2015

Rural Subwatershed Analysis Protocol

PART 2-PRIORITIZING

CREATED BY THE CHISAGO SOIL & WATER CONSERVATION DISTRICT

Version 1.0 March 2015

1 CONTENTS

2 PROTOCOL DEVELOPMENT

Urban Subwatershed Retrofit Assessments (SRAs) have been an important tool for many organizations to help identify and rank the top priority Best Management Practices (BMPs) in urban areas. A standardized protocol was developed for completing SRAs. There was interest in completing a similar targeting and prioritizing analysis for rural areas. Due to major differences in the landscape and water movements in urban and rural areas, the urban SRA protocol is not sufficient in assessing rural areas. Therefore, this document outlines a protocol for Rural Subwatershed Analysis.

This is PART 2 of a 2-part document. Part 1 describes the protocol for targeting the subwatershed or catchment of highest priority. Part 2 describes prioritizing and identifying specific projects within the targeted subwatershed or catchment.

3 TOP 50P! PROJECT

Washington Conservation District developed the Fixing the Top 50 Rural Nonpoint Phosphorus Sources Project (Top50P!). This project is a focused effort to identify, implement, and assess prioritized phosphorus reduction practices in rural areas. The original project was developed for directly contributing tributary areas to Lake St. Croix.

The Top50P! Project protocol was outlined in a document produced by Washington Conservation District titled Rural Subwatershed Analysis Protocol. *The same protocol, along with any changes, additions, or enhancements to the original protocol, is included in this document*. Therefore, it should not be necessary to have the original Top50P! protocol document to conduct a rural subwatershed analysis.

4 ASSUMPTIONS OF THIS DOCUMENT

This is a technical document with specific instructions in how to perform the rural subwatershed analysis protocol. This document is intended for persons who are familiar with advanced GIS operation. The following is a list of assumptions of this document:

- The reader is fluent in the operation of GIS. These instructions are written using ArcMap 10.1.
- The reader has the Spatial Analyst Tools extension (requires a separate license). If you are on a USDA server, the USDA holds a license so the extension should be available to you.
- **Grids used in this protocol are 1 meter size.** If using a different grid size, substitute the grid size throughout the process whenever the instructions say to use 1 as the output cell size.
- In prompt boxes, if the instructions do not indicate an input into a certain box, use the default.
- NRCS's Engineering Tools are used to delineate watersheds and create stream networks.
- Display adjustments of the outputs are not discussed here. The user can adjust the display of the output to best suit their specific needs.
- The reader has access to RUSLE2 software.
- The reader has access to the BWSR Pollution Reduction Calculator (available for download on the BWSR website).

5 WHEN TO SKIP PART 1

This protocol is divided into two parts because many users may be able to skip part one and start with part 2. Part one discusses how to target a subwatershed or catchment within a larger watershed. The results of part one guide the user in choosing which subwatershed(s) or catchment(s) to focus grant funding and technical staff time on in order to achieve the greatest potential pollution reduction.

In many cases, the specific subwatershed or catchment is already determined for the user, often by what grant funding is available. For example, a grant may require that funds are spent only within a certain small watershed or within a certain subwatershed of a larger watershed. In this case, the user can skip part one and start the assessment process at part 2.

6 PRIORITIZING

Now that the area of highest potential soil erosion and phosphorus loading has been targeted, prioritizing can be done on a smaller scale within the targeted subwatershed or catchment.

6.1 SETTING THE RULES

Before starting the desktop analysis, it is helpful to set some rules so that a consistent approach is followed throughout the process. The rules described in this document reflect what was set by the Chisago SWCD during the rural assessment analysis. It is okay to change these rules to better suit your specific project. Just make sure to set these rules and stick to them throughout the assessment.

6.1.1 Level of Assessment

There are a range of potential erosion issues and BMP locations on the landscape. The severity and importance vary. Some are large issues (major gullies) while some are small (shallow erosion on agricultural fields). When performing the desktop scouting, every potential problem regardless of size can be marked, or a threshold can be set. For example, small erosion seen in agricultural fields can be marked or left unmarked. These small areas are less likely to be high priority in the end and therefore may clutter the final report. On the other hand, they could become a larger problem in the future. By identifying them, they are in the report for future investigation. Similarly, some wetlands drain through a wetland. Will these wetlands still be included as possible restorations or will they be left out in favor of wetlands that drain directly into lakes or rivers?

Decide what scale of marking to use in the desktop scouting step. For this protocol, it will be assumed that all potential issues will be marked, regardless of size or severity.

6.1.2 Current Land Cover

Land cover can change annually, especially on agricultural fields. For this assessment, potential erosion issues that were located on hay fields or in herbaceous areas were marked and included in the final report. The concentrated flow path may not be causing any erosion while the field is in hay, but what if the field is converted to an annual row crop? If the potential issue is marked, it will be in the assessment and ranked so that if it is converted, it can be addressed. This will be mentioned again in the modeling section, but all agricultural fields will be modeled as if the current land cover is an annual row crop (corn or soybeans). This is done to reflect an accurate ranking among other fields if the hay field is converted. A note is made in the project profile that the current cover at the time of the report is hay so that the reader knows the site is a potential problem if and when the land cover changes.

6.1.3 Terminology

During desktop scouting, different levels of erosion will be evident. There are many terms used, sometimes interchangeably, for erosion, including ravine, sheet and rill, and gully. Likewise, the terms "ditch" and "surface water" can have different meanings to different people. Table 1 defines what terms were used in this protocol and their definitions.

Table 1. Definitions

Term	Definition
Gully	A large, perennial erosion problem that is not located in an agricultural field. These are often located on the edge of the field.
Concentrated Flow Path	A path where water congregates and runs, often causing erosion. In agricultural fields, these are farmed through. These can also be located in hay fields, pastures, and grasslands where they are not causing erosion large enough to be called a gully.
Ditch	An excavated waterway that is not farmed through. Usually at least 1 foot deep or more. If the farmer goes around it, it is a ditch. If they go through it, it is a concentrated flow path.
Surface Water	Perennial streams, intermittent streams, or ditches that connect directly to streams or lakes; wetlands with perennial surface water that contribute to a stream or lake; and lakes. Isolated basins, if present, are not considered surface water.

6.2 Desktop Scouting

The goal of this step is to locate as many potential issues or BMP sites as possible using GIS before going out into the field. Although it takes some time, the best method known to date is to simply scan around the subwatershed or catchment looking for these locations. There are some very helpful layers to include in the project (Table 2).

Table 2. Layers for Aerial Scouting

Layer	Helpful Hints
Aerial photos	Use as many different photo years as possible. Some issues may be obvious on one photo and not show up at all on another.
Hillshade	Hillshade shows the topography of the land and is excellent for picking out gullies and ditches. Use in combination with a color-ramped DEM for maximum advantage. Also, experiment with the transparency level to improve viewing.
1-Foot contours	Concentrated flow paths on fields and gullies are generally easy to pick out from contours for an experienced GIS user.
Feedlots	The registered feedlot layer helps pinpoint feedlots, but remember this only shows those feedlots that are registered. There may be other animal operations that should be marked. Find these by scanning aerial photos.

6.2.1 Mark Potential Erosion Issues and Pollutant Sources

While scanning around the aerial photos, be sure to switch back and forth between all the layers to get a complete picture of the site. Some things are obvious on one layer but invisible on another. For example, you may not notice a ditch on an aerial photo, but it sticks out on the hillshade layer.

Table 3 shows what problems to look for and mark during this step. There may be additional categories that should be added to this table, depending on the subwatershed being analyzed. The exact category or BMP is not critical or identified in this step; this step simply marks where there may be a problem.

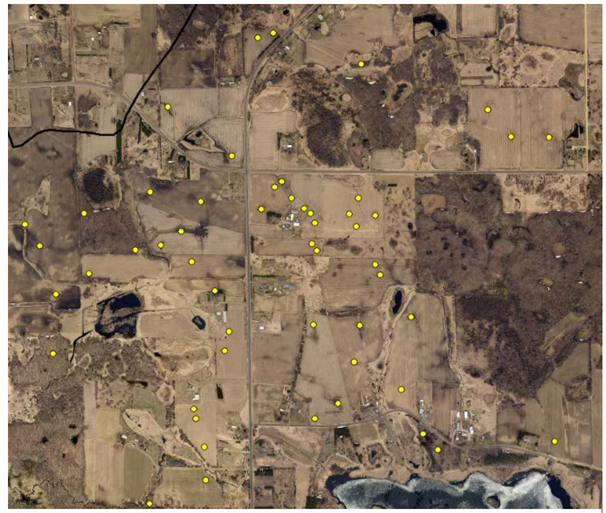


Figure 1. Potential Issues Marked During Desktop Scouting

> *Helpful Hint: See Appendix B - Desktop Scouting Examples for examples of what these categories look like in GIS.*

Table 3. Potential Issues to Mark during Scouting

Category	Description
Gully	A large erosion issue, often having been active for 100 years or more. Best located using contours and/or hillshade layers. Mark the head of the gully.
Concentrated Flow Path	Areas where water concentrates and flows, causing erosion. Erosion can vary from minor to severe. Mark these locations regardless of current land cover because land cover can change, especially in agricultural fields. Use as many layers as possible to pick these out.
Ditches and Streams	Mark the areas that need a filter strip. Any agricultural field that is worked to within 50 feet of a ditch or stream should be marked. Best identified from contours and hillshade.
Pastured Wetlands	Any pastured areas that include or are directly adjacent to a wetland or surface water should be marked. Locating pastures is easiest by reviewing aerial photos, looking for fences, bare soils, and short vegetation. Using the NWI layer helps determine if there is a wetland, but mark the location even if it isn't identified on the NWI and obvious wetlands can be seen on the aerial.
Animal Operations	Feedlots are the most critical to mark. However, some subwatersheds don't have many feedlots, but many have other large animal operations that cause pollution concerns. Mark these.
Stream bank/Shoreline Erosion	Use the contours and hillshade along streams and lakes to look for any areas with very steep slopes. Bank slumping can sometimes been seen on contours.

- Create a new shapefile to mark potential BMP locations in. A point shapefile works well.

> *Helpful Hint: If you do not know how to create a new shapefile, see Appendix A -* Creating a New Shapefile *for step-by-step instructions.*

- Start editing. Put a point where a possible issue or the need for a BMP is evident.

> *Helpful Hint: Mark everything that might be a problem. The field review will help determine if it is really an issue or not. Not everything that is marked in this step has to end up in the final report.*

- Save edits and stop editing.

SUGGESTED FILENAME: WATERSHED_SCOUTING

6.2.2 Identify Steep Slopes

It is easiest to manipulate the display settings on a slope raster to show only the areas that have slopes in excess of 6%. Any slopes over 6% are considered very likely to have sheet and rill erosion and would benefit the most from having permanent vegetation planted.

If you completed Part 1 of this protocol, you should have created a slope raster. Open the properties box on that shapefile by right clicking the layer and selecting Properties.   Check the Source tab to determine if the slope raster was created using Percent Rise or Degrees. If it is Degrees, create a new slope raster using Percent Rise.

Tool Path
ArcToolbox
Spatial Analyst Tools
Surface
Slope

If you did not complete Part 1 of this protocol, you will need to create a slope raster using the instructions below.

- In ArcMap, make sure you have a DEM raster of the subwatershed or catchment in the project.
- Open the Slope tool.
- The input raster is your DEM raster. Choose a location for your output raster.

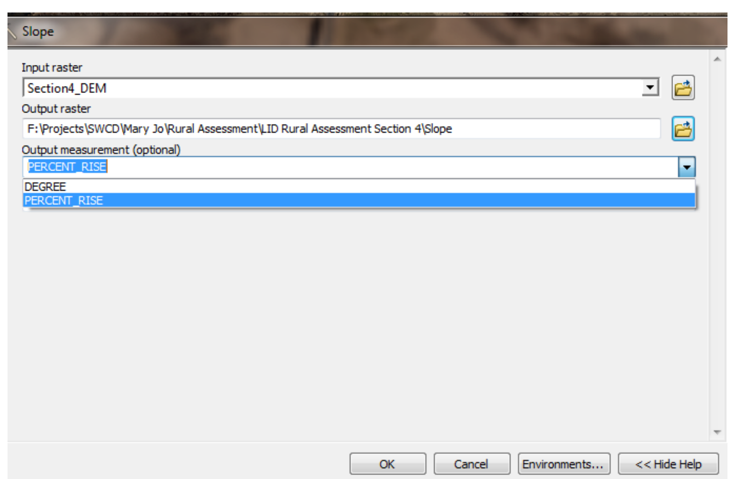


Figure 2. Create Percent Rise Slope Raster

SUGGESTED FILENAME: WATERSHED_SLOPE

- In the output measurement dropdown menu, choose PERCENT RISE and then select OK.
- A new raster should be created into the Table of Contents.
- Right click on this layer and select properties. Open the Symbology tab. By default, the Classified option should be selected in the left hand box. If it's not, select Classified.

- In the Classification section, choose 2 in the Classes drop down menu.
- Then click on Classify. In the Break Values box on the right hand side, adjust the two classes so that they break at 6%. There should be two values in the box. Click on the first one and type in 6. The second one can remain as is.
- Click Ok to return to the Properties box. There should now be 2 boxes showing with a range of 0-6 and 6-the highest slope value you have. Change the color of the class 0-6 to show no color. Select OK.
- The slope raster should now only show slopes over 6%.
- Create a new polygon shapefile.
- Begin editing.
- Scan the agricultural fields within the subwatershed or catchment.
- Draw a polygon around the fields (or portions of fields) with more than 33% of the total field having slopes over 6%.
- Save edits and stop editing.

SUGGESTED FILENAME: WATERSHED_PERMVEG

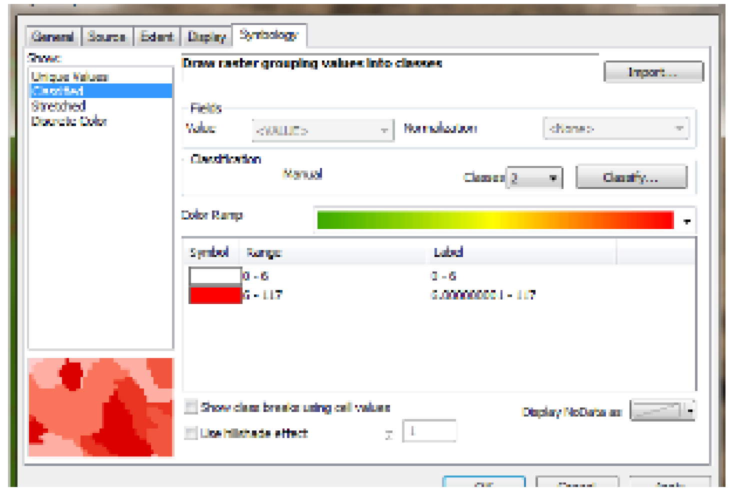


Figure 3 Slope Properties Box

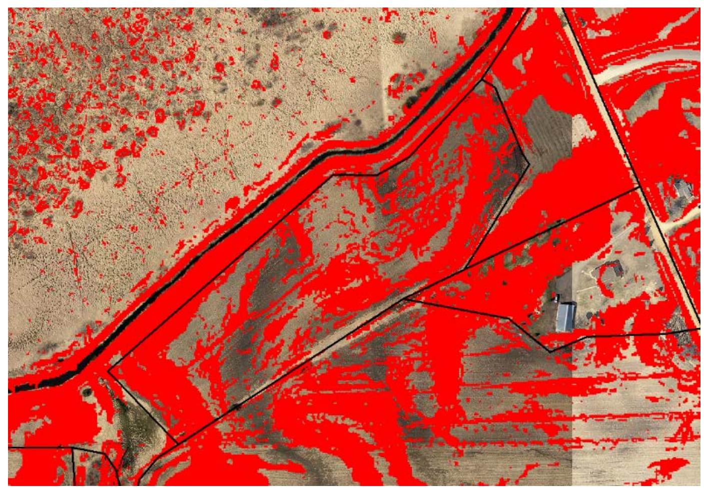


Figure 4. Slopes greater than 6%

6.2.3 Potentially Restorable Wetlands

Many wetlands have been manipulated by ditching and draining. Restoring the hydrology to these wetlands may provide nutrient and sediment removal from stormwater runoff.

For this protocol, wetlands that are a Type 1 or Type 2 and have been partially ditched or drained are marked as potentially restorable. Type 1 wetlands are seasonally flooded basins or floodplains. Type 2 wetlands are wet meadows. After disturbance, these wetlands often become a monoculture of reed canary grass.

Many wetland restorations are not possible or not feasible for a variety of reasons (number of landowners involved, location of wetland, watershed to wetland ratio). For this assessment, all of the wetlands that met the Type 1 or 2 and partially ditched or drained criteria were included. Certain wetland restorations that are not feasible now may become feasible in the future. If desired, professional judgment can be used to rule out certain wetlands so that they are not included in the final report.

- Create a new polygon shapefile.
- Turn on the NWI and the 2013 updated NWI layers.

- Manipulate the display settings so that only Type 1 and Type 2 wetlands are displayed.
- Begin editing the new shapefile.
- Use the Trace tool to copy the outline of Type 1 and Type 2 wetlands that have a visible ditch. The hillshade layer can help detect ditches.

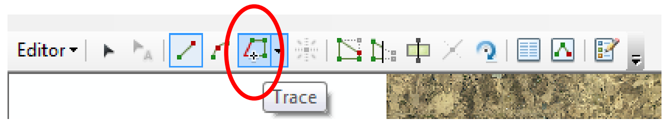


Figure 5 Trace Tool in Editor Toolbar

> *Helpful Hint: Some NWI polygons have a modifier code of "d" to indicate the wetland is ditched. However, there are drained wetlands that do not have the modifier code listed, so make sure to also do a visual search for a ditch channel on all qualified wetlands.*

- Save edits and stop editing.

SUGGESTED FILENAME: WATERSHED_WETLAND RESTO

6.3 Field Review

Once all potential erosion and nutrient loading issues are marked in the GIS project, field verification should be conducted. Print maps that display the marked locations and drive around the subwatershed. Note the location, number, and type of animals in the subwatershed. Verify or discount as many of the marked potential issues as possible. It is not practical to meet with every landowner to verify marked potential issues that cannot be verified from the road. Make notations on the maps to confirm or remove the marked potential issues.

The protocol for the Top50P! project has much more in-depth instructions for field review, including templates to fill out for each issue that is reviewed during the field verification. For the Chisago rural subwatershed assessments, these templates were not used and field review was not as in-depth.

6.4 BMP Identification

This step takes the desktop scouting and field verification information and translates it into a series of specific BMP shapefiles. Table 4 lists the potential erosion issues and pollutant sources that were marked and located during the previous steps and indicates what BMP should be prescribed, as well as what type of new shapefile to create for each.

Table 4. Shapefiles for BMP Identification

Erosion Issue/Pollutant Source	BMP	Shapefile Type	Display
Gully	Gully stabilization	Line	Green, dotted, drawn along length of gully
Concentrated Flow Path-Plowed through	Grassed waterway	Line	Yellow, dashed, drawn along length of concentrated flow path
	Water and sediment control basin	Point	Red, placed at location for WASCOB

Concentrated Flow Path-Edge of field gully	Water and sediment control basin	Point	Red, placed at edge of field and head of gully
Ditch or stream-within 50 feet of active agricultural field	Filter Strip	Line	Green, solid, drawn along location where filter strip is needed
Animal Operation	Various	Polygon	Yellow outline, drawn around feetlot or animal operation
Pastured Wetland	Various	Polygon	Purple outline, drawn around pasture
Steep Slopes*	Permanent Vegetation	Polygon	Turquoise outline, drawn around portion of field to be converted to permanent vegetation
Ditched/Drained Wetland*	Wetland Restoration	Polygon	Purple outline, drawn around wetland
Streambank/Shoreline Erosion	Various	Line	Dark blue, solid, drawn along the portion of the bank that is eroding

*The shapefiles for these categories were already created in the desktop scouting step.

SUGGESTED FILENAMES: WATERSHED_(CHOOSE ONE:WASCOB, WATERWAY, GULLY, FILTERSTRIP, ANIMALOP, PASTURE, BANKEROSION)

The Top50P! protocol instructs users to also document wind erosion, land application of manure, bluffs, and low-density residential development. There are certainly other potential issues that may be relevant in a subwatershed or catchment. There is flexibility for choosing those potential BMPs to include in the rural subwatershed assessment for each individual report.

Helpful Hint: When deciding which BMPs to include in the report, consider the ability to model potential pollution reduction values and if these values can be ranked against other BMPs.

- Turn on the Watershed_Scouting layer. Use this layer and the notes from the field verification to guide you around the subwatershed or catchment.
- Determine what BMP should be used at each of the potential erosion issues and pollutant sources. Make the appropriate mark in the appropriate shapefile until all of the original marks have been allocated to a shapefile or discounted as not being an issue. Use Table 4 to guide these decisions. For personnel familiar with installing grassed waterways and water and sediment control basins, use your professional judgment to mark the BMP that would be best suited to the location.

Helpful Hint: If you are not familiar with how the determination is made between a grassed waterway and a water and sediment control basin, don't spend too much time debating. Set a protocol for yourself and follow it. For example, any concentrated flow paths that have a 6 foot elevation change over 100 feet should be marked as a WASCOB.

6.5 Set Modeling Rules

There are several inputs into the various calculators that have a consistent value during all calculations. Make the decision for each of the following rules and stick with that throughout the modeling process. If you change an input part way through the assessment, the output potential pollution reduction values you get will not be comparable to the values of other projects of the same BMP.

6.5.1 Base Management Practice

In the RUSLE2 model, a base management practice must be chosen. Virtually any combination of management practices can be used. Choose a management regime that is common to the subwatershed or catchment being assessed. For example, in Chisago County most of the farmers conduct fall tillage and plant a corn/soybean rotation. Therefore, the management chosen was “Corn FC Disk Fld Cult- Soybeans FC Disk Fld Cult” (located under CMZ 04, Multi-year Rotation Templates, Corn-Soybeans, CB mulch till).

> *Helpful Hint: Double click on the yellow folder icon next to Base Management to get more information. This allows the user to manipulate the base management to precisely match a specific regime if desired.*

6.5.2 Permanent Vegetation Management Practice

When determining the reduction in soil loss achieved by converting a field in annual row crop production to permanent vegetation, a “permanent vegetation” base management will be used. Choose one that represents a stable vegetation base. For Chisago, the management chosen was “Established Alfalfa, Year 4” (located under CMZ 04, Single Year/Single Crop Templates, Forages, Alfalfa late summer direct seed).

6.5.3 Contouring

In the RUSLE2 model, one of the inputs is called “Contouring”. This refers to the direction of the ridges left by operations that disturb the soil, such as tillage. The direction of the ridges affects how water runs off the field. Water is able to pool in ridges that run across the slope; the water will overflow the ridge when the space behind the ridge is full. In contrast, rows that run up and down the slope do not affect water because the water runs straight down the space between the ridges. There are a variety of settings in between that can be chosen as well.

For the Chisago rural subwatershed assessment, a value in the middle was chosen (relative row grade 50%). Regardless of the choice, set the same value for every time the model is run.

> *Helpful Hint: In RUSLE, the user can right click on any of the inputs and select Help. The help box provides information on what the input is and how to determine it.*

6.5.4 Number of Years

In the BWSR Pollution Reduction Estimator spreadsheet, on the Gully tab, one of the inputs is Number of Years. This value greatly effects the output value. For concentrated flow paths that are farmed through every year, use the value of 1 year. In some cases there are concentrated flow paths in the field that are farmed around, but are not major gullies. These were modeled using 30 years. For large edge-of-field or other perennial gullies, use 100 years (about the beginning of the “farming age”).

6.5.5 Gully Channelization

In the BWSR Pollution Reduction Estimator spreadsheet, on the Gully tab, one of the inputs asks if the gully is channelized, non-channelized, or landlocked. According to the instructions, a value of 1 should be used if the gully is channelized and outlets directly into a surface water. If the gully fans out before reaching surface water, use a value of 2 for non-channelized. Do not use the landlocked option.

6.6 BMP Modeling

The challenge of ranking potential projects is finding a way to be able to compare different BMPs with pollutant reduction numbers derived from different modeling systems against one another. In most cases, it may not be possible. There is no known way to directly compare the pollution reduction gained from a feedlot fix versus a grassed waterway. This protocol ranks the BMPs for filter strips, water and sediment control basins, and grassed waterways together. Separate ranking tables are provided for gully stabilization projects that are not water and sediment control basins, for animal operations, for pastured wetlands, for permanent vegetation conversion, and for wetland restorations.

For practices that have a potential pollution reduction value and an approximate cost, a cost per pound of phosphorus reduction can be determined. This value can be directly compared to other BMP types if desired.

The Board of Water and Soil Resources (BWSR) Pollution Reduction Estimator is used for modeling filter strips, water and sediment control basins, grassed waterways, gullies, and permanent vegetation conversion fields. This spreadsheet is available for free download from the BWSR website on the eLINK page (http://www.bwsr.state.mn.us/outreach/eLINK/index.html). The link is located in the right hand side column. There is also an instruction document available for download in the same location. The spreadsheet has four tabs: sheet and rill, gully, stream and ditch, and filter strip. The sheet and rill and filter strip tabs require inputs from RUSLE to calculate potential pollution reduction.

6.6.1 Filter Strips

The BWSR Pollution Reduction Estimator spreadsheet is used for modeling filter strips. RUSLE2 is needed to determine certain inputs.

- Open the Filter Strip tab in the BWSR Pollution Reduction Estimator
- In ArcMap, open the Attribute Table for the filter strip shapefile (right click on the layer and click Open Attribute Table).
- Add columns to the Attribute Table according to Table 5. In the open Attribute Table, click on the first icon with a drop down menu and select Add Field. **This can only be done when the shapefile is not being edited**.

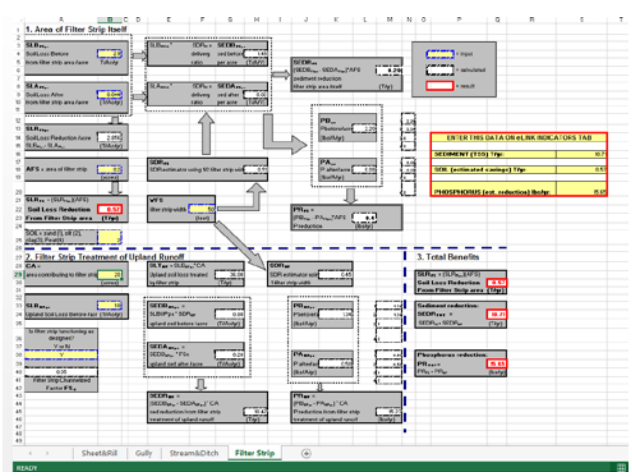


Figure 6. BWSR Pollution Reduction Estimator for Filter Strips

Table 5. Attribute Table Columns

Column Name	Type	Length/ Precision
Landcover	Short Integer	Default
TP	Float	Default
TSS	Float	Default
Sediment	Float	Default

Helpful Hint: It is important to record the inputs to each model. Some people find it helpful to include columns for all the modeling inputs in the Attribute Table in ArcMap. The benefit to this is that all the model inputs are saved in case there is a need to review the model. However, it is time-consuming to input all of the data for every attribute, especially if you have to switch back and forth between screens. See Appendix C - Attribute Tables for additional columns that could be included in the Attribute Table to record all necessary model input data. Also available in Appendix C - Attribute Tables are templates that can be printed out and manually filled in with the model input data. This may be easier than trying to do it on the computer.

- When all of the desired columns have been added to the Attribute Table, start editing the shapefile. Right click on the layer and select Edit Features, then Start Editing. You will need to make sure you have the correct Template selected in the
- Open RUSLE2 program. Open a new profile.

Helpful Hint: If you are not familiar with running RUSLE, use the Simple Template. Click on Options, Template, Load and select the NRCS Simple Template for your area.

- Location: Should be set to your county already.
- Soil: Choose the most dominant soil type for the area of the filter strip itself (the 50 feet adjacent to the stream or ditch).
- Slope Length: 50
- Avg. Slope Steepness: In ArcMap, measure the difference in contours

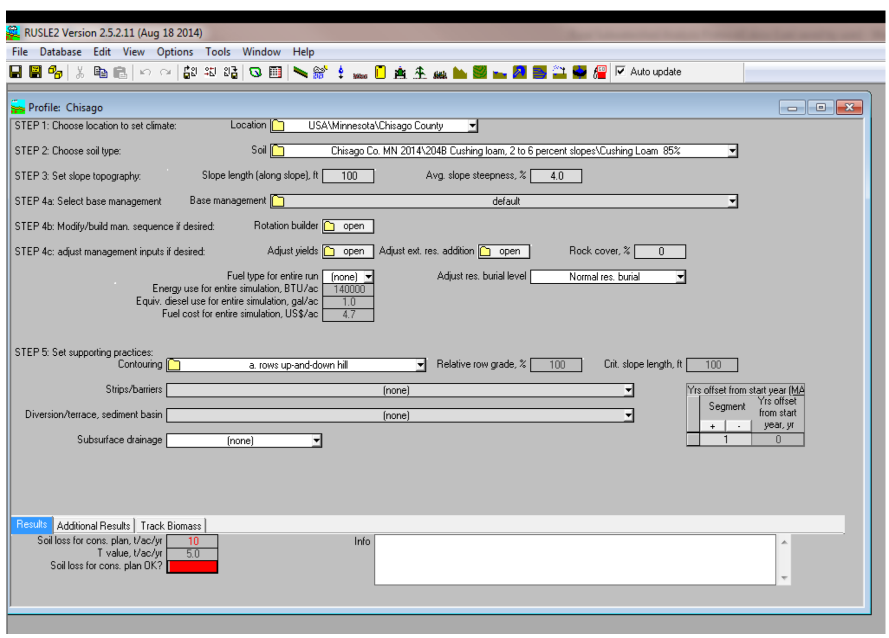


Figure 7. RUSLE2 Simple Template

within the area of the filter strip itself (the 50 feet adjacent to the stream or ditch).

- Base Management: Choose the base management that was chosen for the subwatershed or catchment area (Section 6.5.1). Use this regardless of what the current land cover is.
- Contouring: Relative Row Grade 50%
- The model will automatically re-calculate after each input is changed. Wait for it to finish calculating. The box at the bottom labeled “Soil loss for cons. Plan” is the tons per acre per year of potential soil loss. Input this number into the BWSR Pollution Reduction Estimator first box (SLB_FS).
- Return to RUSLE. Using the same profile that was used in the previous step, add a filter strip in the Strips/Barriers drop down menu. Select Filter Strip, Actual Width, 50-Ft Cool Season Grass Filter Strip.
- Wait for the model to recalculate. Input the number into the BWSR Pollution Reduction Estimator second box (SLA_FS).
- In the BWSR Pollution Reduction Estimator, input the area of the filter strip into the AFS box. To calculate the area of the filter strip, measure the length of the proposed filter strip in ArcMap. Multiply the length by 50 (for a 50 foot wide filter strip). Then divide by 43,560 to convert to acres. Input this number into the spreadsheet AFS box.
- Next, in the BWSR spreadsheet, input the SOIL box with the appropriate number based on the type of soil. Input 1 for sand, 2 for silt, 3 for clay, or 4 for peat.
- The default setting of the WFS (filter strip width) box should be 50. Change it to 50 if this is not the default.
- In the BWSR spreadsheet, input the watershed area of the filter strip into the CA Box. You can determine the watershed area using the NRCS Engineering Tools for watershed delineation (See Appendix D - NRCS Engineering Tools-Watershed Delineation for instructions).
- Return to RUSLE. Close the profile that is open. Do not save. Open a new profile.

Helpful Hint: It is important to close the RUSLE profile and open a new one after the step where the filter strip has been added. If you remove the filter strip and try to run a new calculation in the same profile, the calculation is often wrong.

- Location: Should be set to your county by default.
- Soil: Choose the most dominant soil type of the watershed area.
- Slope Length: Find the area of the watershed with the steepest slope. Measure from the top of the hill to the area where it flattens out. Use this length for the Slope Length.
- Ave. Slope Steepness: Use the change in elevation for the slope length measured in the last step.
- Base Management: Choose the base management that was chosen in Section 6.5.1. Use this regardless of what the current land cover is.
- Contouring: Relative Row Grade 50%
- Wait for the model to recalculate. Input the value into the BWSR Pollution Reduction Estimator in the SLB box under 2. Filter Strip Treatment of Upland Runoff.
- Always select Y for “Is the filter strip functioning as designed?”
- The outputs in the yellow box (Sediment, Soil, and Phosphorus) should now be accurate for the filter strip modeled. Record these values in the Attribute Table or on the paper template for Filter Strips.
- Repeat process with the next filter strip.

6.6.2 Water and Sediment Control Basins, Grassed Waterways, and Gullies

The BWSR Pollution Reduction Estimator is used to model the erosion formed in concentrated flow paths that could be corrected by a water and sediment control basin (WASCOB) or grassed waterway, or in large perennial gullies.

- Open the Gully tab in the BWSR Pollution Reduction Estimator spreadsheet.
- Open the Attribute Table for the appropriate shapefile. Add the appropriate columns to the table. The suggested columns are listed in Table 5. Additional columns are listed in Appendix C - Attribute Tables.
- In the BWSR Pollution Reduction Estimator, choose the appropriate input for soil type in the first box. Input 1 for sand, 2 for silt, 3 for clay, or 4 for peat.
- Determine the volume voided using the following formula: (½(Top width + Bottom width)) * Depth * Length = Volume Voided

> *Helpful Hint: The exact meaning of top width and bottom width are not known and were interpreted differently by different staff members during the work done at Chisago SWCD. We tried to get guidance from BWSR, but an exact answer was never found. For our protocol, we decided top width means if you were standing in the gully, it would be how wide the gully is above your head. Bottom width is the width where your feet would be. Pick an average spot along the length of the gully to take these measurements.*

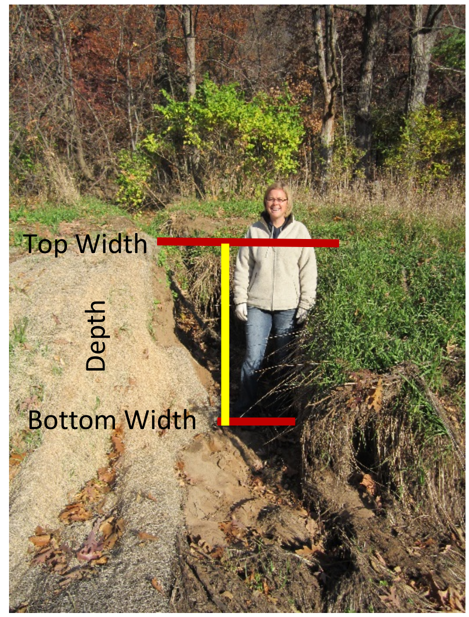


Figure 8. Calculating Volume Voided

For small concentrated flow paths in agricultural fields that are plowed through every year, we assumed the top width and bottom width to be 1 foot each, with a 1 foot depth. To speed things up, for these concentrated flow paths, simply use the length of the concentrated flow path as the input for the VOLV box.

- Insert the Volume Voided into the VOLV box in the BWSR Pollution Reduction Estimator.
- Insert the number of years in the YR box. If the concentrated flow path is plowed through each year, enter 1. If the concentrated flow path or gully is in a field, but plowed around rather than through, enter 30. If the gully is off the field, enter 100. If different year values were chosen in Section 6.5.4, use those. Be consistent throughout.
- In the next box, choose either 1 (channelized) or 2 (non-channelized). We did not use landlocked for the Chisago rural subwatershed assessments.

> *Helpful Hint: A gully is channelized if it outlets directly into a surface water. A gully is non-channelized if it flattens out first, so sediment is deposited before it reaches a surface water.*

- The Distance to surface water box should be used for all non-channelized gullies. This is the distance between where the gully fans out to the nearest surface water. The box does not need to be filled in for channelized gullies.
- At the bottom of the spreadsheet, there is a box to choose Y or N to indicate if a filter strip is present. Set this at N for all BMPs, regardless of if there is a filter strip or not. This helps compare BMPs equally across the map.
- The outputs in the yellow box (Sediment, Soil, and Phosphorus) should now be accurate for the BMP modeled. Record these inputs in the Attribute Table or on the paper template for the appropriate BMP type.
- Repeat process with the next BMP.

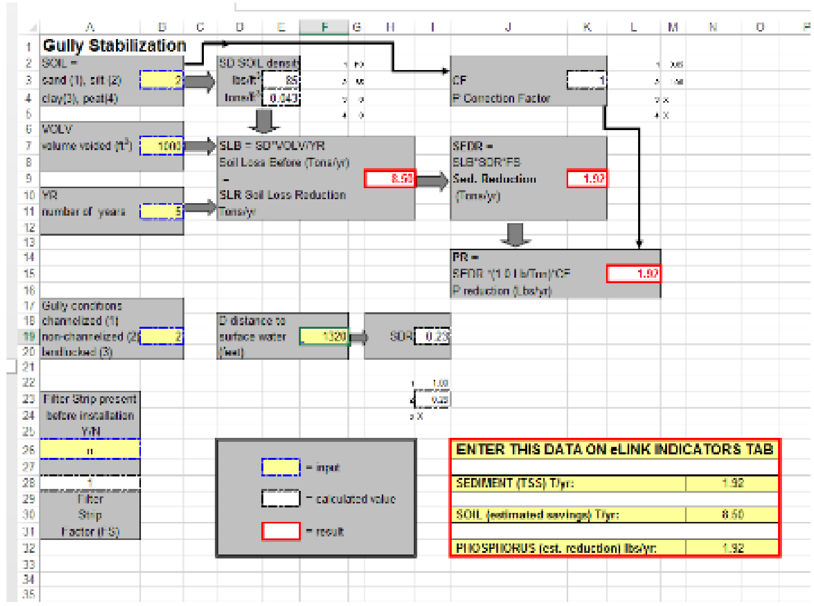


Figure 9. BWSR Pollution Reduction Estimator Gully Tab

6.6.3 Permanent Vegetation Conversion

The BWSR Pollution Reduction Estimator was used for calculating the pollution reduction that can be achieved by converting a steeply sloped field (slopes over 6% covering at least 1/3 of the field) to permanent vegetation. All fields, regardless of current cover were modeled as if they were in annual row crop production.

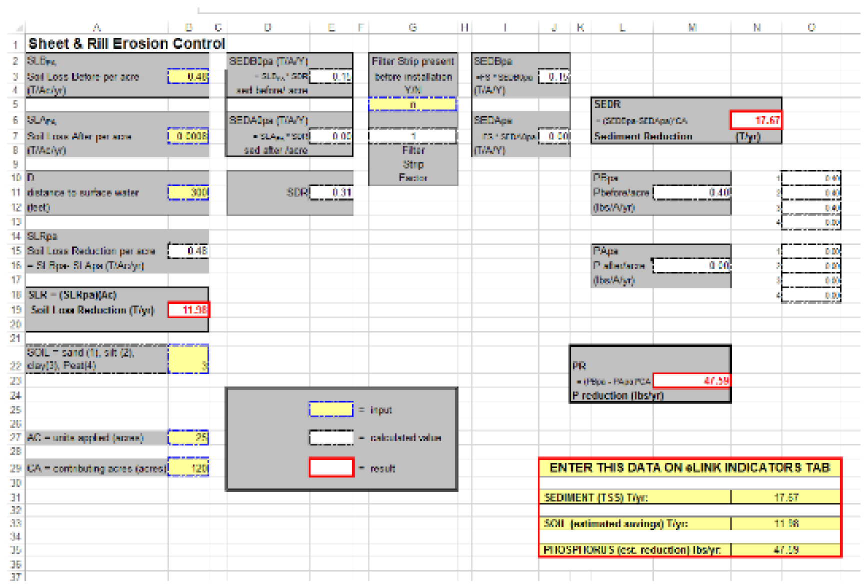


Figure 10. BWSR Pollution Reduction Estimator Sheet and Rill tab

- Open the BWSR Pollution Reduction Estimator spreadsheet to the Sheet and Rill tab.
- Open the Attribute Table for the Permanent Vegetation shapefile in ArcMap. Add the appropriate columns (See Table 5). For additional columns that may be added, see Appendix C - Attribute Tables.
- Open RUSLE2. Open a new profile.
- In RUSLE, determine the Soil Loss Before and the Soil Loss After values for the field (or portion of the field) that should be converted to permanent vegetation. Use the steepest area to take measurements.
- Location: This should be your county by default.

- Soil: Choose the most dominant soil on the field.
- Slope Length: Find the steepest location on the field. Measure from the top of the slope to the area where the slope flattens out. Input this number into the box.
- Avg. Slope Steepness: Determine the change in elevation between the top and bottom of the slope measured in the last step.
- Base Management: Choose the base management that was set in Section 6.5.1. Use this regardless of what the actual land cover currently is.
- Contouring: Select Relative Row Grade 50%.
- Filter Strip: Leave at default.
- Allow the model to finish calculating. Input the value into the BWSR Pollution Reduction Calculator in the Soil Loss Before box.
- Return to RUSLE. Using the same model, change the base management to the management chosen for permanent vegetation in Section 6.5.2.
- Allow the model to re-calculate. Use this value for the Soil Loss After box in the BWSR Pollution Reduction Estimator.
- In the BWSR Spreadsheet, enter the distance from the bottom of the steep slope measured in the above steps to the nearest surface water.
- Enter the appropriate value for the dominant type of soil on the field. Choose 1 for sand, 2 for silt, 3 for clay, or 4 for peat.
- Leave the filter strip present box at a default of “n” for no.
- Enter the number of acres that should be converted to permanent vegetation in the AC (units applied) box.
- Then enter the watershed size in the CA (contributing acres) box.
- The outputs in the yellow box (Sediment, Soil, and Phosphorus) should now be accurate for the field that should be converted to permanent vegetation. Record these values in the Attribute Table or on the paper template for permanent vegetation conversion.
- Repeat process with the next field.

6.6.4 Wetland Restorations

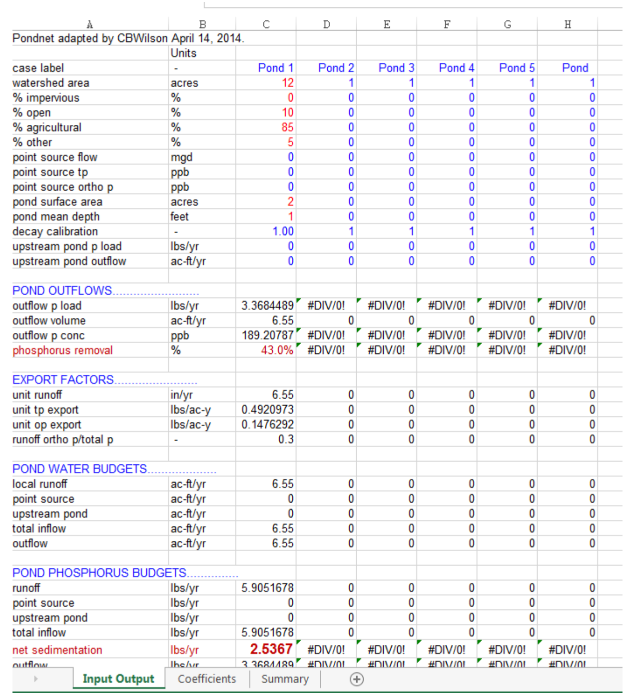
There are two possible modeling methods for wetland restorations. Chose the model that best fits your subwatershed or catchment.

One model was modified from PONDNET by Bruce Wilson of EOR, Inc. The simplified model has inputs for land cover, watershed area, wetland size, and pond depth.

- Create the watershed shapefile for the potentially restorable wetland. Use NRCS Engineering Tools Watershed Delineation tool for this (instructions in Appendix D - NRCS Engineering Tools-Watershed Delineation). If the wetland you are working on is part of a chain of wetlands, the watershed may include other wetlands or even lakes. For the Chisago SWCD rural assessment, we used the outlet of the next upstream Type 1 or 2 wetland in the assessment or lake as the upstream limit of the watershed.

- Use the land cover shapefile in ArcMap to estimate the percentage of impervious, open (lawns, herbaceous, etc.), agricultural (pastures, fields), and other (forests) area in the watershed of a potentially restorable wetland.
- Input the total watershed area into the Watershed Area line, the percentages from above into the appropriate lines, and the area of the wetland into the pond surface area line. Leave the pond mean depth at 1.
- The potential phosphorus removal value is located under Pond Phosphorus Budgets, net sedimentation.

Helpful Hint: To get a copy of this estimator, contact the Chisago SWCD.



A	B	C	D	E	F	G	H
Pondnet adapted by CBWilson April 14, 2014.							
	Units						
case label	-	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond
watershed area	acres	12	1	1	1	1	1
% impervious	%	0	0	0	0	0	0
% open	%	10	0	0	0	0	0
% agricultural	%	85	0	0	0	0	0
% other	%	5	0	0	0	0	0
point source flow	mgd	0	0	0	0	0	0
point source tp	ppb	0	0	0	0	0	0
point source ortho p	ppb	0	0	0	0	0	0
pond surface area	acres	2	0	0	0	0	0
pond mean depth	feet	1	0	0	0	0	0
decay calibration	-	1.00	1	1	1	1	1
upstream pond p load	lbs/yr	0	0	0	0	0	0
upstream pond outflow	ac-ft/yr	0	0	0	0	0	0
POND OUTFLOWS........................							
outflow p load	lbs/yr	3.3684489	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
outflow volume	ac-ft/yr	6.55	0	0	0	0	0
outflow p conc	ppb	189.20787	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
phosphorus removal	%	43.0%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EXPORT FACTORS........................							
unit runoff	in/yr	6.55	0	0	0	0	0
unit tp export	lbs/ac-y	0.4920973	0	0	0	0	0
unit op export	lbs/ac-y	0.1476292	0	0	0	0	0
runoff ortho p/total p	-	0.3	0	0	0	0	0
POND WATER BUDGETS....................							
local runoff	ac-ft/yr	6.55	0	0	0	0	0
point source	ac-ft/yr	0	0	0	0	0	0
upstream pond	ac-ft/yr	0	0	0	0	0	0
total inflow	ac-ft/yr	6.55	0	0	0	0	0
outflow	ac-ft/yr	6.55	0	0	0	0	0
POND PHOSPHORUS BUDGETS...............							
runoff	lbs/yr	5.9051678	0	0	0	0	0
point source	lbs/yr	0	0	0	0	0	0
upstream pond	lbs/yr	0	0	0	0	0	0
total inflow	lbs/yr	5.9051678	0	0	0	0	0
net sedimentation	lbs/yr	**2.5367**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
outflow	lbs/yr	3.3684489	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Figure 11. Modified PONDNET Calculator

The second modeling method uses the BWSR Wetlands Restoration Strategy Framework and the BWSR Pollution Reduction Estimator. Only those watersheds with a watershed to wetland ratio between 5:1 and 20:1 are included in the ranking. Therefore, the first step is to run the watershed size for each identified wetland. Use the NRCS Engineering Toolbox to do this (steps are outlined in Appendix D - NRCS Engineering Tools-Watershed Delineation).

- Open a new profile in RUSLE.
- Location: This should be set at your county by default.
- Soil: Choose the dominant soil of the watershed.
- Slope Length: Find the steepest slope located in the watershed. Measure from the top of the slope to the point where it begins to flatten out. Insert this number into the box.
- Avg. Slope Steepness: Determine the change in elevation from the top to the bottom of the slope measured in the previous step.
- Base Management: Choose the most suitable base management for the watershed. For non-agricultural watersheds, you may need to choose something as close to a permanent land cover as possible, such as long term alfalfa.
- Contouring: If the watershed is predominantly agricultural, choose "Relative row grade 50%". If the watershed is not agricultural, leave this at the default.
- Filter Strip: If there is a strip of vegetation between an agricultural field and the wetland, measure it and select the most appropriate option from the drop down list. If the watershed is not agricultural, leave this at the default setting.
- Let the model finish calculating.
- Insert the output from RUSLE into the BWSR Pollution Estimator Sheet and Rill Erosion tab in the Soil Loss Before box.
- Then calculate a 58% reduction in the Soil Loss Before value. Insert this into the Soil Loss After box. This is assuming that the wetland will capture 58% of the sediment coming into the wetland from the watershed.

- In the Distance to Surface Water box, enter 1.
- In the SOIL box, choose the most appropriate number to represent the soils of the watershed.
- AC is the acres applied. Enter the size of the wetland in acres.
- CA is the contributing acres. Enter the size of the watershed in acres.
- The outputs in the yellow box (Soil, Sediment, and Total Phosphorus) should now be accurate.

6.6.5 Animal Operations and Pastured Wetlands

No modeling was done for the animal operations or pastured wetlands for the Chisago rural subwatershed assessments. There are available models that can be used, such as MINNFarm.

6.6.6 Stream Bank and Shoreline Erosion

No modeling was done for stream bank or shoreline erosion in the Chisago rural subwatershed assessments. However, there is a Stream/Ditch tab in the BWSR Pollution Reduction Estimator designed to estimate the sediment (TSS), soil, and total phosphorus values for bank erosion in streams and ditches. The inputs needed for this model are the soil type (sand, silt, clay, or peat), the volume voided (see instructions in Section 6.6.2 for determining this number), and the number of years (use professional judgment to set “rules” for this input).

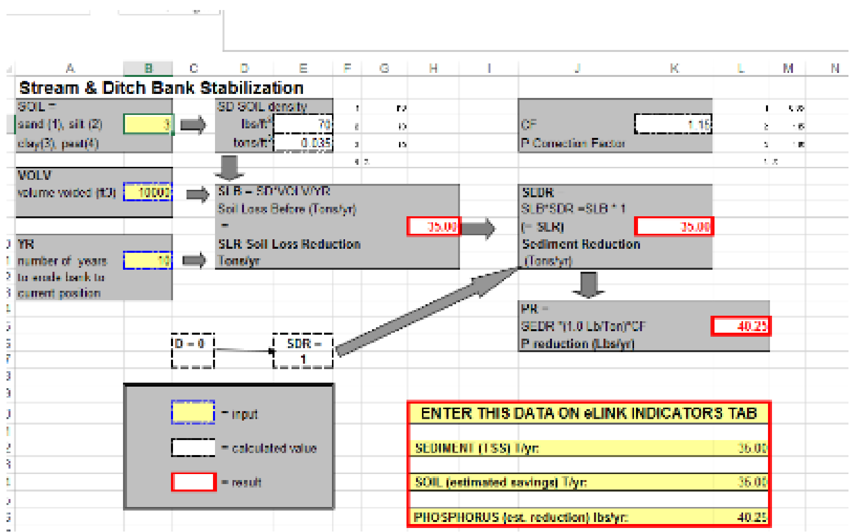


Figure 12. BWSR Pollution Reduction Estimator Stream & Ditch Bank Stabilization tab

6.7 Determining Cost Per Pound of Total Phosphorus

Once all the BMPs have been modeled, a cost for construction of the BMP can be estimated. Then, a cost per pound of Total Phosphorus can be determined and can be used to rank BMPs against each other.

Table 6 was developed by Washington Conservation District as an average estimate of the cost to design, install, and maintain a variety of BMPs.

Table 6 Cost Estimate of BMPs

BMP	Initial Installation Cost ($/Unit)	Contracted Annual Maintenance Cost ($/Unit)	O & M Term (Years)	Design Cost ($70/hr)	Installation Oversight Cost ($70/hr)	Total Installation Cost (Including 1 year maintenance)
Grassed Waterway (per 1,000 feet)	$4.00	$0.25	10	$1,120.00	$560.00	$5,930.00
WASCOB (0-10 acres drainage area)	$8,438.00	$100.00	10	$843.80	$421.90	$9,803.70
WASCOB (10-20 acres drainage area)	$11,250.00	$150.00	10	$1,125.00	$562.50	$13,087.50
WASCOB (20-40 acres drainage area)	$16,875.00	$200.00	10	$1,687.50	$843.75	$19,606.25
Filter Strip (per 10 acres)	$500.00	$10.00	10	$1,120.00	$560.00	$6,780.00
Diversion (per 500 linear feet)	$7.00	$0.25	10	$560.00	$280.00	$4,465.00
Grade Stabilization Structure (0-10 acres drainage area)	$9,250.00	$100.00	10	$925.00	$462.50	$10,737.50
Grade Stabilization Structure (10-20 acres drainage area)	$15,000.00	$150.00	10	$1,500.00	$750.00	$17,400.00
Grade Stabilization Structure (20-40 acres drainage area)	$28,125.00	$200.00	10	$2,812.50	$1,406.25	$32,543.75
Grade Stabilization Structure (40-80 acres drainage area)	$37,500.00	$250.00	10	$3,750.00	$1,875.00	$43,375.00
Grade Stabilization Structure (80-250 acres drainage area)	$56,250.00	$300.00	10	$5,625.00	$2,812.50	$64,987.50
Grade Stabilization Structure (250-500 acres drainage area)	$112,500.00	$350.00	10	$11,250.00	$5,625.00	$129,725.00
Grade Stabilization Structure (500+ acres drainage area)	$150,000.00	$400.00	10	$15,000.00	$7,500.00	$172,900.00
Nutrient Management (per 10 acres)	$11.00	--------	10	$560.00	$280.00	$950.00
Prescribed Grazing (per 10 acres)	$93.00	--------	10	$560.00	$280.00	$1,770.00
Wetland Creation (per 10 acres)	$7,000.00	$45.00	10	$2,800.00	$1,400.00	$74,560.00
Wetland Enhancement (per 10 acres)	$3,000.00	$45.00	10	$2,800.00	$1,400.00	$34,650.00
Wetland Restoration (per 10 acres)	$3,000.00	$45.00	10	$2,800.00	$1,400.00	$34,650.00
Feedlot Fix-Pit (first 500,000 cf storage)	$1.55	$0.01	10	$11,200.00	$5,600.00	$795,050.00
Feedlot Fix-Pit (additional above 500,000 cf storage)	$1.13	$0.01	10	$11,200.00	$5,600.00	$585,050.00
Feedlot Fix-Treatment Swale (per 1,000 square feet)	$4.00	$0.25	10	$2,800.00	$1,400.00	$8,450.00
Feedlot Fix-Relocation	$50,000.00	--------	--------	$11,200.00	$5,600.00	$66,800.00

Use the table to determine the cost for installation of each BMP. Most of the BMPs are listed per a certain length or area. Divide the estimated length or area of the BMP being modeled by the number in the Table to get the cost of the BMP. For example, if you have a 1 acre filter strip marked, divide 1 acre by 10 acres to get the amount it will cost to install the proposed filter strip. Use the last column (Total Installation Cost) as the cost.

Next, determine the cost per pound of Total Phosphorus. For each BMP, divide the estimated cost you just determined by the pounds of phosphorus from the modeling done earlier. This is the cost per pound.

6.8 Ranking

After completing all the modeling and cost estimation for the BMPs identified for the assessment, ranking of the highest priority projects can be completed. There are several ways to rank the projects. Two options will be discussed in this protocol.

6.8.1 Ranking by Top 50 Projects

In line with the Top50P! protocol, ranking can be done as a list of the top 50 (or another number that you choose) individual projects from a variety of BMPs ranked by cost per pound of phosphorus reduction.

Since total phosphorus output values from different models cannot be reliably compared, a ranking list for the **highest potential phosphorus reduction** should be made for each of the BMPs that were modeled using the same calculator. For example, the identified water and sediment control basins would be listed together with the highest potential total phosphorus reduction being at the top of the list. Wetland restorations would be ranked amongst other wetland restorations, and so on.

The **cost per pound of phosphorus** can be compared across different BMPs. You can make a table that ranks all the identified BMPs with their associated cost per pound and rank them by the lowest cost per pound at the top.

6.8.2 Ranking by Field

A second option is to combine the BMPs that were modeled using the BWSR Pollution Reduction Estimator by the field they are located on, giving each field a cumulative phosphorus reduction value. For example, a field may have one water and sediment control basin, 2 grassed waterways, and a filter strip identified on it. The cumulative value for this field would be the sum value of all the BMPs estimated phosphorus reduction. The fields would be ranked by their cumulative total phosphorus reduction values. This method is valuable for meeting with landowners and addressing all the issues on a certain field, rather than just picking one BMP to resolve.

In this method, the phosphorus values from different models still cannot be compared equally. Therefore, wetland restorations, animal operations, and pastured wetlands are still ranked individually by BMP type. It may also be beneficial to rank the fields that should be converted to permanent vegetation separately because the total phosphorus reduction value reflects what would be gained over the whole field. Adding this to the value of any individual BMPs on the field could duplicate and erroneously enlarge the cumulative total phosphorus reduction value. It is also valuable to list gullies separately due to the large reduction numbers that can be associated with these projects.

6.8.3 Create Ranking Document

When the decision on which method to use for ranking is made, the actual ranking can take place. The easiest way we found at Chisago SWCD to do this is to open the Attribute Table for a BMP shapefile in ArcMap. Select the entire table, right click, and select copy. Paste this into an Excel document. If there are many columns in the attribute table, only the Landcover ID number, the total phosphorus, and TSS are needed (and soil if you are going to include this value in the project profile). The other columns can be deleted or hidden in the Excel document.

If the ranking will be completed by field, copy the Attribute Tables from WASCOBs, grassed waterways, and filter strips into the same Excel document. Paste them into a vertical column and delete any blank rows between the sets of pasted data. Then, sort the list by Landcover ID. This will group the fields so those with multiple BMPs can be lumped together into cumulative total phosphorus and TSS values.

Make a new set of columns with the Landcover ID, TP, and TSS. Move the cumulative values over to this column so that each field is only represented once in the column. Then this field can be sorted by TP, highest to lowest. This is your prioritized ranking list for WASCOBs, grassed waterways, and filter strips by field.

The same copy and paste method can be used to bring data from ArcMap into Excel for the other BMP types; then the data can be sorted to create the ranking list.

ArcMap also provides the option of exporting the Attribute Table to an Excel document, but this takes longer than just using copy and paste.

7 Final Report

The prioritizing protocol has been completed. The final step is to put this data into a format that can be used by staff to locate projects and begin project development. A template for Project Profiles is provided here and is based off of the template used in the Urban Subwatershed Retrofit Analysis protocol. For a complete template of the entire final report, use a completed rural subwatershed assessment.

The basic requirements for the final report include:

- Executive summary
- BMP location map of all identified BMPs
- Prioritization list(s) (by field or by each BMP)
- Project Profiles
- Documentation of how the targeting and prioritization were conducted

7.1 Project Profile Template

Chisago Lakes Chain of Lakes Section 3 Watershed-Field 130*

Project Description

This is an agricultural field of about 11 acres. A large concentrated flow path with several branches drains from the field and into a drainage ditch. About half of this field has steep slopes.

BMP Recommendation

The portion of this field that has steep slopes should be converted to permanent vegetation, such as hay or native grasses. If this field continues to be farmed with annual row crops, water and sediment control basins should be installed to stabilize erosion within the concentrated flow paths.

Catchment Summary	
Field Acres	10.5
Current Cover	Corn/Beans
# of Landowners	1
Removed TP (Lb/yr)	44
Removed TSS (Ton/yr)	42
Estimated Cost	$39,330.06
Cost/Lb TP	$894
Model Inputs	
Soil Type	169B;169C
Slopes >6%	Yes

Practice	Removed TP (Lb/yr)	Removed TSS (Ton/yr)	Watershed Size (Acres)	Average Watershed Slope (%)	Distance to Surface Water (Feet)		Estimated Cost	Cost/Lb TP
WASCOB 1	20	20	2.2	4.1	22		$9,803.70	$490
WASCOB 2	3	3	0.8	4.1	22		$9,803.70	$3,268
WASCOB 3	7	7	0.6	4.5	22		$9,803.70	$1,401
WASCOB 4	2	2	0.6	7.8	93		$9,803.70	$4,902
Practice	**Removed TP (Lb/yr)**	**Removed TSS (Ton/yr)**	**Watershed Size (Acres)**	**Average Watershed Slope (%)**	**Existing Filter Strip (Feet)**	**Area (Acres)**	**Estimated Cost**	**Cost/Lb TP**
Filter Strip	12	10	6.1	9.0	20	0.17	$115.26	$10

Chisago Soil & Water Conservation District 24

Figure 13. Example Project Profile

7.2 Parts of the Project Profile

7.2.1 Heading

At the top of the page, the watershed, subwatershed, or catchment name should be provided. The individual field or BMP number (or other identifying marker) should be given.

In the template provided (Figure 13), an asterisk (*) is shown at the end of the heading. This is used to indicate the identified Project Profiles that are also listed on the Permanent Vegetation table. These fields would most benefit by being converted to permanent vegetation. If that is not feasible, the Project Profile lists other BMPs that can be implemented.

7.2.2 Project Description

This is a short sentence or two about the field or project location. Some of the important things to include are the size of the field, the current land cover, observations about the history or probability of future management, and anything else that is important to the management of that location or field.

7.2.3 BMP Recommendation

In this section, a recommendation for one or several BMPs is given. These are the BMPs that are identified on the map that is shown in the Project Profile and that contribute to the cumulative potential total phosphorus reduction for the field. Only those BMPs that are included in that total phosphorus reduction for this field should be given. If the ranking is done by individual BMP, the Project Profile should only include that individual BMP. The other BMPs will have their own Project Profile in the next BMP section.

7.2.4 Catchment Summary Table

This table has information about the field as a whole. The exact categories in the table are different for each BMP. Categories can be added or deleted, but stay consistent throughout the final report. Example tables are not given for BMPs that were not included in the rural subwatershed assessments done by the Chisago SWCD.

Table 7. WASCOB, Grassed Waterway, Filter Strip Catchment Summary Table

Catchment Summary		
Field Acres		Acres of the field that the Project Profile represents
Current Cover		Land cover that is on the field at the time of the assessment
# of Landowners		Number of unique landowners that own a portion of the field
Removed TP (Lb/yr)		Cumulative total of all the BMPs on the field
Removed TSS (Ton/yr)		Cumulative total of all the BMPs on the field
Estimated Cost	$	Estimated cost of installing all the BMPs on the field
Cost/Lb TP	$	Cost per pound of installing all the BMPs on the field
Model Inputs		
Soil Type		List all the soil types that are present on the field
Slopes >6%		Yes or no-are there any slopes on the field over 6%

Table 8. Gully Catchment Summary Table

Catchment Summary		
Length (Feet)		Length of the gully
Depth (Feet)		Depth of the gully
Watershed Size (Acres)		Size of the watershed contributing to the gully
Soil Type		List of all soil types that are present along the gully
Distance to Surface Water (Feet)		Distance from the bottom of the gully to the nearest surface water
Removed TP (Lb/yr)		
Removed TSS (Ton/yr)		

Table 9. Wetland Restoration Catchment Summary Table

Catchment Summary		
Soil Type		List all soil types that are present in the wetland
NWI Wetland Code (Cowardin)		The NWI code given to the wetland. If the code is from the 2013 update, put (2013 update) after the code.
Wetland Type (Circular 39)		The wetland type (1 or 2) of the wetland. If the code is from the 2013 update, put (2013 update) after the code.
Current Wetland Size	Acres	Size of the wetland as delineated by the NWI layer.
Watershed Size	Acres	Size of the watershed contributing to the wetland. If the wetland is in a chain of wetlands, cut off the wetland at the next upstream wetland's outlet.
Watershed to Wetland Ratio		Watershed : Wetland in reduced format
Received Water From		What other identified wetlands, or lakes/streams, contribute to this wetland?
Flows To		Where does the water from this wetland go next?
Dominant Watershed Land Use		List the top one or two most dominant land uses in the watershed.
Number of Landowners		The number of unique landowners that may be affected by a restoration.
Potential Total Phosphorus Reduction	Lbs/yr	

Table 10. Animal Operation Catchment Summary Table

Catchment Summary		
Animal Operation Acres		The size of the feedlot or animal operation.
#/Type Animal		Categories: 0-10, 11-100, 101-250, 250+
# of Landowners		The number of unique landowners that own a portion of the animal operation. Usually 1
Soil Type		List all soils types that are present in the feedlot area.
Wetland Present		Are there NWI identified wetlands present?
Streams Present		Are there streams present in the animal operation area?
Ditching Present		Is there ditching into or out of the animal operation area?
Distance to Surface Water (Feet)		The distance from the edge of the animal operation area to the nearest surface water.

Table 11. Pastured Wetland Catchment Summary Table

Catchment Summary		
Pasture Acres		The size of the pasture.
#/Type Animal		Categories: 0-10, 11-100, 101-250, 250+
# of Landowners		The number of unique landowners that own a portion of the animal operation. Usually 1
Soil Type		List all soils types that are present in the feedlot area.
NWI Wetlands Present		Are there NWI identified wetlands present?
Streams Present		Are there streams present in the animal operation area?
Ditching Present		Is there ditching into or out of the animal operation area?

7.2.5 Map

Include a map that shows the extent of the field and the watershed(s) of the BMP(s). Use an aerial photograph for the background. Turn on the appropriate BMP layer(s) for the Project Profile being created. Label the field that is being described in the Project Profile and any other fields that are mentioned in the Project Description. Label the WASCOBs and grassed waterways so that they can be identified individually. Other BMPs do not need to be labeled.

Helpful Hint: Use the Insert Legend tool to build a legend based on the layers being displayed on the map. In some cases, it may be easier to build your own legend rather than manipulate the display of the layers. For example, when there are multiple polygons in a shapefile (such as the watersheds of several different BMPs that cross field boundaries), but you don't want to display them all, they will still show up in the Legend.

7.2.6 Individual BMP Table

At the bottom of the Profile Page for each field with WASCOBs, grassed waterways, and filter strips, a second table is included that gives specific information for each individual BMP. This allows the reader to identify which BMPs are most crucial to achieving the reported pollution reduction values. Combine the values for filter strip if there are multiple sections of filter strip needed on the same field.

Table 12. Individual BMP Table

Practice	Removed TP (Lb/yr)	Removed TSS (Lb/yr)	Watershed Size (Acres)	Average Watershed Slope (%)	Distance to Surface Water (Feet)	Length (Feet)	Estimated Cost	Cost/Lb TP
GW 1								
Practice	Removed TP (Lb/yr)	Removed TSS (Lb/yr)	Watershed Size (Acres)	Average Watershed Slope (%)	Distance to Surface Water (Feet)		Estimated Cost	Cost/Lb TP
WASCOB 1								
Practice	Removed TP (Lb/yr)	Removed TSS (Lb/yr)	Watershed Size (Acres)	Existing Filter Strip (Feet)	Area (Acres)		Estimated Cost	Cost/Lb TP
Filter Strip								

8 Final Notes

The protocol given here is simply what was done during the first rural subwatershed assessments in Chisago County. The Chisago SWCD staff had very few developed protocols to follow and had to create many of the steps and procedures used in this document. There are almost certainly better ways to complete some of these steps. Feedback and improvements are welcome.

The main thing to remember is to set your "rules" and stick to them during the modeling process. If you change certain inputs part way through the project, your results are no longer valid.

Appendix A

9 Creating a New Shapefile

The best way to create a new shapefile in your project is to use ArcCatalog. ArcMap should be open to the project that requires a new shapefile.

- Click on the ArcCatalog button to open ArcCatalog.
- In the Catalog window, navigate to the location of the project that is currently open. You may want to create a new folder to hold the project and the new shapefile(s) you are going to create, if you don't already have one.
- In the Catalog, right click on the folder where you'd like to store the new shapefile. Select New and then Shapefile. A dialog box will open (Figure 15).
- Enter a name for your new shapefile.
- In the dropdown menu, choose between Point, Polyline, or Polygon.
- Click the Edit button to set the correct coordinate system for your project.
- Then click OK. The new shapefile should appear in the Table of Contents window.

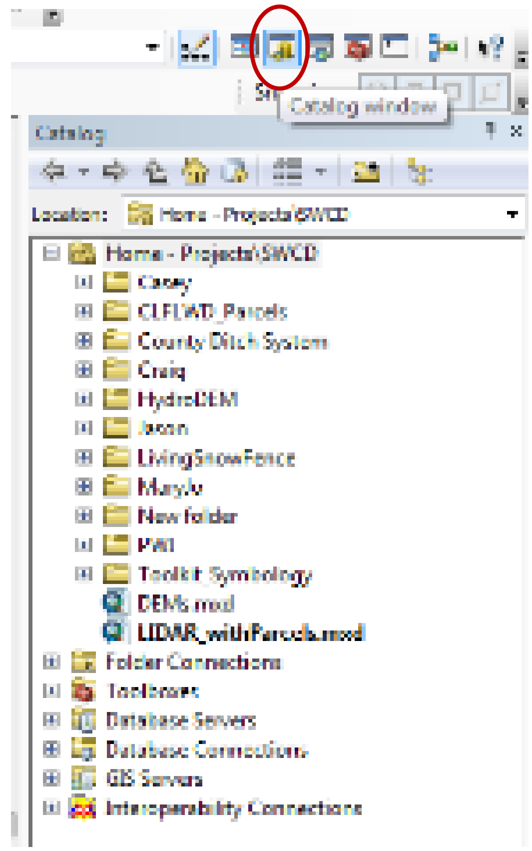


Figure 14 ArcCatalog

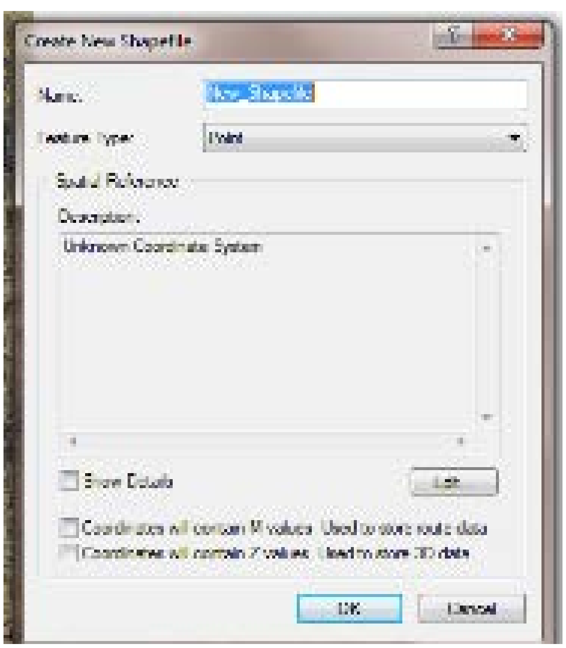


Figure 15 New Shapefile

Appendix B

10 Desktop Scouting Examples

The following are examples of what different potential issues can look like when scouting the aerial photos, hillshade, and contour layers. The series will show different views of the same location to prove how different views can provide different detection levels. Red arrows indicate features that should be marked as a potential problem.

Helpful Hint: Zoom in and out to view the layers at different scales. Certain things may show up at a finer scale that can't be seen when zoomed out.

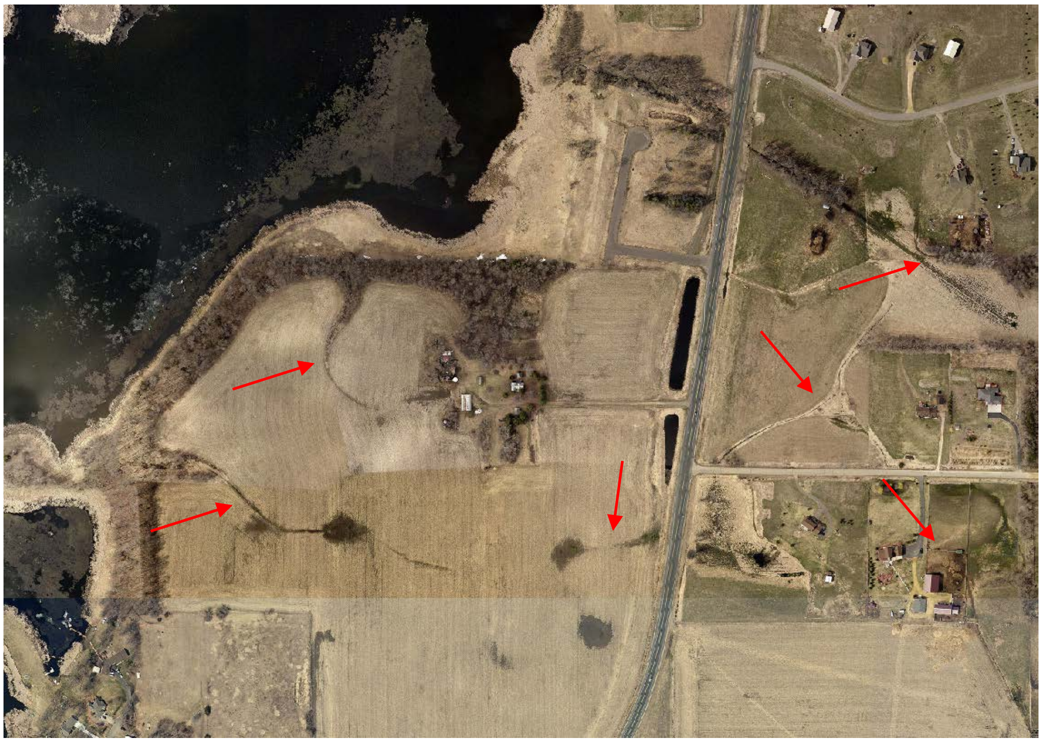


Figure 16. Aerial Photograph Only

Figure 17. Aerial Photograph Only

Figure 18. Hillshade Only

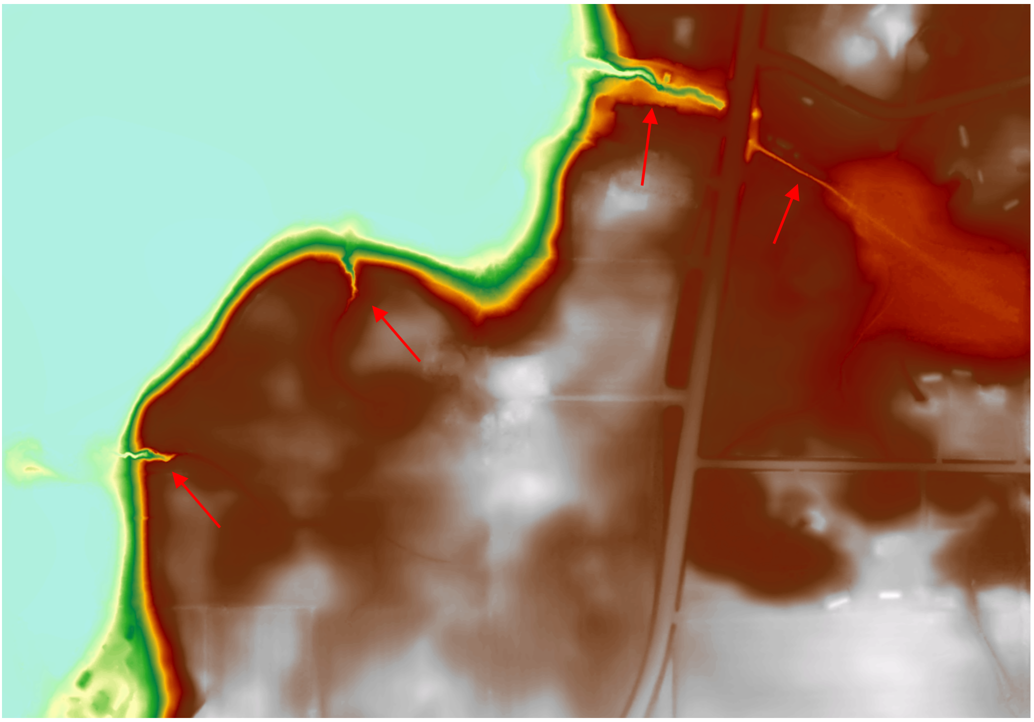


Figure 19. DEM Only

Figure 20. DEM and Hillshade

Figure 21. One-foot Contours

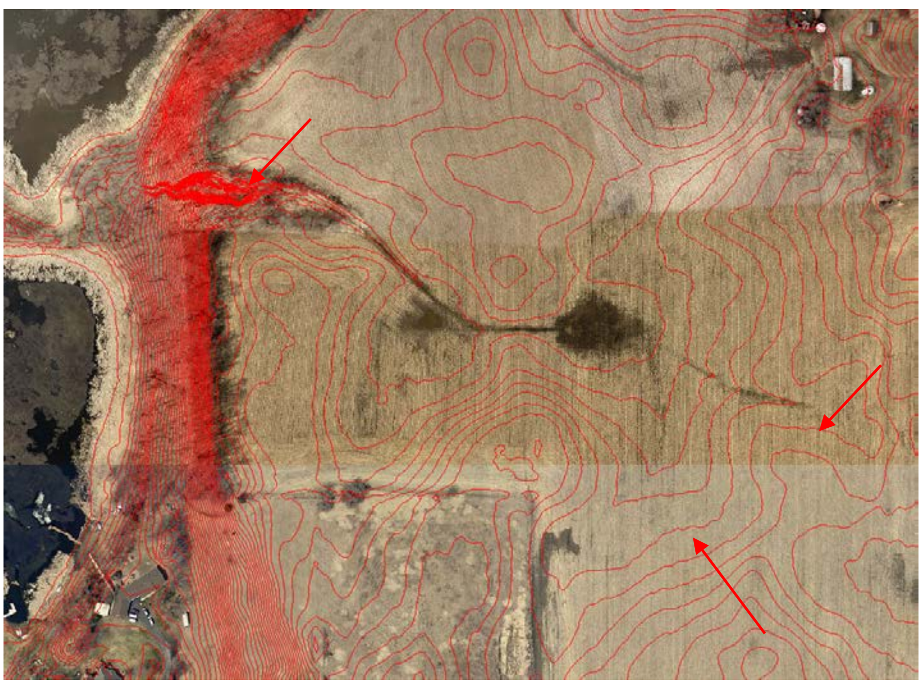


Figure 22. Zoom In on Contours

Helpful Hint: Concentrated flow paths often show up with "sharp" ends that point upstream.

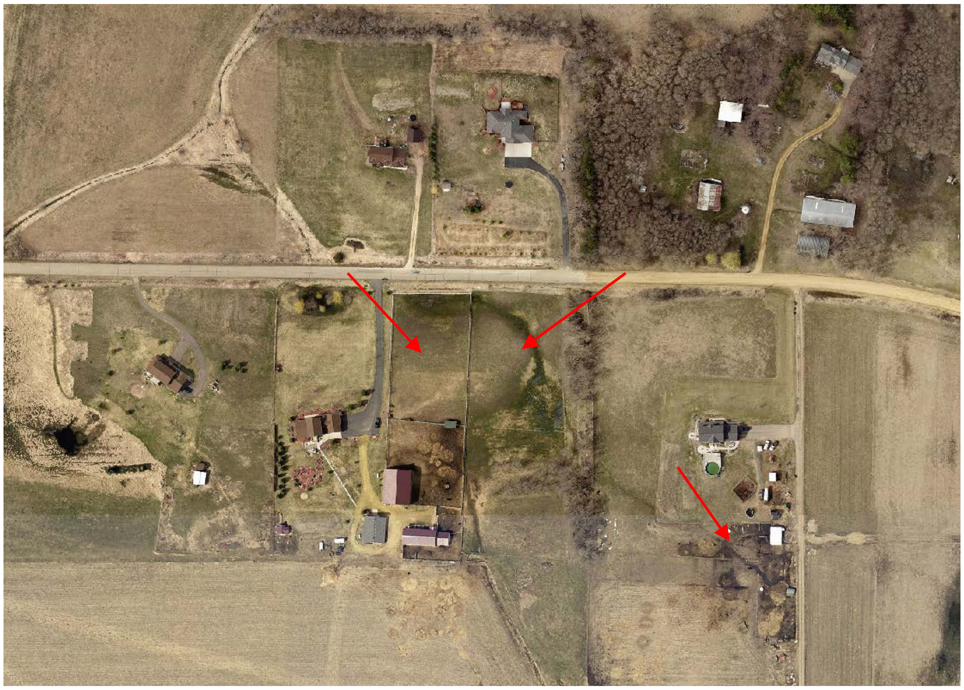


Figure 23. Identifying Pastures and Animal Operations

Appendix C

11 Attribute Tables

In the steps for modeling each BMP type, the minimum columns needed are listed (they are also included here). The additional columns listed here can be added to record the model input values and information that is needed for creating the Project Profiles.

<u>For explanation of inputs and sources, please refer back to the protocol guidance for each specific BMP.</u>

11.1 Water and Sediment Control Basins

The model used for this BMP is the BWSR Pollution Reduction Estimator-Gully tab.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
VOLV	Volume Voided	Float		5	Ft^3	(1/2(Top width + Bottom width)) * Depth * Length		Model
YR	Number of Years	Short Integer	5			See protocol guidance	1 = plowed through 30 = plowed around 100 = gully	Model
COND	Gully condition	Short Integer	5			See protocol guidance	1 = channelized 2 = non-channelized ~~3 = landlocked~~	Model
DSF	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
CC	Current Land Cover	Text	15			Land cover shapefile	CornBeans Hay Herbaceous Pasture Forested Wetland Residential	PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP

Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
Steep	Slopes over 6% present?	Text	5			Soil layer (C or higher letters = steep slopes)	Yes or No	PP
WS	Watershed size	Float		5	Acres	Watershed delineation tool		PP
Slope	Average slope	Float		5		Watershed delineation tool or Rise/Run		PP

11.2 Grassed Waterways

The model used for this BMP is the BWSR Pollution Reduction Estimator-Gully tab.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
VOLV	Volume Voided	Float		5	Ft^3	Length of concentrated flow path		Model
YR	Number of Years	Short Integer	5			See protocol guidance	1 = plowed through 30 = plowed around ~~100 = gully~~	Model
COND	Gully condition	Short Integer	5			See protocol guidance	1 = channelized 2 = non-channelized ~~3 = landlocked~~	Model
DSF	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
CC	Current Land Cover	Text	15			Land cover shapefile	CornBeans Hay Herbaceous Pasture Forested Wetland Residential	PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP

Steep	Slopes over 6% present?	Text	5			Soil layer (C or higher letters = steep slopes)	Yes or No	PP
WS	Watershed size	Float		5	Acres	Watershed delineation tool		PP
Slope	Average slope	Float		5		Watershed delineation tool or Rise/Run		PP

11.3 Gully

The model used for this BMP is the BWSR Pollution Reduction Estimator-Gully tab.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
VOLV	Volume Voided	Float		5	Ft^3	Length of concentrated flow path		Model
YR	Number of Years	Short Integer	5			See protocol guidance	~~1 = plowed through~~ ~~30 = plowed around~~ 100 = gully	Model
COND	Gully condition	Short Integer	5			See protocol guidance	1 = channelized 2 = non-channelized ~~3 = landlocked~~	Model
DSF	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
WS	Watershed size	Float		5	Acres	Watershed delineation tool		PP
LEN	Length	Short Integer	5		Feet	Manual measurement		PP
DEP	Depth	Short Integer	5		Feet	Manual measurement		PP

11.4 Filter Strip

The model used for this BMP is the BWSR Pollution Reduction Estimator-Filter Strip tab. Inputs from RUSLE are required.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer	5			Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SLB_FS	Soil Loss Before of the filter strip itself	Float		10	T/Ac/yr	RUSLE		Model
SLA	Soil Loss After of the filter strip itself	Float		10	T/Ac/yr	RUSLE		Model
AFS	Area of filter strip to be installed	Float		5	Acres	(Length * 50) / 43,560		Model, PP
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
SLB_WS	Soil Loss Before of contributing area	Float		10	T/Ac/yr	RUSLE		Model
EXIST_FS	Existing filter strip width	Text	5		Feet	Manual measurement	<5, or a range (10-20)	PP
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
WS	Watershed size	Float		5	Acres	Watershed delineation tool		Model, PP
Steep	Slopes over 6% present?	Text	5			Soil layer (C or higher letters = steep slopes)	Yes or No	PP
SL	Slope Length	Short Integer	5		Feet	Manual measurement		Model

11.5 Permanent Vegetation

The model used for this BMP is the BWSR Pollution Reduction Estimator-Sheet and Rill tab. Inputs from RUSLE are required.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SLB	Soil Loss Before	Float		10	T/Ac/yr	RUSLE		Model
SLA	Soil Loss After	Float		10	T/Ac/yr	RUSLE		Model
DSW	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
AC	Acres applied (portion of field that should be converted to permanent vegetation)	Float		5	Acres	Manual measurement		Model
TFA	Total Field Acres	Float		5	Acres	Manual measurement		PP
CA	Contributing Acres (watershed size)	Float		5	Acres	Watershed delineation tool		Model
SL	Slope Length	Short Integer	5		Feet	Manual measurement		Model
Slope	Average slope (%)	Float		5	%	Change in elevation/Slope Length		Model

11.6 Wetland Restoration (USING BWSR POLLUTION REDUCTION ESTIMATOR)

The model used for this BMP was the BWSR Pollution Reduction Estimator-Sheet and Rill Tab.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
TSS	Total Suspended Solids	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP
S	Soil	Float		5	T/yr	BWSR Pollution Reduction Estimator		PP-optional
SLB	Soil Loss Before	Float		10	T/Ac/yr	RUSLE		Model
SLA	Soil Loss After	Float		10	T/Ac/yr	RUSLE		Model
SSCP	Sand, Silt, Clay, Peat	Text	5			Soil layer	1 = Sand 2 = Silt 3 = Clay 4 = Peat	Model
SL	Slope Length	Short Integer	5		Feet	Manual measurement		Model
Slope	Average slope (%)	Float		5	%	Change in elevation/Slope Length		Model
AC	Acres applied (portion of field that should be converted to permanent vegetation)	Float		5	Acres	Manual measurement		Model
CA	Contributing Acres (watershed size)	Float		5	Acres	Watershed delineation tool		Model
DSW	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
WET_AREA	Wetland area	Short Integer	5		Acres	Manual measurement		Model, PP
NWI	NWI Wetland Code	Text	10			NWI layer	Ex. PEM1Ad	PP
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
TYPE	Wetland type	Short Integer	5			NWI layer	Ex. 1	PP
WWR	Watershed to Wetland Ratio	Text	10					PP
RWF	Receives water from	Text	20					PP
FLOW	Flows to	Text	20					PP

D_USE	Dominant watershed use	Text	20			Land cover file		PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP

11.7 WETLAND RESTORATION (USING PONDNET MODEL)

The model used for this BMP was a modified version of PONDNET created by Bruce Wilson, EOR.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
TP	Total Phosphorus	Float		5	Lb/yr	BWSR Pollution Reduction Estimator		PP
WS	Watershed Size	Float		5	Acres	Watershed delineation tool		Model, PP
IMP	Percent of watershed that is impervious	Short Integer	5		%	Manual measurement		Model
OPEN	Percent of watershed that is open	Short Integer	5		%	Manual measurement		Model
AG	Percent of watershed that is agricultural	Short Integer	5		%	Manual measurement		Model
OTHER	Percent of watershed that is not IMP, OPEN, or AG	Short Integer	5		%	Manual measurement		Model
DSW	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		Model, PP
WET_AREA	Wetland area	Short Integer	5		Acres	Manual measurement		Model, PP
NWI	NWI Wetland Code	Text	10			NWI layer	Ex. PEM1Ad	PP
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
TYPE	Wetland type	Short Integer	5			NWI layer	Ex. 1	PP
WWR	Watershed to Wetland Ratio	Text	10					PP
RWF	Receives water from	Text	20					PP
FLOW	Flows to	Text	20					PP
D_USE	Dominant watershed use	Text	20			Land cover file		PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP

11.8 Animal Operation

Animal operations were not modeled in the Chisago rural subwatershed assessment. The inputs needed for modeling can be added to the chart if needed.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP
DSW	Distance to Surface Water	Short Integer	5		Feet	Manual measurement		PP
AO_Acre	Animal operation acres	Float		5	Acres	Manual measurement		PP
ANIMAL	Number and type of animal	Text	50			Field verification	0-10, 11-100, 101-250, 250+ Dairy, Bovine, Horse, Unknown	PP
WET	Wetlands Present?	Text	5				Yes or No	PP
STREAM	Streams Present?	Text	5				Yes or No	PP
DITCH	Ditching Present?	Text	5				Yes or No	PP

11.9 Pastured Wetlands

Pastured wetlands were not modeled in the Chisago rural subwatershed assessment. The inputs needed for modeling can be added to the chart if needed.

Column Name	Description	Column Type	Length	Precision	Unit	Source	Optional Inputs	Input For
LC_ID	Land cover ID	Short Integer		5		Land cover shapefile ID column		PP (Project Profile)
Soil	Numeric soil number (ie, 169B)	Text	20			Soil layer	Can have multiple soils listed	PP
OWN	Number of Landowners	Short Integer	5			Parcel data		PP
PW_Acre	Pastured wetland acres	Float		5	Acres	Manual measurement		PP
ANIMAL	Number and type of animal	Text	50			Field verification	0-10, 11-100, 101-250, 250+ Dairy, Bovine, Horse, Unknown	PP
WET	Wetlands Present?	Text	5				Yes or No	PP

STREAM	Streams Present?	Text	5				Yes or No	PP
DITCH	Ditching Present?	Text	5				Yes or No	PP

12 TEMPLATES FOR MANUAL RECORDING

On the following pages are blank templates that can be used to manually record modeling data inputs during the modeling process. This may be easier than switching back and forth between screens to enter data into the Attribute Table of the shapefiles in ArcMap. Use the tables above to reference what should be recorded in the templates.

Water and Sediment Control Basins

PROJECT PROFILE INPUTS							POLLUTION REDUCTION ESTIMATOR INPUTS – GULLY TAB					MODEL OUTPUTS		
LC_ID	CC CornBeans Hay Herbaceous Pasture Forested Wetland Residential	OWN	Soil	Steep Yes No	WS *Acres*	Slope *%*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	VOLV (1/2(Top width + Bottom width)) * Depth * Length	YR 1 = plowed through 30 = plowed around 100 = gully	COND 1 = channelized 2 = non-channelized	DSW *Feet*	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Grassed Waterway

PROJECT PROFILE INPUTS							POLLUTION REDUCTION ESTIMATOR INPUTS – GULLY TAB					MODEL OUTPUTS		
LC_ID	CC CornBeans Hay Herbaceous Pasture Forested Wetland Residential	OWN	Soil	Steep Yes No	WS *Acres*	Slope *%*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	VOLV (1/2(Top width + Bottom width)) * Depth * Length	YR 1 = plowed through 30 = plowed around 100 = gully	COND 1 = channelized 2 = non-channelized	DSW *Feet*	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Gully

PROJECT PROFILE INPUTS									POLLUTION REDUCTION ESTIMATOR INPUTS – GULLY TAB		MODEL OUTPUTS					
LC_ID	CC CornBeans Hay Herbaceous Pasture Forested Wetland Residential	OWN	Soil	Steep Yes No	WS *Acres*	Slope *%*	LEN *Feet*	DEP *Feet*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	VOLV (1/2(Top width + Bottom width)) * Depth * Length	YR 1 = plowed through 30 = plowed around 100 = gully	COND 1 = channelized 2 = non-channelized	DSW *Feet*	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Filter Strip

PROJECT PROFILE INPUTS					POLLUTION REDUCTION ESTIMATOR INPUTS – FILTER STRIP TAB					RUSLE INPUTS			MODEL OUTPUTS		
LC_ID	CC CornBeans Hay Herbaceous Pasture Forested Wetland Residential	OWN	Steep Yes No	EXIST_FS *Feet*	SLB_FS *T/Ac/Yr*	SLA *T/Ac/Yr*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	CA *Acres*	SLB_WS *T/Ac/Yr*	SL *Feet*	Slope *%*	Soil	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Permanent Vegetation

PROJECT PROFILE INPUTS			POLLUTION REDUCTION ESTIMATOR INPUTS – SHEET AND RILL TAB						RUSLE INPUTS			MODEL OUTPUTS		
LC_ID	CC CornBeans Hay Herbaceous Pasture Forested Wetland Residential	TFA *Acres*	SLB *T/Ac/Yr*	SLA *T/Ac/Yr*	DSW *Feet*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	AC *Acres*	CA *Acres*	SL *Feet*	Slope *%*	Soil	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Wetland Restoration (USING BWSR POLLUTION REDUCTION ESTIMATOR)

PROJECT PROFILE INPUTS										POLLUTION REDUCTION ESTIMATOR INPUTS – SHEET AND RILL TAB						RUSLE INPUTS			MODEL OUTPUTS		
LC_ID	D_USE Agricultural Herbaceous Pasture Forested Wetland Residential	WS *Acres*	WET_AREA *Acres*	WWR	NWI	TYPE	RWF	FLOW	OWN	SLB *T/Ac/Yr*	SLA *T/Ac/Yr*	DSW *Feet*	SSCP 1 = Sand 2 = Silt 3 = Clay 4 = Peat	AC *Acres*	CA *Acres*	SL *Feet*	Slope *%*	Soil	TP *Lb/Yr*	TSS *Ton/Yr*	S *Ton/Yr*

Wetland Restoration (USING PONDNET MODEL)

PROJECT PROFILE INPUTS										PONDNET MODEL						MODEL OUTPUTS
LC_ID	D_USE Agricultural Herbaceous Pasture Forested Wetland Residential	Soil	WET_AREA *Acres*	WWR	NWI	TYPE	RWF	FLOW	OWN	WS *Acres*	IMP *%*	OPEN *%*	AG *%*	OTHER *%*	DSW *Feet*	TP *Lb/Yr*

Animal Operation

PROJECT PROFILE INPUTS								
LC_ID	Soil	OWN	DSW *Feet*	AO_Acre *Acres*	ANIMAL	WET	STREAM	DITCH

Pastured Wetlands

PROJECT PROFILE INPUTS							
LC_ID	Soil	OWN	PW_Acre *Acres*	ANIMAL	WET	STREAM	DITCH

Appendix D

13 NRCS Engineering Tools-Watershed Delineation

Several of the models used in this protocol to obtain potential pollution reduction values require the input of watershed size. Watershed size and average slope are also listed in the Project Profiles of several of the BMPs. The tools used to obtain the watershed size and average slope for the rural subwatershed assessments in Chisago County watershed are the delineation tools that are part of the NRCS Engineering Toolbox.

A step-by-step guide to using the NRCS Engineering Tools is also available through NRCS.

The toolbox includes a 3-step process for delineating watersheds. You will need to add this toolbox to ArcToolbox.

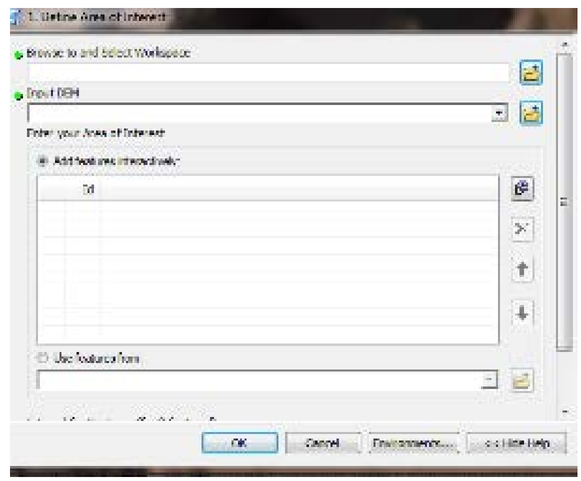


Figure 24. Define Area Of Interest

13.1 Define AOI (Area of Interest)

This step is very simple and produces a series of very useful layers that are automatically added to the project in ArcMap.

- Browse to and Select Workspace: Click the folder icon and select a place to save the shapefiles that will be created.
- Input DEM: Open the drop down menu and select a Digital Elevation Map (DEM) layer from the project. Only the eligible layers will show up in the menu.
- Enter your Area of Interest: Click the arrow top button (looks like an arrow pointing to a pie chart). On the map, draw a box around the area that you want to work in. Draw the box big enough that the entire watershed you are interested in will be included.
- Interval for Contours: Select 1.
- Original DEM Z Units: Leave at default setting.
- Push Ok.

When complete, several new layers should be automatically added to your map and turned on. A 1-foot contour map (usually yellow lines) will show up on top. This layer can sometimes be inaccurate; if you plan to use this contour data, make sure the elevations seem correct. If you have a reliable contour layer, continue to use that layer and ignore this one.

Figure 25. One-foot Contours

A red box that outlines the area of interest will appear. This layer can be turned off.

Further down the list in the Table of Contents, a group of three new layers will appear. These are the Depth Grid, Hillshade, and DEM. The depth grid shows areas of pooling water. This can be helpful in determining where there may be digital dams due to culverts that are not represented on the DEM layer. The Hillshade shows the topography of the land in 3 dimensions. This layer is extremely helpful during the desktop scouting steps of this protocol. Finally, the DEM is displayed as a color ramp by default. It is helpful in visualizing the topography of the land, especially in conjunction with the hillshade layer.

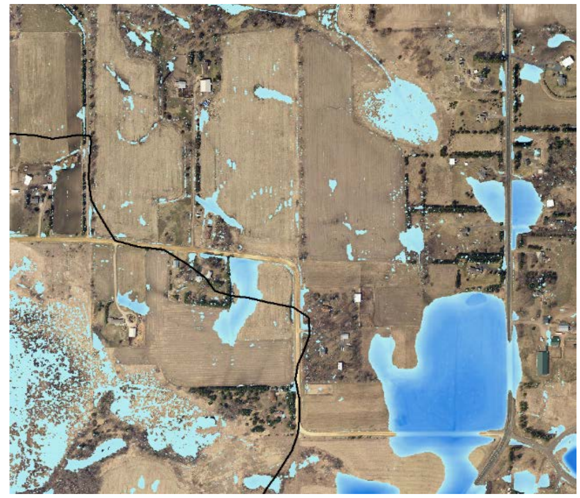


Figure 26. Depth Grid

13.2 Create Stream Network

The next step is to correct the DEM to break digital dams. These are most often located in places where there are culverts.   The DEM shows the elevation of the road, which causes water to "pool" when in reality the water is able to move via the culvert. To correct the DEM, the digital dams must be broken, or "burned through". The second tool, Create Stream Network, does this automatically. The user must supply the placement of culverts.

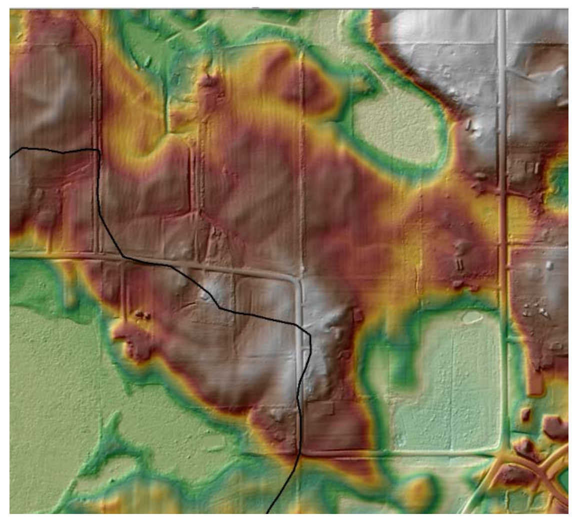


Figure 27. DEM with Hillshade

- Select Project AOI Feature: Open the drop down menu and select the AOI that was created in the previous step.
- Digitize Culverts: This can be done manually using the "Add Features Interactively" box. Click the top button on the right that looks like an arrow with three dots connected by a line. Then in the map, draw a line where there is a culvert.
- Continue this process until all culverts have been added within the area of interest.
- If a culvert layer exists with the location of culverts already digitized, use this instead of manually marking them all. Click the circle next to Use Features From and then use the drop down menu or the folder icon to select the culvert layer.
- Enter Stream Threshold in Acres: The default for this box is 1. You can choose the scale to use; 0.2 gives a good detailed stream network. For large watersheds, use 0.5 or 1. On smaller watersheds, a smaller number is better.
- Click Ok.

A new shapefile called Streams should appear in the Table of Contents and be drawn in the map window. The network of blue lines represent where water runs.

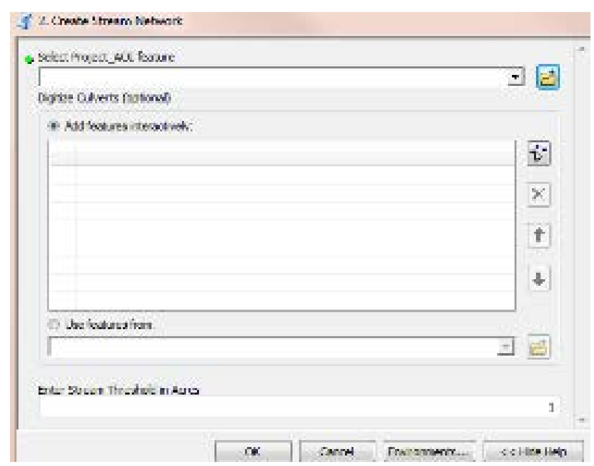


Figure 28. Create Stream Network

Helpful Hint: Double check, especially if culverts were added, that the stream network makes sense. There have been instances where the streams drawn backwards (water running uphill instead of down). If the streams don't seem right, try using a different DEM in the first step.

Figure 29. Stream Network

13.3 Create Watershed

With the stream network turned on, the third step is to delineate watersheds for a specific "pour point". The watershed will delineate the area from which all the water drains to the pour point selected.

- Select AOI Stream Network Feature: Open the drop down menu and select the stream network that was created in the last step.
- Digitize Outlets: Use the top button that looks like an arrow with three dots connected by a line. In the map, draw a line across the stream network segment where the pour point is. The watershed will be determined upstream of this point.

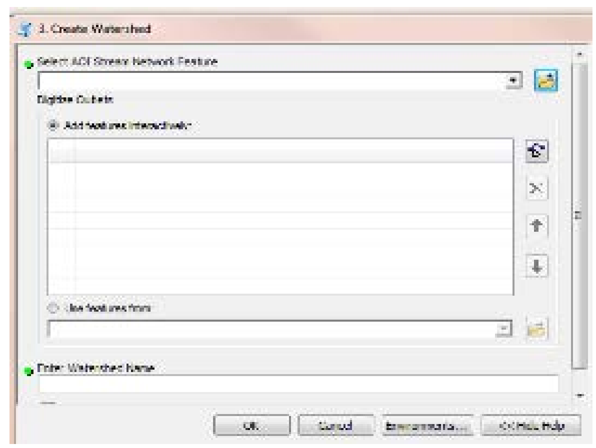


Figure 30. Create Watershed

Helpful Hint: Multiple watersheds can be created in the same step.

Helpful Hint: A long line can be drawn even if it does not cross a stream. For example, a line can be drawn along a potential filter strip to determine the watershed that drains through the entire filter strip. Just double check the accuracy of the watershed because the results can be wrong when using the tool this way.

- Enter a watershed name. This is how the file will be saved.
- If desired, click the box at the bottom next to Create Watershed Flow Path. This will create a line file that shows the longest flow path through the watershed to the pour point.

Figure 31. Watersheds and Outlets

- Click Ok.

Two new shapefiles will appear in the Table of Contents list. The Outlet file will show the pour point and the watershed file delineates the watershed of the pour point. By default, the watershed will be labeled with the acres and average slope of the watershed.

Helpful Hint: The watershed shapefile can be edited if it is not completely accurate, or if manipulations are needed. When edited, the acres and percent slope labels are no longer accurate.

All of the shapefiles created during the watershed delineation process, including the culverts layer, are saved in a geodatabase. The location of the geodatabases was chosen in the first step, creating the Area of Interest in the first box.

Appendix E

14 Troubleshooting

There are numerous places where problems can occur. ArcMap, the NRCS Engineering Tools, and RUSLE2 all seem to have good days and bad days. They are dependent on the inputs of the user and sometimes simply don't work for reasons unknown. This is why it is very important to check the outputs and make sure they seem logical. This section will list some areas that commonly caused problems during the development of this protocol. This by no means is a complete list. When a program simply isn't working, try closing and re-starting. If that doesn't work, try it another day. Sometimes, it works!

14.1 Prioritizing

During the desktop work for the prioritizing section, there can be frustrating errors that occur. Many of them seem related to the computer or the program just having a bad day rather than user error. If none of the suggestions below seem to help, re-start the program or come back another day and try again.

14.1.1 Adding Columns to Attribute Tables

For reasons unknown, you must NOT be editing in order to add a column to an attribute table, but you MUST be editing to fill in the table itself. So if you are editing and wish to add a column, stop editing, add the column, and then start editing again.

14.1.2 NRCS Engineering Tools

If you are using this toolbox, there are a few quirks to note. When choosing the "Workspace" in the step to Create AOI, there cannot be any spaces in the filename. An error message should pop up if you use a name with spaces. If you get other errors, or it says that the process failed, double check that you put the correct inputs into the boxes. If you are sure your inputs are correct and it still won't work, try re-starting or come back another day.

Using the C-drive as the location for the "Workspace" can help speed up the processing time of the tools.

When creating the stream network, make sure you check the output. It has happened that the streams flow the wrong direction (uphill). Sometimes, this can be caused by the incorrect unit on the DEM. Check the DEM properties to see what units are listed (Meters or Feet). It is usually meters. If it is feet, you will need to change the unit in the prompt box for Creating the AOI. At the bottom of the box, there is a drop down menu to choose units for the DEM. Usually, this should be left alone at the default. If you have a DEM in feet, choose Feet from the drop down menu. This is rare.

If the DEM is in meters as usual, try using a different DEM if you have one. This sometimes corrects the streams.

The streams also sometimes come out as a series of parallel lines (often seen over lakes or flat wetlands). If you are trying to create a watershed in this area, it will most often fail or it will give a nonrepresentative watershed. To remedy this, run through the watershed delineation steps again using a smaller AOI around the area that you need to re-define.

Many of the errors occur when trying to create a watershed. Sometimes, the watershed is actually created and can be found and imported from ArcCatalog. Always check there first before trying again. The reasons for watershed delineation errors vary. It seems like pour points that are drawn on the long, parallel lines described above often result in errors. Errors also seem more common when trying to draw multiple watersheds at once. Check ArcCatalog because some of the watersheds are often created. You can pinpoint which pour point caused the error to occur and try again.

Sometimes, the watershed would not work, no matter what was tried. Get creative. One technique is to delineate the watersheds on the streams around the one you want. It should leave a blank space where your watershed is and you can create a polygon that represents your watershed. Another option is to try a pour point further upstream of the pour point you really want. It may work to create a watershed that you can then edit to include the areas downstream.