR=0.417662A^-0.134958 - 0.127097 if A>=200 acres.
Where A is the watershed area (mi²). STEPL calcultes sheet and rill erosion only (using USLE) and does not account for gully erosion and stream bank erosion.

1. Input USLE parameters

Watershed	Cropland					Pastureland					Forest					User Defined						Individual Sub
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P	DR	Area (ac)
W1	140.1	0.167	0.234	0.2	1	140.1	0.167	0.234	0.04	1	140.1	0.167	0.234	0.003	1	140.1	0.167	0.234	0.177	1	0.316	410
W2	140.1	0.167	0.234	0.2	1	140.1	0.167	0.234	0.04	1	140.1	0.167	0.234	0.003	1	140.1	0.167	0.234	0.177	1	0	0
W3	140.1	0.167	0.234	0.2	1	140.1	0.167	0.234	0.04	1	140.1	0.167	0.234	0.003	1	140.1	0.167	0.234	0.177	1	0	0
W4	140.1	0.167	0.234	0.2	1	140.1	0.167	0.234	0.04	1	140.1	0.167	0.234	0.003	1	140.1	0.167	0.234	0.177	1	0	0
W5	140.1	0.167	0.234	0.2	1	140.1	0.167	0.234	0.04	1	140.1	0.167	0.234	0.003	1	140.1	0.167	0.234	0.177	1	0	0

2. Erosion and sediment delivery (ton/year)

Watershed	Cropland	Pasturelan	Forest	User	Erosion	Sediment	Sed.	%Reduction
W1	109.552	21.910	1.643	0.000	133.106	42.120	0.000	0.0
W2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
W3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
W4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
W5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0

3. Nutrient load from sediment (ton/year) and E. coli (MPN/year) / 4. Nutrient load reduction (ton/year) and E. coli (MPN/year)

Watershed	N conc.%	P conc.%	BOD	E. coli conc	N Load	P Load	BOD Load	E. coli Load	N	P	BOD Reduction	E. coli
W1	0.080	0.031	0.160	0.000	0.067	0.026	0.135	0.000	0.000	0.000	0.000	0.000
W2	0.080	0.031	0.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure B8. The *Sediment* worksheet, which uses USLE and the sediment delivery ratio to calculate sediment load from various land uses.

B.9 Reference and CountyData worksheets

The *Reference* and *CountyData* worksheets are hidden from users by default. The reference worksheet contains a standard animal weight table modified from the ASAE standard handbook (ASAE 1998). Animal weight data are used to calculate the animal equivalent unit in the *Animal* worksheet. The reference sheet also contains all the references that STEPL uses for estimating the default input parameter values.

The *CountyData* worksheet has a collection of state and county names, and an USLE parameter value summary by U.S. county (Figure B9). The data on this worksheet are used as default values for USLE table in the *Input* worksheet after you select a state name and a county name.

	F	G	H	I	O	P	Q	R	S
1	State_name-Name	Rainfall (inches	RainDays	Runoff	Rmean	Kmean	LSavg	Cavg	Pavg
2	Alabama-Autauga	60	87.3	19	374.7	0.20	0.29	0.14	0.99
3	Alabama-Baldwin	60	104.4	25.875	550.0	0.21	0.18	0.20	0.99
4	Alabama-Barbour	60	89.2	18	376.7	0.19	0.56	0.15	0.94
5	Alabama-Bibb	60	97.8	21	375.0	0.25	1.09	0.05	0.99
6	Alabama-Blount	60	95.5	24	325.0	0.26	0.77	0.10	0.96
7	Alabama-Bullock	60	97.2	18	375.0	0.25	0.36	0.05	0.96
8	Alabama-Butler	60	97.8	18	425.0	0.24	0.43	0.10	0.95
9	Alabama-Calhoun	60	97.8	23	325.0	0.27	0.36	0.15	1.00
10	Alabama-Chambers	60	97.8	20	346.8	0.21	0.85	0.02	1.00
11	Alabama-Cherokee	60	100.8	22.75	300.0	0.29	0.56	0.20	0.85
12	Alabama-Chilton	60	90.4	20	374.9	0.24	0.44	0.10	0.94
13	Alabama-Choctaw	60	96.3	22	425.0	0.27	0.52	0.03	0.97
14	Alabama-Clarke	60	98.4	19	450.0	0.27	0.30	0.08	1.00
15	Alabama-Clay	60	98.3	26.333	350.0	0.20	0.62	0.02	1.00
16	Alabama-Cleburne	60	97.3	21.333	325.0	0.30	0.55	0.06	0.96
17	Alabama-Coffee	60	99.7	20	450.0	0.18	0.38	0.14	0.84
18	Alabama-Colbert	60	97.8	24.5	300.0	0.29	0.33	0.23	0.99
19	Alabama-Conecuh	60	93.3	20	449.8	0.21	0.30	0.14	0.91
20	Alabama-Coosa	60	97.8	24	350.3	0.20	0.54	0.03	0.99
21	Alabama-Covington	60	100	21	474.7	0.20	0.36	0.09	0.93
22	Alabama-Crenshaw	60	97.8	18	425.0	0.19	0.36	0.15	0.90
23	Alabama-Cullman	60	101.7	24	325.0	0.25	0.65	0.06	0.96
24	Alabama-Dale	60	97.8	20	424.9	0.17	0.42	0.19	0.86
25	Alabama-Dallas	60	96.4	18	399.9	0.25	0.21	0.12	1.00
26	Alabama-De Kalb	60	115	26.333	300.0	0.24	0.62	0.15	0.91
27	Alabama-Elmore	60	97.8	19	375.0	0.23	0.29	0.18	0.93
28	Alabama-Escambia	60	93.3	23	525.0	0.20	0.22	0.19	0.90
29	Alabama-Etowah	60	96.9	24	325.0	0.27	0.37	0.09	0.96
30	Alabama-Fayette	60	98.5	22	350.0	0.29	0.60	0.11	0.95
31	Alabama-Franklin	60	97.8	24	323.4	0.22	0.43	0.07	0.98
32	Alabama-Geneva	60	98.2	21.333	450.0	0.19	0.37	0.19	0.88
33	Alabama-Greene	60	97.5	20	373.8	0.29	0.23	0.04	1.00
34	Alabama-Hale	60	97.2	20	372.3	0.27	0.26	0.04	0.98
35	Alabama-Henry	60	89	18	400.0	0.17	0.42	0.22	0.90
36	Alabama-Houston	60	97.8	20	424.8	0.18	0.27	0.21	0.90
37	Alabama-Jackson	60	108.8	28	275.0	0.24	0.24	0.15	0.98
38	Alabama-Jefferson	60	98.3	27	350.0	0.28	0.67	0.02	1.00

Figure B9. ***CountyData*** **worksheet, which contains USLE parameter values by U.S. county.**

Appendix C: STEPL Worksheets Summary

1. *Input* Worksheet

Function:

This worksheet collects input for STEPL. Average annual precipitation, number of days with measurable precipitation, correction factors for precipitation and number of days with precipitation, and USLE soil erosion parameter values are automatically entered once the user selects a state name, a county name, and a weather station name.

User input:

Required: State name, county name, weather station name, land use areas, percent of pavement in feedlots, agriculture animals, number of months that manure is applied to croplands, number of septic systems in each watershed, and septic system failure rates.

Optional: Treat all the subwatersheds as parts of a single watershed, groundwater load calculation, number of people that discharge wastewater directly, reduction percentage of direct wastewater discharge, soil hydrologic group, reference runoff curve numbers, nutrient concentrations in runoff and soils, urban land use distribution, and area/amount/frequency/reduction of cropland irrigation

Visible tables:

Input watershed land use area (ac) and precipitation (in)
Input agricultural animals
Input septic system and illegal direct wastewater discharge data
Modify the Universal Soil Loss Equation (USLE) parameters
Select average soil hydrologic group (SHG)
Reference runoff curve number (may be modified)
Detailed urban reference runoff curve number (may be modified)
Nutrient concentration in runoff (mg/L)
Nutrient concentration in shallow groundwater (mg/L)
Input or modify urban land use distribution
Input irrigation area (ac) and irrigation amount (in)

Hidden tables:

None

2. *General Input Data* Worksheet

Function:

This is the first worksheet generated by the main program, STEPL.exe. It shows the number of watersheds, land uses, pollutants, and animal types the user specified in the VB interface. Users may use it to verify general input information. Note that it also contains the date and time the worksheet was generated.

User input:

None

Visible tables:
Summary of initial user's input
Hidden tables:
None

3. *Land&Rain* Worksheet

Function:
Calculates surface runoff (inches) and runoff volume (acre-feet) for land uses in each watershed using the Soil Conservation Service (SCS, now Natural Resources Conservation Service or NRCS) curve number method.
User input:
Rainfall initial abstraction factor (default = 0, range 0 to 0.2)
Visible tables
- Input watershed land use area (ac) and precipitation (in)
- Select average soil hydrologic group
- Reference runoff curve number (may be modified)
- Annual runoff by land uses (ac-ft)
- Nutrient concentration in runoff (mg/L)
- Reference soil infiltration fraction for precipitation
- Calculated infiltration volume (ac-ft)

Hidden tables:
- Curve number CN
- Calculated runoff (in)
- Detailed urban land use area (ac)
- Urban runoff curve number
- Runoff by urban land use (in)
- Urban annual runoff (ac-ft)
- Irrigation runoff (in)
- Runoff reduction by land uses (ac-ft) (for irrigation reduction in cropland)
- Infiltration fraction based on SHG
- Calculated infiltration (in)

Notes:
- Tables for precipitation, number of days with precipitation, and runoff are provided through a menu under the customized menu bar "STEPL."
- A reference table for correction factors for precipitation and number of days with precipitation is provided through a menu under the customized menu bar "STEPL."

4. *Animal* Worksheet

Function:
Inputs animal-related information for each land use in each watershed.
User input:
Wild animal densities in agricultural areas (default to zeros)
Visible table:
Agricultural animals

Hidden tables:
- Wildlife density in cropland
- Estimated wildlife and AEU in watersheds
- Total animal equivalent units and nutrient concentrations
- AEU and nutrient in runoff (mg/l)

5. *BMPs* Worksheet

Function:

Allows users to select best management practices (BMPs) for cropland, pastureland, forest, user-defined land, feedlot, and urban.

User input:
- Select appropriate BMPs for different land uses
- Specify partial area (% area) BMP applications
- Use the ***Urban BMP Tool*** for setting and changing LIDs/BMPs for urban land uses
- Use the ***Gully and Streambank Erosion*** for defining the dimensions for each gully formation and impaired streambank in a separate *Gully&Streambank* worksheet
- Optional: Enter the watershed-wide combined BMP efficiencies

Visible tables
- BMPs and efficiencies for different pollutants on cropland
- BMPs and efficiencies for different pollutants on pastureland
- BMPs and efficiencies for different pollutants on forest
- BMPs and efficiencies for different pollutants on user-defined land use
- BMPs and efficiencies for different pollutants on feedlot
- BMPs and efficiencies for different pollutants on urban
- Combined watershed BMP efficiencies from the BMP calculator.

6. *Urban* Worksheet

Function:

Calculates pollutant load from urban runoff and potential load reductions from various BMPs using the runoff volume x concentration approach.

User input:

Urban BMP Tool: Select urban LID/BMPs and the application areas for the selected urban land uses.

Visible tables:
- (Urban) pollutant concentration in runoff (mg/l)
- Urban land use distribution
- Effective BMP application area
- Selected urban BMPs
- Percentage of BMP effective area (%)
- Pollutant loads from urban in lb/yr

Hidden tables:
- Urban runoff (ac-ft)
- Total urban N load (kg)
- Selected urban N reduction efficiency
- Urban N reduction (kg)
- Total urban P load (kg)
- Selected urban P reduction efficiency
- Urban P reduction (kg)
- Total urban BOD load (kg)
- Selected urban BOD reduction efficiency
- Urban BOD reduction (kg)
- Total urban TSS load (kg)
- Selected urban TSS reduction efficiency
- Urban TSS reduction (kg)

7. *Gully&Streambank* Worksheet

Function:

Calculates pollutant load from gully and streambank erosion and potential load reductions due to the BMPs implementation.

User input:

The dimensions, BMP efficiency, and soil textural class for each gully formation and impaired streambank.

Visible tables:
- Gully dimensions in the different watersheds
- Impaired streambank dimensions in the different watersheds

Hidden tables:
- Load and load reduction (lb/year, GU=Gully; SB=Streambank) in the different watersheds

8. *Feedlots* Worksheet

Function:

Calculates pollutant load from feedlots based on animal types, weight, and average rainfall.

User input:

Input young animal numbers if available

Visible tables:
- Select a range of paved percentage for feedlots
- Agricultural animals
- Load from feedlot (lb/yr)

Hidden tables:
- Feedlot load calculation
- Ratio of nutrients produced by animals relative to 1,000 lb. of slaughter steer

9. ***Septic*** Worksheet

Function:

Computes pollutant (nitrogen, phosphorus, and BOD) load from failing septic systems and illegal direct discharges.

User input:

None

Visible tables:

- Nutrient load from septic systems (lb/hr)
- Septic nutrient load in lb/yr

Hidden tables:

Assumed average flow rate and concentrations reaching the stream (from overcharge of the failed septic systems and direct wastewater discharge)

10. ***Sediment*** Worksheet

Function:

- Calculates erosion and sediment load from land and watersheds using USLE.
- Calculates load reduction in sediment and nutrients from BMPs.

User input:

None

The sediment delivery ratio (SDR) is calculated either using the total watershed area or the individual subwatershed (or project) area (the default) on the basis of the user's selection on the *Input* page, which has a checkbox for treating all the subwatersheds as parts of a single watershed.

Visible tables:

- Input USLE parameters
- Erosion and sediment delivery (ton/year)
- Nutrient load from sediment (ton/year)
- Nutrient load reduction (ton/year)

Hidden tables:

- BMPs and efficiencies
- Erosion and sediment delivery after BMPs (ton/year)
- Sediment and sediment nutrients by land uses (tons/year)

11. ***Total Load*** Worksheet

Function:

Summarizes pollutant loads from different worksheets by watersheds and land uses.

User input:

None

Visible tables:

- Total load by watershed(s)
- Total load by land uses (with BMP)

Hidden tables:
- Nutrient load from runoff (lb/year) without BMPs
- Nutrient load reduction in runoff with BMPs (lb/yr)
- Nutrient and sediment load by land uses with BMPs (lb/yr)
- Load from groundwater by land uses with BMP (lb/year)

12. *Graphs* Worksheet

Function:
Plots the pollutant and sediment load by land use and watersheds.
User input:
None
Visible charts:
- Comparison of nutrient loads among the watersheds
- Comparison of sediment loads among the watersheds
- Comparison of nutrient reductions among the watersheds
- Comparison of sediment reductions among the watersheds
- Total nitrogen load by land uses (with BMP) (lb/yr)
- Total phosphorus load by land uses (with BMP) (lb/yr)
- Total BOD load by land uses (with BMP) (lb/yr)
- Total sediment load by land uses (with BMP) (t/yr)

Hidden tables (copied from the *Total Load* worksheet):
- Copy of total load by land uses (with BMP)
- Copy of total load by watersheds

13. *BMPList* Worksheet

Function:
Displays BMP efficiency data and provides users the ability to add, change, or delete the data.
User input:
None or new BMP names and pollutant removal efficiencies.
Visible tables:
List of BMP names and pollutant removal efficiencies for cropland, pastureland, forest, user-defined land, feedlots, and urban land.
Hidden tables:
None

14. *Reference* Worksheet

Function:
Provides necessary reference data or parameter values used for the calculations in other sheets, including typical animal weight.
User input:
None
Visible tables:
Standard animal weight table modified from ASAE standard handbook (ASAE 1998)

Hidden tables:
None

15. *CountyData* Worksheet

Function:
Provides necessary default county data or parameter values used for the calculations in other sheets.
User input:
None
Visible tables:
State names, precipitation, number of rain days and runoff by U.S. counties, and 1992 USLE parameters by U.S. counties.
Hidden tables:
None

16. *WeatherData* Worksheet

Function:
Provides necessary default weather station data used for the calculations in other sheets.
User input:
None
Visible tables:
State name, station ID, precipitation correction factor, rain days correction factor, annual precipitation, annual precipitation greater than 5mm, annual rain days, annual rain days exceeding 5mm of precipitation.
Hidden tables:
None

17. *USLE_Parms* Worksheet

Function:
Provides Universal Soil Loss Equation (USLE) parameters by state-county used for the calculations in other sheets.
User input:
None
Visible tables:
State-County, Rmean, Kmean, LSavg, Cavg, Pavg
Hidden tables:
None

18. *ManureApplication* Worksheet

Function:
Calculates the area-weighted frequency of manure application based on user-defined input.
User input:
Total acres, acres in each treatment area, number of months manure is applied to each treatment area.
Visible tables:
Estimated area-weighted frequency of application
Hidden tables:
None

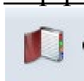
19. *CombinedBMPEfficiency* Worksheet

Function:
Calculates the area-weighted combined efficiency of multiple BMPs in parallel across a watershed.
User input:
Total land use acres, land use type, acres of each treatment area, BMP type in each treatment area
Visible tables:
Estimated area-weighted combined efficiency of multiple BMPs
Hidden tables:
None

Appendix D: Guide for Using STEPL On-line Data Access System

The "STEPL Model Input Data Server" uses ArcGIS Viewer for Flex 2.1. The ArcGIS Viewer for Flex is a ready-to-deploy, configurable client application that is built on the ArcGIS API for Flex. The Viewer application is designed to work with ArcGIS Server and ArcGIS Online Web services. The web interface (Figure D1) of this "On-line Data Access System" has the following key features:

- Top panel: Search watershed boundary feature is selected by default.

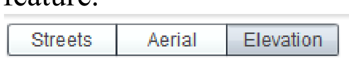
  
  Add bookmark to the current extent of the map or zoom to the previously saved book mark location.

  
  Search watershed boundary and report STEPL model input data.

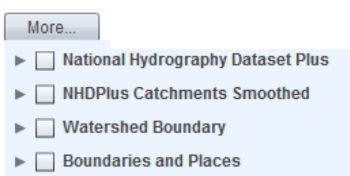
  
  Identify feature on the map (select at least one from the 

  list of background maps).

  
  Print the current view of the map.
- Mid panel: An extent of United States of America elevation map is shown by default.
- Right panel: Select background map and additional GIS data layers as an optional feature.

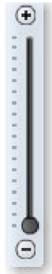
  Switch background map to view street, aerial, or elevation map.

  Select check box to view additional background map layers.
- Left panel:

  
  Zoom to full extent of the map (to see the entire map). Pan the map (right, left, up, and down).

  
  Zoom to previous or next extent of the map.



Zoom in or out sliding bar.

Pan the map (move the map in the view).

Zoom in to a location on the map (by rectangle).

Zoom out from a location on the map (by rectangle).

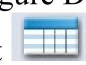
Bottom panel:

Overview map window.

Shows map scale and location (latitude and longitude) of the cursor on the map.

D.1. Steps for using the STEPL on-line data access system

Step 1. On the watershed search window (Figure D1), select a State name from the state list. The map will zoom to the State you have selected.

Step 2. Select a County name from the County list (Figure D1). The map will zoom to the County you have selected. Click the run report  button to obtain a report in a new window which provides data for the entire county, or go to Step 3.

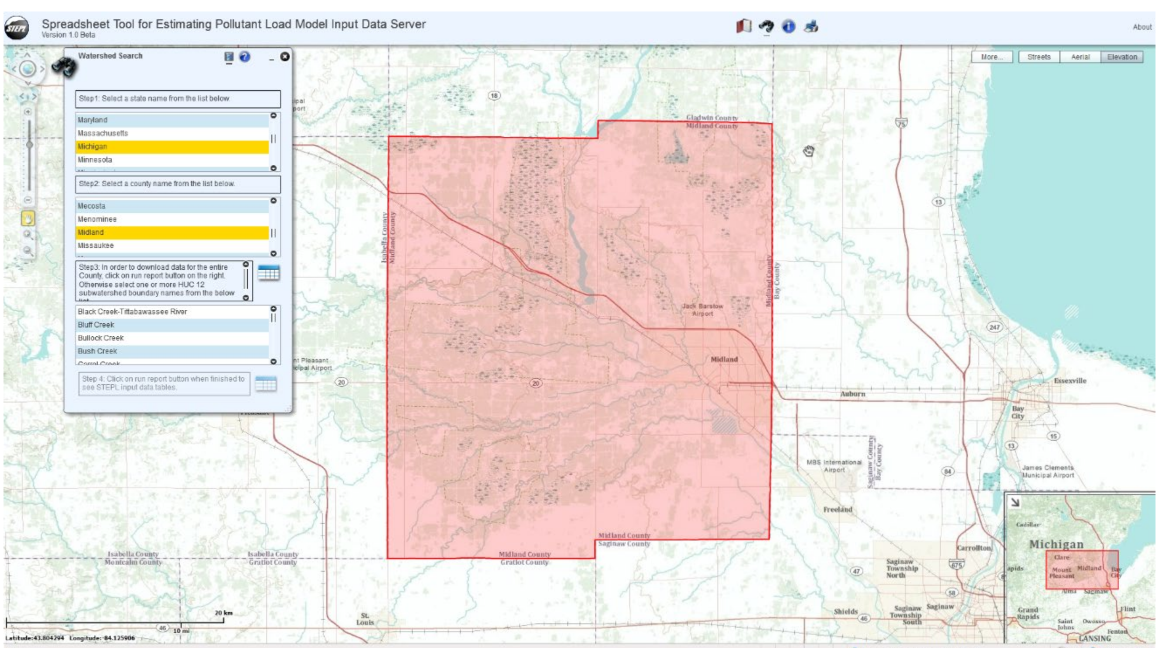


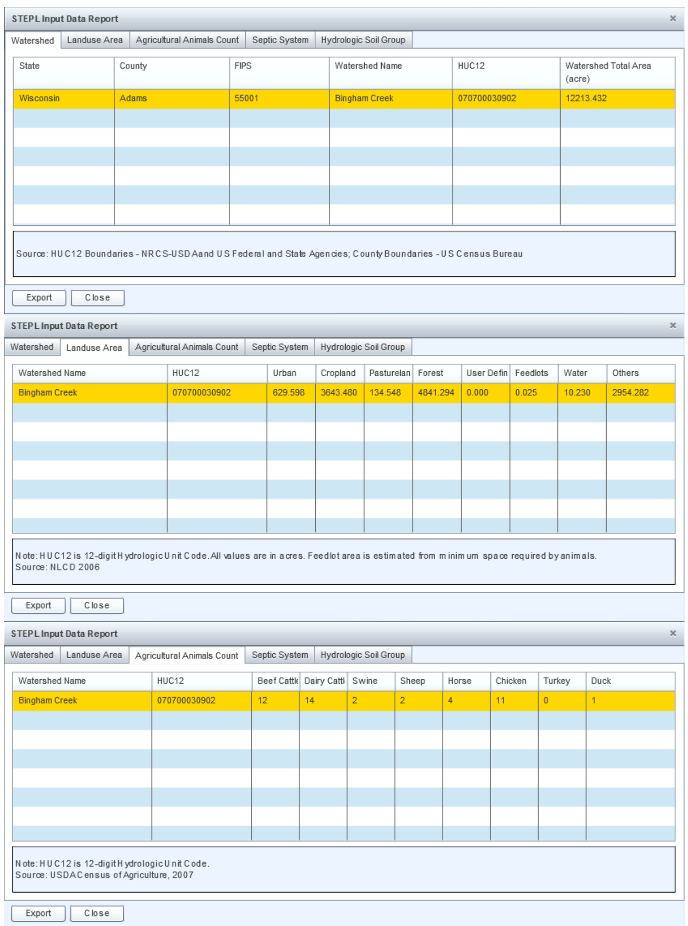
Figure D1. STEPL on-line data access system: ArcGIS Viewer for Flex 2.1 interface

Step 3. Select one or more subwatershed(s) names from the HUC12 subwatershed list (Figure D1). The map will zoom to and will show the selected HUC12 subwatershed(s).

Step 4. Click the run report  button to obtain a report in a new window. The report will provide the following tables for the selected HUC12 subwatershed(s) you have selected:

- Information for selected HUC12 subwatersheds (based on USDA-NRCS, USGS, and USEPA)
- Landuse area (in acres) for selected HUC12 subwatershed(s) (based on NLCD and USDA Cropland Data Layer (CDL), 2011)
- Agricultural animals distribution for selected HUC12 subwatershed(s) (based on USDA Census of Agriculture, 2012)
- Septic system data for selected HUC12 subwatershed(s) (based on septic system surveys by National Small Flows Clearinghouse in 1992 and 1998)
- Hydrological soil group for selected HUC12 subwatershed(s) (based on STATSGO database)

The table format is consistent with the required table format in the STEPL model.



STEPL Input Data Report

Watershed | Landuse Area | Agricultural Animals Count | Septic System | Hydrologic Soil Group

State	County	FIPS	Watershed Name	HUC12	Watershed Total Area (acre)
Wisconsin	Adams	55001	Bingham Creek	070700030902	12213.432

Source: HUC12 Boundaries - NRCS-USDA and US Federal and State Agencies; County Boundaries - US Census Bureau

Export | Close

STEPL Input Data Report

Watershed | Landuse Area | Agricultural Animals Count | Septic System | Hydrologic Soil Group

Watershed Name	HUC12	Urban	Cropland	Pasturelan	Forest	User Defin	Feedlots	Water	Others
Bingham Creek	070700030902	629.598	3643.480	134.548	4841.294	0.000	0.025	10.230	2954.282

Note: HUC12 is 12-digit Hydrologic Unit Code. All values are in acres. Feedlot area is estimated from minimum space required by animals.
Source: NLCD 2006

Export | Close

STEPL Input Data Report

Watershed | Landuse Area | Agricultural Animals Count | Septic System | Hydrologic Soil Group

Watershed Name	HUC12	Beef Cattle	Dairy Cattl	Swine	Sheep	Horse	Chicken	Turkey	Duck
Bingham Creek	070700030902	12	14	2	2	4	11	0	1

Note: HUC12 is 12-digit Hydrologic Unit Code.
Source: USDA Census of Agriculture, 2007

Export | Close

Figure D2. STEPL on-line data access system: STEPL input data tables

Landuse areas in *Landuse Area* table include feedlots. Feedlot areas are estimated based on the following minimum space requirement by farm animals:

- Beef cow: 25 ft^2
- Dairy cow: 40 ft^2
- Swine: 15 ft^2
- Chicken: 1 ft^2
- Horse: 45 ft^2
- Sheep: 8 ft^2
- Turkey: 6 ft^2
- Duck: 3 ft^2

Step 5. Export the results from the report tables to an Excel spreadsheet for use in STEPL model to estimating the pollutant loads.

D.2. Rules/Assumptions made for STEPL on-line data access system

- The user can select only one State and one County name from each list.
- The user can select one or more HUC12 subwatershed(s) from the list.
- The results are generated at HUC12 level.
- The landuse data source is NLCD 2006.
- The agricultural animal data source is at the County level and is summarized at the HUC12 level based on the pastureland area weighted ratio.
- The septic system data source is at the County level and is summarized at the HUC12 level based on the low-density residential area weighted ratio.
- The Hydrologic Soil Group (HSG) is summarized at the HUC12 subwatershed.

D.3. The URLs for the Web services used in this application

- Street Map: https://server.arcgisonline.com/ArcGIS/rest/services/World_Street_Map/MapServer
- Aerial Map: https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer
- Elevation Map: https://server.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer
- Boundaries and Places: https://server.arcgisonline.com/ArcGIS/rest/services/Reference/World_Boundaries_and_Places_Alternate/MapServer
- State and County Boundaries: https://services.nationalmap.gov/ArcGIS/rest/services/govunits/MapServer
- Watershed Boundary: https://watersgeo.epa.gov/ArcGIS/rest/services/OW/WBD_WMERC/MapServer
- NHDPlus Catchments (Simplified): https://watersgeo.epa.gov/arcgis/rest/services/NHDPlus_NP21/Catchments_NP21_Simplified/MapServer

- National Hydrography Dataset Plus: https://watersgeo.epa.gov/arcgis/rest/services/NHDPlus_NP21/NHDSnapshot_NP21_Labeled/MapServer

Appendix E: STEPL Underlying Formulas Documentation

STEPL Underlying Formulas

Contents

1. Introduction

The purposed of this document is to provide all relevant equations and methods used in the STEPL spreadsheet program. STEPL employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs), including Low Impact Development practices (LIDs) for urban areas. It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

$$\text{Total Load from various Sources} = \text{Urban} + \text{Cropland} + \text{Pastureland} + \text{Forest} + \text{Feedlots} + \text{User} - \text{Defined} + \text{Septic} + \text{Gully} + \text{Streambank} + \text{Groundwater} \quad \text{Equation 1}$$

2. Surface Runoff

The Runoff Curve Number (CN) method is used to estimate runoff from urban land, cropland, pastureland, forest and a user-defined landuse. The runoff equation used is:

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S} \ or\ Q = \frac{(P - \alpha \cdot S)^2}{P - \alpha \cdot S + S} \quad \text{Equation 2}$$

Where:

Q = Surface Runoff (in/day)

P = Rainfall (in) per event.

STEPL calculates the average rainfall per even as follows:

P = (Annual Rainfall x Rainfall correction factor) ÷ (Rain days x Rain day correction factor)

$$P = (AR \cdot R_{cor})/(Rdays \cdot RD_{cor}) \quad \text{Equation 3}$$

Where:

AR = Average Annual rainfall

Rdays = Average rain days in a year

R_{cor} = Rainfall correction factor refers to the percentage of rainfall events that exceed 5 mm/event

RD_{cor} = Rain day correction factor refers to the percentage of rain day events that generate runoff

Ia = Initial abstraction which determines the initial rainfall retention on the land surface. Ia is given by αS (where α ranges from 0 to 0.2). Note that STEPL uses zero initial abstraction factor as a default value. This is because rainfall and rainy days correction factors are already considering that runoff occurs when it rains more than 5mm in a day, a criterion used to calculate the correction factors. For example, for a value of α = 0 Equation 2 reduces to $P^2/(P+S)$

S = Potential maximum retention after runoff begins (in). S is related to the soil and cover conditions of the drainage area through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \left(\frac{1000}{CN}\right) - 10 \quad \text{Equation 4}$$

The estimated average daily runoff volume is multiplied by the corrected number of average rain days in a year to calculate the annual runoff volume.

$$Annual\ Runoff\ Volume\ (ac-ft) = \frac{Q}{12} \times A\ \times (Rdays \cdot RD_{cor}) \quad \text{Equation 5}$$

Where:

Q = surface runoff (in)

A = area of landuse (acres)

Rdays = Average rain days in a year

RD_{cor} = Rain day correction factor refers to the percentage of rain day events that generate runoff

STEPL also includes the Irrigation runoff contribution to Croplands when irrigation is applied. The irrigation runoff depth (Q_{irr}) is calculated using Equation 1. The water depth per irrigation (inches) is used instead of the rainfall (P). The annual runoff volume for cropland is calculated as the sum of the surface runoff volume and irrigation volume.

$$\begin{aligned} Annual\ Runoff\ Volume\ Cropland\ (ac-ft) &= Runoff\ Volume\ of\ Cropland + Irrigated\ Runooff\ volume \\ &= \frac{Q}{12} \times A \times (Rdays \cdot RD_{cor}) + \frac{Q_{irr}}{12} \times A_{irr}\ \times IF \end{aligned} \quad \text{Equation 6}$$

Where:

Q_{irr} = Irrigation runoff (in)

A_{irr} = Cropland acres irrigated

IF = Irrigation frequency (#/year)

Urban load is calculated based on the loading from nine separate landuse categories – Commercial, Industrial, Institutional, Transportation, Multi-Family, Single-Family, Urban-Cultivated, Vacant (developed), and Open Space. The surface runoff depth for each Urban category is calculated using Equation 5.

3. Nutrient Load from Runoff

Urban

The following equations refers to the total load calculation for Urban land. The loading is calculated using the calculated annual runoff volume and assumed nutrient and *E. coli* EMC concentration in runoff, for each of the nine urban landuse categories

$$W_N = [V \cdot C_N] \times 4047 \cdot 0.3048/1000 \quad \text{Equation 7}$$

$$W_P = [V \cdot C_P] \times 4047 \cdot 0.3048/1000 \quad \text{Equation 8}$$

$$W_{BOD} = [V \cdot C_{BOD}] \times 4047 \cdot 0.3048/1000 \quad \text{Equation 9}$$

$$W_{TSS} = [V \cdot C_{TSS}] \times 4047 \cdot 0.3048/1000 \quad \text{Equation 10}$$

$$W_{ecoli} = [V \cdot C_{ecoli}] \times 4047 \cdot 0.3048/1000 \quad \text{Equation 11}$$

Where:

W_N, W_P, W_{BOD}, W_{ecoli}, W_{TSS} = annual N, P, BOD, *E. coli*, and TSS (sediment) loads from Urban land (Kg)

V = the total calculated annual runoff volume from the various urban landuse categories (ac-ft)

C_N, C_P, C_{BOD}, C_{ecoli}, C_{TSS} = urban pollutant (N, P, BOD, *E. coli*, and TSS) concentration in runoff in mg/L

Cropland and Pasture

The following equations refer to the total load calculation for Cropland and Pasture land. The loading is calculated using the calculated annual runoff and assumed nutrient and *E. coli* concentration in runoff.

$$W_N = V \times \left[\left(1 - \frac{N_m}{12}\right) \cdot C_N + \left(\frac{N_m}{12}\right) \cdot C_{N_{mn}}\right] \times 4047 \cdot \frac{0.3048}{454} \quad \text{Equation 12}$$

$$W_P = V \times \left[\left(1 - \frac{N_m}{12}\right) \cdot C_P + \left(\frac{N_m}{12}\right) \cdot C_{P_{mn}}\right] \times 4047 \cdot \frac{0.3048}{454} \quad \text{Equation 13}$$

$$W_{BOD} = V \times \left[\left(1 - \frac{N_m}{12}\right) \cdot C_{BOD} + \left(\frac{N_m}{12}\right) \cdot C_{BOD_{mn}}\right] \times 4047 \cdot \frac{0.3048}{454} \quad \text{Equation 14}$$

$$W_{ecoli} = V \times \left[\left(1 - \frac{N_m}{12}\right) \cdot C_{ecoli} + \left(\frac{N_m}{12}\right) \cdot C_{ecoli_{mn}}\right] \times 4047 \cdot \frac{0.3048}{454} \cdot 10 \cdot 453592 \quad \text{Equation 15}$$

Where:

W_N, W_P, W_{BOD}, W_{ecoli} = annual N, P, BOD, and *E. coli* loads from Cropland and Pasture land (lbs)

V = the calculated annual runoff volume (ac-ft)

N_m = number of months manure is applied

C_N, C_P, C_{BOD}, C_{ecoli} = N, P, BOD or *E. coli* nutrient concentration in agricultural area or pasture area in mg/L

C_{N_nm}, C_{P_mn}, C_{BOD_mn} = N, P, BOD or *E. coli* nutrient concentration in manured agricultural area or manured pasture area in mg/L

Note that nutrient concentrations are calculated based on input of number of agricultural animals in the watershed. Animal Equivalent Counts (AEU; 1 AEU = 1000 lb/ac) are first calculated based on typical animal mass (lb) and counts of animals. The calculated AEU for each watershed is then used to estimate the nutrients in cropland and pasture runoff, based on literature values (for manured and non-manured areas).

Forested and User Defined

The Forested and User-Defined landuse annual runoff loading is calculated using the calculated annual runoff and assumed nutrient concentration in runoff for forested landuse.

$$W_N = [V \cdot C_N] \times 4047 \cdot 0.3048/454 \quad \text{Equation 16}$$

$$W_P = [V \cdot C_P] \times 4047 \cdot 0.3048/454 \quad \text{Equation 17}$$

$$W_{BOD} = [V \cdot C_{BOD}] \times 4047 \cdot 0.3048/454 \quad \text{Equation 18}$$

$$W_{ecoli} = [V \cdot C_{ecoli}] \times 4047 \cdot 0.3048/454 \cdot 10 \cdot 453592 \quad \text{Equation 19}$$

Where:

W_N, W_P, W_{BOD}, W_{ecoli} = annual N, P, BOD, and *E. coli* loads from Forested or User-Defined landuse (lbs)

V = the calculated annual runoff volume (ac-ft)

C_N, C_P, C_{BOD}, C_{ecoli} = N, P, BOD or *E. coli* nutrient concentration in Forested or User-Defined landuse area

4. Sediment Loading Calculations

Sediment loads (from Cropland, Pastureland, Forest, and User-defined landuses) are calculated based on the Universal Soil Loss Equation (USLE) equation and sediment delivery ratio (DR). The USLE equation to calculate the mean annual soil loss (E) is calculated as follows:

$$E = R \cdot K \cdot LS \cdot C \cdot P \cdot DA$$ Equation 20

Where:

E = the computed annual soil loss (sheet and rill erosion) in tons/year

R = the rainfall factor

K = the soil erodibility factor

LS = the topographic factor which combines the slope length and gradient

C = the cropping management factor

P = the erosion control practice factor

$$W_{sed} = E \cdot DR$$ Equation 21

Where:

DR = sediment delivery ratio,

Wsed = Sediment Load in tons/year

Sediment delivery ratio is calculated using:

$$DR = 0.42 \cdot A^{-0.125} \qquad if\ A < 200\ acres$$ Equation 22

$$DR = 0.417662 \cdot \mathrm{A}^{-0.134958} - 0.127097 \quad if\ A > 200\ acres$$ Equation 23

Where:

A = watershed area (mi^2).

STEPL calculates only sheet and rill erosion using USLE. Gully erosion and stream bank erosion are calculated separately.

5. Nutrient and Sediment Runoff Loads with BMP application

Pasture, Forested, and User-Defined

The nutrient, BOD, *E. coli*, and sediment load calculations after BMP application for Pasture, Forested and User-Defined landuse are given below:

$$W_{N1} = W_N - W_N \cdot e + SED_N \times 2000 \quad \text{Equation 24}$$

$$W_{P1} = W_P - W_P \cdot e + SED_P \times 2000 \quad \text{Equation 25}$$

$$W_{BOD1} = W_{BOD} - W_{BOD} \cdot e + SED_{BOD} \times 2000 \quad \text{Equation 26}$$

$$W_{ecoli1} = W_{ecoli} - W_{ecoli} \cdot e + SED_{ecoli} \quad \text{Equation 27}$$

$$SED = E \cdot DR\ (1 - e) \cdot 2000 \quad \text{Equation 28}$$

Where:

W_N, W_P, W_{BOD}, W_{ecoli} = annual N, P, BOD or *E. coli* loads (lbs)

SED = sediment load (lbs/year)

SED_N, SED_P, SED_{BOD}, SED_{ecoli}, are the nutrient loading (tons/year) from the sediment

SED_N, SED_P, SED_{BOD} and SED_{ecoli} are calculated as follows:

$$SED_N = E \cdot DR\ (1 - e) \cdot \%soil\ N\ conc \cdot 2/100 \quad \text{Equation 29}$$

$$SED_P = E \cdot DR\ (1 - e) \cdot \%soil\ P\ conc \cdot 2/100 \quad \text{Equation 30}$$

$$SED_{BOD} = E \cdot DR\ (1 - e) \cdot \%soil\ BOD\ conc \cdot 2/100 \quad \text{Equation 31}$$

$$SED_{ecoli} = E \cdot DR\ (1 - e) \cdot \%soil\ ecoli\ conc/100 \quad \text{Equation 32}$$

Where:

e = BMP efficiency

Cropland

The nutrient, BOD, *E. coli*, and sediment load calculations after BMP application for Cropland are as follows:

$$W_{N1} = (W_N - (V_{irr} \cdot C_N) \times 4047 \cdot 0.3048/454) \cdot e + (V_{irr} \cdot C_N) \times 4047 \cdot 0.3048/454 + SED_N \times 2000$$ Equation 33

$$W_{P1} = (W_N - (V_{irr} \cdot C_P) \times 4047 \cdot 0.3048/454) \cdot e + (V_{irr} \cdot C_P) \times 4047 \cdot 0.3048/454 + SED_P \times 2000$$ Equation 34

$$W_{BOD1} = (W_{BOD} - (V_{irr} \cdot C_{BOD}) \times 4047 \cdot 0.3048/454) \cdot e + (V_{irr} \cdot C_{BOD}) \times 4047 \cdot 0.3048/454 + SED_{BOD} \times 2000$$ Equation 35

$$W_{ecoli1} = (W_{ecoli} - (V_{irr} \cdot C_{ecoli}) \times 4047 \cdot 0.3048/454 \cdot 10 \cdot 453592) \cdot e + (V_{irr} \cdot C_{ecoli}) \times 4047 \cdot 0.3048/454 \cdot 10 \cdot 453592 + SED_{ecoli}$$ Equation 36

Where:

C_N, C_P, C_{BOD}, C_{ecoli} = N, P, BOD or *E. coli* nutrient concentration in agricultural area

Urban

The nutrient, BOD, *E. coli*, and sediment load calculations after BMP application for Urban land areas are given below. A separate loading value is calculated for each of the Urban landuse categories depending on whether a BMP is applied on it or not. The resulting loading from each of the nine Urban landuse categories is then summed up to calculate the total Urban load.

$$W_{N1} = W_N - W_N \cdot e \cdot \%A_{eff}$$ Equation 37

$$W_{P1} = W_P - W_P \cdot e \cdot \%A_{eff}$$ Equation 38

$$W_{BOD1} = W_{BOD} - W_{BOD} \cdot e \cdot \%A_{eff}$$ Equation 39

$$W_{ecoli1} = W_{ecoli} - W_{ecoli} \cdot e \cdot \%A_{eff}$$ Equation 40

$$W_{TSS1} = W_{TSS} - W_{TSS} \cdot e \cdot \%A_{eff}$$ Equation 41

Where:

W_{N1}, W_{P1}, W_{BOD1}, W_{ecoli1}, W_{TSS1} = annual N, P, BOD, *E. coli*, and TSS (sediment) loads from Urban land (Kg) after application of BMP

W_N, W_P, W_{BOD}, W_{ecoli}, W_{TSS} = annual N, P, BOD, *E. coli*, and TSS (sediment) loads from Urban land (Kg)

e = BMP efficiency application to the Urban landuse category

$\%A_{eff}$ = percentage of BMP effective area for each of the Urban landuse categories.

$$\text{Total N Load (lb/year)} = 2000 \times \sum_{i=1}^{9} W_{N1}$$ Equation 42

$$\text{Total P Load (lb/year)} = 2000 \times \sum_{i=1}^{9} W_{P1}$$ Equation 43

$$\text{Total BOD Load (lb/year)} = 2000 \times \sum_{i=1}^{9} W_{BOD1}$$ Equation 44

$$\text{Total ecoli Load (lb/year)} = 2000 \times \sum_{i=1}^{9} W_{ecoli1}$$ Equation 45

$$\text{Total TSS Load (lb/year)} = 2000 \times \sum_{i=1}^{9} W_{TSS1}$$ Equation 46

Where:

i refers to each of individual Urban landuse category

STEPL also calculates flow volume reductions for selected Urban LID and infiltration BMP practices for each of the Urban landuse categories.

The approach involves calculation of BMP storage capacity and the runoff volume per event. The computed BMP storage capacity is then compared with the runoff volume per event to determine the captured volume per event for the BMP (based on the minimum of both the computed volumes.

$$\text{BMP storage capacity (ac} - \text{ft)} = \text{DA} \cdot \text{PI} \cdot \text{RD}/12$$ Equation 47

$$\text{Runoff volume per event (ac} - \text{ft)} = \text{DA} \cdot \text{PI} \cdot \text{P}/12$$ Equation 48

$$\text{Captured volume per event} = \text{minimum(BMP storage capacity, Runoff volume)}$$ Equation 49

$$\text{Captured volume per year (gal)} = (\text{Per\_captured\_Vol\_per\_Event}/100 \cdot \text{DA\_Runoff\_volume}) \times 325850.58 \quad \text{Equation 50}$$

Where:

DA = BMP drainage area (acre)

PI = Percent imperviousness within the drainage area, assuming 100% by default (%)

RD = Impervious area runoff depth to be captured (in)

P = Rainfall (in) per event.

$$\text{Percent Captured Volume per Event} = (\text{BMP storage capacity}/\text{Runoff volume per event})\text{x}100 \quad \text{Equation 51}$$

Note that when the capture volume per event is equal to the runoff volume in Equation 49 then the percent captured volume is 100 percent.

$$\text{DA\_Runoff\_volume} = \text{LU\_Runoff\_volume} * \text{BMPDAAr} / \text{LUArea} \quad \text{Equation 52}$$

In addition, STEPL also provides an estimate of the required BMP surface area or the required number of BMP units depending the type of BMP chosen.

$$\text{Required BMP surface area (acres)} = \frac{\text{BMP storage capacity(ac–ft)}}{\text{Typical design BMP storage depth(ft)}} \quad \text{Equation 53}$$

$$\text{Required BMP units} = \frac{\text{BMP storage capacity(ac–ft)} \cdot 325850.58 \text{ (gal/acft)}}{\text{Typical design unit volume (e.g., rain barrel) (gal)}} \quad \text{Equation 54}$$

6. Groundwater

Groundwater infiltration is estimated as a fraction of the precipitation. STEPL uses reference soil infiltration fractions for precipitation (P) for the various landuses based on hydrologic soil group (HSG) to calculate the amount of infiltration to groundwater.

$$Infiltration\ (in) = Infiltration\ Fraction\ \times P\ (in)$$ Equation 55

The infiltrated volume or groundwater volume is then calculated as follows:

$$Infiltration\ Volume\ (ac\text{–}ft) = \frac{Infiltration\ (in)}{12} \times A\ (ac) \times (Rdays \cdot RD_{cor})$$ Equation 56

Note that for urban areas, in order to calculate the amount infiltrated, the pervious areas are first calculated. The pervious area is calculated based on the difference between the total urban area and impervious area. The impervious area is calculated based on assumed percent imperviousness for the various urban landuse categories.

$$\begin{aligned}Pervious\ Urban\ Area(ac) &= Total\ Urban\ Area - (Commercial \cdot 0.85 + \text{Industrial} \cdot 0.7 \\ &+ \text{Institutional} \cdot 0.5 + \text{Transportation} \cdot 0.95 + \text{Multi} - \text{Family} \\ &\cdot 0.75 + \text{Single} - \text{Family} * 0.3 + \text{Urban} - \text{Cultivated} \cdot 0.01 \\ &+ \text{Vacant} - \text{developed} \cdot 0.7 + \text{Open Space} \cdot 0.01)\end{aligned}$$ Equation 57

Groundwater volumes from Feedlot areas are calculated using the calculated infiltration from Urban areas and the Feedlot pervious area. The Feedlot pervious area is calculated based on the contribution from Feedlot areas and a fraction based on Feedlot percent paved area as shown below:

$$\begin{aligned}Feedlot\ Pervious\ Area(ac) \\ &= Feedlot\ Area \times pervious\ fraction\ based\ on\ feedlot\,\%\ paved\end{aligned}$$ Equation 58

Feedlot Percent Paved and associated fraction used in STEPL

Percent paved	Pervious Fraction
0-24%	0.875
25-49%	0.625
50-74%	0.375
75-100%	0.125

7. Feedlot Calculations

Pollutant loads from feedlots in STEPL are based on animal types, weight, and average rainfall. Runoff volume from the feedlots are calculated based on contributing area in acres, feedlot percent paved, and average event rainfall in inches.

$$V\ (ac\text{–}\ in) = Q\ (in) \cdot A(ac) \qquad \text{Equation 59}$$

Where:

A = contributing feedlot area (acres)

Q = surface runoff (inches) and is calculated as

The surface runoff (Q) calculations are based on the SCS runoff curve number method as discussed in Section 2-Surface Runoff. Note that the CN used in the runoff calculations is estimated based on the selected range of percent imperviousness in the feedlot.

Nutrient contributions in cropland from animals are used to derive load estimates for feedlots. The equivalent animal units (EAU) for N, P, BOD, and *E. coli* (*E. coli* currently is just a place holder) are first calculated using the equation below for each watershed.

$$EAU = No. \times Factor \qquad \text{Equation 60}$$

Where:

No. = number of animals

Factor = Ratio of nutrients produced by animals relative to 1000 lb. of slaughter steer

The Animal Unit Density (AUD) and % manure pack using the following equation:

$$AUD = \ EAU\ /\ A \qquad \text{Equation 61}$$

If AUD < 100, percent manure pack = AUD;

If AUD > 100, percent of manure pack = 100%

Finally, the pollutant concentration of in the feedlot runoff is calculated using the following equation:

$$C_{feedlot} = \ Fraction\ of\ manure\ pack \times \ Constant \qquad \text{Equation 62}$$

Where:

$C_{feedlot}$ = runoff concentration from Feedlot (mg/L)

Fraction of manure pack = manure pack/100

Constant is pollutant specific and based on 100% manure pack. N constant = 1500 mg/L, P constant = 300 mg/L, and BOD constant = 2000 mg/L

The calculated runoff volume and concentration from Feedlots (Equation 59 and Equation 62) are then used to calculate the Feedlot loading.

$$W_{feedlot}(lb/year) = V\ (ac\text{–}in) \cdot\ (Rdays \cdot RD_{cor}) \cdot C_{feedlot}(mg/L) \cdot 0.227 \qquad \text{Equation 63}$$

8. Septic Load

The septic load is calculated as the sum of the failing septic load and the direct wastewater loading.

$$\text{Septic Load}\left(\frac{\text{lb}}{\text{year}}\right) = \left[\text{Failing Septic Load}\left(\frac{\text{lb}}{\text{hr}}\right) + \text{Direct Wastewater Load}\left(\frac{\text{lb}}{\text{hr}}\right)\right] \times 24 \times 365$$

Equation 64

The Failing Septic Load and Direct Wastewater Load calculations are shown below.

Failing Septic Load

The failing septic load is calculated using the failing septic flow and an average concentration reaching the stream from septic overcharge. The failing septic flow is calculated using the number of septic systems (tanks), the failure rates (percentage), and the ratio of persons per septic system.

$$\text{Failing Septic Load}\left(\frac{\text{lb}}{\text{hr}}\right) = \left[\text{Failing Septic Flow}\left(\frac{\text{L}}{\text{hr}}\right) \times \text{Avg. concentration reaching stream from septic overcharge}\left(\frac{\text{mg}}{\text{L}}\right)\right]/453592$$

Equation 65

Where:

$$\text{Failing Septic Flow (L/hr)} = \text{Population of Failing Septic (persons)} \times \text{Typical Septic Overcharge Flow Rate (gal/day/person)} \times (3.785412/24)$$

Equation 66

The population of failing septic is calculated as follows:

$$\text{Population of Failing Septic (persons)} = \text{No. of Septic Systems} \times \text{Population per Septic System} \times \text{Septic Failure Rate\%}$$

Equation 67

Typical Septic Overcharge Flow Rate in STEPL is 70 gal/day/person (range of 45 to 100).

The average concentration reaching the stream from septic overcharge are determined based on ranges observed in literature for Total Nitrogen, Total Phosphorous, and Organics (BOD) (as specified in the STEPL model). Note *E. coli* is included but currently a placeholder as no values are populated.

Direct Wastewater Load

$$\text{Direct Wastewater Load}\left(\frac{\text{lb}}{\text{hr}}\right) = \left[\text{Direct Wastewater Flow}\left(\frac{\text{L}}{\text{hr}}\right) \times \text{Avg. concentration}\left(\frac{\text{mg}}{\text{L}}\right)\right] / 453592$$

Equation 68

Direct wastewater flow is calculated based on per capita flow 75 gal/day/person (range of 75 to 125) and the specified direct discharge population as:

$$\text{Direct Wastewater Flow}\left(\frac{\text{L}}{\text{hr}}\right) = \text{percapita flow (gal/day/person)} \times \text{direct discharge population(persons)} \times (3.785412/24)$$

Equation 69

Average concentrations reaching the stream from wastewater load as specified in STEPL for Total Nitrogen, Total Phosphorous, and Organics (BOD). Note *E. coli* is included but currently a placeholder as no values are populated.

9. Gully Erosion Load

The annual load due to Gully Erosion (GE) for each watershed is calculated as the sum of the all the impaired Gully loading as follows:

$$\text{GE Sediment Load (lb/year)} = 2000 \times \sum_{i=1}^{n}[(\text{TW}+\text{BW})\cdot \text{D}\cdot \text{L}\cdot \text{Wt}/\text{T}/2]$$ Equation 70

$$\text{GE Nitrogen Load (lb/year)} = 2000 \times \%\ \text{Soil N Conc} \times \sum_{i=1}^{n}[(\text{TW}+\text{BW})\cdot \text{D}\cdot \text{L}\cdot \text{Wt}\cdot \text{NCF}/\text{T}/2]$$ Equation 71

$$\text{GE Phosphorous Load (lb/year)} = 2000 \times \%\ \text{Soil P Conc} \times \sum_{i=1}^{n}[(\text{TW}+\text{BW})\cdot \text{D}\cdot \text{L}\cdot \text{Wt}\cdot \text{NCF}/\text{T}/2]$$ Equation 72

$$\text{GE BOD Load (lb/year)} = 2000 \times \%\ \text{Soil BOD Conc} \times \sum_{i=1}^{n}[(\text{TW}+\text{BW})\cdot \text{D}\cdot \text{L}\cdot \text{Wt}\cdot \text{NCF}/\text{T}/2]$$ Equation 73

Where:

TW = top width (ft)

BW = bottom width (ft)

D = depth (ft)

L = length (ft)

Wt. = Soil Dry Weight (ton/ft3) – based on soil textural class

NCF = Nutrient correction factor – based on soil textural class

T = time (number of years) that the gully has taken to form the current size

STEPL uses default 0.08, 0.031, and 0.160 % soil nitrogen, phosphorous and BOD values which can be updated.

The gully erosion load reduction is calculated using a specified BMP efficiency due to gully stabilization (0 to 1) as follows:

$$\text{GullyErosionLoad Reduction} = \text{GullyErosionLoad} \times \text{BMP Efficiency}$$ Equation 74

10. Impaired Streambank Load

The annual load due to Streambank (SB) Erosion for each watershed is calculated as the sum of the all the impaired stream bank loading as follows:

$$\text{SB Sediment Load (lb/year)} = 2000 \times \sum_{i=1}^{n} \text{L} \cdot \text{H} \cdot \text{LRR} \cdot \text{Wt}$$ Equation 75

$$\text{SB Nitrogen Load (lb/year)} = 2000 \times \%\ \text{Soil N Conc} \times \sum_{i=1}^{n} \text{L} \cdot \text{H} \cdot \text{LRR} \cdot \text{Wt} \cdot \text{NCF}$$ Equation 76

$$\text{SB Phosphorous Load (lb/year)} = 2000 \times \%\ \text{Soil P Conc} \times \sum_{i=1}^{n} \text{L} \cdot \text{H} \cdot \text{LRR} \cdot \text{Wt} \cdot \text{NCF}$$ Equation 77

$$\text{SB BOD Load (lb/year)} = 2000 \times \%\ \text{Soil BOD Conc} \times \sum_{i=1}^{n} \text{L} \cdot \text{H} \cdot \text{LRR} \cdot \text{Wt} \cdot \text{NCF}$$ Equation 78

Where:

L = length (ft)

H = height (ft)

LRR = lateral recession rate (ft/yr) – based on categorization of LRR i.e. slight, moderate, severe or very severe

Wt. = Soil Dry Weight (ton/ft3) – based on soil textural class

NCF = Nutrient correction factor – based on soil textural class

STEPL uses default 0.08, 0.031, and 0.160 % soil nitrogen, phosphorous and BOD values.

The stream bank load reduction is calculated using a specified BMP efficiency due to stream bank stabilization (0 to 1) as follows:

$$\text{StreamBankLoad Reduction} = \text{StreamBankErosionLoad} \times \text{BMP Efficiency}$$ Equation 79

Appendix F: Release Notes

RELEASE NOTES:
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March 2018

Version 4.4 release.

1. Updated runoff depth calculation formula. The revised equation removed the hardcoded coefficient of 0.8 in the denominator, which is valid only when the specified initial abstraction is 0.2. The revised equation is general and takes into account the specified initial abstraction coefficient (set to zero by default which is recommended for STEPL) and correctly accounts for the initial abstraction.
2. Fixed Feedlot Pervious area calculation to correctly calculate the area.
3. Fixed load reduction calculation formula refernces for Forested and User-defined landuse. Beta release had incorrect references to the BMP reduction efficiencies for Forested and User-defined landuse.
4. Added a reporting/logging capability to export/save intermediate Combined BMP efficiency calculations.

September 2017

Version 4.4 (beta) was released.

Updates in this version include:
1. adding new agricultural BMPs (cropland and pastureland) and updating the pollutant efficiency numbers for nutrients.
2. adding new weather stations and updating the weather data for the entire country.
3. adding manure application on pastureland. The previous versions provide manure applications on cropland only.
4. adding a new worksheet to calculate the average number of months for manure application with varying application frequency across the watershed.
5. adding flow volume reductions for infiltration practices on urban land use.
6. adding a new worksheet to calculate the combined efficiency from multiple types of management practices on the same landuse category.
7. adding a simple optimization algorithm (Excel Solver) to identify the extent of treatment areas to meet the load reduction target from the given BMP types (customized spreadsheet model).
8. adding two customized spreadsheet models with 10 watersheds and 30 watersheds
9. adding a new pollutant E.coli as a place holder for next release.
10. adding a reporting function to export the model input/output summary tables and plots in a word document.

March 2014

Version 4.3 was released.

Updates in this version include:
1. updating Puetro Rico weather dataset (increased stations from 5 to 21) using the daily NCDC rain gages.
2. summarizing average annual rainfall (1981-2013) at the station level (not at county) and counting the days if rainfall > 5 mm/day.
3. filtering the weather stations pick list in STEPL spreadsheet model based on the user selected state.

April 2013

Version 4.2 was released.

Updates in this version include:
1. adding Puetro Rico dataset at the local assessment unit boundaries.
2. modifying BMP calculator tool for a bug fix.
3. adding an option to create STEPL model in Excel 2010 format.

December 10,2006

Version 4.1 beta was released.

New features added:
1. The program was modified to work with Excel 2007.

October 28, 2006

1. Users can now calculate gully and streambank erosion in the new Gully&Streambank worksheet.
2. Users can now calculate pollutant loading from shallow groundwater using the groundwater option on the Input worksheet.
3. Users now have the option (on the Input worksheet) to calculate pollutant loads for:
    (1) the entire watershed (treat all the subwatersheds as the pats of a larger watershed, considering sediment transport routing loss in the watershed), or
    (2) the individual watershed or project area (treat subwatersheds or areas as independent project areas, no watershed transport routing is considered).

September 29, 2005

1. Users can now specify partial area BMP applications in the BMPs worksheet.

March 29, 2005

1. A bug related to the urban BMP application area is fixed

September 24, 2004

Version 3.0 beta was released.

New features added:

1. Rainfall correction factors have been compiled and incorporated into the model.
2. Model can now estimate load reductions from projects dealing with direct wastewater discharge
3. Model can now estimate load reductions from projects dealing with runoff reduction from irrigation conservation.
4. Model can now estimate load reductions from projects dealing with Low Impact Development.
5. Users can now copy the calculated BMP efficiencies from BMP calculator to STEPL Excel sheets.

July 28, 2003

Version 2.2 was released.
The best management practice database can be changed, added, and deleted through the BMPList worksheet.

December 14, 2001

A BMP calculator was developed (Visual C++) and linked to the STEPL in this release. Changes were made in STEPL to use the composite BMP efficiencies from the BMP calculator.

October 18, 2001

This is the readme file of STEPL 2.0

1. System Requirements

    Windows 95/ 98/ NT/2000.
    MS Excel 97/2000. MS Excel 2000 is recommended.
    30 MB hard disk space.

2. Installing STEPL

To install STEPL, you run the setup.exe in the distribution CD.
STEPL can also be downloaded as a zipped file.
If you downloaded the STEPL2.zip file, unzip it to a temporary directory and then run the setup.exe program.
It is recommended that you install STEPL in the default STEPL folder on the target drive.
Reboot your computer.

3. Tips

- Set your Excel security level to Medium.
- Enable Macros when you start a file created by STEPL program.
- Study the 'sample.xls" or "sample97.exe" examples with the User's Guide.
- As you become more and more familiar with STEPL, you may change parameter values in the optional input tables, or view the hidden sheets and tables.

Contact stepl@tetratech.com for more information about STEPL.

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